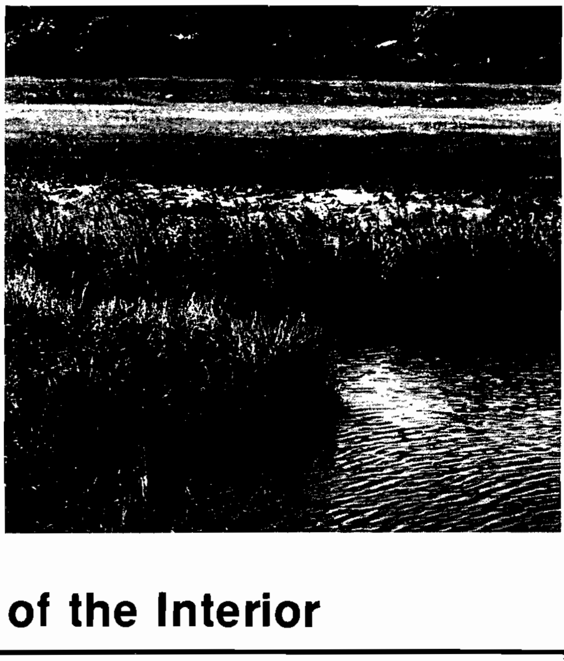
National Wetlands Inventory

JULY 1985

WETLANDS OF NEW JERSEY








U.S. Department of the Interior

Fish and Wildlife Service

WETLANDS OF NEW JERSEY

by

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CHAPTER 1.
Introduction

Wet habitats generally occurring between uplands and deepwater areas are considered wetlands. They are commonly referred to by a number of terms based on their location and characteristics, including salt marsh, tidal marsh, wet meadow, shrub swamp, bog, hardwood swamp, cedar swamp and pitch pine lowland. These areas are important natural resources with numerous values, e.g., fish and wildlife habitat, flood protection, erosion control, water quality maintenance, and recreation.

The U.S. Fish and Wildlife Service and other conservation organizations have always recognized the importance of wetlands to waterfowl, other migratory birds and wildlife. The Service's responsibility for protecting these habitats comes largely from international treaties between the United States and other countries concerning migratory birds and from the Fish and Wildlife Coordination Act. The Service has been active in protecting these resources through various programs. The National Wildlife Refuge System was established to preserve and enhance migratory bird habitat in strategic locations across the country. The Service also reviews Federal projects and applications for Federal permit that involve wetland alteration.

Since the 1950's, the Service has been particularly concerned about wetland losses and their impact on fish and wildlife populations. In 1954, the Service conducted the first nationwide wetlands inventory which focused on important waterfowl wetlands. This survey was performed to provide information for considering fish and wildlife impacts in land-use decisions. The results of this inventory were published in a well-known Service report entitled **Wetlands of the United States**, commonly referred to as Circular 39 (Shaw and Fredine 1956).

Since this survey, 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 1960's, the general public in many States became more aware of wetland values and concerned about wetland losses. They began to realize that wetlands provided significant public benefits besides fish and wildlife habitat, especially flood protection and water quality maintenance. Prior to this time, wetlands were regarded by most people as wastelands, whose best use could only be attained through alteration, e.g., draining for agriculture, dredging and filling for industrial and housing developments and filling with sanitary landfill. Scientific studies demonstrating wetland values, especially for coastal marshes, were instrumental in increasing public awareness of wetland benefits and stimulating concern for wetland protection. Consequently, several States passed laws to protect coastal wetlands, including Massachusetts (1963), Rhode Island (1965), Connecticut (1969), New Jersey (1970), Maryland (1970), Georgia (1970), New York (1972) and Delaware (1973). Several of these States subsequently adopted inland wetland protection legislation: Massachusetts, Rhode Island, Connecticut and New York. Most other States with coastal wetlands followed the lead of these northeastern States. During the early 1970's, the Federal government also assumed greater responsibility for wetland protection through 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.

With increased public interest in wetlands and strengthened government regulation, the Service considered how it could contribute to this resource management effort. Because it has prime responsibility for protection and management of the Nation's fish and wildlife and their habitats, the Service recognized the need for sound ecological information to make decisions regarding policy, planning, and management of the country's wetland resources. In 1974, the National Wetlands Inventory Project was established to generate and disseminate scientific information on the characteristics and extent of the Nation's wetlands. The purpose of this information is to foster wise use of U.S. wetlands and to provide data for making accurate resource decisions.

Two very different kinds of information are needed: (1) detailed maps and (2) status and trends reports. First, detailed wetland maps for geographic areas of critical concern are needed for impact assessment of site-specific projects. These maps serve a purpose similar to the Soil Conservation Service's soil survey maps, the National Oceanic and Atmospheric Administration's coastal geodetic survey maps, and the Geological Survey's topographic maps. Detailed wetland maps are used by local, State and Federal agencies as well as by private industry and organizations 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 other uses. To date, over 10,000 maps have been produced, covering 40% of the lower 48 States, 10% of Alaska, and all of Hawaii. Present plans are to complete wetland mapping for at least 55% of the conterminous

U.S. and 16% of Alaska by 1988. Secondly, national estimates of the current status and recent losses and gains of wetlands are needed in order to provide improved information for reviewing the effectiveness of existing Federal programs and policies, for identifying national or regional problems and for general public awareness. Technical and popular reports about these trends have been recently published (Frayer, *et al.* 1983; Tiner 1984).

Need for a Wetlands Inventory in New Jersey

New Jersey is the most densely populated of our 50 States, with almost 10% of the U.S. population living within 50 miles of New Brunswick (Robichaud and Buell 1973). This dense population creates a high demand for real estate for housing and industry and numerous municipalities encourage wetland development by zoning wetlands for such uses.

A wetlands inventory was needed for New Jersey for several reasons: (1) no detailed statewide information existed on the distribution and extent of New Jersey's wetlands and deepwater habitats, (2) increasing development pressures threatened the remaining inland wetlands, and (3) many inland wetlands were still not adequately protected by State or Federal law. Although extensive mapping of coastal wetlands had been completed by the State, no comparable maps existed for inland wetlands, except for the Pine Barrens. Also, changes in coastal wetlands undoubtedly occurred since the State's maps were prepared in the early 1970's. While coastal wetlands were protected through the Wetlands Act of 1970, development pressures on inland wetlands intensified particularly in northern New Jersey, where wetlands, in many cases, represented the last large tracts of undeveloped land. In the late 1970's, the Pinelands Area and Pinelands National Reserve were being established in southern New Jersey, which ultimately provided special protection to wetlands. Yet many inland wetlands outside the Pinelands were still relatively unprotected, although the Federal Clean Water Act of 1977 provided some regulation over wetland uses involving deposition of fill. Thus, in 1979, the Service initiated a wetlands inventory in New Jersey to provide government administrators, private industry and others with improved information for project planning and impact evaluation and for making land-use decisions. This inventory would produce detailed wetland maps for the entire State, identify the current status of New Jersey's wetlands and serve as the base from which future changes can be determined.

Description of the Study

New Jersey is one of the 13 northeastern states within the Service's Northeast Region. New Jersey's landscape is highly varied as a result of differences in geology, soils, climate, and vegetation. Robichaud and Buell (1973) described in great detail the relationship between vegetation and other factors. Five physiographic regions can be found within the State: (1) Outer Coastal Plain, (2) Inner Coastal Plain, (3) Piedmont, (4) Highlands, and (5) Ridge and Valley (Figure 1). The nearly level coastal plain in the south is contrasted by more hilly area of the north. The climate is continental with cold winters and hot, humid summers. The growing season begins as early as March 15 in the southwestern part of the State and as late as April 4 in the northwest. Length of the growing season varies from 220-240 days in northern New Jersey to 245-255 days in southern New Jersey. Precipitation averages 42.94 inches along the coast, 44.95 inches in the south and 46.96 inches in the north.

Purpose and Organization of this Report

The purpose of this publication is to report the findings of the Service's wetlands inventory of New Jersey - the first State completed by the National Wetlands Inventory Project - and to summarize existing information on New Jersey's wetlands. The following chapters will include 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), wetlands trends (Chapter 8), and wetland protection (Chapter 9). The Appendix contains a list of plants found in New Jersey's wetlands. Scientific names of plants follow the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982). A figure showing the general distribution of New Jersey's wetlands and deepwater habitats is provided as an enclosure at the back of this report.

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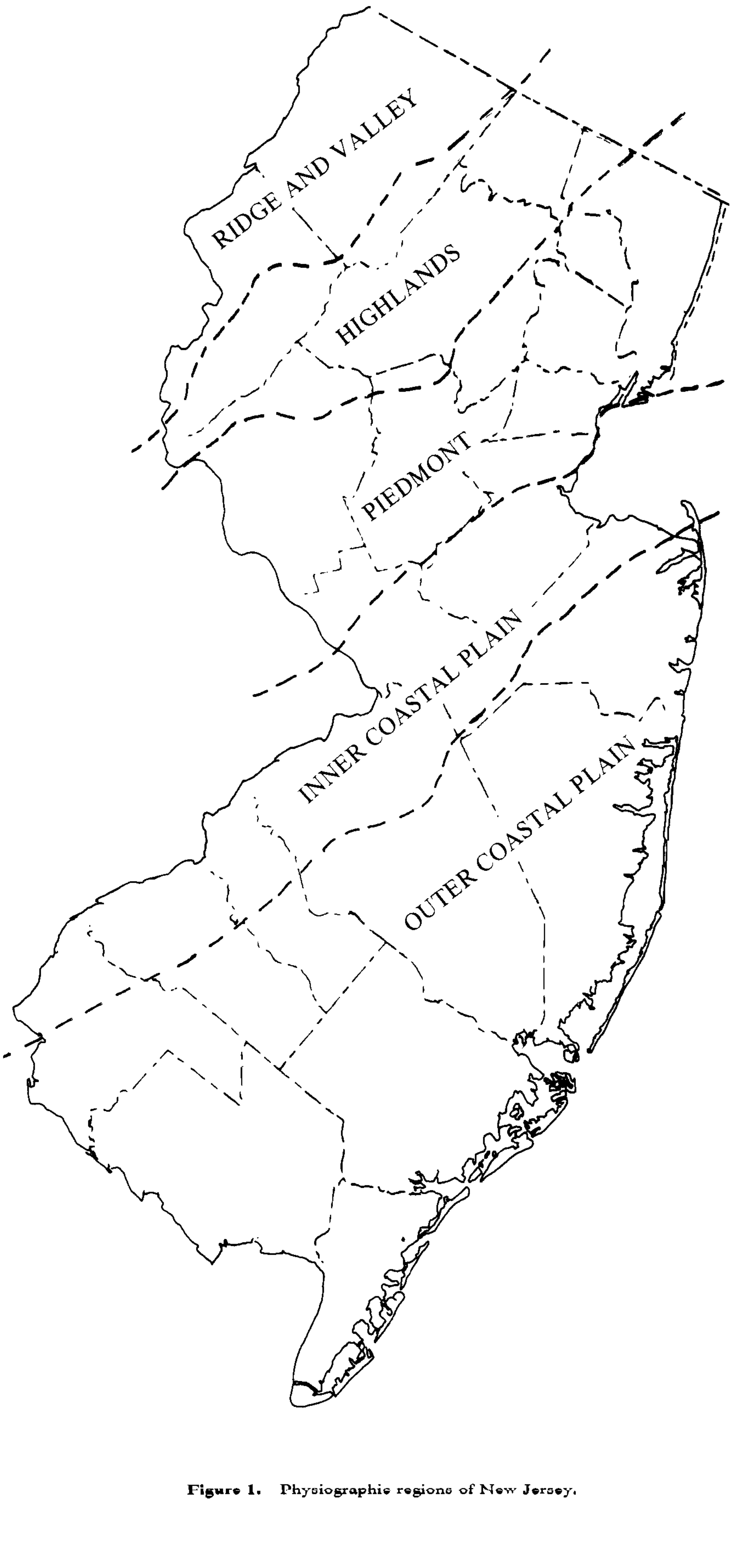

Figure 1. Physiographic regions of New Jersey.

CHAPTER 2.

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

Introduction

To begin inventorying the Nation's wetlands, the Service needed a definition of wetland and a classification system to identify various wetland types. The Service, therefore, examined recent wetland inventories throughout the country to learn how others defined and classified wetlands. The results of this examination were published as **Existing State and Local Wetlands Surveys (1965-1975)** (U.S. Fish and Wildlife Service 1976). More than 50 wetland classification schemes were identified. Of those, only one classification - the Martin, *et al.* system (1953) - was nationally based, while all others were regionally focused. In January 1975, the 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 the 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 Wetland 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 hierarchial 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 units, 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 Service's wetland classification system was developed by a four member team, i.e., Dr. Lewis M. Cowardin (U.S. Fish and Wildlife Service), Virginia Carter (U.S. Geological Survey), Dr. Francis C. Golet (University of Rhode Island) and Dr. 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, the Service's classification system has been widely used by Federal, State, and local agencies, university scientists, and private industry and non-profit organizations for identifying and classifying wetlands. At the First International Wetlands Conference in New Delhi, India, scientists from around the world adopted the Service's wetland definition as an international standard and recommended testing the applicability of the classification system in other areas, especially in the tropics and subtropics (Gopal, *et al.* 1982). Thus, the system appears to be moving quickly towards its goal of providing uniformity in wetland concept and terminology.

The Service's Definition of Wetland

Conceptually, wetlands lie between the better drained, rarely flooded uplands and the permanently flooded deep waters of lakes, rivers and coastal embayments (Figure 2). Wetlands generally include the variety of marshes, bogs, swamps, 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. Some wetlands, however, occur on slopes where they are associated with ground-water seeps. To accurately inventory this resource, the Service had to determine where along this natural wetness continuum wetland ends and upland begins. While many wetlands lie in distinct depressions or basins that are readily observable, the wetland-upland boundary is not always that easy to identify. This is especially true in the Pine Barrens where many wetlands occur in almost imperceptably shallow depressions, covering vast acreages with just a slight change in elevation. In these areas, only a skilled wetland ecologist or other specialist can accurately identify the wetland boundary. To help ensure accurate and consistent wetland determination, an ecologically based definition was constructed by the Service.

Wetlands were historically defined by scientists working in specialized fields, such as botany or hydrology. A botanical definition would focus on the plants adapted to flooding and/or saturated soil conditions, while a hydrologist's definition would emphasize fluctuations in the position of the water table relative to the ground surface over time. A more complete definition of wetland involves a multi-disciplinary approach. The U.S. Fish and Wildlife Service has taken this approach in developing its wetland definition and classification system.

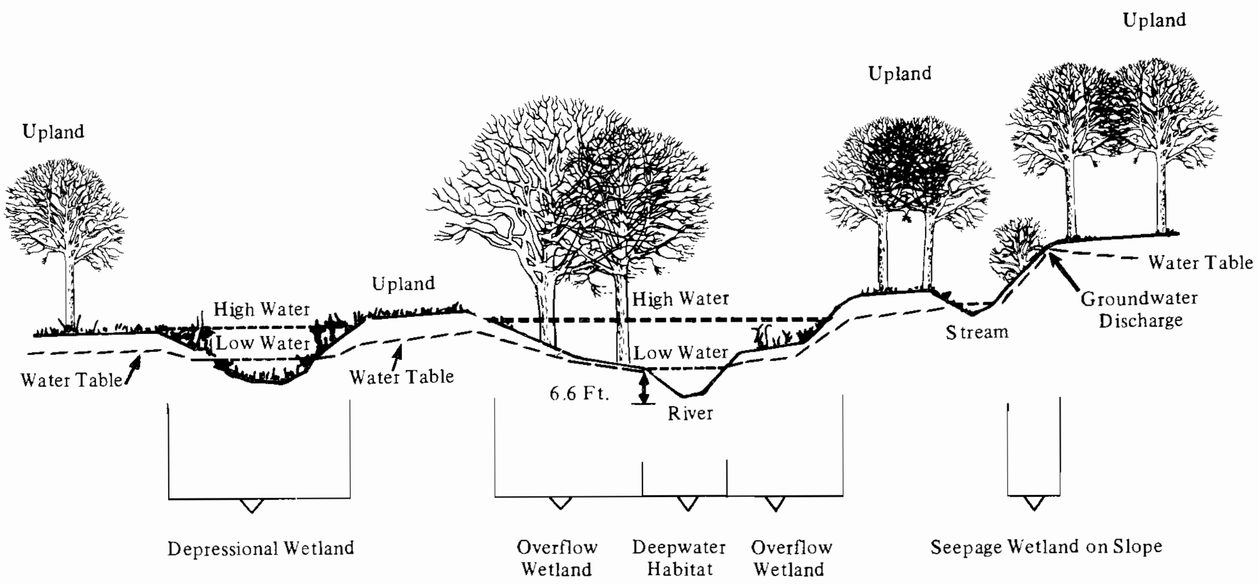

Figure 2. Schematic diagram showing wetlands, deepwater habitats, and uplands on the landscape. Note differences in wetlands due to hydrology and topographic position.

In developing a multi-disciplinary definition of wetland, the Service first acknowledged that "There is no single, correct, indisputable, ecologically sound definition for wetlands, primarily because of the diversity of wetlands and because the demarcation between dry and wet environments lies along a continuum" (Cowardin, *et al.* 1979). After all, a wealth of wetland definitions grew out of different needs for defining wetlands among various groups or organizations, e.g., wetland regulators, waterfowl managers, hydrologists, flood control engineers and water quality experts. The Service has not attempted to legally define wetland, since each State or Federal regulatory agency has defined wetland somewhat differently to suit its administrative purposes (Table 1). Therefore, according to existing wetland laws, a wetland is whatever the law says it is. For example, New Jersey's Coastal Wetland Protection Act (N.J. Stat. Ann. 13:9A-1 to 13:9A-10) defines coastal wetland as "any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the State of New Jersey along the Delaware Bay and Delaware River, Raritan Bay . . ., including those areas now or formerly connected to tidal action whose surface is at or below an elevation of one foot above local extreme high water and upon which may grow or is capable of growing some, but not necessarily all, of the following: salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardi*), salt marsh grass (*Spartina alterniflora*), ..." This definition also specifically excludes land "subject to the jurisdiction of the Hackensack Meadowlands Development Commission," even though the Commission controls the use of extensive tidal marshes. Thus, this legal definition restricts the term "coastal wetland" to tidal marshes having a specific assemblage of plants within certain geographical boundaries. The Service needed a definition that would allow accurate identification and delineation of the Nation's wetlands for resource management purposes.

The Service specifically defines wetlands as follows: *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."* (Cowardin, *et al.* 1979)

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

Particular attention should be paid to the reference to flooding or soil saturation during the growing season in the Service's wetland definition. When soils are covered by water or saturated to the surface, free oxygen is not available to plant roots. During the growing season, most plant roots must have access to free oxygen for respiration

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 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 Fish and Wildlife Service definition and is being used for conducting an inventory of the Nation's wetlands. It replaces the previous definition which is also outlined in this table. Emphasizes flooding and/or soil saturation, hydric soils and vegetation. Shallow lakes and ponds are included as wetland. Comprehensive lists of wetland plants and soils are being developed to further clarify this definition.
U.S. Fish and Wildlife Service and U.S. Soil Conservation Service (Shaw and Fredine 1956)	"Wetlands are lowlands covered with shallow and sometimes temporary or intermittent waters." They include marshes, swamps, bogs, wet meadows, potholes, sloughs, river overflow lands, and shallow lakes and ponds.	Former Fish and Wildlife Service definition. Although this definition is generally weak, 20 individual wetland types were described in terms of water permanence and depth, salinity and vegetation. This is the official definition of the U.S.D.A. Soil Conservation Service. Wetland definition includes shallow lakes and ponds, but not permanent waters of streams, reservoirs and deep lakes.
U.S. Army Corps of Engineers (Federal Register, July 19, 1977; July 22, 1982)	Wetlands are "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."	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 wetland.
State of New Jersey (N.J. Pinelands Comprehensive Management Plan, 1980; Pinelands Protection Act - N.J. STAT. ANN. Section 13:18-1 to 13:29.)	"Wetlands are those lands which are inundated or saturated by water at a magnitude, duration and frequency sufficient to support the growth of hydrophytes. Wetlands include lands with poorly drained or very poorly drained soils as designated by the National Cooperative Soils Survey of the Soil Conservation Service of the United States Department of Agriculture. Wetlands include coastal wetlands and inland wetlands, including submerged lands." "Coastal wetlands are banks, low-lying marshes, meadows, flats, and other lowlands subject to tidal inundation which support or are capable of supporting one or more of the following plants:" twenty-nine plants are listed. "Inland wetlands" are defined as including, but not limited to, Atlantic white cedar swamps (15 plants listed), hardwood swamps (19 plants specified), pitch pine lowlands (10 plants listed), bogs (12 plants identified), inland marshes (6 groups of plants listed), lakes and ponds, and rivers and streams.	State regulatory definition. Emphasizes geographic location (i.e., Pinelands Area), vegetation, wet soils, and flooding or soil saturation. Lakes, ponds, rivers and streams are included in this wetland definition.
State of New Jersey (Coastal Wetland Protection Act-N.J. STAT ANN. Section 13:9A-1 to 13:9A-10)	"Coastal wetlands" are "any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the Delaware Bay and Delaware River, Raritan Bay, Sandy Hook Bay, Shrewsbury River including Navesink River, Shark River, and the coastal inland waterways extending southerly from Manasquan Inlet to Cape May Harbor, or at any inlet,estuary or those areas now or formerly connected to tidal whose surface is at or below an elevation of 1 foot above local extreme high water, and upon which may grow or is capable of growing some, but not necessarily all, of the following:" 19 plants are listed. Coastal wetlands exclude "any land or real property subject to the jurisdiction of the Hackensack Meadowlands Development Commission . . . ."	State regulatory definition for tidal wetlands. Emphasizes tidal flooding, geographic location, elevation and vegetation.

and growth; flooding at this time would have serious implications for the growth and survival of most plants. In a wetland situation, plants must be adapted to cope with these stressful conditions. If, however, flooding only occurs in winter when the plants are dormant, there is little or no effect on them.

Wetlands typically fall within one of the following five 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 with hydrophytes but with non-hydric soils (e.g., margins of impoundments where hydrophytes have colonized non-hydric but now flooded soils), (4) areas without soils but with hydrophytes (e.g., seaweed-covered rocky shores), and (5) 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 wetland. Areas with completely drained hydric soils are, however, good indicators of historic wetlands, which may be suitable for restoration through mitigation projects.

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

The Service's Wetland Classification System

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

The Service's wetland classification system is hierarchial or vertical in nature proceeding from general to specific, as noted in Figure 3. In this approach, wetlands are first defined at a rather broad level - the **system**. The term **system** represents "a complex of wetlands and deepwater habitats that share the influence of similar hydrologic, geomorphologic, chemical, or biological factors." Five systems are defined: Marine, Estuarine, Riverine, Lacustrine and Palustrine. The Marine System generally consists of the open ocean and its associated coastline, 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 (e.g., rivers and streams), Lacustrine, (e.g., lakes, reservoirs and large ponds) or Palustrine (e.g., marshes, bogs, swamps and small shallow ponds). Thus, at the most general level, wetlands can be defined as either Marine, Estuarine, Riverine, Lacustrine or Palustrine (Figure 4).

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

Below the subsystem, we encounter the **class** level which describes the general appearance of the wetland or deepwater habitat in terms of the dominant vegetative life form or the composition of the substrate, where vegetative cover is less than 30% (Table 2). Of the 11 classes, five refer to areas where vegetation covers 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, where the composition of the substrate and degree of flooding distinguish classes: Rock Bottom, Unconsolidated Bottom, Reef (sedentary invertebrate colony), Streambed, Rocky Shore, and Unconsolidated Shore. Permanently flooded unvegetated areas are classified as either Rock Bottom or Unconsolidated Bottom, while exposed areas are typed as Streambed, Rocky Shore or Unconsolidated Shore. Invertebrate reefs are found in both permanently flooded and exposed areas.

Each class is further divided into subclasses to better define the type of substrate in unvegetated areas (e.g., bedrock, rubble, cobble-gravel, mud, sand, and organic) or the type of dominant vegetation (e.g., persistent or nonpersistent emergents, moss, lichen, or broad-leaved deciduous, needle-leaved deciduous, broad-leaved ever-

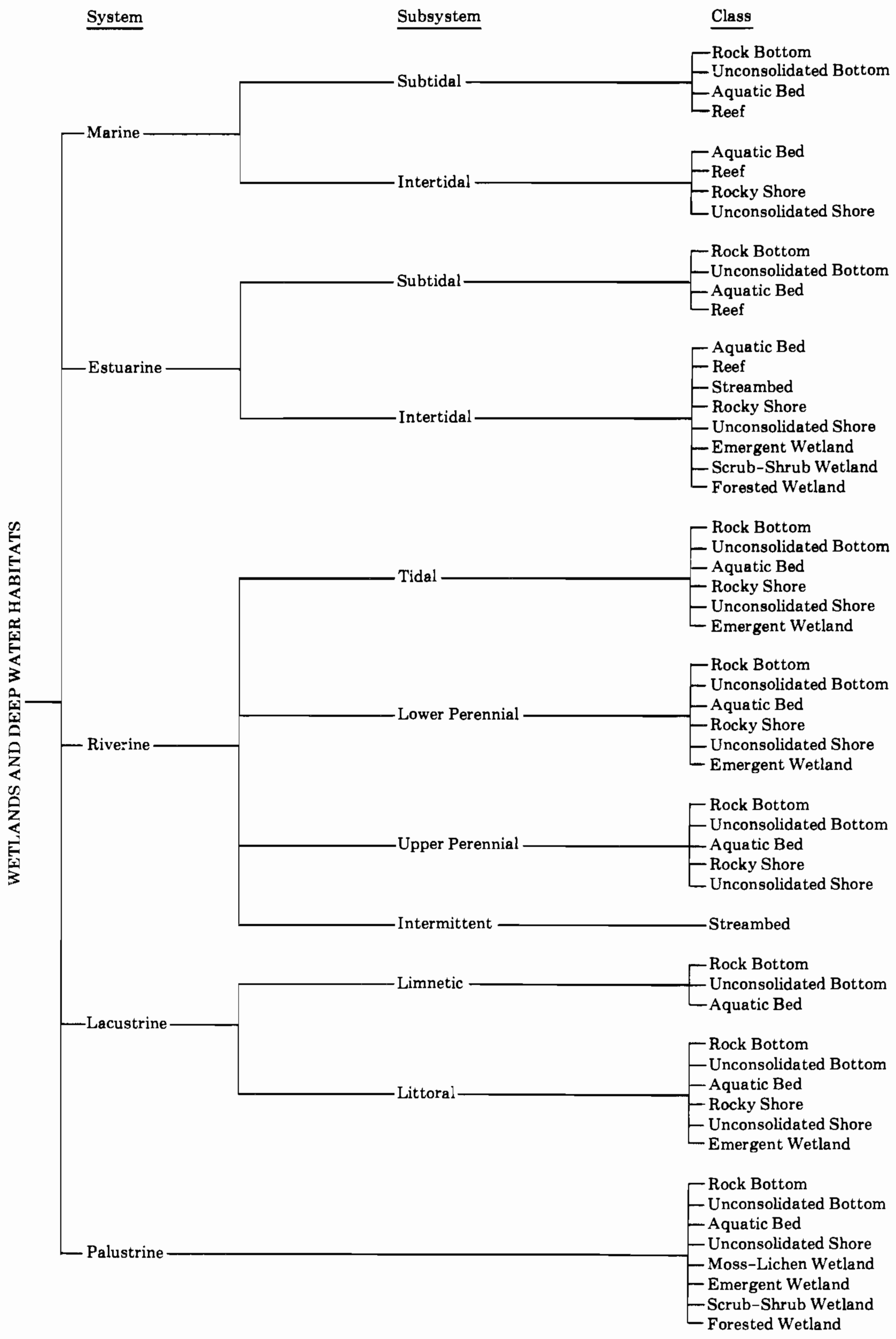

Figure 3. Classification hierarchy of wetlands and deepwater habitats showing systems, subsystems, and classes. The Palustrine System does not include deepwater habitats (Cowardin, *et al.* 1979).

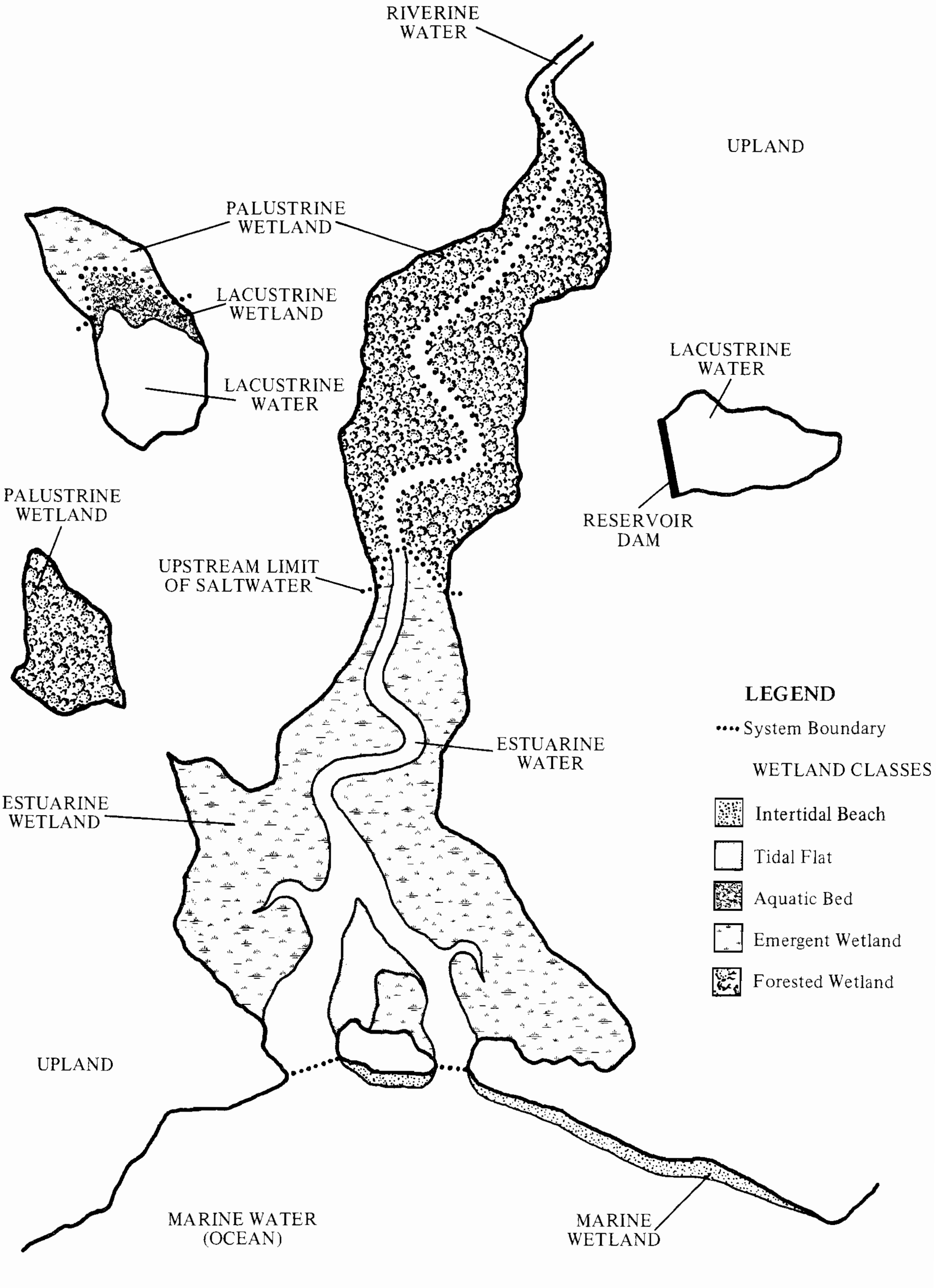

Figure 4. Diagram showing major wetland and deepwater habitat systems. Predominant wetland classes for each system are also designated.

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 stones and less than 30% vegetative cover.	Cobble-gravel; Sand; Mud; Organic
Aquatic Bed	Generally permanently flooded areas vegetated by plants growing principally on or below the water surface line.	Algal; Aquatic Moss; Rooted Vascular; Floating Vascular
Reef	Ridge-like or mound-like structures formed by the colonization and growth of sedentary invertebrates.	Coral; Mollusk; Worm
Streambed	Channel whose bottom is completed dewatered at low water periods.	Bedrock; Rubble; Cobble-gravel; Sand; Mud; Organic; Vegetated
Rocky Shore	Wetlands characterized by bedrock, stones or boulders with areal coverage of 75% or more and with less than 30% coverage by vegetation.	Bedrock; Rubble
Unconsolidated Shore*	Wetlands having unconsolidated substrates with less than 75% coverage by 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 greater than 20 feet (6 m) tall.	Broad-leaved Deciduous; Needle-leaved Deciduous; Broad-leaved Evergreen; Needle-leaved Evergreen; Dead

green, needle-leaved evergreen and dead woody plants). Below the subclass level, dominance type can be applied to specify the predominant plant or animal in the wetland community.

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

Water regime modifiers describe flooding or soil saturation conditions and are divided into two main groups: (1) tidal and (2) nontidal. Tidal water regimes are used where water level fluctuations are largely driven by oceanic tides. Tidal regimes can be subdivided into two general categories, one for saltwater and brackish water tidal areas and another for freshwater tidal areas. This distinction is needed because of the special importance of seasonal river overflow in freshwater tidal areas. By contrast, nontidal modifiers define conditions where surface water runoff, ground-water discharge, and/or wind effects (i.e., lake seiches) cause water level changes. Both tidal and nontidal water regime modifiers are presented and briefly defined in Table 3.

Water chemistry modifiers are divided into two categories which describe the water's salinity or hydrogen

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 exposed	Flooded year-round except during extreme droughts
		Semipermanently flooded	Flooded throughout the growing season in most years
		Seasonally flooded	Flooded for extended periods in growing season, but surface water is usually absent by end of growing season
		Saturated	Surface water is seldom present, but substrate is saturated to the surface for most of the season
		Temporarily flooded	Flooded for only brief periods during growing season, with water table usually well below the soil surface for most of the season
		Intermittently flooded	Substrate is usually exposed and only flooded for variable periods without detectable seasonal periodicity (Not always wetland: may be upland in some situations)
		Artificially flooded	Duration and amount of flooding is controlled by means of pumps or siphons in combination with dikes or dams

ion concentration (pH): (1) salinity modifiers and (2) pH modifiers. Like water regimes, salinity modifiers have been further subdivided into two groups: halinity modifiers for tidal areas and salinity modifiers for nontidal areas. Estuarine and marine waters are dominated by sodium chloride, which is gradually diluted by fresh water as one moves upstream in coastal rivers. On the other hand, the salinity of inland waters is dominated by four major cations (i.e., calcium, magnesium, sodium and potassium) and three major anions (i.e., carbonate, sulfate, and chloride). Interactions between precipitation, surface runoff, ground-water flow, evaporation, and sometimes

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

Coastal Modifiers[1]	**Inland Modifiers**[2]	**Salinity (o/oo)**	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.

plant evapotranspiration form inland salts. Table 4 shows ranges of halinity and salinity modifiers which are modifications of the Venice System (Remane and Schlieper 1971). The other set of water chemistry modifiers are pH modifiers for identifying acid (pH<5.5), circumneutral (5.5-7.4) and alkaline (pH>7.4) waters. Some studies have shown a good correlation between plant distribution and pH levels (Sjors 1950; Jeglum 1971). Moreover, pH can be used to distinguish between mineral-rich and mineral-poor wetlands.

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

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

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CHAPTER 3.

National Wetlands Inventory Techniques and Results

Introduction

The National Wetlands Inventory Project relies heavily on remote sensing techniques and field investigations for wetlands identification and mapping. High-altitude aerial photography ranging in scale from 1:60,000 to 1:80,000 serves as the primary remote imagery source. Once suitable high-altitude photography is obtained, there are seven major 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. Upon publication of final wetland maps for New Jersey, the Service constructed a wetland database, where all National Wetlands Inventory maps were digitized and data entered into a computer. This database generated acreage summaries on wetlands and deepwater habitats on a county basis. The procedures used to inventory New Jersey'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 in New Jersey in 1979, the Service reviewed past wetlands surveys to ensure that no duplication would occur. Major inventories included the Service's surveys of important waterfowl wetlands in 1954, 1959 and 1965, N.J. Department of Environmental Protection coastal wetlands mapping in 1972 and a New Jersey State Museum-supported inventory of large inland wetlands of the Pine Barrens. Although the State's coastal wetlands were mapped in great detail, no comparable wetland mapping existed statewide. The National Wetlands Inventory would fulfill this data gap by conducting a comprehensive inventory of New Jersey's wetland resources. An updated summary of major wetland-related inventories in the State is presented in Table 5.

Mapping Photography

For mapping New Jersey's wetlands, the Service used 1:80,000 black and white photography for nearly all of the State (see Figure 5). Most of this imagery was acquired from the fall of 1975 to the spring of 1977. For the most northern part of the State, however, the best available high-altitude photography was from the spring of 1972. Also three areas along the Pennsylvania and Delaware borders were mapped using spring 1981 photography. During the initial inventory, these areas had been unintentionally missed. Particular attention should be placed upon the photo date of each map, since wetlands may have undergone changes, either natural or human-induced, since that time. In general, the effective date of this inventory can be considered 1976-77.

Field Investigations

Prior to performing photo interpretation, the biologists conduct field investigations in project areas to become familiar with the variety of wetlands. Field check sites are identified by scanning the photography to locate different wetland types and questionable areas. Information is collected in the field on the classification of wetlands and on their vegetation. Through this field work, photo interpreters learn to identify the different wetland types on the aerial photographs, which is essential to accurate wetland mapping. When needed, ground truthing surveys are later conducted to resolve significant interpretation problems. Detailed notes were taken at more than 250 sites throughout the State. In addition to these sites, observations were made of countless other wetlands for classification purposes and notations were recorded on appropriate topographic maps. In total, approximately seven weeks were spent in the field from the spring of 1978 to the fall of 1981.

Photo Interpretation and Collateral Data

High-altitude aerial photographs were viewed in stereo by specially trained biologists using mirror and binocular stereoscopes. They identified wetlands from uplands, delineated wetland boundaries and classified each wetland, using National Wetlands Inventory mapping conventions as a guide (U.S. Fish and Wildlife Service 1981). Since the New Jersey inventory and numerous others commenced prior to publication of the Service's official wetland classification system, the operational draft of this system (Cowardin, *et al.* 1977) was used.

During photo interpretation, biologists also examined existing wetland information from many sources. This

Table 5. Wetland inventories conducted in New Jersey. This list represents the more significant surveys and does not include local studies.

Date of Survey	Lead Agency	Wetlands Mapped	Comments
1977-83	U.S. Fish & Wildlife Service	Coastal and inland wetlands	First comprehensive inventory of New Jersey's wetland and deepwater habitat resources. Two sets of wetland maps produced: 1:24,000 and 1:100,000. Wetland classified according to Cowardin, *et al.* (1977). Minimum mapping unit = 1-3 acres. Mostly 1975-77 photography used, 1972 for northern areas. Identified 915,960 acres of wetland and 412,949 acres of deepwater habitat. Final report (Tiner 1985).
1980	N.J. Pinelands Commission	Coastal and inland wetlands within the Pinelands	Vegetation maps produced at 1:24,000 showing wetland types: cedar swamp, hardwood swamp, pitch pine lowland forest, coastal marsh, inland marsh and bog. Also mapped rivers, streams, ponds, impoundments and coastal waters. 1978-79 photography used. Minimum mapping unit = 2 acres.
1979-ongoing	N.J.D.E.P. Office of Environmental Analysis	All lands now or formerly flowed by the tides at or below mean high water.	Tidelands mapped at 1:2400. Maps show current and former tidelands that are state-owned, unless the Tidelands Resource Council has granted or sold them.
1979	N.J.D.E.P. Division of Coastal Resources	Coastal submerged aquatic beds	Submerged vegetation maps produced at 1:24,000 showing major species communities. Final report (Macomber and Allen 1979).
1975	Hackensack Meadowlands Development Commission	Hackensack coastal wetlands	Generalized map of wetland bio-zones showing mudflat, low salt marsh, high salt marsh, diked marsh and mixed marsh. Report (HMDC 1975).
1973	N.J.D.E.P. Division of Fish, Game & Shellfisheries	Coastal wetlands	Study conducted to identify coastal marsh losses and their causes. Identified 201,373 acres of coastal marshes in 1973 and a 24% loss in twenty years (1953-73). Report (Ferrigno, *et al.* 1973).
1973	N.J. State Museum	Inland wetlands of the Pine Barrens	Vegetation and land use maps produced at 1:24,000 showing wetland types: marsh, bog, cedar swamp, hardwood swamp and pitch pine lowland forest. 1956 photography was used. Minimum mapping unit = 20 acres . Report (McCormick and Jones 1973).
1973	Rutgers University, University of Delaware and Philadelphia Academy of National Sciences	Coastal wetlands in Delaware Estuary	Wetland maps produced at 1:24,000 showing dominant emergent or shrub vegetation. Minimum mapping unit = 0.5 acres.
1972	N.J. Department of Environmental Protection	Coastal wetlands	Surveyed for N.J. Wetlands Act of 1970. Wetland maps produced at 1:2400 showing major plant communities and "biological high water line." Minimum mapping unit = 1-5 acres.
1972	N.J. Department of Environmental Protection	Hackensack wetlands	Identified 6,870 acres of wetlands and categorized according to ecological values. Report (NJDEP 1972).
1965	U.S. Fish & Wildlife Service	Coastal wetlands	Resurvey of coastal marshes. Identified 232,651 acres in 1964 and loss of 11,673 acres (1959-64). Report (FWS 1965).
1959	U.S. Fish & Wildlife Service	Coastal wetlands	Resurvey of coastal wetlands. Identified 244,324 acres in 1959 and loss of 12,936 acres (1954-59). Report (FWS 1959).
1954	U.S. Fish & Wildlife Service	Coastal & inland wetlands of importance to waterfowl	Not comprehensive; focused on 90% of the wetlands important to waterfowl. Minimum mapping unit = 40 acres. Identified 367,160 acres in 1954. Report (FWS 1954).

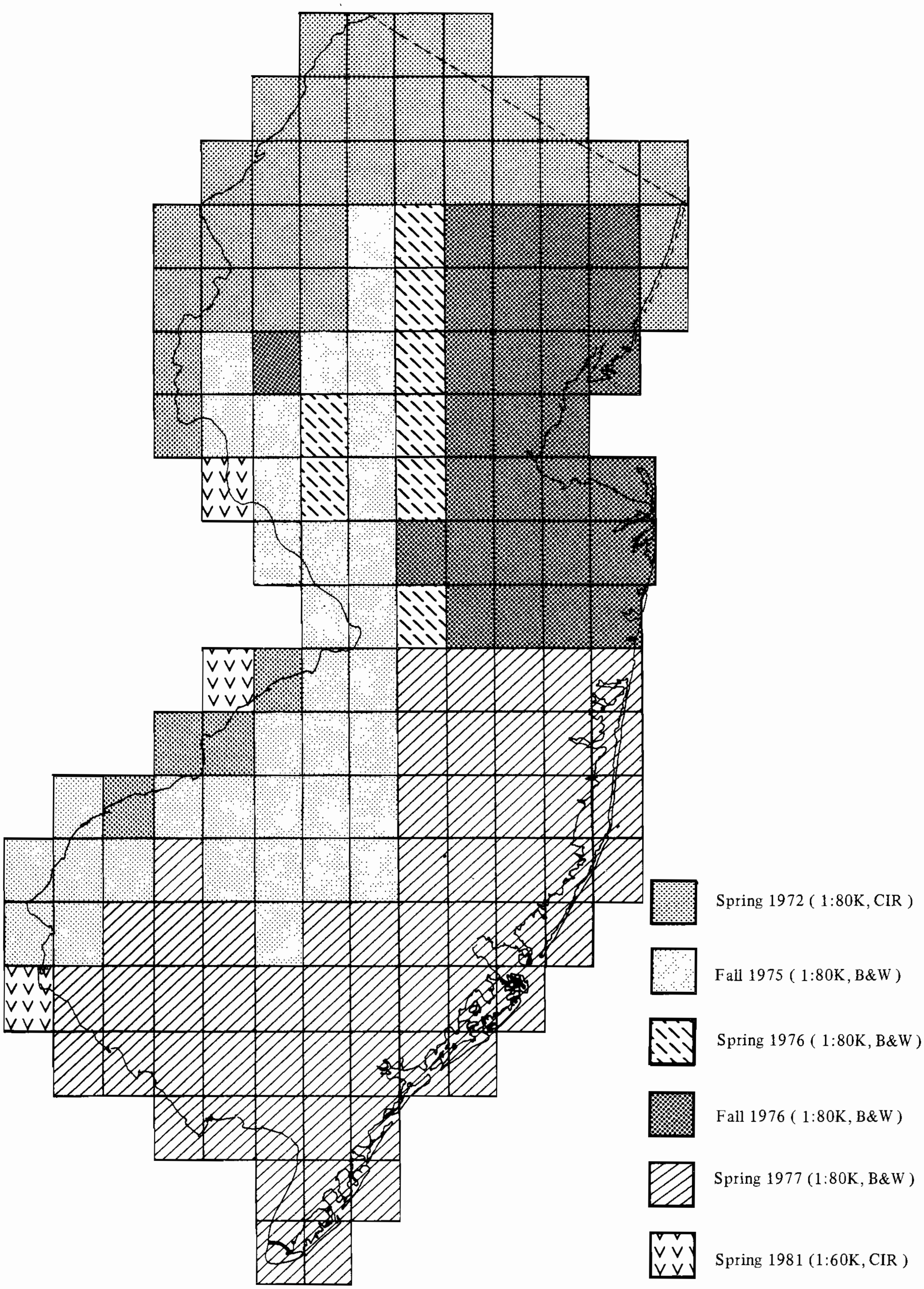

Figure 5. Index of aerial photography used for the National Wetlands Inventory in New Jersey.

step helps insure the completeness of the wetlands inventory. Collateral data sources used to aid in wetland detection and classification included:

(1) 1:80,000 color infrared photography (1972);
(2) U.S. Geological Survey topographic maps;
(3) U.S.D.A. Soil Conservation Service soil surveys;
(4) U.S. Department of Commerce coastal and geodetic survey maps;
(5) New Jersey Department of Environmental Protection submerged vegetation maps;
(6) New Jersey Department of Environmental Protection coastal wetland maps;
(7) The Pine Barrens: Vegetation Geography (McCormick and Jones 1973);
(8) New Jersey anadromous fish inventory report (Zich 1977);
(9) Delaware River Estuarine Marsh Survey report (Walton and Patrick 1973).

Although extremely efficient and accurate for inventorying wetlands, photo interpretation does have certain limitations. Consequently, some problems arose during the course of the survey that required additional field work or use of collateral data to resolve. These problems and their resolution are discussed below.

1. Delineation of estuarine and riverine (tidal) systems. For inventory purposes, the boundary between brackish tidal waters and fresh tidal waters needed to be established. To do this, the results of Zich (1977) were used. This study of anadromous fishes identified approximate limits of saltwater penetration and the head of tide (upstream limit of tidal influence) in New Jersey's coastal rivers.

2. Delineation of the oligohaline (slightly brackish) segment of estuaries. Obviously, this cannot be accomplished by photo interpretation. Collateral data was consulted to identify this zone. N.J.D.E.P. coastal wetland maps provided information on plant species composition of coastal marshes. Occurrence of more typical freshwater plants like wild rice (*Zizania aquatica*) and arrow arum (*Peltandra virginica*) in estuarine waters were indicative of strong freshwater influence characteristic of the oligohaline zone. Delineation of oligohaline marshes in this way was conservative.

3. Identification of submerged vegetation in coastal waters. It was not possible to identify submerged aquatic beds in coastal areas with the photography used for the inventory. The State of New Jersey has completed a detailed survey of these areas and has produced a set of submerged vegetation maps for the coast (Macomber and Allen 1979). This information was transferred directly to National Wetlands Inventory maps to provide a more complete picture of New Jersey's wetlands and deepwater habitats.

4. Tidal flooding of wetlands. Photography used for this survey was not tide-coordinated, therefore, on rare occasions, some emergent wetlands may have been obscured by flooding waters. In these situations, undetected emergent wetlands were included as part of the open water class of estuaries and tidal rivers.

5. Identification of forested wetlands in southern New Jersey. In the Pine Barrens, the available aerial photography for mapping was unfortunately taken in the fall when leaves were still on many of the deciduous trees. This made identification of some forested wetlands particularly difficult. To resolve this problem, soil surveys and additional field investigations were used to help identify these wetlands. Results of field checking of wetland maps by N.J. Pinelands Commission biologists have confirmed an overall good classification accuracy for these wetlands, although some areas may be slightly underestimated.

6. Identification of freshwater aquatic beds. Due to use of spring photography in many areas, aquatic beds in freshwater ponds and lakes were not identifiable. These wetlands were, therefore, included as part of the open water class. Maps, however, do show some aquatic beds usually where observed during field investigations.

7. Inclusion of small upland areas within wetland boundaries. Small islands of higher elevations and better drained upland areas naturally exist in many wetlands. Due to minimum mapping units, small upland areas may be included within designated wetlands. Field inspections and/or use of larger scale photography can be used to refine wetland boundaries when necessary.

Draft Map Production

Upon completion of photo interpretation, two levels of quality assurance were performed: (1) regional quality control and (2) national consistency quality assurance. Regional review of each interpreted photo was accomplished by the Regional Office's National Wetlands Inventory staff to ensure identification of all wetlands and proper classification. By contrast, national quality control by the National Wetlands Inventory Group at St. Petersburg, Florida entailed spot checking of photos to ensure that national standards have been successfully followed. Once approved by quality assurance, draft large-scale (1:24,000) wetland maps were produced by the Group'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, Absecon Subfield Office;
(2) U.S. Army Corps of Engineers (New York and Philadelphia Districts);
(3) U.S.D.A. Soil Conservation Service;
(4) U.S. Environmental Protection Agency (Region II);
(5) National Marine Fisheries Service;
(6) N.J. Department of Environmental Protection;
(7) N.J. Pinelands Commission

In addition to this multi-agency review, the Regional Office's National Wetlands Inventory staff conducted field checks and a thorough examination of draft maps to ensure proper placement of wetland polygons and labels as well as accurate classification.

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 Database Construction

Upon publication of the final wetland maps in the fall of 1981, the Service started construction of a statewide wetland database by digitizing the large-scale maps. The database and its applications are described by Tiner and Pywell (1983). The database, created by December 1982, allowed generation of county and statewide wetland acreage summaries and gave the Service the capability to produce color-coded wetland maps for specific areas. Duplicate tapes of this wetland database were given to N.J. Department of Environmental Protection for inclusion in the State's geographic information system. Consequently, the State has the ability to generate wetland maps and statistics.

Wetlands Inventory Results

National Wetlands Inventory Maps

A total of 174 large-scale (1:24,000) wetland maps were produced, while 8 small-scale (1:100,000) wetland maps were also made. These maps identify the size, shape and type of wetlands and deepwater habitats in accordance with National Wetlands Inventory specifications. The minimum mapping unit for wetlands ranged between 1 and 3 acres. A recent evaluation of National Wetlands Inventory maps in Massachusetts determined that these maps had accuracies exceeding 95% (Swartwout, *et al.* 1982). 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. Final maps have been available for New Jersey since the fall of 1981. Figure 6 shows an example of a 1:24,000 map. Copies of these maps can be ordered from the N.J. Department of Environmental Protection, Bureau of Collections and Licensing, Maps and Publications, CN-401, Trenton, NJ 08625.

Wetland and Deepwater Habitat Acreage Summaries

State Totals

According to the National Wetlands Inventory, in the mid-1970's New Jersey possessed roughly 916,000 acres of wetland and 413,000 acres of deepwater habitat, excluding marine waters and smaller rivers and streams that either appear as linear features on wetland maps or wetlands that were not identified due to their small size. About 19% of the State's land surface was represented by wetland.

The relative extent of major wetland types is shown in Figure 7. The State's wetlands largely fell within two systems - Palustrine and Estuarine. The general distribution of estuarine and palustrine wetlands is shown on the enclosed figure at the back of this report.

Palustrine wetland, covering 613,531 acres, was more than twice as abundant as estuarine wetland. Over half of this wetland acreage (371,378 acres) was deciduous forested wetland, which was mostly red maple swamp. Interestingly, evergreen forested wetland totaled 108,618 acres, nearly all of which was found in the Pine Barrens region. Other substantial palustrine wetlands included deciduous scrub-shrub wetland (50,534 acres), nontidal emergent wetland (28,403 acres), evergreen scrub-shrub wetland (24,434 acres), shallow pond (17,818 acres), and farmed wetland (6,590 acres of cranberry bogs). The State's freshwater tidal wetlands were limited to 9,612 acres. Tidally influenced palustrine emergent and shrub wetlands comprised 5, 756 acres, while riverine tidal flats and emergent wetlands made up the remainder. Forested wetlands subject to periodic tidal flooding were not separated from the nontidal forested wetlands.

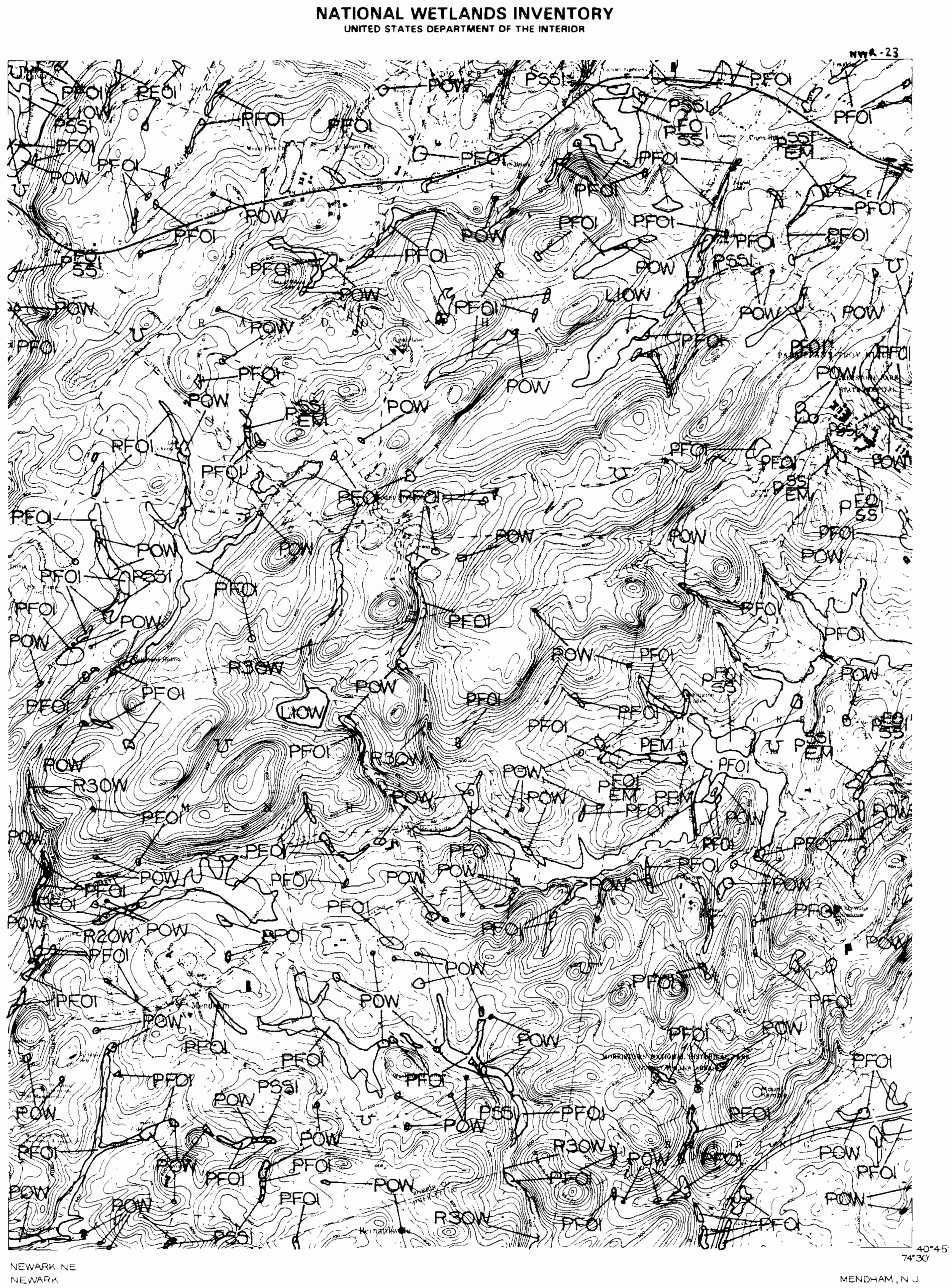

Figure 6. Example of a National Wetlands Inventory map. This is a reduction of a 1:24,000 scale map.

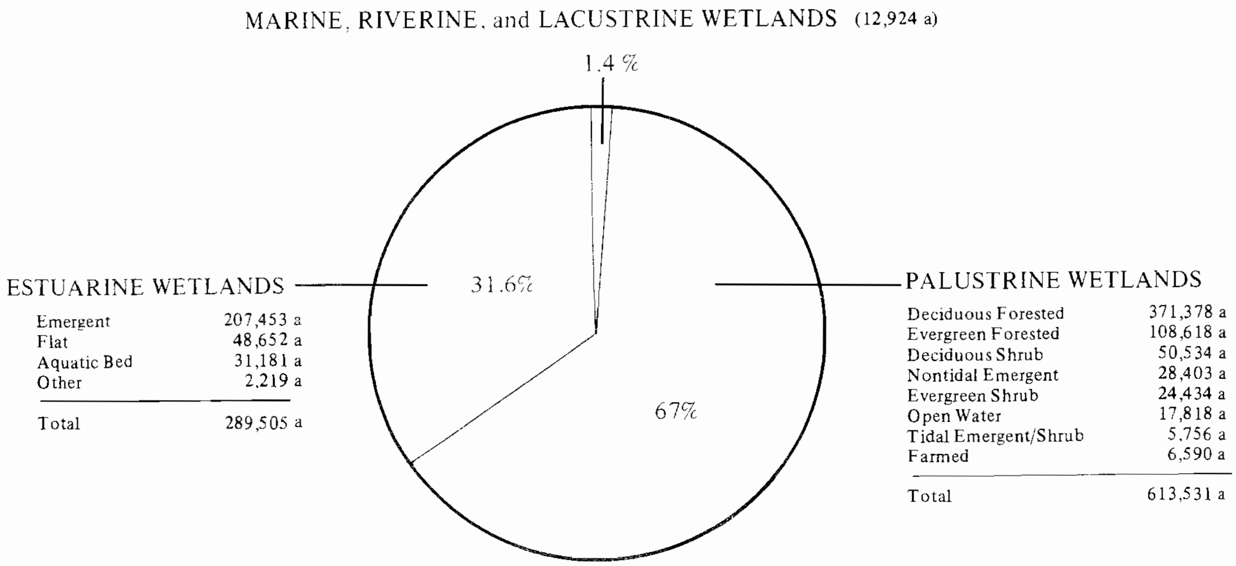

Figure 7. Relative abundance of New Jersey wetlands.

Of the 289,505 estuarine wetland acres, 72% was emergent wetland. Most of this acreage was salt and brackish marsh (201,448 acres), while 6,005 acres of slightly brackish or oligohaline marsh were inventoried. Intertidal flats accounted for 48,652 acres and aquatic beds for 31,181 acres.

Other wetlands found included 1,578 acres of lacustrine wetlands associated with lakes and reservoirs and 7,481 acres of marine beaches and bars. Lacustrine wetlands consisted of either nonpersistent emergent wetlands, aquatic beds or flats.

Deepwater habitat acreage in New Jersey totaled 412,949 acres, excluding marine waters. Most of this (87% or 357,523 acres) was represented by estuarine or brackish tidal water of bays and coastal rivers. Tidal fresh water rivers amounted to 11,708 acres, while other freshwater rivers totaled 5,484 acres. Lakes and reservoirs covered 38,234 acres.

County Totals

Acreages of wetland and deepwater habitat for each county are found in Tables 6 and 7, respectively, while Figure 8 shows the relative abundance of wetland in each county. Atlantic County had the largest extent of wetland (148,149 acres) and was closely followed by two other coastal counties: Burlington (136,297 acres) and Ocean (128,531 acres). If the percentage of the county occupied by wetland is examined, Cape May County led all others with more than half the county being wetland. Atlantic, Ocean, Cumberland, Burlington and Salem Counties followed with 40.7%, 31.3%, 30.9%, 26% and 25.3%, respectively. The presence of vast acreages of coastal marshes in these counties was responsible for their lead over non-coastal counties in this category.

Considering the extent of deepwater habitat, the coastal counties again had more acreage than inland counties (Table 7). The existence of large bays behind barrier islands in coastal areas greatly contributed to this difference. Cumberland County with much of the New Jersey portion of Delaware Bay far exceeded all other counties in deepwater habitat acreage. Lakes and reservoirs (lacustrine waters), by contrast, were most extensive in northern New Jersey, particularly Morris and Sussex Counties.

The relative abundance of the more extensive wetlands - the estuarine and palustrine wetlands - are displayed in Figures 9 and 10, respectively. The extent of different wetland types and deepwater habitats for each county is discussed in the following subsections.

Atlantic County

Atlantic County had more wetland than any other county. Its 148,149 acres of wetland covered nearly 41% of the county. This county ranked only second to Cape May County in the percentage of its land area that is represented by wetland. Slightly more than 33% of Atlantic's wetland resource was palustrine deciduous forested wetland, while estuarine emergent wetland made up 30%. Evergreen forested wetland was also quite abundant, comprising 16% of all wetland acreage.

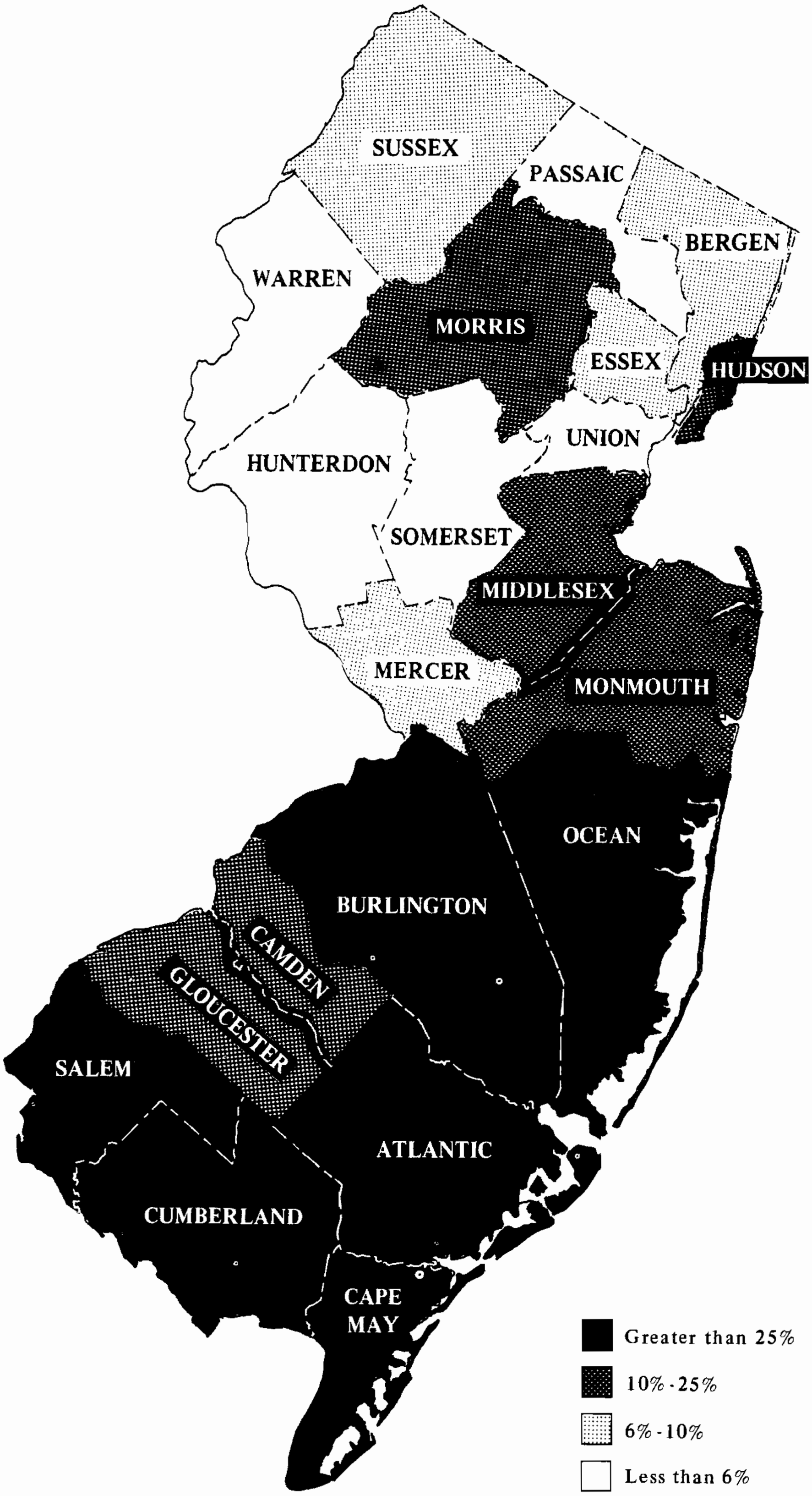

Figure 8. Percentage of each New Jersey county covered by wetland.

Table 6. Wetland acreage of New Jersey counties. Percentage of county represented by wetland and ranking based on wetland acreage are also indicated. Land area figures based on **The World Almanac and Book of Facts** (Delury 1979).

County	Land Area (sq. mi.)	Land Area (Acres)	Wetland Area (Acres)	% County Represented by Wetland	Ranking Order By Wetland Acreage
Atlantic	569	364,160	148,149	40.7	1
Bergen	234	149,760	10,084	6.7	16
Burlington	819	524,160	136,297	26.0	2
Camden	221	141,440	20,922	14.8	12
Cape May	267	170,880	89,581	52.4	5
Cumberland	500	320,000	98,950	30.9	4
Essex	130	83,200	6,833	8.2	17
Gloucester	329	210,560	36,844	17.5	8
Hudson	47	30,080	3,897	13.0	20
Hunterdon	423	270,720	5,450	2.0	18
Mercer	228	145,920	11,819	8.1	14
Middlesex	312	199,680	24,022	12.0	11
Monmouth	476	304,640	32,700	10.7	9
Morris	468	299,520	40,264	13.4	7
Ocean	642	410,880	128,531	31.3	3
Passaic	192	122,880	5,042	4.1	19
Salem	365	233,600	58,987	25.3	6
Somerset	307	196,480	11,127	5.7	15
Sussex	527	337,280	30,771	9.1	10
Union	103	65,920	3,053	4.6	21
Warren	362	231,680	12,637	5.5	13
State Total	**7,521**	**4,813,440**	**915,960**	**19.0**	

Table 7. Deepwater habitat acreage of New Jersey counties. Note: (1) Figures do not include marine waters; (2) Riverine acreages are conservative, since linear map features were not measured; (3) Part of Delaware Bay was not mapped because no U.S.G.S. topographic maps exist; estuarine water acreage for this area was approximated and not included within Cumberland or Cape May totals.

County	Estuarine Waters (Acres)	Riverine Waters (Acres)	Lacustrine Waters (Acres)	Total (Acres)	Ranking Order
Atlantic	13,744	146	1,584	15,474	6
Bergen	5,324	336	2,089	7,749	8
Burlington	1,755	3,429	1,880	7,064	11
Camden	0	2,245	343	2,588	17
Cape May	39,747*	4	572	40,323	3
Cumberland	89,586*	166	3,129	92,881	1
Essex	1,151	161	662	1,974	18
Gloucester	764	4,406	656	5,826	12
Hudson	9,170	0	0	9,170	7
Hunterdon	0	1,125	3,504	4,629	14
Mercer	0	1,068	424	1,492	19
Middlesex	4,688	103	887	5,678	13
Monmouth	30,284	5	1,547	31,838	4
Morris	0	162	6,921	7,083	10
Ocean	49,196	9	1,595	50,800	2
Passaic	0	493	3,688	4,181	15
Salem	21,248	343	928	22,519	5
Somerset	0	447	77	524	21
Sussex	0	886	6,405	7,291	9
Union	866	81	251	1,198	20
Warren	0	1,577	1,090	2,667	16
(Unmapped Area within Delaware Bay)	90,000			90,000	
State Total	**357,523**	**17,192**	**38,234**	**412,949**	

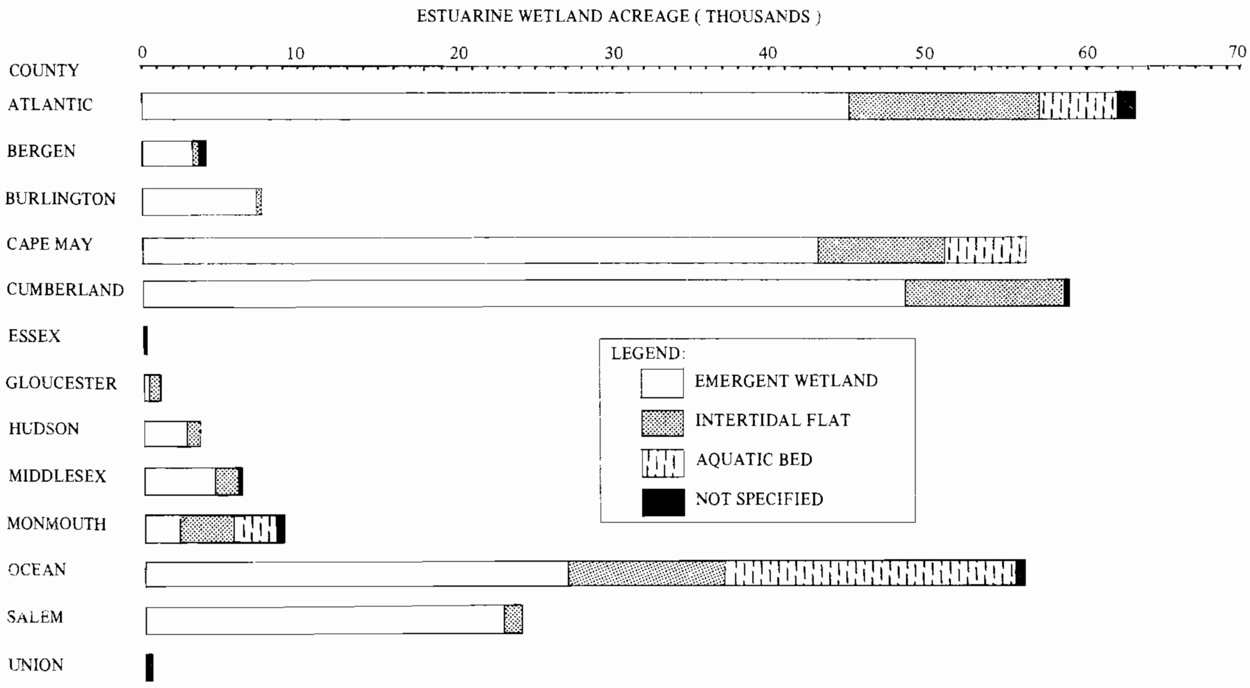

Figure 9. Relative distribution of estuarine wetland in New Jersey.

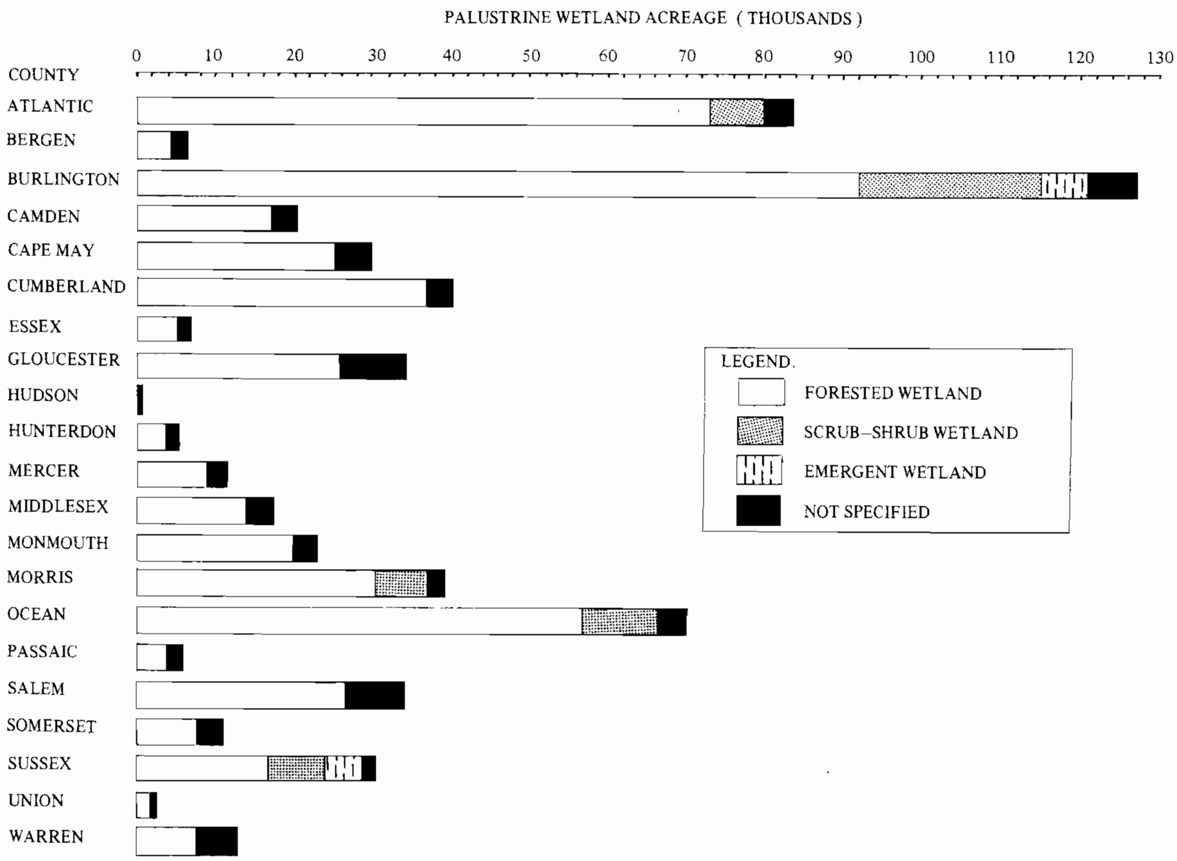

Figure 10. Relative distribution of palustrine wetland in New Jersey.

Marine Wetlands	1,722 a.
Estuarine Wetlands	
Aquatic Bed	4,861 a.
Emergent	45,089 a.
Flat	11,827 a.
Other	874 a.
Estuarine Subtotal	62,651 a.
Riverine Tidal Wetlands	132 a.
Lacustrine Wetlands	13 a.
Palustrine Wetlands	
Open Water	815 a.
Tidal Emergent/Shrub	332 a.
Nontidal Emergent	1,383 a.
Deciduous Scrub-Shrub	3,093 a.
Evergreen Scrub-Shrub	4,158 a.
Deciduous Forested	49,365 a.
Evergreen Forested	23,528 a.
Farmed	957 a.
Palustrine Subtotal	83,631 a.
Atlantic County Total	148,149 a.

Deepwater habitat in Atlantic County amounted to 15,474 acres which were mostly estuarine waters. Marine waters were not included in this figure.

Bergen County

Bergen County was ranked 16th among counties in the extent of wetlands. Only about 7% of the county was covered by wetland (10,084 acres). Most of this resource was palustrine wetland (6,319 acres), with deciduous forested wetland comprising 43% of the county's wetland acreage. Estuarine emergent wetland was also extensive, accounting for about 33% of the acreage.

Estuarine Wetlands	
Emergent	3,230 a.
Other	494 a.
Estuarine Subtotal	3,724 a.
Riverine Tidal Wetlands	41 a.
Palustrine Wetlands	
Open Water	679 a.
Emergent	560 a.
Deciduous Scrub-Shrub	753 a.
Deciduous Forested	4,327 a.
Palustrine Subtotal	6,319 a.
Bergen County Total	10,084 a.

This county also possessed 7,749 acres of deepwater habitat. Most of this was estuarine water, with lacustrine water (e.g., reservoirs) also important.

Burlington County

With a total of 136,297 acres of wetland, Burlington County was the second leading county in wetland acreage, surpassed only by Atlantic County. Wetland represented 26% of the county's land area. Sixty-seven percent of the wetland acreage was forested wetland, with 38% being deciduous and 29% evergreen. Only 5% of Burlington's wetland acreage was estuarine emergent wetland.

Estuarine Wetlands	
Emergent	7,482 a.
Flat	137 a.
Estuarine Subtotal	7,619 a.
Riverine Tidal Wetlands	846 a.
Lacustrine Wetlands	756 a.
Palustrine Wetlands	
Open Water	1,754 a.
Tidal Emergent/Shrub	1,774 a.
Nontidal Emergent	3,887 a.
Deciduous Scrub-Shrub	10,882 a.
Evergreen Scrub-Shrub	12,422 a.
Deciduous Forested	51,980 a.
Evergreen Forested	39,645 a.
Farmed	4,732 a.
Palustrine Subtotal	127,076 a.
Burlington County Total	136,297 a.

Burlington County had 7,064 acres of deepwater habitat, with freshwater rivers predominating.

Camden County

Camden County had 20,922 acres of wetland, which represented nearly 15% of the county. Nearly all of this acreage was palustrine wetland, while a few hundred acres of freshwater tidal flat were also inventoried. Forested wetland comprised 81% of Camden's wetland resource.

Riverine Tidal Flats	417 a.
Lacustrine Wetlands	41 a.
Palustrine Wetlands	
Open Water	737 a.
Tidal Emergent/Shrub	399 a.
Nontidal Emergent	445 a.
Deciduous Scrub-Shrub	970 a.
Evergreen Scrub-Shrub	872 a.
Deciduous Forested	10,353 a.
Evergreen Forested	6,688 a.
Palustrine Subtotal	20,464 a.
Camden County Total	20,922 a.

Most of Camden's 2,588 acres of deepwater habitat were freshwater rivers and streams. Only 343 acres of lakes and reservoirs were found.

Cape May County

More than half of Cape May County was wetland and no other county had a higher proportion of this resource. Cape May's 89,581 acres of wetland made it fifth-ranked among other counties in wetland acreage. Cape May was also fourth-ranked in the extent of estuarine wetland. This wetland type made up 63% of the county's wetland acreage, while palustrine wetland, mostly deciduous forested wetland, comprised nearly all of the remainder. Estuarine emergent wetland alone accounted for 48% of the wetland resource.

Marine Wetlands	3,611 a.
Estuarine Wetlands	
Aquatic Bed	5,135 a.
Emergent	42,854 a.
Flat	7,862 a.
Other	260 a.
Estuarine Subtotal	56,111 a.
Palustrine Wetlands	
Open Water	782 a.
Tidal Emergent/Shrub	40 a.
Nontidal Emergent	1,510 a.
Deciduous Scrub-Shrub	1,817 a.
Evergreen Scrub-Shrub	238 a.
Deciduous Forested	21,785 a.
Evergreen Forested	3,687 a.
Palustrine Subtotal	29,859 a.
Cape May County Total	89,581 a.

Cape May County ranked third in deepwater habitat acreage. Due to the presence of a good portion of Delaware Bay in the county, estuarine waters prevailed, comprising nearly all of this resource.

Cumberland County

Cumberland County ranked fourth in wetland abundance. Its 98,950 wetland acres covered slightly less than a third of the county. Estuarine wetland predominated, representing nearly 60% of the wetland acreage. Almost half of the county's wetlands was made up of estuarine emergent wetland, while 41% was palustrine wetland, with deciduous forested wetland most abundant.

Estuarine Wetlands	
Emergent	48,764 a.
Flat	9,823 a.
Other	69 a.
Estuarine Subtotal	58,656 a.
Lacustrine Wetlands	55 a.
Palustrine Wetlands	
Open Water	854 a.
Tidal Emergent	44 a.
Nontidal Emergent	541 a.
Deciduous Scrub-Shrub	1,665 a.
Evergreen Scrub-Shrub	441 a.
Deciduous Forested	29,994 a.
Evergreen Forested	6,700 a.
Palustrine Subtotal	40,239 a.
Cumberland County Total	98,950 a.

Cumberland County had more deepwater habitat than any other county. Its 92,881 mapped acres were comprised largely of a portion of Delaware Bay. Not included in this figure are estuarine waters in the middle of the Bay where no maps were produced. A total of 3,129 acres of lacustrine water was also significant.

Essex County

Only about 8% of Essex County was comprised of wetland. Almost all of its 6,833 wetland acres were palustrine. Deciduous forested wetland accounted for 77% of the wetland acreage. Only 31 acres of estuarine wetland were inventoried.

Estuarine Wetlands	31 a.
Riverine Tidal Wetlands	2 a.
Palustrine Wetlands	
Open Water	141 a.
Emergent	522 a.
Deciduous Scrub-Shrub	855 a.
Deciduous Forested	5,282 a.
Palustrine Subtotal	6,800 a.
Essex County Total	6,833 a.

A total of 1,974 acres of deepwater habitat was found in Essex County. Most of this was estuarine water.

Gloucester County

Gloucester County was eighth-ranked in wetland abundance. Its 36,844 wetland acres covered nearly 18% of the county. Ninety-three percent of this acreage was palustrine wetland, with the remainder being estuarine and riverine tidal wetland. Freshwater tidal emergent wetland (4,033 acres) was more abundant than brackish emergent marsh (1,027 acres), but both types were overshadowed by the 21,383 acres of deciduous forested wetland that accounted for 58% of the county's wetland acreage.

Estuarine Wetlands	
Emergent	548 a.
Flat	479 a.
Estuarine Subtotal	1,027 a.
Riverine Tidal Wetlands	1,634 a.
Lacustrine Wetlands	6 a.
Palustrine Wetlands	
Open Water	1,156 a.
Tidal Emergent/Shrub	2,399 a.
Nontidal Emergent	2,045 a.
Deciduous Scrub-Shrub	2,058 a.
Evergreen Scrub-Shrub	326 a.
Deciduous Forested	21,383 a.
Evergreen Forested	4,743 a.
Farmed	67 a.
Palustrine Subtotal	34,177 a.
Gloucester County Total	36,844 a.

Deepwater habitat covered 5,826 acres of Gloucester County with riverine water predominating.

Hudson County

Hudson County ranked next to last in wetland acreage, with only 3,897 acres. Thirteen percent of the county was covered by wetland. Estuarine wetland made up nearly all (94%) of the wetland acreage. Estuarine emergent wetland was more than twice as extensive as estuarine intertidal flat.

Estuarine Wetlands	
Emergent	2,476 a.
Flat	1,179 a.
Estuarine Subtotal	3,655 a.
Palustrine Wetlands	
Open Water	100 a.
Emergent	111 a.
Other	31 a.
Palustrine Subtotal	242 a.
Hudson County Total	3,897 a.

Hudson County was seventh-ranked in deepwater habitat. Estuarine water made up all of the 9,170 deepwater habitat acres inventoried.

Hunterdon County

Only 2% of Hunterdon County was wetland, totaling 5,450 acres. Nearly all of it was palustrine wetland with deciduous forested wetland alone representing 68% of the acreage.

Riverine Wetlands	9 a.
Lacustrine Wetlands	214 a.
Palustrine Wetlands	
Open Water	690 a.
Emergent	401 a.
Deciduous Scrub-Shrub	429 a.
Deciduous Forested	3,707 a.
Palustrine Subtotal	5,227 a.
Hunterdon County Total	5,450 a.

Hunterdon County had 4,629 acres of deepwater habitat, mostly comprised of lakes and reservoirs.

Mercer County

Wetland covered 11,819 acres or 8% of Mercer County. Nearly all was palustrine wetland, with about 77% being deciduous forested wetland. The only tidal wetlands in Mercer County were freshwater tidal marshes and flats.

Riverine Tidal Wetlands	35 a.
Lacustrine Wetlands	66 a.
Palustrine Wetlands	
Open Water	427 a.
Tidal Emergent/Shrub	422 a.
Nontidal Emergent	419 a.
Deciduous Scrub-Shrub	1,356 a.
Deciduous Forested	9,094 a.
Palustrine Subtotal	11,718 a.
Mercer County Total	11,819 a.

Only 1,492 acres of deepwater habitat were found in Mercer County. This led to a 19th ranking among counties.

Middlesex County

Middlesex County was middle-ranked (11th) in wetland abundance. Its 24,022 wetland acres covered 12% of the county. About 73% of this acreage was palustrine wetland, with the rest being estuarine wetland. Deciduous forested wetland accounted for 58% of the county's wetland acreage, while estuarine emergent wetland comprised 19%.

Estuarine Wetlands	
Emergent	4,575 a.
Flat	1,668 a.
Other	95 a.
Estuarine Subtotal	6,338 a.

Lacustrine Wetlands	108 a.
Palustrine Wetlands	
Open Water	731 a.
Tidal Emergent	42 a.
Nontidal Emergent	1,145 a.
Deciduous Scrub-Shrub	1,378 a.
Deciduous Forested	13,997 a.
Evergreen Forested	283 a.
Palustrine Subtotal	17,576 a.
Middlesex County Total	24,022 a.

The county was also middle-ranked (13th) in extent of deepwater habitat. Most of its 5,678 deepwater acres were estuarine waters.

Monmouth County

With 32,700 acres of wetland, Monmouth County ranked ninth in wetland acreage. This total represented about 11% of the county. Palustrine and emergent wetlands dominated, making up 71% and 27% of the wetland resource, respectively. Deciduous forested wetland alone accounted for 57%.

Marine Wetlands	438 a.
Estuarine Wetlands	
Aquatic Bed	2,802 a.
Emergent	2,318 a.
Flat	3,540 a.
Other	257 a.
Estuarine Subtotal	8,917 a.
Lacustrine Wetlands	27 a.
Palustrine Wetlands	
Open Water	1,027 a.
Tidal Emergent/Shrub	94 a.
Nontidal Emergent	788 a.
Deciduous Scrub-Shrub	1,939 a.
Deciduous Forested	18,576 a.
Evergreen Forested	879 a.
Farmed	15 a.
Palustrine Subtotal	23,318 a.
Monmouth County Total	32,700 a.

Monmouth County's 31,838 acres of deepwater habitat made it fourth-ranked among other counties. The vast majority of deepwater habitat was estuarine water.

Morris County

Wetland covered 40,264 acres or 13% of Morris County. As a result, the county was seventh-ranked in wetland abundance. Almost all wetlands were palustrine, with only a few lacustrine wetlands inventoried. Deciduous forested wetland represented 76% of the county's wetland acreage, while deciduous shrub wetland made up 14%.

Lacustrine Wetlands	68 a.
Palustrine Wetlands	
Open Water	1,715 a.
Emergent	2,291 a.
Deciduous Scrub-Shrub	5,595 a.
Deciduous Forested	30,582 a.
Evergreen Forested	13 a.
Palustrine Subtotal	40,196 a.
Morris County Total	40,264 a.

Morris County was middle-ranked (10th) in deepwater habitat acreage. Nearly all of this acreage was comprised of lakes and reservoirs.

Ocean County

Ocean County ranked third in wetland abundance, with 128,531 acres inventoried. Thirty-one percent of the county was covered by wetland. Palustrine and estuarine wetlands occurred in nearly equal amounts, representing 55% and 44% of the wetland resource, respectively. Nearly 28% was deciduous forested wetland, followed by estuarine emergent wetland (21%), evergreen forested wetland (17%) and estuarine aquatic bed (14%).

Marine Wetlands	1,710 a.
Estuarine Wetlands	
Aquatic Bed	18,383 a.
Emergent	26,879 a.
Flat	10,265 a.
Other	647 a.
Estuarine Subtotal	56,174 a.
Riverine Tidal Wetlands	34 a.
Lacustrine Wetlands	129 a.
Palustrine Wetlands	
Open Water	1,186 a.
Emergent	1,090 a.
Deciduous Scrub-Shrub	4,067 a.
Evergreen Scrub-Shrub	5,947 a.
Deciduous Forested	35,718 a.
Evergreen Forested	21,657 a.
Farmed	819 a.
Palustrine Subtotal	70,484 a.
Ocean County Total	128,531 a.

Due to presence of large coastal bays, Ocean County was second-ranked in deepwater habitat acreage. Nearly all of its 50,800 deepwater acres were estuarine waters.

Passaic County

Only 4% of Passaic County was represented by wetland, all of which was palustrine. A total of 5,042 acres was inventoried, giving the county a 19th ranking. About 75% of the wetland resource was deciduous forested wetland, with the rest being divided between scrub-shrub wetland, emergent wetland and shallow ponds.

Palustrine Wetlands	
Open Water	403 a.
Emergent	211 a.
Deciduous Scrub-Shrub	671 a.
Deciduous Forested	3,757 a.
Palustrine Subtotal	5,042 a.
Passaic County Total	5,042 a.

Lacustrine waters prevailed in Passaic County. Of its 4,181 acres of deepwater habitat, 88% was represented by lakes and reservoirs.

Salem County

Wetland occupied 58,987 acres or 25% of Salem County. Consequently, the county ranked sixth in wetland abundance. Palustrine wetland made up 58% of the wetland acreage, with 45% being deciduous forested wetland. Estuarine emergent wetland comprised nearly 40%.

Estuarine Wetlands	
Emergent	22,867 a.
Flat	1,118 a.
Estuarine Subtotal	23,985 a.
Riverine Tidal Wetlands	715 a.
Palustrine Wetlands	
Open Water	1,014 a.
Tidal Emergent/Shrub	210 a.
Nontidal Emergent	3,425 a.
Deciduous Scrub-Shrub	2,491 a.
Evergreen Scrub-Shrub	30 a.
Deciduous Forested	26,398 a.
Evergreen Forested	719 a.
Palustrine Subtotal	34,287 a.
Salem County Total	58,987 a.

Salem County was fifth-ranked in deepwater habitat acreage. Most of its 22,519 acres were estuarine waters.

Somerset County

Only 5.7% of Somerset County was wetland, with a total of 11,127 acres inventoried. All of the county's wetlands were palustrine, although smaller riverine and lacustrine wetlands undoubtedly exist locally. Deciduous forested wetland represented about 75% of the wetland resource.

Palustrine Wetlands	
Open Water	574 a.
Emergent	1,322 a.
Deciduous Scrub-Shrub	954 a.
Deciduous Forested	8,277 a.
Palustrine Subtotal	11,127 a.
Somerset County Total	11,127 a.

The county ranked last in extent of deepwater habitat. Only 524 acres were inventoried and of this, most were rivers and streams.

Sussex County

Sussex County was middle-ranked (10th) in wetland acreage. Its 30,771 wetland acres covered about 9% of the county. Nearly all the wetland was palustrine, with deciduous forested wetland accounting for 56% alone.

Lacustrine Wetlands	92 a.
Palustrine Wetlands	
Open Water	1,915 a.
Emergent	4,492 a.
Deciduous Scrub-Shrub	6,863 a.
Deciduous Forested	17,333 a.
Evergreen Forested	76 a.
Palustrine Subtotal	30,679 a.
Sussex County Total	30,771 a.

The county was also middle-ranked (9th) in deepwater habitat abundance. Of its 7,291 acres, most were comprised of lakes and reservoirs.

Union County

Less than 5% of Union County was covered by wetland. In wetland abundance, it ranked last. Most (61%) of its 3,053 acres was deciduous forested wetland, whereas estuarine emergent wetland comprised only 12%.

Estuarine Wetlands	
Emergent	355 a.
Flat	262 a.
Estuarine Subtotal	617 a.
Palustrine Wetlands	
Open Water	164 a.
Emergent	237 a.

Deciduous Scrub-Shrub	167 a.
Deciduous Forested	1,868 a.
Palustrine Subtotal	2,436 a.
Union County Total	3,053 a.

Regarding deepwater habitat acreage, Union County ranked near the bottom (20th), with only Somerset County having less. Most of its deepwater areas were estuarine waters.

Warren County

With 12,637 acres of wetland, Warren County was middle-ranked (13th) in wetland abundance. Only 5.5% of the county was wetland, with palustrine wetland making up nearly all of this. Sixty percent of the wetland resource was deciduous forested wetland. Shrub and emergent wetlands comprised 32%.

Lacustrine Wetlands	3 a.
Palustrine Wetlands	
Open Water	954 a.
Emergent	1,578 a.
Deciduous Scrub-Shrub	2,501 a.
Deciduous Forested	7,601 a.
Palustrine Subtotal	12,634 a.
Warren County Total	12,637 a.

Warren County possessed only 2,667 acres of deepwater habitat. Riverine and lacustrine waters occurred in nearly equal amounts.

Summary

The National Wetlands Inventory Project has completed an inventory of New Jersey's wetlands using aerial photo interpretation methods. Detailed wetland maps have been produced for the entire State. A wetland database has been constructed through computer mapping techniques. This database produced wetland acreage summaries for the State and for each county. Nearly 916,000 acres of wetland and 413,000 acres of deepwater habitat were inventoried in New Jersey. Thus, about 19% of the State was represented by wetland.

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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 New Jersey. Human activities have also exerted influence on wetland formation and hydrology. The following subsections address general differences between New Jersey's inland and coastal wetlands in their formation and hydrology.

Wetland Formation

The area's glacial history was especially significant in wetland formation throughout the State. Recent events like rising sea level and natural accretion and erosion along rivers and behind coastal barrier islands and beaches continue to build or modify wetlands. Construction of farm ponds, impoundments, and reservoirs may also create wetlands.

Inland Wetland Formation

Major factors creating wetlands vary throughout the State, but past glaciation has played an important role in most areas. Wolfe (1977) described in detail the relationship between geology and New Jersey's landscapes and much of the following discussion is based on his work. From 80,000 to 18,000 years ago, northern New Jersey was buried under glacial ice (Figure 11). This great ice sheet was nearly a mile thick. During this Ice Age, roughly one third of the world's land area was covered by ice compared to only 10% of today's surface. The presence of the glacier also affected the climate of southern New Jersey, making it tundra-like.

Most of northern New Jersey's wetlands were formed in glacial lakes and depressions during the post-glacial period, beginning about 18,000 years ago. Almost all of the State's natural lakes lie north of the glacier's southern edge (terminal moraine). Glacial lakes were created in three ways: (1) in rock basins scoured by glacial erosion (e.g., Sand Pond), (2) in depressions formed by melting ice blocks left by the retreating glacier (e.g., Lake Grinnel and Franklin Lake), and (3) in basins produced by glacial drift obstructions of river valleys (e.g., Swartswood Lake, Green Pond, Lake Hopatcong and Macopin Lake). Ice blocked north flowing streams like the Wallkill River, Black River, and Pequest River, creating lakes in the valleys. Large glacial lakes were also associated with major watersheds, i.e., the Passaic, the Hackensack and the Hudson. Lake Passaic was one of the largest of these now extinct glacial lakes. At its peak, it was about 30 miles long, 8 to 10 miles wide and 160 to 240 feet deep (Wolfe 1977). When the glacier receded, Lake Passaic and numerous other glacial lakes drained and wetlands formed in these basins (Figure 12). Large wetland complexes like Great Swamp, Great Piece Meadows, Troy Meadows and Black Meadows now exist where Lake Passaic once did.

Filling of shallow glacial lakes is still occurring. Niering (1953) described this situation as hydrarch succession for Pine Bog in High Point State Park. The center of the Bog is an open water body called Lost Lake. The Lake is surrounded by a floating peat moss mat, where leatherleaf dominates and other typical northern bog species are also present. Closer to the land's edge, trees like red maple, black spruce, black gum and yellow birch are abundant. Eventually, the entire lake may become wetland. This natural succession is occurring elsewhere in the State. Dansereau and Segadas-Vianna (1952) have described the evolution of bogs in eastern North America.

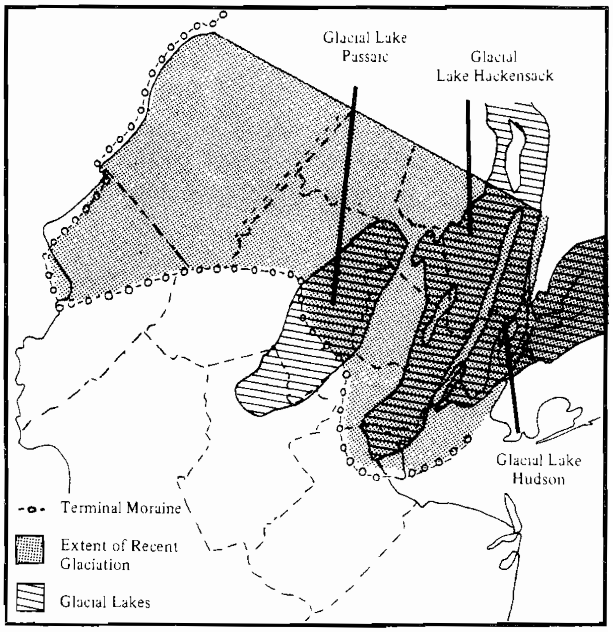

Figure 11. Extent of recent glaciation in New Jersey (modified from Wolfe 1977). Much of northern New Jersey was buried under glacial ice from 80,000 to 18,000 years ago.

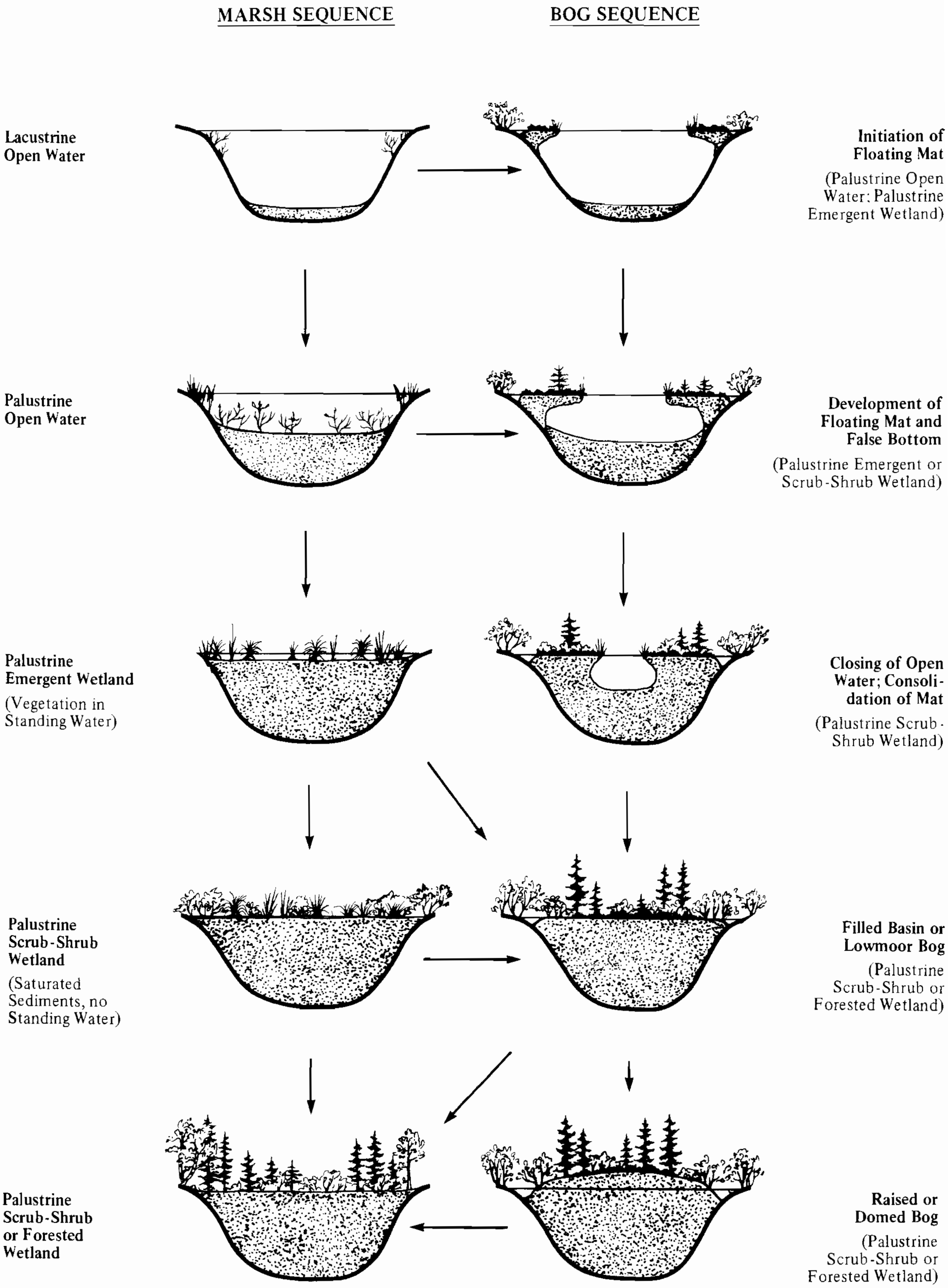

Figure 12. Marsh and bog successional patterns (adapted from Dansereau and Segadas-Vianna 1952).

Beaver activity and human actions may also create wetlands by altering hydrologic regimes to flood former upland areas. In these situations, wetland plants quickly invade to take advantage of the wetter conditions. Beaver activity is now of minor importance, although prior to heavy trapping, beaver played a more prominent role in wetland formation. Today, beaver populations are increasing due to wildlife management practices and they are most common in Sussex County (Ferrigno 1984). Farm pond, artificial lake, and reservoir construction may also create wetlands, yet in many instances natural vegetated wetlands are altered by permanent flooding. Farm ponds may be completely overgrown with vegetation including emergent, submergent, floating-leaved, and floating plants. Along the shorelines of larger water bodies, emergent wetlands and aquatic beds may become established in shallow water. Niering (1953) noted that sedimentation of artificial impoundments is favoring colonization by emergent wetland plants. In time, these areas could become shrub wetlands and eventually forested wetlands. Recently, wetlands have also been created in conjunction with government-financed projects, such as highway construction, port expansion, and flood control impoundments, to mitigate for unavoidable losses of natural wetlands. The U.S. Army Corps of Engineers has successfully established wetlands, particularly in tidal areas at several locations across the country. Restoration of previously drained wetlands has also been successfully accomplished by the Service and others in the Prairie Pothole Region of North and South Dakota. Similar opportunities exist in New Jersey where wetlands have been drained for crop production.

In southern New Jersey, glacial events created a climate where temperatures were below freezing for much of the year from 80,000 to 18,000 years ago. Permafrost developed under these conditions which now exist in Alaska, Canada, and Siberia. A boreal forest of spruce, pine and fir covered the southern New Jersey landscape during the Ice Age (Sirkin, *et al.* 1970). Thermokarst basins formed due to alternate freezing and thawing. Where underlain by impervious clays, these basins became ponds or vegetated wetlands as the climate warmed with the retreat of the glacier. Today, wetlands are prevalent along streams and in isolated depressions largely due to the high water table characteristic of the Pine Barrens. For further information on the vegetational history of the Pine Barrens, please refer to Heusser (1979).

Wetlands have also formed on floodplains along rivers and large streams throughout the State. In mature floodplains, wetlands are found on the inner floodplain terrace behind the natural levees. The levees are composed of coarser materials and are better drained than the inner floodplain which is characterized by silts and clays and poor drainage. Early stages in floodplain development are characterized by extensive marshes bordering streams which gradually become shrub and forested wetlands as sedimentation raises surface elevations (Nichols 1915). Wistendahl (1958) reported on the hydrology and vegetation of the Raritan River floodplain which represents a relatively mature stage.

Coastal Wetland Formation

At maximum glaciation nearly 18,000 years ago, much of the world's ocean waters were stored as glacial ice. This lowered sea levels approximately 425 feet from their present levels. The New Jersey coastline was then 80 miles east of its present position and the coastal plain was more than twice its current size (Wolfe 1977). When the glacier began to melt, water was released to the ocean, thereby raising sea levels. Sea level continues to rise at about one foot per century at Atlantic City and at 1.5 feet per century at Sandy Hook (Hicks 1972). With this increase in sea level, barrier islands have moved landward and stream valleys have been submerged. Evidence of submergence can be found in salt marshes where dead Atlantic white cedar trees and stumps may be present. Jaworski (1980) found that salt marsh vegetation has covered the remains of freshwater plants, providing further evidence of coastal submergence and the landward migration of salt marshes.

Heusser (1949) investigated the history of the Secaucus Bog, which is part of the Hackensack Meadowlands. In the 1800's, it was an Atlantic white cedar-dominated wetland and black spruce and larch reached their southernmost limit here. By 1935, the last of the cedars died. Today, the former bog is flooded by saline tidal waters and occupied by common reed and narrow-leaved cattail. Rising sea level and dredging of the Hackensack River have increased salt water tidal influence in this area.

Coastal marshes typically develop behind barrier islands or beaches and along tidal rivers (Figure 13). Sediments are transported by rivers flowing to the sea as well as by ocean currents. When the river meets the sea, sediments begin to settle out of solution forming deltas and bars at the river's mouth and intertidal flats. Sedimentation also takes place when tidal currents slow as during slack water periods. The rate and extent of sedimentation depends on the original size and age of the estuary, present erosion rate upstream and deposition by the river and marine tides and currents (Reid 1961). Redfield (1972) has described salt marsh development. Initially, mud and silt are deposited to form tidal flats in shallow areas. As elevations exceed mean sea level, smooth cordgrass becomes established. The presence of this vegetation further slows the velocity of flooding waters, causing more sedimentation. Sediments continue to build up to a level where erosion and deposition are in relative equilibrium. The high salt marsh is formed in this way. In many areas along the

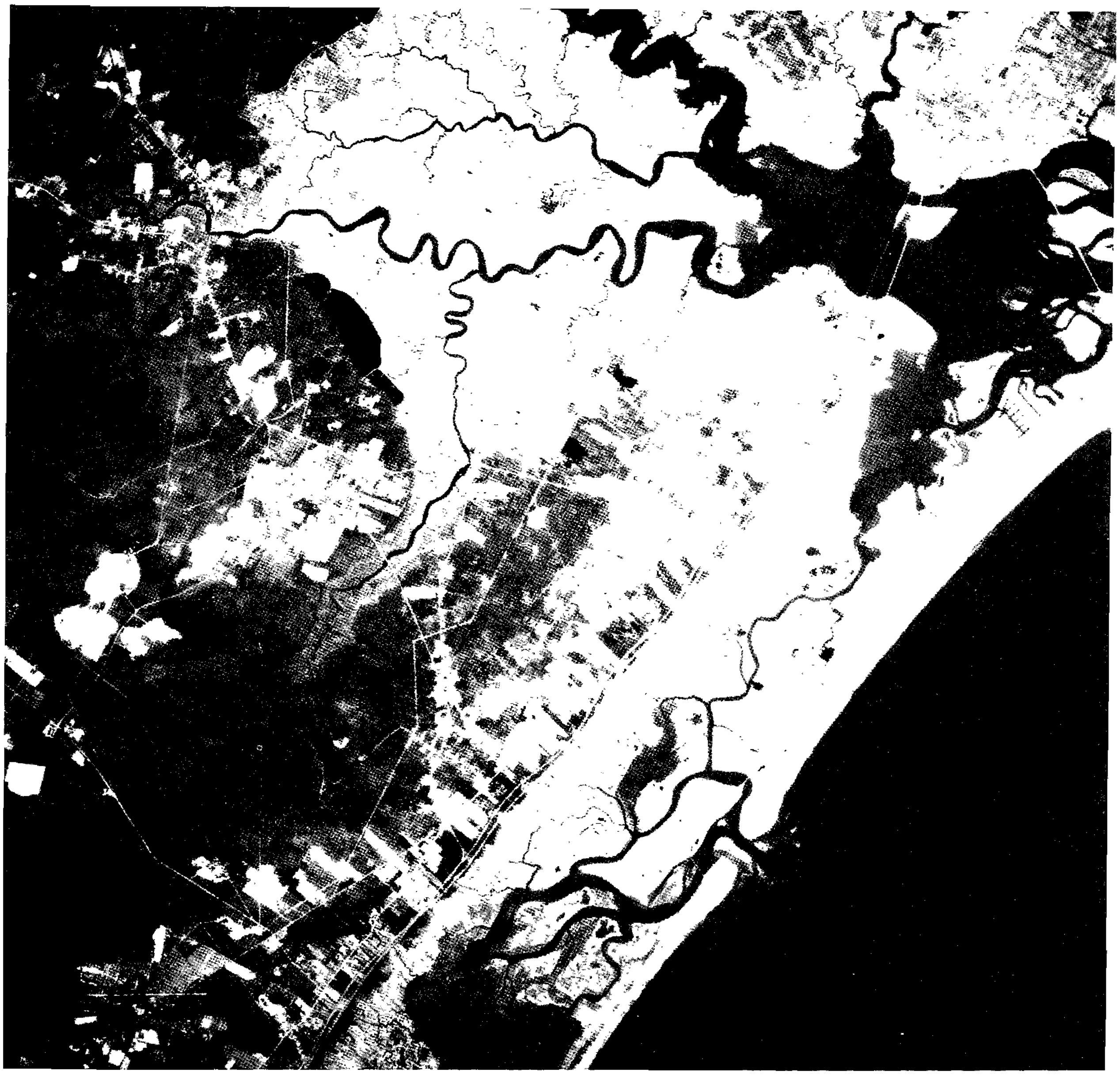

Figure 13. Coastal marshes naturally develop behind barrier islands and along tidal rivers.

Atlantic coast, salt marshes are gradually advancing into low-lying uplands or into nontidal wetlands. This latter situation has been described by Heusser (1949) and Potzger (1952). This landward migration is largely attributed to the global rise in sea level.

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 determine the nature of the soils and the types of plants and animals living in wetlands. An accurate assessment of hydrology unfortunately requires extensive knowledge of the frequency and duration of flooding, water table fluctuations and ground-water relationships. This information can only be gained through intensive and long term studies. There are, however, ways to generally recognize differences in hydrology or water regime. At certain times of the year, like during spring floods or high tides in coastal areas, hydrology is apparent. 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, and (3) water-stained leaves on the ground. These signs and knowledge of the water table and wetland vegetation help us recognize hydrologic differences between wetlands. The Service's wetland classification

Table 8. Tidal ranges of mean and spring tides at selected locations in New Jersey (U.S. Department of Commerce 1978).

Location	Mean Tide Range (ft.)	Spring Tide Range (ft.)	Mean Tide Level (ft.)
Hackensack River at Kearny Point	5.0	6.0	2.5
Raritan River at South Amboy	5.0	6.0	2.5
at New Brunswick	5.8	7.0	2.9
Shrewsbury River at Sea Bright	1.7	2.1	0.6
Barnegat Bay at Mantoloking	0.5	0.6	0.2
at Barnegat Inlet	3.1	3.8	1.5
Little Egg Harbor at Beach Haven	2.2	2.7	1.1
Great Bay at Graveling Point	3.4	4.1	1.7
Great Egg Harbor River at Mays Landing	4.0	4.8	2.0
Maurice River at Millville	6.0	7.0	3.0
Delaware Bay at Miah Maull Shoal Light	5.5	6.5	2.7
Delaware River at Oldsman Point	5.6	5.9	2.8
at Trenton	6.8	7.1	3.4

system (Cowardin, *et al.* 1979) includes water regime modifiers to descibe 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 ground-water discharge. The state of our knowledge in wetland hydrology has been reported by Carter and others (1979) and Leitch (1981).

Tidal Wetland Hydrology

In coastal areas, ocean-driven tides are the dominant hydrologic feature of wetlands. Along the Atlantic coast, tides are semidiurnal 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 tides (i.e., "spring tides") usually occur during full and new moons. In New Jersey, tidal ranges vary from 0.5 feet (0.15m) in Barnegat Bay to 7.1 feet (2.17m) in the Delaware River at Trenton (Table 8). 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 large coastal bays. For example, strong winds in Barnegat Bay may raise or lower normal high and low tides by as much as 3 feet (U.S. Department of Commerce 1964).

In coastal wetlands, differences in hydrology (tidal flooding) create two zones that can be readily identified: (1) regularly flooded zone and (2) 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 the air for long periods and flooded only for brief periods of variable length. The high marsh is usually flooded during spring tides. The upper margins of the high marsh may be flooded, however, only during storm tides which are more frequent in winter. Estuarine plants have adapted to these differences in hydrology and certain plants are good indicators of different water regimes (Table 9).

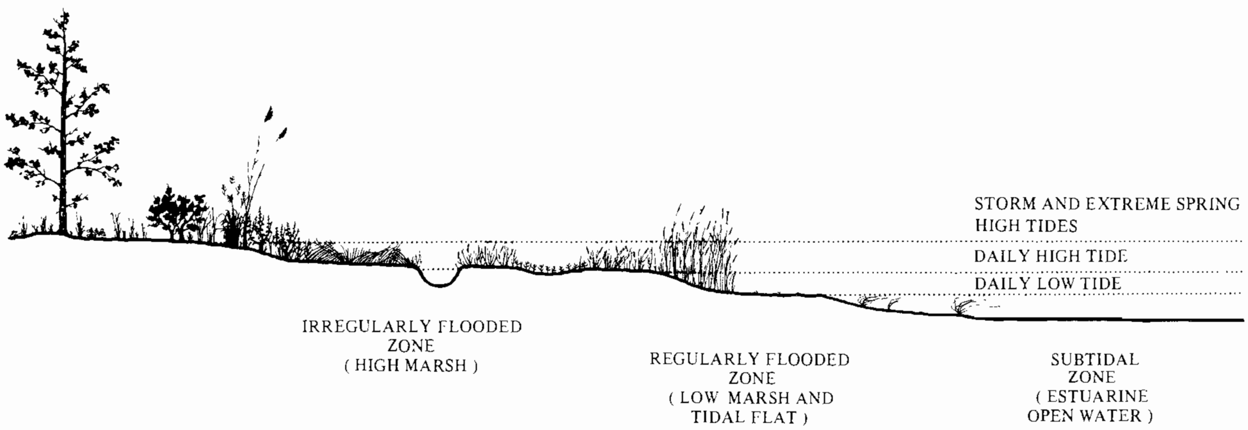

Figure 14. Hydrology of coastal marsh, showing different zones of flooding. The regularly flooded zone is flooded at least once daily by the tides, while the irregularly flooded zone is flooded less often.

Table 9. Examples of plant indicators of the predominant tidal water regimes for New Jersey's estuarine wetlands. These plants are generally good indicators of tidal flooding regimes.

Water Regime	Indicator Plants
Regularly Flooded	Smooth Cordgrass (tall form) Water Smartweed Spatterdock Water Hemp Pickerelweed
Irregularly Flooded	Salt Hay Grass Spike Grass Smooth Cordgrass (short form) Black Grass Switchgrass Big Cordgrass Olney Three-square Bur Marigold

Some strictly freshwater wetlands are also subject to tidal flooding. They lie above the estuary where virtually no ocean-derived salts (i.e., less than 0.5 parts per thousand) are found. Here river flow and tidal flooding interact to create a rather complicated hydrology. Areas flooded and exposed at least once daily by the tides are considered regularly flooded like they are downstream in the estuary, yet wetlands that are not subject to daily tidal flooding are generally classified as seasonally flooded-tidal and temporarily flooded-tidal. They represent the more common water regimes in these situations, with the frequency and duration of flooding being the main hydrologic differences between them. Seasonally flooded-tidal wetlands are often flooded by tides and flooded waters may be present for long periods, especially during spring runoff. Temporarily flooded-tidal areas are flooded infrequently and when flooded, water does not usually persist for more than a few days. These wetlands, especially forested wetlands, are quite similar in appearance to their nontidal counterparts, yet water levels are subject to tidal fluctuations.

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 (i.e., seiches) across large freshwater lakes (e.g., Great 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 rainfall periods (Figure 15). Ground water discharges into depressional wetlands when 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 or ground-water discharge or both. The Great Swamp in northern New Jersey is a good example of the latter (Vecchioli, *et al.* 1962; Miller 1965). Streamflow and associated wetlands in the Pine Barrens are largely maintained by ground-water discharge from the underlying aquifer (Rhodehamel 1979). The role of hydrology in maintaining freshwater wetlands is discussed by Gosselink and Turner (1978).

Freshwater rivers and streams usually experience greatest flooding in winter and early spring, with maximum flooding occurring in March. Such flooding is

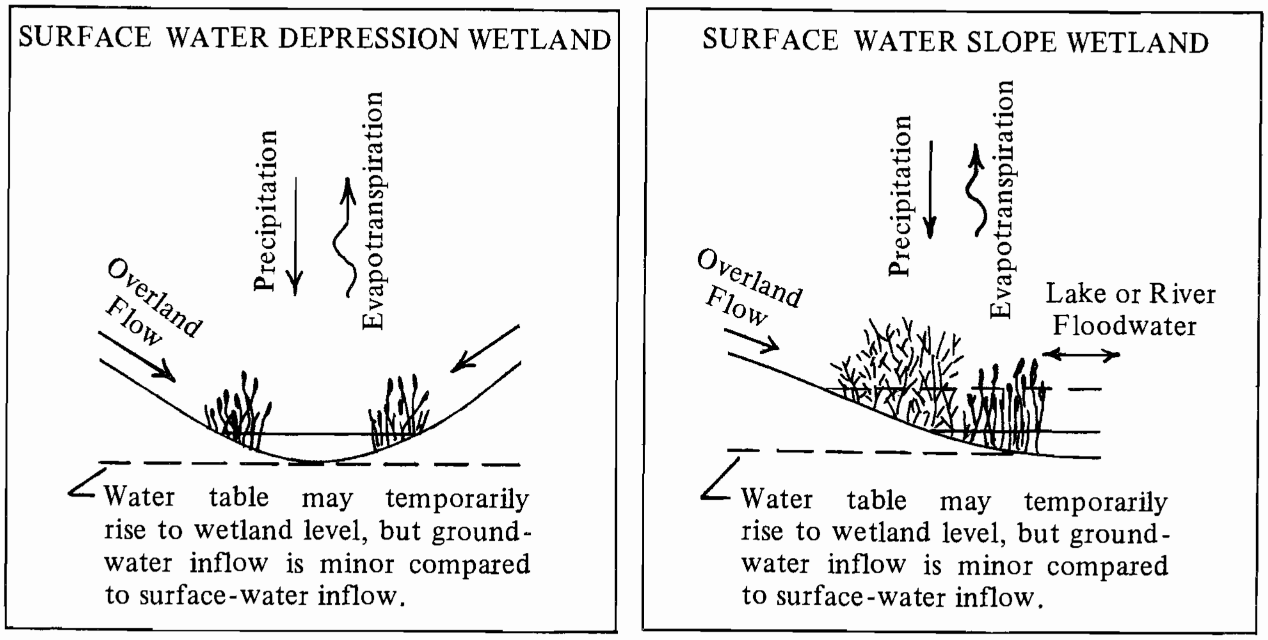

Figure 15. Hydrology of surface water wetlands (redrawn from Novitski 1982).

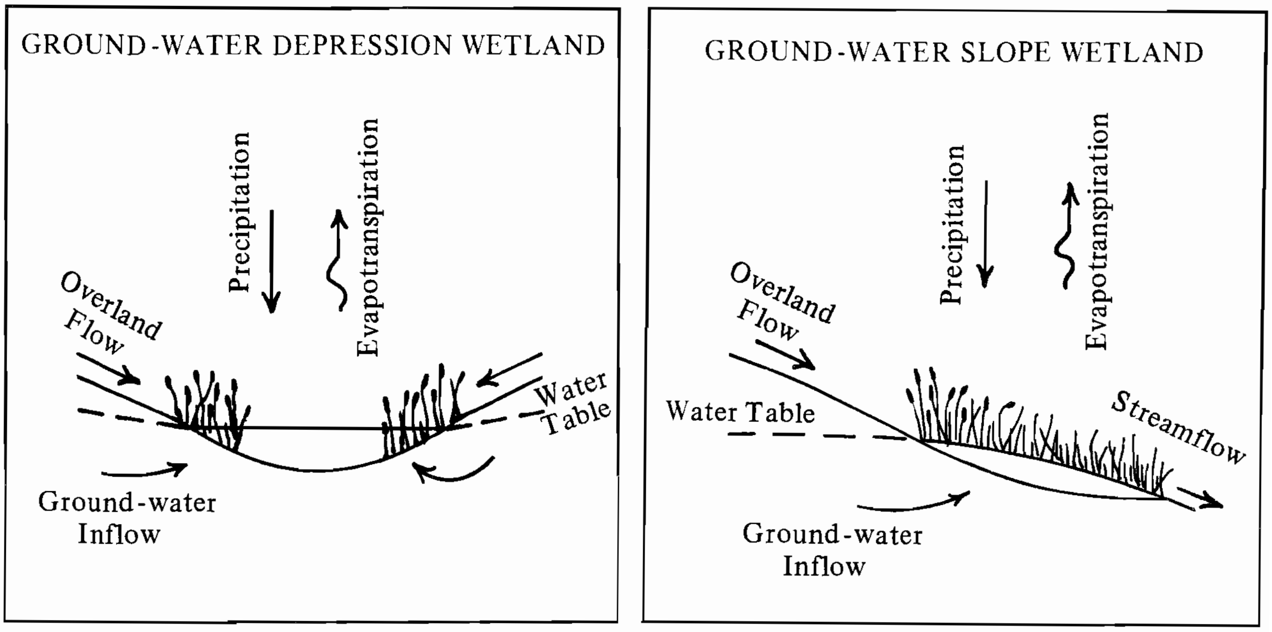

Figure 16. Hydrology of ground-water wetlands (redrawn from Novitski 1982).

associated with frozen soil, snow melt, and/or spring rains. In the Raritan River, for example, flooding reaches its maximum in March near the start of the growing season (Wistendahl 1958). Flooding in this river is variable and unpredictable, with as many as 16 floods occurring in a single year. Normally, however, flooding is less frequent. In the North Branch of the Raritan River, Buchholz (1981) found that flooding results from overflow of backwater streams rather than from overflow of the mainstem river. Backwater stream levees are lower in elevation and are easily breached by rising waters. Minor drainage within the floodplain may, therefore, significantly affect flooding and drainage patterns. In the Raritan River watershed, average monthly precipitation is greatest in summer, but despite this, floods reach their yearly low in June and August. At this time, less water is available for runoff due to high evapotranspiration and to interception of rainfall by plant leaves. In the fall, the hurricane season normally brings heavy rains which increase flood heights and duration (Wistendahl 1958).

Water table fluctuations follow a similar pattern (Figure 17). 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 or flood the wetland surface for variable periods. In May or June, the water table may begin to drop, reaching its low point in September or October. Most of the fluctuation relates to rainfall patterns, yet longer days, increasing air temperatures, increasing evapotranspiration and other factors are responsible for the consistent lowering of the water table from spring through summer.

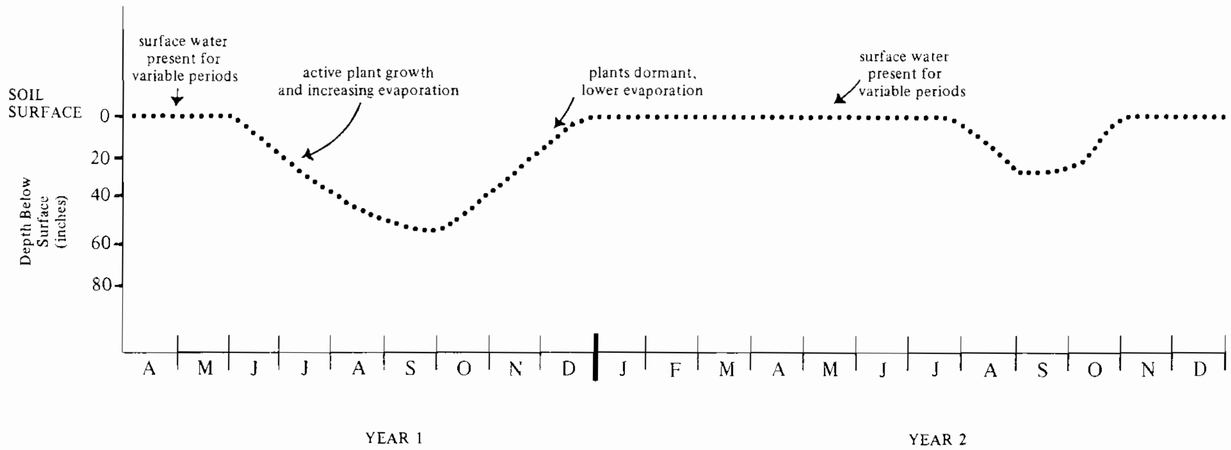

Figure 17. Example of water table fluctuations in a seasonally flooded wetland (adapted from Lyford 1964). In general, the water table is at or near the surface through the winter and spring, drops markedly in summer, and begins to rise in the fall. As shown, the water table fluctuates seasonally and annually.

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 2 weeks or less), the wetland is considered temporarily flooded. During the summer, the water table may drop to 3 feet or more below the surface in these wetlands. This situation is prevalent along floodplains. It also occurs in the Pine Barrens where wetlands are directly connected to the underlying ground-water aquifer (Rhodehamel 1979). Flooding for longer periods is described by three common water regimes: (1) seasonally flooded, (2) semipermanently flooded, and (3) permanently flooded. A seasonally flooded wetland typically has standing water visible for more than 1 month, but usually by late summer, such water is absent. At this time, however, the water table remains within 1.5 feet of the surface. By contrast, a semipermanently 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 water table lies at or very near the surface. The wettest wetlands are permanently flooded, yet they also may be exposed during extreme droughts. These areas include open water bodies where depth is less than 6.6 feet, e.g., ponds and shallow portions 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 considerable slopes in association with springs (i.e., points of active ground-water discharge), where they are commonly called "seeps". Their soils are saturated to the surface for most of the growing season and the water regime is, therefore, classified as saturated. Other saturated wetlands exist in isolated 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 10. Hydrologic conditions, e.g., water table fluctuation, flooding, and soil saturation, for each of New Jersey's hydric soils are generally discussed in the following chapter. For more detailed information on wetland hydrology, the reader is referred to the following sources.

Table 10. Examples of plant indicators of nontidal water regimes for New Jersey's palustrine wetlands.

Water Regime	**Indicator Plants**
Permanently Flooded	White Water Lily Pondweeds Water Shield Spatterdock
Semipermanently Flooded	Buttonbush Wild Rice Burreeds Pickerelweed
Seasonally Flooded	Atlantic White Cedar Alders Highbush Blueberry Broad-leaved Cattail Tussock Sedge
Temporarily Flooded	Silver Maple Pin Oak Sycamore Goldenrods
Saturated	Steeplebush Black Spruce Leatherleaf Sheep Laurel

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CHAPTER 5.

Hydric Soils of New Jersey

Introduction

The predominance of undrained hydric soil is a key attribute for identifying wetlands (Cowardin, *et al.* 1979), although artificially created wetlands do exist on non-hydric soils. Hydric soils naturally develop in wet depressions, on floodplains, on seepage slopes, and along the margins of coastal and inland waters. Knowledge of hydric soils is particularly useful in distinguishing the drier wetlands from uplands, where the more typical wetland plants are less common or absent. This chapter focuses on New Jersey's hydric soils, e.g., their characteristics, distribution and extent.

Definition of Hydric Soil

Hydric soils have been defined by the U.S.D.A. Soil Conservation Service (1982) as soil that is either: (1) saturated at or near the soil surface with water that is virtually lacking free oxygen for significant periods during the growing season, or (2) flooded frequently for long periods during the growing season. This definition attempts to identify soils that support the growth and reproduction of hydrophytes or wetland vegetation. These soils are either saturated and/or flooded long enough to produce anaerobic (no oxygen) conditions in the soil, thereby affecting the reproduction, growth and survival of plants. Plants growing in wetlands must also 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 are now completely drained, are not usually considered hydric soils. These soils must be checked in the field to verify that drainage measures will remain functional under normal or design conditions. Where drainage system failure results, such soils can revert to hydric conditions. This condition must be determined on a site-specific basis. Also, excluded from the definition of hydric soils are soils that were not naturally wet, but are now subject to periodic flooding or soil saturation for specific management purposes (e.g., waterfowl impoundments) or flooded by accident (e.g., highway-created impoundments). Hydrophytic vegetation is usually present in these created wetlands.

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, while soils with less organic content are mineral soils. For a technical definition, the reader is referred to **Soil Taxonomy** (U.S.D.A. Soil Conservation Service 1975).

Build-up of organic matter 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, such as leaves, stems and roots, and encourage their accumulation as peat or muck over time. Consequently, most organic soils are characterized as very poorly drained soils. Organic soils typically form in water-logged depressions where peat or muck deposits range today 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.

Organic soils can be further 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 as peat or muck and here hydric mineral soils have developed. These soils have standing water and/or are saturated within 1.5 feet of the surface for significant periods. Soil saturation may result from low-lying topographic position, ground-water seepage, or the presence of a slowly permeable layer (e.g., clay, confining bed, fragipan or hardpan). In the Pine Barrens, wet soils are related more to the high water table than to low soil permeability (Tedrow 1979). Hydric

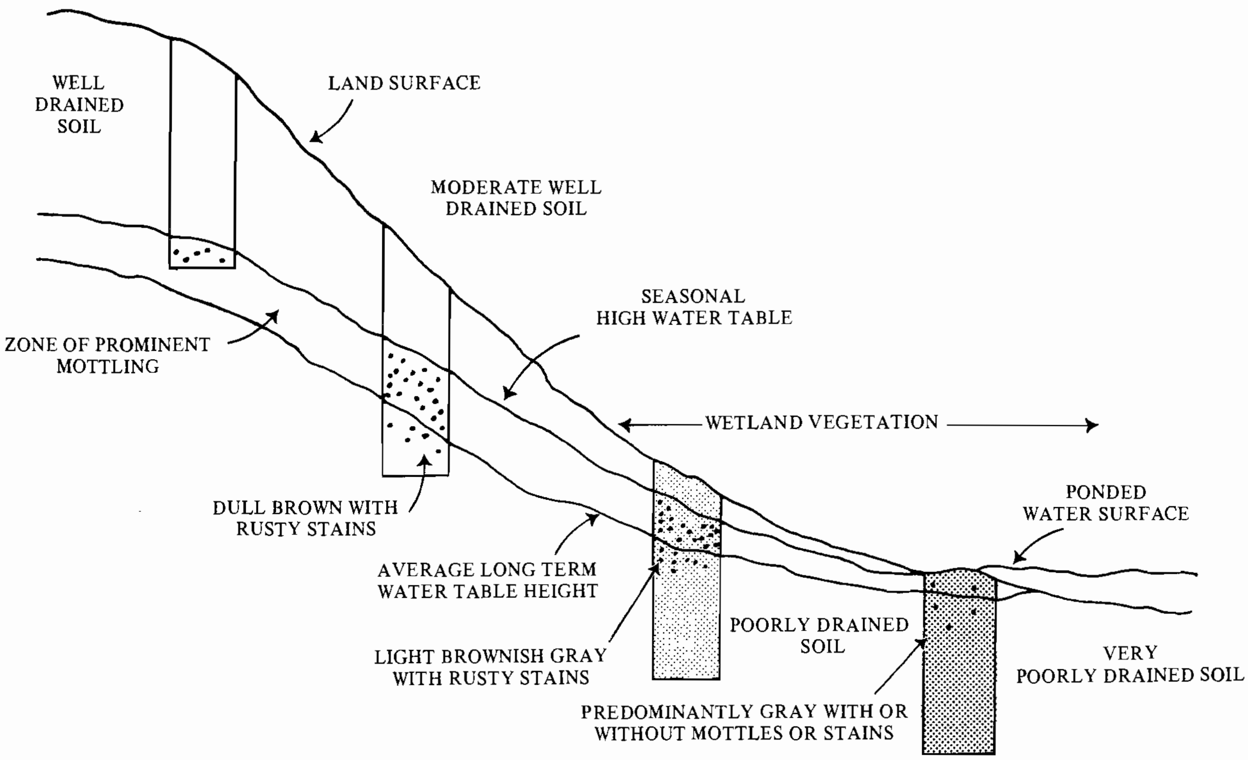

Figure 18. Soil characteristics change from well-drained uplands to very poorly drained wetlands. Note that an increase in grayness of color is associated with increasing soil wetness, and that mottling occurs within the zone of the fluctuating table (redrawn from U.S.D.A. Soil Conservation Service illustration).

mineral soils are predominantly gray in color with variable mottling of bright colors. Characteristic gray colors develop through gleying, where the soil remains anaerobic, keeping iron and other compounds in reduced forms. Mottling occurs when the water table fluctuates during the growing season, allowing oxidation of iron and manganese (Patrick 1983). In most soils, depth and duration of saturation can be correlated to the quantity, nature, and pattern of soil mottling (Figure 18). Soils that are predominantly gray with reddish-brown or yellow mottles are usually saturated for much longer periods than soils that are predominantly yellow or brown with gray mottles. Poorly drained mineral soils usually have distinct mottles within 6 to 10 inches of the surface, while mottling usually occurs immediately below the surface in very poorly drained mineral soils (Hill 1973). In mineral soils with a shallow organic surface layer, distinct mottles occur immediately below this layer. Mottles may not be visible in some soils due to masking by organic matter. While gleying and mottling are characteristic of nearly all hydric mineral soils, sandy soils with brighter colors may be saturated. This happens where the oxygen content of the soil remains high enough so that reduction does not occur (Daniels, *et al.* 1973). Vepraskas and Wildling (1983) have proposed technical criteria for identifying these soils as hydric.

National List of Hydric Soils

To help the Service clarify its wetland definition, the U.S.D.A. Soil Conservation Service (SCS) agreed to develop a list of hydric soils. During formulation of this list, it became obvious that many soils exhibited some but not all of the common wetness characteristics and that the soils of the United States would be better grouped into three categories: hydric soils, soils with hydric conditions, and better drained soils that do not have hydric properties (Patrick 1983). Consequently, the SCS developed two national lists: (1) hydric soils and (2) soils with hydric conditions. The first list represents soils that are always associated with wetland in their natural, undrained state. They almost always support hydrophytic vegetation. By contrast, the latter list contains soils that may under certain circumstances be coincident with wetland. On-site field evaluations are needed to determine whether these soils support a predominance of hydrophytes. An examination of these two lists has suggested that the hydric soils list is conservative, while the list of soils with hydric conditions is too broad (Patrick 1983). Copies of these lists can be obtained from SCS's State Office. In 1985, a national technical committee was established to reassess the definition of hydric soils and the previous national list.

New Jersey Hydric Soils

The national lists of hydric soils were furthered refined for New Jersey in discussions between the Service's NWI personnel and the SCS's soil scientists. More than 60 soils were identified as hydric soils. These soils are listed in Table 11 according to their degree of association with wetlands. Three general groups were identified: (1) Group 1 - soils that nearly always display consistent hydric conditions, (2) Group 2 - soils displaying consistent hydric conditions in most places, and (3) Group 3 - soils displaying hydric conditions in few places. Group 2 and 3 soils require additional verification in the field to determine whether the soil at that site exhibits hydric conditions. All soils displaying hydric conditions in the field are considered hydric soils.

Table 11. Hydric soils of New Jersey. These soils are grouped according to their degree of association with wetlands. Note: Alluvial Land as mapped by soil surveys does include wetland, however due to its variability (including wet and dry environments), it could not be categorized within one of the three groups. Also, wet phases of somewhat poorly drained soils not on this list may also on occasion be associated with wetland.

Group 1 - Soils that nearly always display consistent hydric conditions.

Soil Series Or Land Type	Taxonomy	Soil Series Or Land Type	Taxonomy
Adrian	Terric Medisaprists	Lyons	Mollic Haplaquepts
Bayboro	Umbric Paleaquults	Lyons, Stony	Mollic Haplaquepts
Berryland	Typic Haplaquods	Manahawkin	Terric Medisaprists
Bibb	Typic Fluvaquents	Matlock	Typic Umbraquults
Biddeford	Histic Humaquepts	Muck	N/A
Bowmansville	Aeric Fluvaquents	Mullica	Typic Humaquepts
Carlisle	Typic Medisaprists	Norwich	Typic Fragiaquepts
Chippewa	Typic Fragiaquepts	Norwich, Stony	Typic Fragiaquepts
Cokesbury	Typic Fragiaquults	Pocomoke	Typic Umbraquults
Cokesbury, Stony	Typic Fragiaquults	Portsmouth	Typic Umbraquults
Colemantown	Typic Ochraquults	Preakness	Typic Humaquepts
Croton	Typic Fragiaqualfs	Sloan	Fluvaquentic Haplaquolls
Doylestown	Typic Fragiaquults	St. Johns	Typic Haplaquods
Elkton	Typic Ochraquults	Sulfaquents	N/A
Fluvaquents	N/A	Sulfihemists	N/A
Fresh Water Marsh	N/A	Swamp	N/A
Halsey	Mollic Haplaquepts	Tidal Marsh	N/A
Humaquepts	Cumulic Humaquepts	Wallkill	Thapto-histic Fluvaquents
Keansburg	Typic Umbraquults	Wayland	Mollic Fluvaquents
Lamington	Typic Fragiaquults	Weeksville	Typic Humaquepts
Livingston	Mollic Haplaquepts	Whitman	Humic Fragiaquepts
		Whitman, Stony	Humic Fragiaquepts

Group 2 - Soils displaying consistent hydric conditions in most places, but additional verification is needed.

Soil Series Or Land Type	Taxonomy	Soil Series Or Land Type	Taxonomy
Atherton	Aeric Haplaquepts	Passaic (Parsippany variant)	Aeric Ochraqualfs
Atsion	Aeric Haplaquods	Plummer	Grossarenic Paleaquults
Fallsington	Typic Ochraquults	Raynham	Aeric Haplaquepts
Fredon	Typic Ochraquults	Reaville (wet variant)	Aquic Hapladalfs
Haledon (wet variant)	Aquic Fragiudalfs	Ridgebury	Aeric Fragiaquepts
Leon	Aeric Haplaquods	Ridgebury, Stony	Aeric Fragiaquepts
Othello	Typic Ochraquults	Shrewbury	Typic Ochraquults
Parsippany	Aeric Ochraqualfs	Watchung	Typic Ochraqualfs
Pasquotank	Typic Haplaquepts	Watchung, Stony	Typic Ochraqualfs

Group 3 - Soils displaying hydric conditions in few places and additional verification is needed.

Soil Series Or Land Type	Taxonomy	Soil Series Or Land Type	Taxonomy
Abbottstown	Aeric Fragiaqualfs	Rowland	Fluvaquentic Dystrochrepts
Amwell	Aquic Fragiudalfs	Turbotville	Aquic Fragiudalfs
Chalfont	Aquic Fragiudalfs	Venango (Albia)	Aeric Fragiaqualfs
Hammonton	Aquic Hapludults	Venango, Stony	Aeric Fragiaqualfs
Klej	Aquic Quartzipsamments	Whippany	Aquic Hapludalfs
Lenoir	Aeric Paleaquults	Unnamed	Udifluvents and Ochrepts

Nine types of organic soils have been mapped: Adrian, Carlisle, Fresh Water Marsh, Manahawkin, Muck, Peat, Swamp, Sulfihemists and Tidal Marsh. The remaining soils are mineral soils. In the 19 counties mapped by SCS, organic soils occupy 375,276 acres, while hydric mineral soils encompass 610,260 acres. In total, hydric soils recently covered approximately 25% of the State. Unfortunately, these figures exaggerate today's actual extent of wetlands, since they do not account for alteration of wetland areas through drainage and recent filling and impoundment construction.

County Acreage of Hydric Soils

Due to their abundant tidal marshes, coastal counties, i.e., Atlantic, Burlington, Ocean, Cumberland, Salem, and Cape May, have the largest acreage of hydric soils as well as the highest percentage of the county represented by these soils when compared with non-coastal counties (Table 12). They are closely followed by Sussex, Monmouth and Morris Counties, while Passaic, Somerset, Bergen and Union counties have the least amount of hydric soils acreage.

Acreages of each hydric soil found within each SCS mapped county are presented in Table 13. A brief discussion of these hydric soils appears in the following section.

Table 12. Ranking of counties according to total acreage of hydric soils and percentage of county represented by these soils (based on SCS soil mapping of 19 counties in New Jersey).

Rank	County	Total Acreage of Hydric Soils	Rank	County	% of County Represented by Hydric Soils
1	Atlantic	132,920	1	Cape May	41.9
2	Burlington	114,470	2	Atlantic	36.5
3	Ocean	104,630	3	Salem	35.7
4	Cumberland	98,400	4	Cumberland	30.6
5	Salem	77,760	5	Ocean	25.5
6	Cape May	70,800	6	Burlington	23.6
7	Sussex	67,670	7	Gloucester	21.7
8	Monmouth	56,290	8	Sussex	21.2
9	Morris	54,069	9	Morris	18.7
10	Gloucester	45,420	10	Camden	18.3
11	Middlesex	34,160	11	Monmouth	18.2
12	Mercer	25,883	12	Middlesex	18.0
13	Camden	24,595	13	Mercer	17.6
14	Warren	21,760	14	Passaic	12.4
15	Hunterdon	15,650	15	Warren	9.6
16	Somerset	15,109	16	Somerset	7.9
17	Passaic	13,490	17	Bergen	5.9
18	Bergen	8,930	18	Hunterdon	5.7
19	Union	3,530	19	Union	5.3

Table 13. Acreages of hydric soils within each county (based on U.S.D.A. Soil Conservation Service's soil surveys). Soils are listed by soil series or by a more general designation (e.g., tidal marsh, muck, and alluvial land). The percentage coverage by each hydric soil is indicated for each county. Total land acreage for each county is also shown. Note: Group 3 soils are not included in these figures because they are only occasionally associated with wetland. Also, Essex and Hudson Counties were not mapped by SCS, therefore, no data on their hydric soils exist.

County (Total Land Acreage)	Hydric Soil Type	Acreage Of Soil Type In County	% Of County Covered By Soil Type
Atlantic (364,224)	Atsion	28,800	7.9
	Berryland	13,730	3.8
	Muck	25,200	6.9
	Pocomoke	22,700	6.2
	Tidal Marsh	42,490	11.7
	Atlantic Total =	132,920	36.5
Bergen (149,760)	Adrian	590	0.4
	Carlisle	275	0.2
	Haledon (wet variant)	955	0.6
	Fluvaquents	1,915	1.3
	Preakness	1,995	1.3
	Sulfihemists and Sulfaquents	3,200	2.1
	Bergen Total =	8,930	5.9
Burlington (483,432)	Alluvial Land	23,400	4.8
	Atsion	25,880	5.4
	Berryland	8,300	1.7
	Colemantown	4,600	1.0
	Fallsington	2,650	0.5
	Keansburg	2,300	0.5
	Marsh	9,780	2.0
	Muck	16,600	3.4
	Pasquotank	4,100	0.8
	Pocomoke	6,600	1.4
	Shrewsbury	10,260	2.1
	Burlington Total =	114,470	23.6
Camden (134,420)	Colemantown	200	0.1
	Fallsington	1,300	1.0
	Leon	4,750	3.5
	Loamy Alluvial Land	2,300	1.7
	Muck	6,700	5.0
	Pasquotank	2,210	1.6
	Pocomoke	800	0.6
	Sandy Alluvial Land	2,000	1.5
	Shrewsbury	1,125	0.8
	St. Johns	2,550	1.9
	Tidal Marsh	150	0.1
	Weeksville	510	0.4
	Camden Total =	24,595	18.3
Cape May (168,948)	Berryland	950	0.6
	Muck	6,400	3.8
	Pocomoke	16,900	10.0
	Tidal Marsh	46,550	27.6
	Cape May Total =	70,800	41.9

County (Total Land Acreage)	Hydric Soil Type	Acreage Of Soil Type In County	% Of County Covered By Soil Type
Cumberland (321,536)	Atsion	5,850	1.8
	Berryland	4,100	1.3
	Fallsington	11,200	3.5
	Muck	18,900	5.9
	Othello	1,250	0.4
	Pocomoke	9,800	3.0
	Tidal Marsh	47,300	14.7
	Cumberland Total =	98,400	30.6
Gloucester (209,700)	Alluvial Land	5,200	2.5
	Bayboro	200	0.1
	Colemantown	200	0.1
	Elkton	1,400	0.7
	Fallsington	9,100	4.3
	Fresh Water Marsh	300	0.1
	Leon	4,500	2.1
	Matlock	120	0.1
	Muck	13,100	6.2
	Pasquotank	1,000	0.5
	Pocomoke	1,600	0.8
	St. Johns	1,300	0.6
	Tidal Marsh	7,400	3.5
	Gloucester Total =	45,420	21.7
Hunterdon (275,494)	Alluvial Land	2,660	1.0
	Bowmansville	2,000	0.7
	Cokesbury	2,780	1.0
	Croton	5,600	2.0
	Reaville (wet variant)	1,700	0.6
	Watchung	910	0.3
	Hunterdon Total =	15,650	5.7
Mercer (146,869)	Alluvial Land	3,374	2.3
	Bowmansville	1,534	1.0
	Doylestown	4,277	2.9
	Elkton	1,527	1.0
	Fallsington	1,291	0.9
	Fresh Water Marsh	2,066	1.4
	Othello	8,239	5.6
	Plummer	2,088	1.4
	Portsmouth	1,296	0.9
	Watchung	191	0.1
	Mercer Total =	25,883	17.6
Middlesex (189,644)	Atsion	4,700	2.5
	Elkton	4,050	2.1
	Fallsington	8,190	4.3
	Humaquepts	3,250	1.7
	Manahawkin	2,250	1.2
	Mullica	1,250	0.7
	Parsippany	2,470	1.3
	Reaville (wet variant)	800	0.4
	Shrewsbury	1,200	0.6
	Sulfaquents	2,625	1.4
	Sulfihemists	2,625	1.4
	Watchung	750	0.4
	Middlesex Total =	34,160	18.0

County (Total Land Acreage)	Hydric Soil Type	Acreage Of Soil Type In County	% Of County Covered By Soil Type
Monmouth (304,640)	Atsion	5,840	1.9
	Berryland	12,600	4.1
	Colemantown	2,240	0.7
	Elkton	3,530	1.1
	Fallsington	3,790	1.2
	Humaquepts	14,100	4.6
	Manahawkin	2,840	0.9
	Shrewsbury	8,550	2.8
	Sulfaquents and Sulfihemists	2,800	0.9
	Monmouth Total =	56,290	18.2
Morris (289,810)	Adrian	3,450	1.2
	Alluvial Land	4,900	1.7
	Biddeford	2,950	1.0
	Carlisle	7,900	2.7
	Cokesbury	10,600	3.7
	Muck	1,930	0.7
	Parsippany	10,550	3.6
	Preakness	4,759	1.6
	Ridgebury	6,150	2.1
	Whitman	930	0.3
	Morris Total =	54,069	18.7
Ocean (410,325)	Atsion	26,940	6.6
	Berryland	16,650	4.1
	Humaquepts	490	0.1
	Manahawkin	26,800	6.5
	Mullica	6,350	1.5
	Shrewsbury	1,200	0.3
	Sulfaquents	13,100	3.2
	Sulfihemists	13,100	3.2
	Ocean Total =	104,630	25.5
Passaic (109,126)	Alluvial Land	860	0.8
	Carlisle	1,390	1.3
	Haledon (wet variant)	1,080	1.0
	Muck	770	0.7
	Norwich	1,960	1.8
	Parsippany	1,470	1.3
	Preakness	1,020	0.9
	Ridgebury	4,940	4.5
	Passaic Total =	13,490	12.4
Salem (217,834)	Bayboro	2,280	1.0
	Berryland	4,034	1.9
	Bibb	4,400	2.0
	Elkton	4,000	1.8
	Fallsington	7,011	3.2
	Fresh Water Marsh	3,300	1.5
	Muck	4,200	1.9
	Othello	12,729	5.8
	Peat	1,060	0.5
	Pocomoke	3,046	1.4
	Tidal Marsh	31,700	14.6
	Salem Total =	77,760	35.7

County (Total Land Acreage)	Hydric Soil Type	Acreage Of Soil Type In County	% Of County Covered By Soil Type
Somerset (191,608)	Bowmansville	2,350	1.2
	Cokesbury	220	0.1
	Croton	2,050	1.1
	Elkton	330	0.2
	Fluvaquents	740	0.4
	Lamington	480	0.2
	Parsippany	4,970	2.6
	Watchung	3,969	2.1
	Somerset Total =	15,109	7.9
Sussex (318,786)	Alluvial Land	1,340	
	Atherton	2,550	0.8
	Carlisle	12,100	3.8
	Chippewa	6,100	1.9
	Fredon	2,920	0.9
	Halsey	2,000	0.6
	Livingston	3,750	1.2
	Lyons	2,460	0.8
	Norwich	16,850	5.3
	Preakness	670	0.2
	Raynham	1,150	0.4
	Swamp	3,800	1.2
	Wallkill	530	0.2
	Wayland	2,050	0.6
	Whitman	9,400	2.9
	Sussex Total =	67,670	21.2
Union (65,920)	Aquepts	1,200	1.8
	Carlisle-Adrian complex	530	0.8
	Haledon (wet variant)	420	0.6
	Parsippany	850	1.3
	Sulfihemists and Sulfaquents	530	0.8
	Union Total =	3,530	5.3
Warren (227,973)	Adrian	1,650	0.7
	Carlisle	3,550	1.6
	Chippewa	4,410	1.9
	Cokesbury	2,560	1.1
	Fredon	2,050	0.9
	Halsey	1,540	0.7
	Lyons	1,900	0.8
	Wayland	4,100	1.8
	Warren Total =	21,760	9.6

Description of Hydric Soils

This section briefly discusses key features of each hydric soil shown in Table 11. This information was obtained from published county soil surveys. Since such data are not available for Essex and Hudson Counties, no reference to these counties is given. If interested in these counties, the reader is advised to contact the appropriate SCS county office.

Abbottstown Series

The Abbottstown series is comprised of a somewhat poorly drained, loamy soil with a fragipan developed in the lower subsoil. It occurs in nearly level to gently sloping areas. These soils are saturated within 1.5 feet of the surface in fall, winter and early spring due to the presence of a seasonally high perched water table. Abbottstown soils are located in Hunterdon, Mercer and Somerset Counties.

Adrian Series

Adrian soils are very poorly drained organic soils consisting of 18 to 50 inches of well decomposed muck and underlain by sand. They have formed in kettle depressions, former glacial lake beds and floodplains. The water table is at the surface for most of the year. Where adjacent to streams, these soils are subjected to stream overflow, usually in winter and spring. Adrian soils occur in Bergen, Morris, Warren, and Union Counties. In Union County, they are mapped as a complex with Carlisle.

Albia Series

See Venango Series for discussion.

Alluvial Land Type

Alluvial land type is a mixture of soils that is too variable to map as a soil series unit. It ranges from moderately well drained soils to very poorly drained soils depending on site-specific conditions. This type occurs along rivers and perennial streams. Alluvial areas are subjected to frequent flooding, most commonly in early spring. The water table is quite variable. In low areas, the water table is at the surface in winter and falls to 1 foot below in the summer. Ponding of water may be observed in places in late fall, winter and early spring due to the high water table. At higher levels, alluvial land may be only occasionally flooded, with the water table in winter 2 to 3 feet below the surface and in summer 3 to 4 feet below. Alluvial soils are mapped in Burlington, Camden, Gloucester, Hunterdon, Mercer, Morris, Passaic and Sussex Counties.

Amwell Series

The Amwell Series consists of moderately well drained and somewhat poorly drained soils with a firm fragipan developed below 21 inches. These soils occur on gentle and strong slopes. They have a seasonal high water table perched at a depth of 1 to 4 feet from winter until early spring. The somewhat poorly drained group of these soils are occasionally associated with wetland. Amwell soils are mapped only in Somerset County.

Atherton Series

The Atherton Series consists of poorly to very poorly drained, loamy soils. It occurs on glacial outwash terraces, in slight depressions adjacent to streams and in low spots where surface and seepage water collect. Although seldom flooded, these soils are saturated for long periods by a high water table, but are aerated for variable periods during the growing season. Atherton soils are only found in Sussex County.

Atsion Series

Atsion soils are poorly drained, sandy soils. Typically, these soils occur in broad flats, depressions and drainage channels. They sometimes border tidal marshes where they are subjected to tidal flooding during severe coastal storms. The water table reaches its height within 1 foot of the surface in December and normally drops to a depth of 2 to 4 feet by the end of July or August. During normal rainfall years, these soils are saturated 6 to 8 months of the year. Atsion soils are found in Atlantic, Burlington, Cumberland, Middlesex, Monmouth and Ocean Counties.

Bayboro Series

The Bayboro series consists of very poorly drained, clayey soils. They are covered by water much of the winter and during wet periods, since they occur at low elevations. Bayboro soils are found in Gloucester and Salem Counties.

Berryland Series

Berryland soils are very poorly drained, sandy soils. These soils usually occur in wide depressions, and lowland flats and along streams. In some areas, they have formed adjacent to tidal marshes where they are subjected to tidal flooding during severe coastal storms. Where bordering larger streams, these soils experience frequent flooding for short periods. During a normal rainfall year, these soils are saturated for 7 to 9 months. The water table reaches its peak in April with saturation to the surface and begins to drop in late May, attaining its lowest level (about 2 feet) by the end of July or August. Berryland soils are located in Atlantic, Burlington, Cape May, Cumberland, Monmouth, Ocean, and Salem Counties.

Bibb Series

The Bibb series consists of somewhat poorly drained to very poorly drained, silty, or loamy soils with high organic content. Since it usually occurs in bottomlands of streams, this soil is subject to frequent flooding. Bibb soils are only mapped in Salem County.

Biddeford Series

Biddeford soils are composed of very poorly drained, silty or clayey soils. They have formed in stratified, glacial lacustrine deposits. They are associated with depressions, streams and old meander scars of major rivers. These soils are frequently flooded (Figure 19) and the water table is at or near the surface for most of the year, except in summer. Biddeford soils are only mapped in Morris County.

Bowmansville Series

The Bowmansville series consists of poorly to somewhat poorly drained, clayey silty, loamy soils. These soils have formed in glacial till and granitic gneiss. They occur in depressions and on floodplains, where they are subjected to very frequent flooding. In some locations, Bowmansville is found at higher levels which are seldom flooded, yet water does pond there. Most of the flooding takes place in spring, with occasional summer or fall flooding due to heavy storms. Bowmansville soils are located in Hunterdon, Mercer, and Somerset Counties.

Carlisle Series

The Carlisle series includes very poorly drained organic (muck) soil. It occurs in depressions, which were glacial lakes or ponds, and in low areas bordering lakes, ponds and streams. Carlisle consists of a highly decomposed muck about 18 inches deep, which overlies at least 42 inches of less decomposed muck where fibrous woody material can be distinguished. The water table is at or near the surface from late fall to late spring, while in summer it drops to a depth of 2 feet or more. Most areas are subjected to frequent or annual flooding. Carlisle mucks are located in Bergen, Morris, Passaic, Sussex, Warren and Union Counties. In Union County, they are mapped as a complex with Adrian muck.

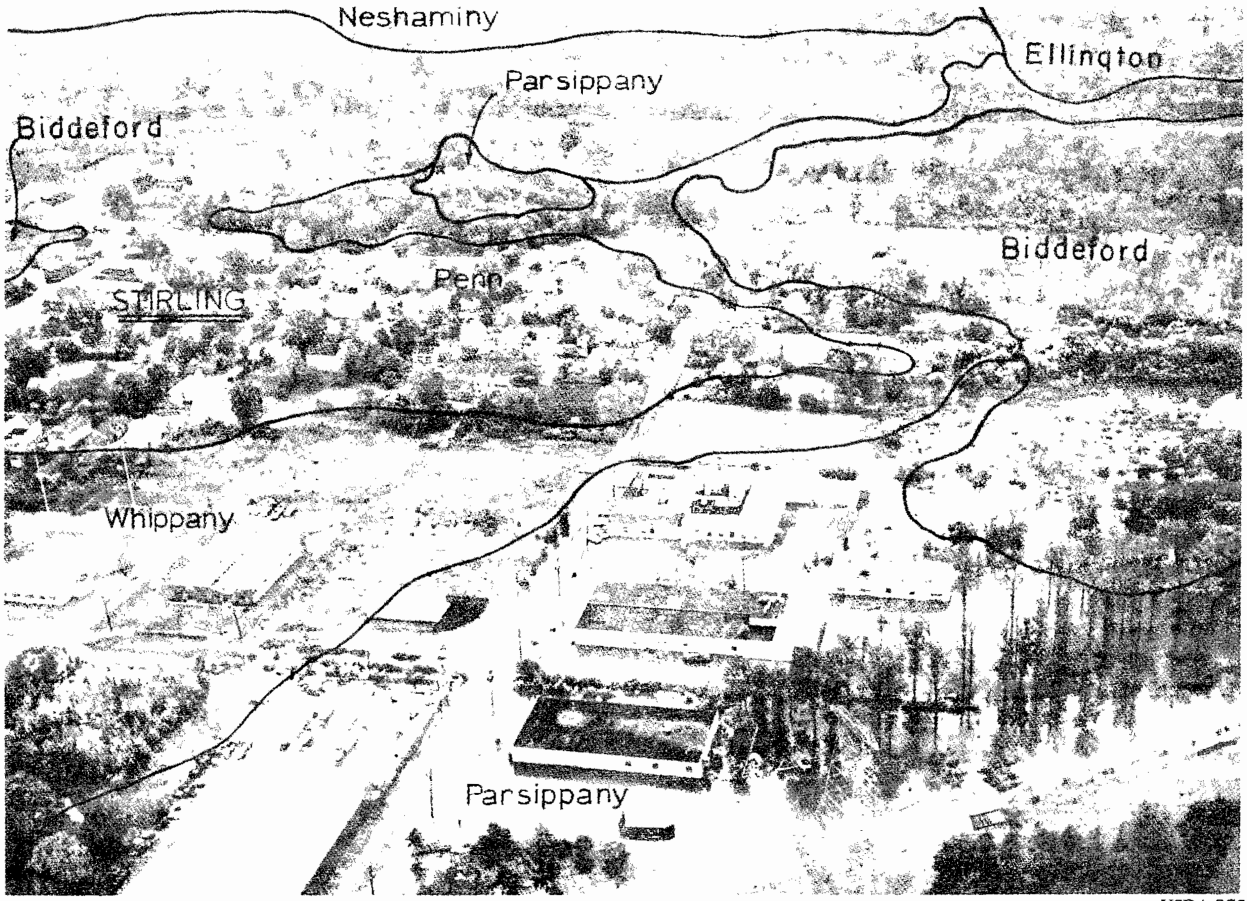

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Figure 19. Many hydric soils are subjected to flooding for variable periods during the year. During the 1958 flood in Stirling, nearly all Parsippany and Biddeford soils (hydric) were covered with water, while the Penn soils did not flood (Eby 1976).

Chalfont Series

Chalfont soils are somewhat poorly drained soils having a fragipan between 15 and 40 inches below the surface. They occur in sloping areas. A seasonal high water table is perched on the fragipan at a depth of 0.5 to 1.5 feet. On occasion, Chalfont soils are associated with wetland. These soils are mapped in Hunterdon, Mercer, Middlesex, and Somerset Counties.

Chippewa Series

The Chippewa series consists of poorly to very poorly drained, silty loams where a fragipan has developed in the lower subsoil at a depth of 18 inches. In some areas, Chippewa soils are very or extremely stony. They are found at the heads of streams and along streams and drainageways. A perched water table is at or near the surface from November to May. Where adjacent to streams, some of these soils may be periodically flooded. Chippewa soils are mapped only in Sussex and Warren Counties.

Cokesbury Series

Cokesbury soils are poorly drained, loamy soils with a moderately well-developed fragipan at 21 to 32 inches. In some areas, these soils are very or extremely stony. They occur in waterways and depressions as well as in gently sloping areas. A perched water table is within 1 foot of the surface from September to June. Cokesbury soils are located in Hunterdon, Morris, Somerset and Warren Counties.

Colemantown Series

The Colemantown series consists of poorly drained, highly mottled loamy soil. It occurs in depressions and at the headwaters of streams. Normally, these soils have ponded water and a saturated substratum for 8 to 10 months of the year. In summer, however, the water table drops to 3 feet or more. Colemantown soils are found in Burlington, Camden, Gloucester, and Monmouth Counties. In Gloucester County, these soils were mapped as a complex with poorly drained Matlock soils.

Croton Series

The Croton series includes poorly drained, loamy soils with a fragipan present at 19 to 33 inches. It forms in hillside seepage areas, in slight depressions on upland flats and along drainages, where it remains wet until late in the spring. A perched water table is within 1 foot of the surface in winter and spring. Croton soils are limited to Hunterdon and Somerset Counties.

Doylestown Series

Doylestown soils are poorly drained, silty soils. They are found in depressions, along drainageways and on gentle slopes with seepage areas. This soil remains saturated until late spring. Doylestown soils are only found in Mercer County, where they are mapped as a complex with Reaville (wet variant) soils.

Elkton Series

The Elkton series consists of poorly drained, clayey or silty loam soils that have formed in former marine deposits. It occurs in slight depressions of upland flats, small circular depressions and low-lying areas. The water table is at the surface from fall through spring. Elkton soils are mapped in Gloucester, Mercer, Middlesex, Monmouth, Salem, and Somerset Counties.

Fallsington Series and Fallsington Variant

Fallsington soils are poorly drained, sandy loam soils. They have formed in depressions, along streams where they are subjected to frequent flooding, and along tidal marshes where flooding results from severe coastal storms. These soils are generally saturated for 6 to 8 months of the year (i.e., December to May) with the water table normally less than 1 foot below the surface. In summer, the water table drops to 2 feet or more. In winter, some areas have water ponding on the surface. Fallsington soils are mapped in Burlington, Camden, Cumberland, Gloucester, Mercer, Middlesex and Salem Counties.

Fluvaquents

Fluvaquents consist of poorly and very poorly drained soils of variable composition that occur on lower flood-plains. They are formed in glacial till, granitic gneiss and limestone washed from adjacent uplands. The water table is within 1 foot of the surface from late fall through early spring. Flooding from stream overflow takes place several times each year. Fluvaquents soils are mapped in Bergen and Somerset Counties.

Fredon Series

The Fredon series is comprised of poorly drained, loamy soils. It is present in glacial stream terraces slightly above stream floodplains, in depressions and in seepage areas on slopes. The water table is within 1 foot of the surface from September to June. In floodplain areas, these soils are subjected to periodic flooding, usually in the spring. Fredon soils are located only in Sussex and Warren Counties.

Fresh Water Marsh or Marsh

The Fresh Water Marsh or Marsh type consists of organic soils, usually underlain by loamy mineral soil. The organic layer ranges from a few inches to several feet in thickness and is comprised primarily of decomposed fibers and roots. These soils form along large streams and are flooded by heavy rains or extremely high tides. In some upland areas, these soils occur in depressions. They are normally saturated for most of the year and flooded frequently. Fresh Water Marsh soils are mapped in Gloucester, Mercer, and Salem Counties.

Haledon Series (Wet Variant)

Haledon (wet variant) soils include poorly drained, loamy soils, with a fragipan developed in the lower subsoil. They occur along waterways, in depressions, and on toe slopes near basalt ridges. A perched water table is at or near the surface for most of the year. Haledon (wet) soils are located in Bergen, Passaic, Middlesex, and Union Counties.

Halsey Series

Halsey soils consist of very poorly drained, loamy soils formed in glacial outwash areas. They have formed at the headwaters of streams and in depressions both in low areas along streams and in gently sloping outwash terraces. Where they are adjacent to streams, these soils are subjected to occasional or frequent flooding. The water table is within 6 inches of the surface from September to June. Halsey soils are mapped only in Sussex and Warren Counties.

Hammonton Series

The Hammonton series consists of moderately well drained and somewhat poorly drained soils. These soils occur in depressions and on low divides and side slopes. They have a seasonal high water table at a depth of 1.5 to 4 feet from late fall to early spring. Hammonton soils are associated with wetland in a few places. These soils are located in Atlantic, Cape May, Cumberland, Middlesex, and Ocean Counties.

Humaquepts

Humaquepts range from somewhat poorly drained to very poorly drained, sandy or loamy soils on floodplains of perennial and intermittent streams. They are flooded several times per year, mostly in spring. For very poorly drained sites, the water table is at or near the surface from November to June, whereas somewhat poorly drained sites have a high water table 0.5 to 1.5 feet below the surface from January to May. Humaquepts are mapped in Middlesex, Monmouth, and Ocean Counties.

Keansburg Series

The Keansburg series consists of very poorly drained, loamy soils that contain some glauconite. They have formed in large circular depressions and along streams. While saturated 8 to 10 months of the year, the soils begin to dry out in late spring. In summer, the water table drops to about 3 feet. Ponding can occur during the late winter. Keansburg soils are mapped only in Burlington County.

Klej Series

Klej soils are moderately well drained and somewhat poorly drained sandy soils. They exist in depressions and low divides. A seasonal high water table is present at a depth of 1.5 to 4 feet below the surface from late fall to early spring. Klej soils are associated with wetland in a few places. They are mapped in Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Middlesex, Ocean, and Salem Counties.

Lamington Series

Lamington soils include poorly drained, clayey and silty loam soils with a well-developed fragipan at a depth of 23 to 45 inches. They occur on stream terraces in old ox-bows and stream meanders. Water may temporarily pond on the surface in places. A seasonal high water table is perched above the fragipan during the winter and early spring. Lamington soils are mapped only in Somerset County.

Lenoir Series

The Lenoir series is comprised of somewhat poorly drained, silty clay soils that occupy low positions. Ponding occurs in winter and early spring and often lasts until late in spring. These soils are wet much of the year and are frequently ponded during the winter and spring. Lenoir soils are recognized in Gloucester, Mercer, and Salem Counties, where they have been mapped with Keyport silt loams.

Leon Series

Leon soils consist of poorly drained, sandy soils with little or no mottling. They occur in level areas bordering swamps or in circular depressions. The water table is within 1 foot of the surface in winter and within 2 feet in summer. Leon soils are mapped only in Camden and Gloucester Counties, where they are frequently associated with St. Johns sands.

Livingston Series

Livingston soils are very poorly drained, silty clay loam or clayey soils. They have formed in low areas adjacent to streams, where they are occasionally flooded by overflow. The water table is at or near the surface for long periods during the year and ponding occurs in winter and early spring. Livingston soils are mapped only in Sussex County.

Lyons Series

The Lyons series consists of poorly to very poorly drained, silty loam soils formed in glacial till. In some areas, Lyons soils are very or extremely stony. They occur in upland depressions and along streams. These soils are saturated for 6 months or more during the year, usually from November until June. In late winter and spring, some ponding occurs. Lyons soils are located in Sussex and Warren Counties.

Manahawkin Series

Manahawkin soils are very poorly drained, organic soils with more than 3 feet of black muck. They have formed on floodplains, in depressions and on broad upland flats. The water table is at the surface from November to June, and drops to between 1 and 2 feet in summer or to 3 feet during extreme droughts. Manahawkin soils are mapped in Middlesex, Monmouth, and Ocean Counties.

Matlock Series

The Matlock series consists of poorly drained, loamy soils that have developed in marine clay deposits. Water ponds on the surface of these soils during most of the winter and during other wet periods. Matlock soils are located in Gloucester County, where they have been mapped with the Colemantown series.

Muck

The Muck land type is a very poorly drained, organic soil with a highly decomposed organic layer of 16 inches to more than 4 feet. It occupies areas adjacent to streams, broad and deep upland flats and areas bordering tidal marshes which are subject to short periods of flooding during severe coastal storms. Muck is saturated 10 to 12 months of the year. The water table can drop in summer to 1 or 2 feet below the surface only during extreme droughts. Mucks are quite widespread and have been mapped in Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Morris, Passaic and Salem Counties.

Mullica Series

The Mullica series consists of very poorly drained, sandy loam soils. These soils have formed in depressions and broad flats and adjacent to streams where they are subjected to occasional flooding. The water table is at or near the surface from November to June, with some ponding occurring. In summer, the water table normally drops to 2 or 3 feet. During drought periods, it may drop to 5 feet. Mullica soils are located in Middlesex and Ocean Counties.

Norwich Series

Norwich soils include poorly drained, stony silt loams with a fragipan developed at 24 to 32 inches in the lower subsoil. These soils occur in waterways and depressions or on toe slopes of rocky highlands. A seasonal high water table is perched at or near the surface from late winter through early spring and remains within 2 feet for most of the year. Norwich soils are mapped only in Passaic and Sussex Counties.

Othello Series

The Othello series is comprised of poorly drained, silty clay loam soils. These soils occur in low areas, on slight slopes and adjacent to tidal marshes, where they are subject to occasional flooding during severe coastal storms. The water table is at the surface or within 1 foot from late October to June and drops to 3 to 5 feet in summer. Othello soils are located in Cumberland, Mercer and Salem Counties.

Parsippany Series and Parsippany Variant

Parsippany soils are poorly drained, silt loam soils that formed in stratified glacial lacustrine deposits. Where located along major streams and rivers, these soils are often subject to flooding. The water table is at or near the surface from winter through early spring and falls to 3 to 4 feet in summer. Ponding is likely to occur during heavy rain periods. Parsippany soils are mapped in Middlesex, Morris, Passaic, Somerset, and Union Counties. (Note: Parsippany Variant has been renamed as the Passaic Series.)

Pasquotank Series

The Pasquotank series includes poorly drained, sandy loamy soils. They occur in circular depressions and in other low-lying areas. These soils are saturated for 6 to 8 months of the year, with water ponding in certain areas in winter or after heavy summer rains. The water table usually drops to 3 feet in summer, begins to rise in the fall and remains high (i.e., within 1 foot of the surface) throughout winter and spring. Pasquotank soils are located in Burlington, Camden and Gloucester Counties.

Plummer Series

Plummer soils are poorly drained, sandy soils. These soils are wet for most of the year. The water table is near the surface in winter, remains high in early spring and drops to as much as 4 feet in summer. Plummer soils are mapped only in Mercer County.

Pocomoke Series

The Pocomoke series consists of very poorly drained, loamy soils. Their surface layers usually have a high organic content. They occur in broad depressions and narrow drainages and along tidal marshes. The water table is at the surface from October to May, dropping to 2 feet or more in summer, and rising again in September and reaching its peak in April. Where located adjacent to streams or tidal marshes, these soils are occasionally flooded. Pocomoke soils are located in Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester and Salem Counties.

Portsmouth Series

The Portsmouth series consists of very poorly drained, clayey and silty soils which have formed in circular depressions. The water table is at the surface from winter through spring and falls only slightly to between 1 and 2 feet in summer. Portsmouth soils are mapped only in Mercer County.

Preakness Series

Preakness soils include both poorly drained and very poorly drained, sandy loams. They occur on glacial outwash plains, and in isolated depressions, narrow drainages and swales between outwash terraces. The water table is at or near the surface from late fall through spring and drops to 2 or 3 feet in summer. Flooding occurs annually in the spring with an occasional summer flood. Preakness soils are mapped in Bergen, Morris, Passaic and Sussex Counties.

Raynham Series

The Raynham series is comprised of poorly to somewhat poorly drained, silt loam soils. They occur on level and gently sloping areas. The water table is near the surface during wet periods, especially in spring, but the soil is usually aerated for variable periods during the growing season. Raynham soils are mapped only in Sussex County.

Reaville Series (Wet Variant)

Reaville (wet variant) soils are poorly drained, silt loams. They have formed on upland flats where seepage water usually collects. They are saturated in the winter and early spring, but are aerated for variable periods during the spring, summer and fall. Reaville wet soils are mapped in Hunterdon and Middlesex Counties.

Ridgebury Series

The Ridgebury series consists of poorly drained, loamy soils with a well-developed fragipan in the lower subsoil. In some areas, these soils are very or extremely stony. These soils have formed in shallow drainages and depressions. The water table is perched at or near the surface from late winter through early spring. Ponding occurs in places and may persist for extended periods. Ridgebury soils are mapped only in Morris and Passaic Counties.

Rowland Series

Rowland soils are deep, moderately well drained and somewhat poorly drained soils. They occur on floodplains of rivers and major streams. Due to this position, they are subject to frequent flooding. In lower positions, they may be flooded long enough to support wetland vegetation. Rowland soils are mapped in Mercer, Middlesex and Somerset Counties.

Shrewsbury Series and Shrewsbury Clay Substratum

Shrewsbury soils include poorly drained, loamy soils with a moderate organic content. They occur in depressions and broad flats. These soils are normally saturated 6 to 8 months of the year (i.e., November to April or June), with the water table dropping to 4 feet in summer. In some low-lying places, they are subjected to occasional flooding (Figure 20). Shrewsbury soils are mapped in Burlington, Camden, Middlesex, Monmouth and Ocean Counties.

Sloan Series

Sloan soils consist of very poorly drained soils formed in recent alluvium on floodplains. They have developed along major rivers and streams, often in association with Wayland soils. Most areas are flooded every year. Sloan soils are present in Sussex and Warren Counties.


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Figure 20. Farmed Shrewsbury soil showing water ponding in depressions.

St. Johns Series

St. Johns soils are very poorly drained, sandy soils usually with a thin, firm subsoil layer. They occur in circular depressions and adjacent to large streams. The seasonal high water table is at or within 1 foot of the surface most of the year, but drops to 2 feet or more in summer. St. Johns soils are mapped in Camden and Gloucester Counties.

Sulfaquents and Sulfihemists

Sulfaquents and Sulfihemists include poorly drained and very poorly drained soils. Sulfaquents are dominated by silt loam textures, whereas sulfihemists are mucks containing few undecayed organic fragments. They are both tidal marsh soils subject to tidal flooding. The water table is on or near the surface and fluctuates very little. These soils are mapped in Bergen, Middlesex, Monmouth, Ocean, and Union Counties. In other counties, these soils are mapped as Tidal Marsh.

Swamp

The Swamp land type consists of very poorly drained soils. The content of organic matter is variable. Swamp soils have formed along streams, ponds and lakes and in low depressions with poor surface drainage. These soils are saturated to the surface for at least 10 months per year. Although only mapped in Sussex County, this type of soil is mapped elsewhere in the State as Freshwater Marsh, Muck or Marsh.

Tidal Marsh

The Tidal Marsh land type consists of very poorly drained, silty or mucky flats that are associated with estuarine bays and coastal rivers. While these soils are all near sea level in elevation, microtopography (i.e., small elevation changes) determines how frequently each area is flooded - daily or less often. These soils are almost continuously saturated. Tidal Marsh soils are mapped in Atlantic, Camden, Cape May, Cumberland, Gloucester, and Salem Counties. Jaworski (1980) characterized these soils and examined the distribution of vegetation under different soil conditions.

Turbotville Series

Turbotville soils consist of somewhat poorly drained soils having a moderately developed fragipan below 20 inches. They have formed in glacial till or stream deposits. A seasonal high water table is perched at 0.5 to 1.5 feet below the surface. In places, after heavy rains, water ponds on these soils for several days. Turbotville soils are associated with wetland in a few places. These soils are mapped in Hunterdon and Morris Counties.

Venango Series

The Venango series includes somewhat poorly drained, silty loamy soils with a fragipan developed in the subsoil at 15 to 20 inches. It occurs in slight depressions between ridges and along drainages. A perched water table is 12 to 24 inches above the fragipan from January to April and is usually absent in summer. Venango soils are mapped in Warren County.

Wallkill Series

Wallkill soils are very poorly drained, silt loams underlain by an organic deposit. They have developed along streams and in low places. The water table is at or near the surface most of the year. Where adjacent to a stream, these soils are subjected to occasional stream overflow. Wallkill soils are mapped only in Sussex County.

Watchung Series

The Watchung series includes poorly drained, loamy soils. In some areas, these soils are very or extremely stony. These soils are found in low places and on gentle slopes. They are wet most of the year, with a seasonal high water table at or near the surface from late fall through early spring. Watchung soils occur in Hunterdon, Mercer, Middlesex, and Somerset Counties.

Wayland Series

The Wayland series consists of poorly drained, loamy soils formed in recent alluvium. Since they are located on floodplains, these soils are subjected to frequent and generally annual flooding. The water table is near the surface from November to June. Wayland soils are mapped only in Sussex and Warren Counties.

Weeksville Series

Weeksville soils are very poorly drained, loamy soils with a high content of fine sand in the surface layer and subsoil. They occur in depressions where water may pond. In many locations, the water table is ponded at the surface in winter, while the subsoil remains only moist. The water table usually drops below 5 feet during the summer. Weeksville soils are mapped only in Camden County.

Whippany Series

The Whippany Series consists of somewhat poorly drained soils. They exist in nearly level and gently sloping areas, where they have formed in glacial lake beds. These soils have a moderately high water table and a seasonal high water table at a depth of 0.5 to 1.5 feet below the surface from late fall to early spring. Whippany soils may at times be associated with wetland. These soils are mapped in Morris, Passaic, and Somerset Counties.

Whitman Series

Whitman soils include very poorly drained, stony sandy loam and sandy loam soils with a very firm substratum at 10 to 30 inches. They are in depressions, seepage areas, streams and floodplains. A perched water table is at or near the surface for long periods during winter and spring and after heavy or long rains. Ponding of water frequently occurs. Whitman soils are mapped in Morris and Sussex Counties.

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CHAPTER 6.

Vegetation and Plant Communities of New Jersey's Wetlands

Introduction

The vast majority of New Jersey's wetlands are characterized by dense growths of plants adapted to existing hydrologic, water chemistry and soil conditions, although some wetlands have little or no apparent vegetation. Most wetland definitions have relied heavily on dominant vegetation for identification and classification purposes. The presence of "hydrophytes" or wetland plants is one of the three key attributes of the Service's wetland definition (Cowardin, *et al.* 1979). Vegetation is the most conspicuous feature of wetlands and one that can be readily identified in the field. Other wetland characteristics, i.e., hydric soil and hydrology, are not as easily recognized and often 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 New Jersey'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." The Service defines a "hydrophyte" 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 saturated soil conditions of marshes, swamps, bogs and bottomland forests. Teskey and Hinckley (1977) have reviewed physiological responses and tolerance mechanisms of woody vegetation to flooding.

The Service has prepared a comprehensive preliminary list of the Nation's hydrophytes to help clarify its wetland definition and facilitate wetland identification. This national wetland plant list has been divided into regional lists, including one for the Northeast (U.S. Fish and Wildlife Service 1982). Currently the preliminary Northeast list is undergoing technical review by the scientific community. The Service recognizes four types of hydrophytes: (1) obligate, (2) facultative wet, (3) facultative, and (4) facultative upland. Obligate hydrophytes are those plants which nearly always occur in wetlands (at least 99% of the time). They are the best vegetative indicators of wetland. The facultative types can be found in both wetlands and uplands to varying degrees. Facultative wet plants are usually associated with wetlands (from 66% to 99% of the time) and are generally good indicators of wetland, while purely facultative hydrophytes show no affinity to wetlands or uplands and are found in wetlands with a frequency of occurrence between 33-66%. By contrast, facultative upland plants are more typical of uplands, but do, on occasion (less than 33% of the time), occur in wetlands. When present in wetlands, they are usually in drier wetlands or at higher elevations in wetter areas. In addition to these four types, the Service's list of hydrophytes also identifies drawdown plants which invade normally unvegetated wetlands (e.g., exposed shores) during extreme dry periods. These plants are often pioneer species with upland affinities. Examples of different types of hydrophytes for New Jersey are presented in Table 14.

New Jersey Hydrophytes

Since the Service's wetland plant list is not final, an interim list of New Jersey's wetland plants was compiled for this report. In preparing this list, field notes from wetlands inventory field surveys and the findings of more than 30 scientific publications on New Jersey's wetland vegetation were reviewed. Over 1,000 vascular plants were recorded: 50+ trees, 100+ shrubs, 20+ vines, 750+ emergents and 80+ aquatics (Appendix). Since this list is based on actual observations, it does not contain all of the plants that potentially exist in New Jersey's wetlands, yet it probably includes all of the common plants and the majority of minor species, such as cosmopolitan weeds that occur in both wetlands and uplands, and numerous rare plants. Scientific names of vascular plants referred to in this report conform with the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982).

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,

Table 14. Examples of wetland plants types occurring in New Jersey. Obligate plants are nearly always found in wetlands (at least 99% of the time); Facultative Wet 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 33-66% of the time; Facultative Upland plants are occasionally present in wetlands (less than 33% of the time).

Hydrophyte Type	Plant Common Name	Scientific Name
Obligate	Royal Fern	*Osmunda regalis*
	Pondweeds	*Potamogeton* spp.
	Smooth Cordgrass	*Spartina alterniflora*
	Soft Rush	*Juncus effusus*
	Cattails	*Typha* spp.
	Boneset	*Eupatorium perfoliatum*
	Swamp Azalea	*Rhododendron viscosum*
	Big Cranberry	*Vaccinium macrocarpon*
	Buttonbush	*Cephalanthus occidentalis*
	Atlantic White Cedar	*Chamaecyparis thyoides*
Facultative Wet	Cinnamon Fern	*Osmunda cinnamomea*
	Salt Hay Grass	*Spartina patens*
	Common Reed	*Phragmites australis*
	Grass-leaved Goldenrod	*Euthamia graminifolia*
	Lowland Broomsedge	*Andropogon virginicus* var. *abbreviatus*
	Steeplebush	*Spiraea tomentosa*
	Dwarf Huckleberry	*Gaylussacia dumosa*
	Highbush Blueberry	*Vaccinium corymbosum*
	Sweet Pepperbush	*Clethra alnifolia*
	Silver Maple	*Acer saccharinum*
	Pin Oak	*Quercus palustris*
Facultative	Foxtail Grass	*Setaria geniculata*
	Wrinkled Goldenrod	*Solidago rugosa*
	Purple Joe-Pye-weed	*Eupatoriadelphus purpureum*
	Sheep Laurel	*Kalmia angustifolia*
	Southern Arrowwood	*Viburnum dentatum*
	Red Maple	*Acer rubrum*
	Black Gum	*Nyssa sylvatica*
Facultative Upland	Bracken Fern	*Pteridium aquilinum*
	May Apple	*Podophyllum peltatum*
	Snowberry	*Symphoricarpos albus*
	Black Huckleberry	*Gaylussacia baccata*
	Beech	*Fagus grandifolia*
	American Holly	*Ilex opaca*
	White Ash	*Fraxinus americana*
	White Oak	*Quercus alba*

i.e., 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 mounds adjacent to ditches (Bourn and Cottam 1950). Sipple (1971) observed that salt marsh vegetation now occurs further upstream in the Hackensack River and attributed increased saltwater penetration to Ordell Reservoir's reduction of freshwater inflow into the estuary. Repeated timber cutting and severe fires have had a profound effect on wetland communities in the Pine Barrens (Little 1950, 1979; McCormick 1979). A recent study of the effects of regional land-use changes on Pine Barrens swamps found that urbanization has added nutrients to both surface and ground waters, resulting in floristic changes (Ehrenfeld 1983). Plants adapted to nutrient poor, acid conditions were replaced by non-Pine Barrens plants.

While New Jersey is relatively small in size, its location along the East Coast gives rise to high plant and landscape diversity. Five physiographic regions can be identified: (1) Ridge and Valley, (2) Highlands, (3) Piedmont, (4) Inner Coastal Plain, and (5) Outer Coastal Plain (Figure 1). Physical and biotic factors have interacted within each physiographic region to create a wealth of plant communities in New Jersey. Robichaud and Buell (1973) have reported on the predominant influences on the State's vegetation and on the variety of vegetation types, including wetlands.

Wetland Plant Communities

Wetlands occur in New Jersey in all five ecological systems inventoried by the Service's National Wetlands Inventory: Marine, Estuarine, Riverine, Lacustrine and Palustrine. In coastal areas, the estuarine marshes, which include salt and brackish tidal marshes and flats, are most abundant, with marine wetlands generally limited to intertidal beaches along the shoreline and bars at the mouths of tidal inlets. Overall, however, palustrine wetlands predominate, representing about two-thirds of the State's wetlands. They include the overwhelming majority of freshwater marshes, swamps, bogs and ponds. Riverine and lacustrine wetlands are largely restricted to aquatic beds and nonpersistent emergent wetlands along the shores of rivers and lakes. The following sections discuss major wetland types in each ecological system as defined by Cowardin and others (1979). Descriptions are based on field observations and a review of scientific literature.

Marine Wetlands

The Marine System includes the open ocean overlying the continental shelf and the associated coastline. Deepwater habitats predominate in this system, with wetlands generally limited to sandy intertidal beaches and bars at the mouths of coastal inlets. Largely due to heavy wave action, vegetation is sparse and scattered along the upper zones of beaches. Beach plants are so few that Martin (1959) did not consider the beach as a significant vegetation zone in his classic study of the vegetation of Island Beach State Park. Vascular plants like sea rocket (*Cakile edentula*) and saltwort (*Salsola kali*) may be common. Other beach plants include seaside spurge (*Euphorbia polygonifolia*), sandbur (*Cenchrus tribuloides*), beach grass (*Ammophila breviligulata*), beach orach (*Atriplex arenaria*), cocklebur (*Xanthium strumarium*), sea purslane (*Sesuvium maritimum*), and beach bean (*Strophostyles helvola*) (Harshberger 1900; Silberhorn 1982).

Estuarine Wetlands

The Estuarine System consists of tidal brackish waters and contiguous wetlands where ocean water is at least occasionally diluted by freshwater runoff from the land. It generally begins behind barrier islands and at the mouth of coastal rivers and extends upstream in rivers to fresh water where no measureable amounts of ocean-derived salts (less than 0.5 parts per thousand) can be detected. Estuarine wetlands are most extensive behind barrier islands and along Delaware Bay.

From a salinity standpoint, New Jersey estuaries can be divided into three distinct reaches: (1) polyhaline - strongly saline areas (18-30 parts per thousand), (2) mesohaline - moderate salinity areas (5-18 ppt), and (3) oligohaline - slightly brackish areas (0.5-5 ppt). Large coastal rivers, such as the Mullica, become increasingly fresher upstream from the river's mouth as salt water is diluted by the river's freshwater discharge. Since river discharge varies during the year, the salinity of coastal rivers varies accordingly. A variety of wetlands develop in estuaries largely because of differences in salinity and duration and frequency of flooding. Major wetland types include: (1) intertidal flats, (2) aquatic beds, (3) emergent wetlands and (4) scrub-shrub wetlands.

Estuarine Intertidal Flats

Intertidal flats of mud and/or sand are extremely common in estuaries, particularly between salt marshes and open coastal bays. They are typically flooded by tides and exposed to air twice daily, although some flats are only intermittently exposed by spring and storm tides. Tidal flats are generally devoid of macrophytes, although smooth cordgrass (*Spartina alterniflora*) may occur in isolated clumps at higher levels. Microscopic plants, especially diatoms, euglenoids, dinoflagellates and blue-green algae, are often extremely abundant, yet inconspicuous (Whitlatch 1982). Intertidal flats covered by macroalgae or vascular plants are classified as vegetated flats (Cowardin, *et al.* 1977). Plants of vegetated flats are similar to estuarine aquatic beds, with the alga sea lettuce (*Ulva lactuca*) being particularly common.

Estuarine Aquatic Beds

Macroalgae and vascular plants form extensive aquatic beds in shallow waters and irregularly exposed flats of estuaries. Aquatic beds are most abundant in the more saline parts of New Jersey's estuaries behind barrier islands where large bays exist. In these areas, common plants include three algae and two vascular plants: sea lettuce, spaghetti grass (*Codium fragile*), red algae (*Gracilaria* spp.), eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*), respectively (Good, *et al.* 1978; Sugihara, *et al.* 1979). Taylor (1970) reported 147 types of macroalgae from New Jersey estuaries.

The distribution of submerged aquatic vegetation in New Jersey has been mapped and described by Macomber and Allen (1979). In general, sea lettuce dominates estuarine areas from Cape May north to Great Bay and north of the Metedeconk River. Between these areas, little algae has been observed. Sea lettuce is also quite dense in shallow rivers and sounds north of Barnegat Bay. By contrast, the large bays from Great Bay (e.g., Little Egg Harbor and Barnegat Bay) to the Metedeconk River are largely dominated by vascular plants, especially eelgrass and widgeon grass. Sago pondweed (*Potamogeton pectinatus*) and horned pondweed (*Zannichellia palustris*) replace eelgrass in bay areas of decreasing salinity.

In lower salinity (mesohaline and oligohaline) portions of coastal rivers such as the Mullica, aquatic beds are formed by other plants, including pondweeds (*Potamogeton perfoliatus, P. pusillus* and *P. epihydrus*), eastern lilaeopsis (*Lilaeopsis chinensis*), wild celery (*Vallisneria americana*), naiad (*Najas flexilis*) and submergent forms of Parker's pipewort (*Eriocaulon parkeri*) and hooded arrowhead (*Sagittaria calycina*) (Arsenault 1981; Ferren, *et al.* 1981). Wild celery, naiad, pipewort and ribbonleaf pondweed (*P. epihydrus*) may be oligohaline species, while the other two pondweeds and eastern lilaeopsis may be indicative of mesohaline waters. Horned pondweed and widgeon grass may also be found in these lower salinity waters, but are more abundant at higher salinities (Arsenault 1981).

Estuarine Emergent Wetlands

Differences in salinity and tidal flooding within estuaries have a profound effect on the emergent vegetation, which is visually apparent. Plant composition markedly changes from the more saline portions to the slightly brackish areas. Even within areas of similar salinity, vegetation differs largely due to frequency and duration of tidal flooding and locally to freshwater runoff. Examples of estuarine wetland plant communities are listed in Table 15. Estuarine emergent wetlands, as defined by Cowardin and others (1979), can be further subdivided for discussion purposes into (1) salt marshes, (2) brackish marshes, and (3) oligohaline marshes.

Salt marshes

The more saline (polyhaline) reaches of estuaries are dominated by salt marshes. These estuarine wetlands are most widespread along the coast from the Atlantic Highlands and Sandy Hook to Cape May and Delaware Bay. A distinct zonal pattern exists due to tidal flooding, with two general zones identified: (1) low marsh and (2) high marsh (Figure 21).

The low marsh is flooded at least once daily by the tides. A tall form of smooth cordgrass dominates this zone from approximately mean sea level to the mean high water mark. A recent study in Connecticut found that the tall form of smooth cordgrass was an accurate indicator of the landward extent of mean high tide (Kennard, *et al.* 1983).

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Figure 21. Example of New Jersey salt marsh communities: (a) low marsh of smooth cordgrass (tall form) along creek and high marsh above and (b) high marsh panne (depression) dominated by glassworts.

Above this level is the high marsh which is flooded less often and is exposed for much greater periods. The high marsh may be divided into subzones based on flooding and vegetation differences (Figure 22). These zones often form a complex mosaic rather than a distinct zonal pattern (Good 1965). Plant diversity increases with several species being abundant, including a short form of smooth cordgrass, salt hay grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardii*), switchgrass (*Panicum virgatum*), high-tide bush (*Iva frutescens*), and common reed (*Phragmites australis*). Other common marsh plants are sea lavender (*Limonium carolinianum* and *L. nashii*), glassworts (*Salicornia bigelovii, S. europaea* and *S. virginica*), marsh orach (*Atriplex patula*), salt marsh asters (*Aster subulatus* and *A. tenuifolius*), marsh pinks (*Sabatia dodecandra* and *S. stellaris*), sea blites (*Suaeda linearis* and *S. maritima*), spikerushes (*Eleocharis* spp.), salt marsh bulrush (*Scirpus robustus*), and seaside goldenrod (*Solidago sempervirens*). Pools and tidal creeks within the salt marshes may be vegetated with widgeon grass, sea lettuce or other algae.

The short form of smooth cordgrass forms extensive stands just above the low marsh. Within these areas, shallow depressions called pannes can be found. These pannes are subjected to extreme temperatures and salinity.

Table 15. Representative estuarine wetland plant communities in New Jersey.

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)	Marsh Fleabane, Glassworts	Sea Lavender, Salt Hay Grass, Spike Grass, Marsh Orach, Perennial Salt Marsh Aster, Salt Marsh Bulrush	Irregularly Flooded
Emergent (Polyhaline)	Salt Hay Grass	Spike Grass, Smooth Cordgrass (short form)	Glasswort, Marsh Orach	Irregularly Flooded
Emergent (Polyhaline)	Switchgrass	Seaside Goldenrod, Poison Ivy	Sea Myrtle, Grass-leaved Goldenrod, Bayberry, Salt Hay Grass, Common Reed, Marsh Pink, Red Cedar	Irregularly Flooded
Scrub-Shrub (Polyhaline)	High-tide Bush	Black Grass, Spike Grass, Salt Hay Grass	Perennial Salt Marsh Aster, Seaside Goldenrod, Sea Lavender, Sea Myrtle	Irregularly Flooded
Emergent (Mesohaline)	Olney Three-square	Spike Grass, Salt Hay Grass, Marsh Fleabane	Seaside Gerardia, Rose Mallow, Perennial Salt Marsh Aster, Spikerush	Irregularly Flooded
Emergent (Mesohaline)	Smooth Cordgrass/ Big Cordgrass	None	Common Reed, High-tide Bush, Sea Myrtle	Irregularly Flooded
Emergent (Mesohaline)	Common Reed	None	Smooth Cordgrass, Spike Grass, Salt Hay Grass, Slough Grass, High-tide Bush, Goldenrods, Asters, Smartweeds, Sea Myrtle	Irregularly Flooded
Emergent (Oligohaline)	Narrow-leaved Cattail	Water Smartweed	Water Hemp, Water Parsnip, Big Cordgrass, Soft-stemmed Bulrush, Arrow Arum, Wild Rice	Irregularly Flooded
Emergent (Oligohaline)	Big Cordgrass	Bur Marigold, Common Three-square	Water Parsnip, St. John's-wort, Lowland White Aster, Royal Fern, Arrow Arum, Rice Cutgrass, Hedge Bindweed	Irregularly Flooded
Emergent (Oligohaline)	Common Three-square	Wild Rice	Smooth Cordgrass, Water Hemp, Water Smartweed, Arrow Arum, Spikerush	Regularly Flooded

Summer salinities may exceed 40 parts per thousand (Martin 1959). Although they may be devoid of plants, many pannes are colonized by the short form of smooth cordgrass, glassworts, marsh orach, salt marsh fleabane (*Pluchea purpurascens*) and saltwort (Good 1965; Martin 1959; personal observations). Blue-green algae may form dense mats in salt pannes. Pannes are particularly striking in late summer and fall, when the glassworts turn deep red in color.

Above the short cordgrass marsh, two grasses predominate: salt hay grass and spike grass. Salt hay grass often forms nearly pure stands and is probably the more abundant of the two, while spike grass is commonly intermixed. Spike grass appears to dominate in the more poorly drained areas of the high marsh. The short form of smooth cordgrass also frequently occurs in this zone. Extensive areas of salt hay grass have been diked for hay farming along Delaware Bay. Black grass, which is actually a rush, is typically found at slightly higher elevations and is often associated with high-tide bush. Many ditches and natural creeks throughout the high marsh are immediately bordered by tall or intermediate forms of smooth cordgrass, while old spoil mounds adjacent to the mosquito ditches are often colonized by high-tide bush. At the upland edge of salt marshes, switchgrass, common reed, sea myrtle (*Baccharis halimifolia*), high-tide bush, and red cedar (*Juniperus virginiana*)

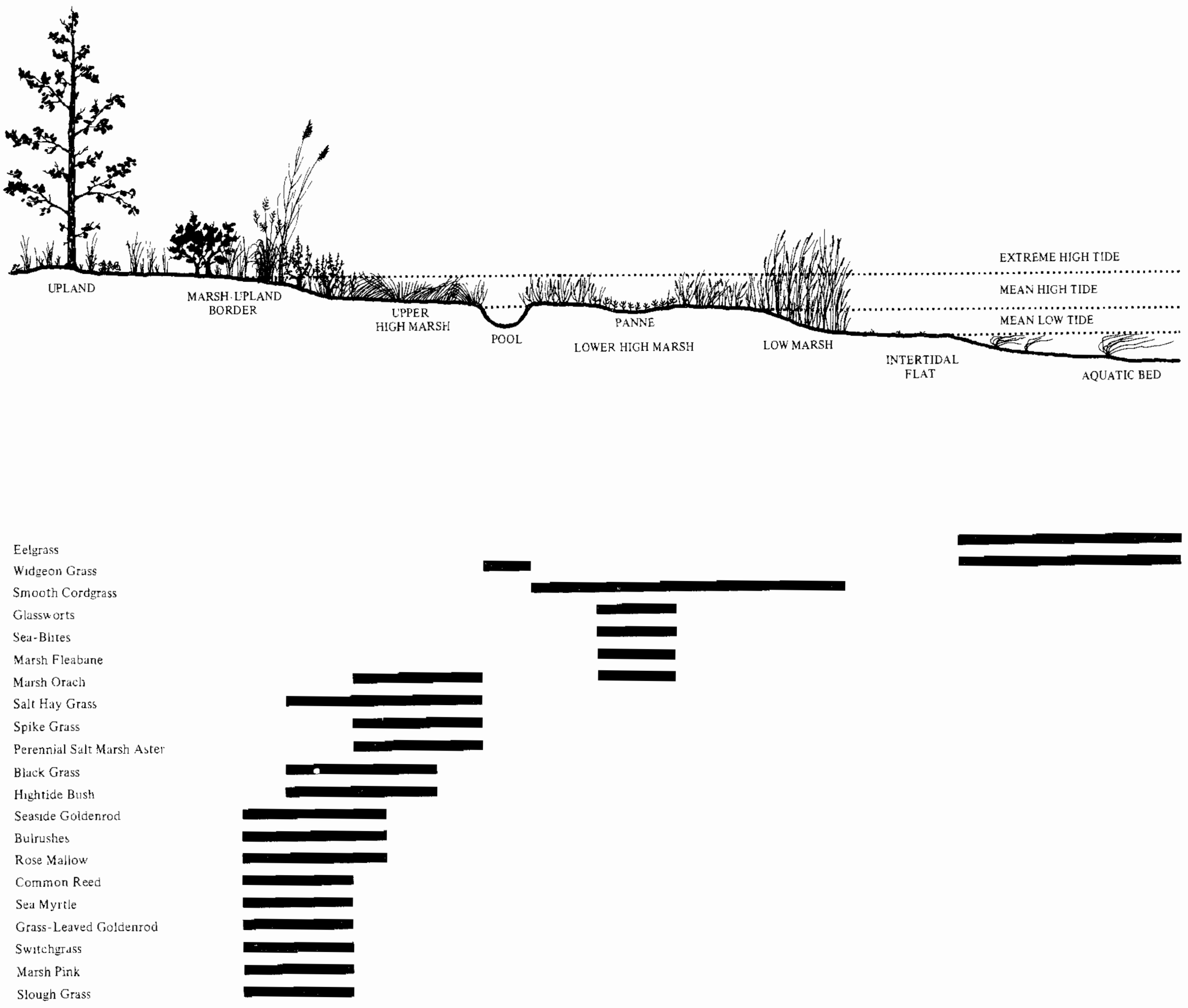

Figure 22. Generalized distribution of vegetation in New Jersey salt marsh. Note increased plant diversity along marsh-upland border.

may form the salt marsh border. Other plants have also been observed in border areas, including bayberry (*Myrica pensylvanica*), poison ivy (*Toxicodendron radicans*), seaside rose (*Rosa rugosa*), marsh fern (*Thelypteris thelypteroides*), seaside goldenrod, grass-leaved goldenrod (*Euthamia graminifolia*), foxtail grass (*Setaria geniculata*), slough grass (*Spartina pectinata*), spikerushes, marsh pink (*Sabatia stellaris*), and Canada rush (*Juncus canadensis*) (Martin 1959; Sugihara, *et al.* 1979; personal observations). Where freshwater influence from the upland is strong, narrow-leaved cattail (*Typha angustifolia*), salt marsh bulrush, three-squares (*Scirpus americanus* and *S. pungens*), marsh fern, rose mallow (*Hibiscus moscheutos*), and other brackish species may occur in abundance. In some areas along the coast (e.g., Barnegat Bay), salt marshes grade into freshwater forested wetlands.

Numerous scientific studies have been undertaken in New Jersey's salt marshes (Harshberger 1900, 1909; Martin 1959; Good 1965; Sugihara, *et al.* 1979; Ferren, *et al.* 1981 and others). In addition, the Service has reviewed the ecology of New England high salt marshes which is a useful reference (Nixon 1982).

Brackish marshes

The brackish marshes in the middle (mesohaline) reach of estuaries are exposed to the widest ranges in salinity (5 to 18 ppt), varying considerably with the seasons. In spring, these marshes are mildly brackish due to heavy river discharge, while in late summer during low freshwater flows, salt water penetrates farther upstream and the salinity of the brackish marshes approaches that of the more saline marshes. From a vegetation standpoint, this area begins the large zone of transition where some of the common salt marsh plants like smooth cordgrass, salt hay grass, spike grass, salt marsh aster and salt marsh bulrush first mix with freshwater species, e.g., arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*), jewelweed (*Impatiens capensis*), common three-square (*Scirpus pungens*), water smartweed (*Polygonum punctatum*), water parsnip (*Sium suave*), rice cutgrass (*Leersia oryzoides*), and soft-stemmed bulrush (*Scirpus validus*) (Ferren 1975; Ferren, *et al.* 1981; personal observations). 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 dominates at lower salinities (Ferren 1975).

At least four plants may reach their maximum abundance in New Jersey's estuarine marshes: (1) narrow-leaved cattail (Figure 23), (2) big cordgrass (*Spartina cynosuroides*), (3) common reed, and (4) Olney three-square (*Scirpus americanus* = *S. olneyi*). These plants represent the major dominance types of the mesohaline marshes and generally occupy the irregularly flooded areas. Narrow-leaved cattail and common reed also occur to a lesser extent along the banks at lower elevations. Other common brackish plants include water hemp (*Amaranthus cannabinus*), eastern lilaeopsis, salt marsh bulrush, rose mallow, salt marsh fleabane, seashore mallow (*Kosteletzkya virginica*), and mock bishopweed (*Ptilimnium capillaceum*). Mesohaline marshes are most common in southern New Jersey along large tidal rivers, such as the Maurice, the Mullica, the Great Egg Harbor and the Salem. Hog Island in the Mullica River represents an excellent example of the transition between brackish marshes and the oligohaline and salt marshes. Ferren and others (1981) commented that drastic periodic salinity changes have resulted in floristic instability on the island, particularly along the water's edge. By contrast, vegetative changes in the marsh interior are gradual, with smooth cordgrass replacing arrow arum.

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Figure 23. Mesohaline marsh in southern New Jersey. Narrow-leaved cattail predominates.

In northern New Jersey, mesohaline marshes are largely dominated by common reed and do not have the variety of plants common to the south. The Hackensack Meadowlands, for example, represents the largest mesohaline marsh complex in northern New Jersey. The salinity averages between 12 and 15 ppt, although concentrations as low as 0 to 3 ppt are not uncommon (Hackensack Meadowlands Development Commission 1975). Urban development in the New York metropolitan area has greatly stressed these wetlands through disturbances including drainage, landfills, toxic waste disposal, highway construction, industrial and residential development and air and water pollution (Figure 24). The majority of the Meadowlands is dominated by common reed which does particularly well in disturbed and degraded areas.

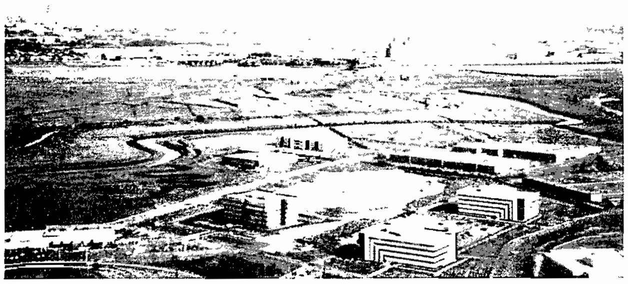

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Figure 24. The Hackensack Meadowlands are part of the largest estuarine wetland complex in northern New Jersey. This area has been subjected to intense urban development since the late 1800's.

In tracing the history of vegetation for the Hackensack Meadows, Sipple (1971) identified 5 estuarine marsh types: (1) common reed type, (2) smooth cordgrass-water hemp type, (3) salt hay grass-marsh orach-glasswort type, (4) narrow-leaved cattail type, and (5) salt marsh fleabane type. Common reed was ubiquitous in the area and represented the most common vegetation type. The other types were rather localized communities. Other plants found in the Meadows include big cordgrass, spike grass, salt hay grass, Olney three-square, rose mallow, annual salt marsh aster (*Aster subulatus*), seaside goldenrod, and common three-square. In low salinity tidal pools, dwarf spikerush (*Eleocharis parvula*) and soft-stemmed bulrush often occur. Smooth cordgrass dominates creek banks in higher salinity waters and is associated with big cordgrass and water hemp at lower salinities. Recent observations suggest an increase in smooth cordgrass as old dikes are breached by more saline tidal waters.

Oligohaline marshes

Only traces of ocean-derived salts characterize the uppermost (oligohaline) estuarine marshes. They are predominantly influenced by fresh water with saltwater intrusion generally restricted to late summer and most important within tidal channels. Oligohaline marshes may possess the highest diversity of all estuarine wetlands, since they lie between the strictly freshwater tidal marshes and the more brackish mesohaline wetlands. The regularly flooded zone is often dominated by nonpersistent emergents, such as arrow arum, wild rice (*Zizania aquatica*), spatterdock (*Nuphar luteum*), common three-square or pickerelweed (Ferren 1975; personal observations). Smooth cordgrass can still be found along the banks in decreasing amounts where it is intermixed with freshwater species or in monospecific clumps. Big cordgrass is common at higher elevations. Mixed plant communities typify the irregularly flooded areas. In the Mullica River, Ferren and others (1981) identified two mixed communities related to substrate differences. On peat, community dominants consisted of creeping spikerush (*Eleocharis fallax*), sedge (*Carex hormathodes*), salt hay grass, bulrushes (*Scirpus* spp.), rose mallow, and seashore mallow. Mud substrates contained a different assemblage of dominant plants: hooded arrowhead, spikerush (*Eleocharis olivacea*), umbrella sedges (*Cyperus* spp.) and marsh fleabane (*Pluchea odorata*). At the upper limits of the oligohaline reach, estuarine marshes are virtually indistinguishable from the freshwater tidal marshes with main differences being the abundance of wild rice and the absence of brackish plants like smooth cordgrass in these freshwater marshes.

Estuarine Scrub-Shrub Wetlands

Estuarine shrub wetlands are not extensive along the New Jersey coast, although some rather large stands exist in the high marsh zone of salt marshes. They are usually dominated by high-tide bush (Figure 25). This shrub is especially common along mosquito ditches where it has become established on mounds of deposited material and at higher elevations in salt marshes near the upland. Black grass and salt hay grass often grow beneath high-tide bush. Other common estuarine shrubs include sea myrtle and bayberry. These woody plants frequently grow along the upper edges of salt marshes in association with switchgrass.

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Figure 25. High-tide bush characterizes the majority of estuarine scrub-shrub wetlands in New Jersey. Red cedar trees are on higher ground.

Riverine Wetlands

The Riverine System encompasses all of New Jersey's freshwater rivers and their tributaries, including the freshwater tidal segments of the Delaware River (i.e., north of the Delaware Memorial Bridge) and other large coastal rivers where salinity is less than 0.5 ppt. This system is 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 restricted to nonpersistent emergent wetlands, aquatic beds and unvegetated shallow water or exposed areas. These wetlands are most extensive in tidal freshwater areas due to exposure of vast acreages of mudflats at low tide. The Delaware River and its tributaries contain the bulk of the State's riverine tidal marshes. Since the 1970's, these wetlands have received much attention by scientists (McCormick 1970a; McCormick and Ashbaugh 1972; Walton and Patrick 1973; Good and Good 1974; Good, *et al.* 1975; Ferren 1975; Whigham and Simpson 1975; Ferren and Schuyler 1980), while other riverine wetlands have been little studied. Recently, the vegetation of Pine Barrens streams has been investigated (Morgan, *et al.* 1983).

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Figure 26. Freshwater tidal marsh in Burlington County, New Jersey. Note flooding of spatterdock, a broad-leaved emergent plant, in the regularly flooded zone.

Riverine Tidal Wetlands

Freshwater tidal marshes exhibit a zonation pattern similar to their estuarine counterparts (Figure 26). Two 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 which also consist of intertidal mudflats. The low marsh is flooded at least once daily by the tides. High marsh areas are flooded less often by tides and are classified as palustrine wetlands by Cowardin and others (1979). The Service has recently reviewed the ecology of eastern tidal freshwater marshes (Odum, *et al.* 1984).

The dominant low marsh plants are nonpersistent emergents, including wild rice, spatterdock, water smartweed (*Polygonum punctatum*), bur marigold (*Bidens laevis*), broadleaf arrowhead (*Sagittaria latifolia*), water hemp, arrow arum and pickerelweed. These plants generally dominate the regularly flooded zones and intermix with persistent emergents at higher elevations to form large stands of palustrine tidal wetlands (Figure 27). Wild rice is widespread in these tidal marshes because it can germinate under a wide range of hydrologic regimes (Whigham and Simpson 1977). Pure and mixed stands of wild rice, spatterdock, and arrow arum usually characterize the majority of riverine tidal marshes (McCormick and Ashbaugh 1973; Good and Good 1974; personal observations). Pickerelweed, water smartweed, and water hemp are also dominant along tidal stream channels. Along the Mullica River, Parker's pipewort, quillwort (*Isoetes riparia*), dwarf St. John's-wort (*Hypericum mutilum*), bog rush (*Juncus pelocarpus*), and hedge hyssop (*Gratiola aurea*) have been observed on sand and gravel shores (Ferren, *et al.* 1981). Major freshwater tidal emergent wetland communities for the Hamilton Marshes in Trenton are listed in Table 16.

Vegetation is not always evident in these 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 in spring. Tidal riverine emergent wetlands, therefore, appear as mudflats during low tide in the winter and early spring. During the growing season, the visual picture or physiognomy of these wetlands changes drama-

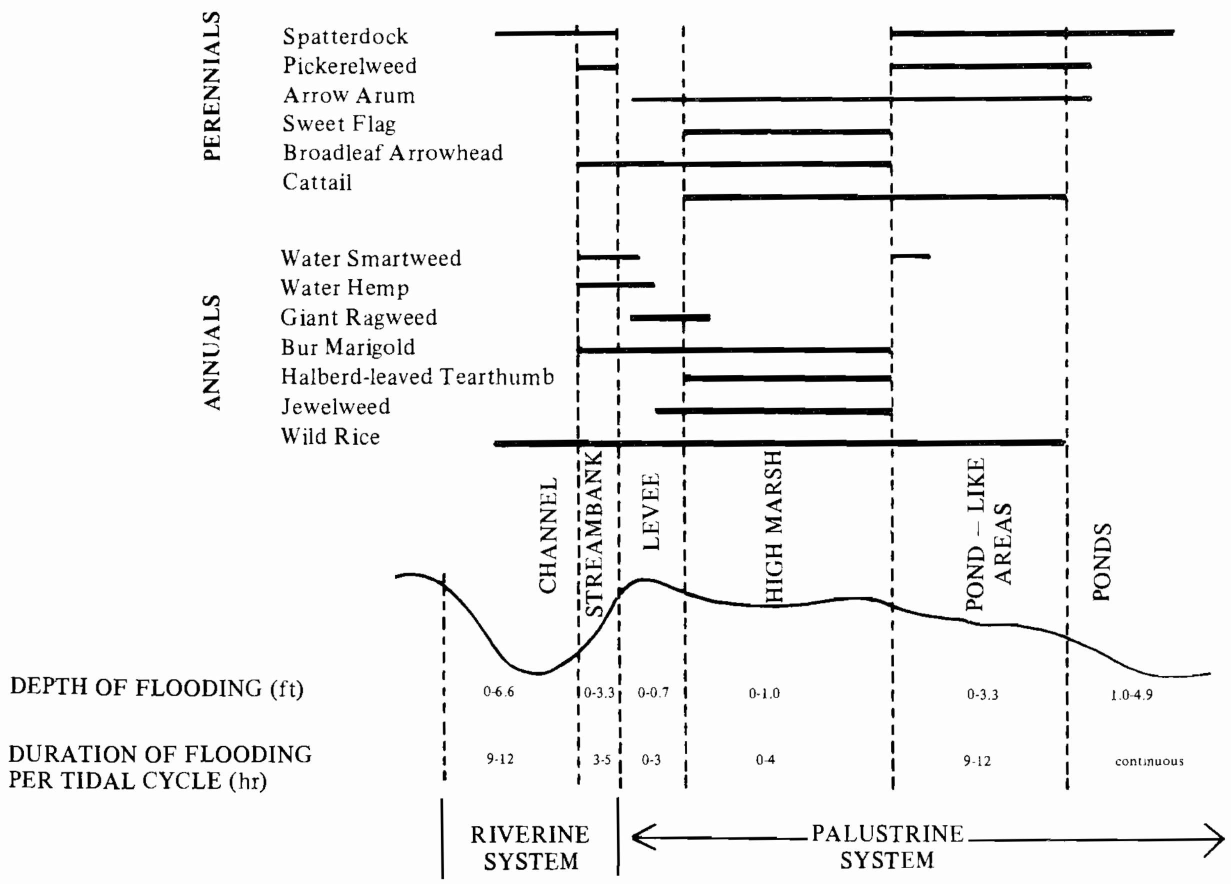

Figure 27. Generalized plant zonation in a freshwater tidal wetland (adapted from Simpson, *et al.* 1983). Note that wetland vegetation occurs in two systems - Riverine and Palustrine.

Table 16. Major freshwater tidal wetland communities in the Hamilton Marshes, Trenton, New Jersey (from Whigham and Simpson 1975). Communities have been arranged according to ecological system. Riverine communities are flooded daily by the tides, while palustrine communities are flooded less often, except for ponds that are continuously flooded.

System	Dominance Types	Associated Vegetation	Wetland Location
Riverine	Spatterdock/Wild Rice	Wild Celery, Broadleaf Arrowhead, Water Milfoil	Stream Channel
	Spatterdock/Water Hemp/ Broadleaf Arrowhead/Pickerelweed	Water Smartweed, Wild Rice	Stream Bank
	Spatterdock/Wild Rice/ Pickerelweed	Water Smartweed, Water Hemp	Stream Bank
Palustrine	Cattails/Arrow Arum/Sweet Flag	Jewelweed, Halberd-leaved Tearthumb, Arrow-leaved Tearthumb, Rose Mallow	High Marsh
	Purple Loosestrife/ Arrow Arum	Jewelweed, Rose Mallow, Tearthumbs	High Marsh
	Sweet Flag/Arrow Arum	Jewelweed, Tearthumbs	High Marsh
	Bur Marigold/Arrow Arum/Tearthumbs	Broadleaf Arrowhead, Water Hemp, Jewelweed	High Marsh
	Giant Ragweed/Arrow Arum	Jewelweed, Tearthumbs	High Marsh
	Reed Canary Grass	None specified	High Marsh
	Wild Rice/Bur Marigold/Sweet Flag/Broadleaf Arrowhead	None specified	High Marsh
	Spatterdock/Pickerelweed/Water Smartweed	Broadleaf Arrowhead, Wild Rice, Purple Loosestrife	Pond-like Area subject to tidal fluctuations (alternately flooded and exposed)
	Arrow Arum/Wild Rice	Broadleaf Arrowhead, Water Smartweed	Pond-like Area
	Purple Loosestrife	Arrow Arum, Spatterdock, Rose Mallow	Pond-like Area
	Cattails	Arrow Arum, Water Smartweed	Pond-like Area
	Rose Mallow	Purple Loosestrife, Arrow Arum, Spatterdock	Pond-like Area
	Spatterdock	Pickerelweed, Waterweed, Pondweed, Water Smartweed	Tidal Pond (permanently flooded)
	Purple Loosestrife	Spatterdock, Arrow Arum, Water Smartweed, Rose Mallow	Tidal Pond
	Rose Mallow	Spatterdock, Arrow Arum, Water Smartweed, Purple Loosestrife	Tidal Pond

tically. In mid to late April, annual seedlings cover the high marsh (R.L. Simpson, pers. comm.). By late spring and early summer, broad-leaved emergents, particularly spatterdock, arrow arum and arrowhead, dominate, since their leaves are among the first to emerge. As the season progresses, taller growing plants like water hemp, wild rice, smartweeds, jewelweed, and bur marigold become visually dominant. If, however, one looks closely a dense understory of spatterdock can often be seen (McCormick and Ashbaugh 1972). Bur marigold becomes evident in late September and early October when its large yellow flowers appear.

Riverine Nontidal Wetlands

Although the majority of the State's wetlands probably lie along nontidal rivers and streams, only a fraction of these are considered riverine wetlands according to the Service's classification system (Cowardin, *et al.* 1979). Riverine wetlands are largely restricted to fringes of nonpersistent emergent plants growing on river banks or in shallow water and to aquatic beds within the 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. Here non-persistent emergent plants like burreeds, pickerelweed, arrowheads, arrow arum, cutgrasses and smartweeds colonize exposed banks or very shallow waters (Figure 28). Aquatic beds may also form in slightly deeper waters of clear rivers and streams. Important aquatic bed plants include submerged forms of burreeds and arrow-heads, riverweeds and pondweeds (*Potamogeton* spp.), spatterdock and white water lily (*Nymphaea odorata*). A recent study of Pine Barrens streams (Morgan, *et al.* 1983) found these plants associated with others, such as bayonet rush (*Juncus militaris*), false loosestrife (*Ludwigia palustris*), larger water starwort (*Callitriche heterophylla*), three-way sedge (*Dulichium arundinaceum*), cardinal flower (*Lobelia cardinalis*), and Virginia meadow beauty (*Rhexia virginica*). Algae in these streams have been described by Moul and Buell (1979). In contrast, fast flowing upper perennial streams of northern New Jersey's mountains mainly support beds of aquatic weeds and mosses, e.g., *Podostemum, Fissidens, Fontinalis, and Hypnum* (Fairbrothers and Moul 1965). These plants grow on stones and boulders in the streambeds.

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Figure 28. Aquatic vegetation is present in many New Jersey streams. Here, riverine aquatic beds are bordered by palustrine wetland.

Palustrine Wetlands

The majority of New Jersey's wetlands, i.e., freshwater marshes, bogs, swamps and bottomland forests, are classified as palustrine wetlands. They represent the most floristically diverse group of wetlands in the State. Considerable vegetation change can be observed in palustrine wetlands from north to south and within regions due to differences in climate, hydrology, water chemistry (pH), soils and human 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. Certain tidally influenced freshwater areas also represent palustrine wetlands. Many plants may be restricted to one or two sets of hydrologic regimes, but a great many like red maple (*Acer rubrum*), purple loosestrife (*Lythrum salicaria*) and cattails tolerate a wide range of flooding and soil saturation conditions. Woody plants as a group appear to have the widest range. Although their tolerances may be high, many wetland plants are usually more prevalent under particular water regimes and may, therefore, be used as good indicators of flooding duration and soil saturation. Examples of plant-water regime relationships are presented in Table 17. Palustrine wetland plant communities are discussed by class in the following subsections. The reader should recognize the diversity of these communities and that this discussion attempts to characterize only the major types.

Palustrine Aquatic Beds

Natural and man-made ponds are common throughout the State. These permanently flooded water bodies comprise the "wettest" of the 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 and reservoirs. Common dominance types include floating species like duckweeds; rooted vascular plants such as spatterdock, white water lily, water shield (*Brasenia schreberi*) and pondweeds; and green algae. For additional information, please refer to the discussion of lacustrine wetlands.

Palustrine Emergent Wetlands

Palustrine emergent wetlands are freshwater marshes dominated by persistent and nonpersistent grasses, rushes, sedges, forbs, 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.

Table 18. Common dominance types for New Jersey's palustrine emergent wetlands. The asterisk (*) denotes species characteristic of the Pine Barrens.

Northern New Jersey	Southern New Jersey
Cattails	Cattails
Arrow Arum	Common Reed
Tussock Sedge	Water Willow
Rice Cutgrass	Purple Loosestrife
Water Willow	Rice Cutgrass
Reed Canary Grass	Burreeds
Spikerushes	Arrow Arum
Bluejoint	Goldenrods
Woolgrass	Woolgrass
Sedges	Soft Rush
Common Reed	Pickerelweed
Soft Rush	Smartweeds
Burreeds	Three-way Sedge
Pickerelweed	Sedges
Sweet Flag	*Twig Rush
Millet	*Bayonet Rush
Purple Loosestrife	*Canada Rush
Smartweeds	*Pipeworts
Arrowheads	*Bull Sedge
Bulrushes	*Cottongrass
Goldenrods	*Golden Club
	*Lowland Broomsedge
	*Manna Grasses
	*Beakrushes

In northern marshes, water willow, pickerelweed, arrowheads, burreeds, cattails, and soft-stemmed bulrush are common in semipermanently flooded areas. Seasonally flooded wetland dominants include cattails, tussock sedge, bluejoint, sweet flag, smartweeds, bulrushes, purple loosestrife, and arrow arum. Broad-leaved cattail and purple loosestrife are frequent co-dominants in northern New Jersey marshes. Sweet flag commonly forms nearly pure stands in depressions of wet pastures in the northern half of the State. Goldenrods (*Euthamia graminifolia* and *Solidago* spp.) and Joe-Pye-weeds (*Eupatoriadelphus purpureus* and others) often reflect drier situations of temporarily flooded emergent wetlands. Soft rush often occurs in a short form in temporarily flooded meadows, while a robust (taller) form grows in seasonally flooded areas. Reed canary grass can also be found in both temporarily flooded and seasonally flooded wetlands. Other common plants in northern emergent wetlands include jewelweed, blue flag (*Iris versicolor*), skunk cabbage (*Symplocarpus foetidus*), bugleweeds (*Lycopus* spp.), marsh fern, crowfoots (*Ranunculus* spp.), Angelica (*Angelica atropurpurea*), sensitive fern (*Onoclea sensibilis*), winter cress (*Barbarea vulgaris*), soft-stemmed bulrush, swamp milkweed (*Asclepias incarnata*), boneset (*Eupatorium perfoliatum*), asters (*Aster novae-angliae, A. novi-belgii*, and others), blue vervain (*Verbena hastata*), New York ironweed (*Vernonia noveboracensis*), false nettle (*Boehmeria cylindrica*), and mock bishopweed. Shrubs are often scattered in clumps throughout marshes and found along the upland border. They include Allegheny blackberry (*Rubus allegheniensis*) and poison ivy in temporarily flooded situations and swamp rose, buttonbush, winterberry (*Ilex verticillata*), poison sumac (*Toxicodendron vernix*), highbush blueberry (*Vaccinium corymbosum*), alders (*Alnus* spp.), willows, and red maple saplings in seasonally flooded marshes. More wide ranging shrubs are meadowsweet (*Spiraea latifolia*), steeplebush (*Spiraea tomentosa*), silky dogwood (*Cornus amomum*), and southern arrowwood (*Viburnum dentatum*). Examples of northern marsh communities are shown in Figure 29.

Freshwater marshes in the Pine Barrens of southern New Jersey are quite different from marshes in the rest of the State (Figure 30). The acid waters of Pine Barrens streams create conditions that favor colonization by other plants. Here, dominant emergents consist of bayonet rush, wild rice, bull sedge (*Carex bullata*), pipeworts (*Eriocaulon* spp.), Canada rush, twig rush (*Cladium mariscoides*), cottongrass (*Eriophorum virginicum*), golden club (*Orontium aquaticum*), manna grass (*Glyceria obtusa*), coast sedge (*Carex exilis*), Virginia meadow beauty, three-way sedge, beakrushes (*Rhynchospora alba* and others), redroot (*Lachnanthes caroliniana*), lowland broomsedge (*Andropogon virginicus* var. *abbreviatus*), and twisted yellow-eyed grass (*Xyris torta*) (Olsson 1979; personal observations). Other common plants include sundews (*Drosera* spp.), panic grass (*Panicum* spp.), shortleaf milkwort (*Polygala brevifolia*), peat mosses (*Sphagnum* spp.), wild oat grass (*Danthonia sericea* var. *epilis*), bog aster (*Aster nemoralis*), toothleaf flatsedge (*Cyperus dentatus*), bog rush (*Juncus pelocarpus*), forked rush (*J. dichotomus*), rice cutgrass, eastern burreed (*Sparganium americanum*), woolgrass, pickerelweed, spikerushes, St. John's-worts (*Triadenum virginicum* and *Hypericum* spp.), bladderworts (*Utricularia* spp.), and orchids (e.g., *Platanthera blephariglottis*). Less common plants in seasonally flooded "savannas" include purple pitcher plant (*Sarracenia purpurea*), bog asphodel (*Narthecium americanum*), slender blue flag (*Iris prismatica*), gold-crest (*Lophiola americana*), false asphodel (*Tofieldia racemosa*), royal fern (*Osmunda regalis*), Bartonia (*Bartonia virginica*), twisted yellow-eyed grass, and ten-angled pipewort (*Eriocaulon decangulare*) (Harshberger 1916; Olsson 1979). Dense St. John's-wort (*Hypericum densiflorum*) is abundant in these areas, while big cranberry (*Vaccinium macrocarpon*) may be locally common. In temporarily flooded "savannas", scattered pitch pine (*Pinus rigida*) and clumps of inkberry (*Ilex glabra*), bayberry, sheep laurel (*Kalmia angustifolia*), fetterbush (*Leucothoe racemosa*), red chokeberry (*Aronia arbutifolia*), black chokeberry (*A. melanocarpa*), witherod (*Viburnum cassinoides*) and leatherleaf (*Chamaedaphne calyculata*) may be found (Harshberger 1916). According to McCormick (1979), Pine Barrens savannas are not as extensive as they were at the turn of the century,

Figure 29. Examples of palustrine emergent wetlands in northern New Jersey: (a) burreed marsh, (b) broad-leaved cattail marsh, (c) soft rush-dominated wet meadow, and (d) tussock sedge meadow, with cattail marsh.

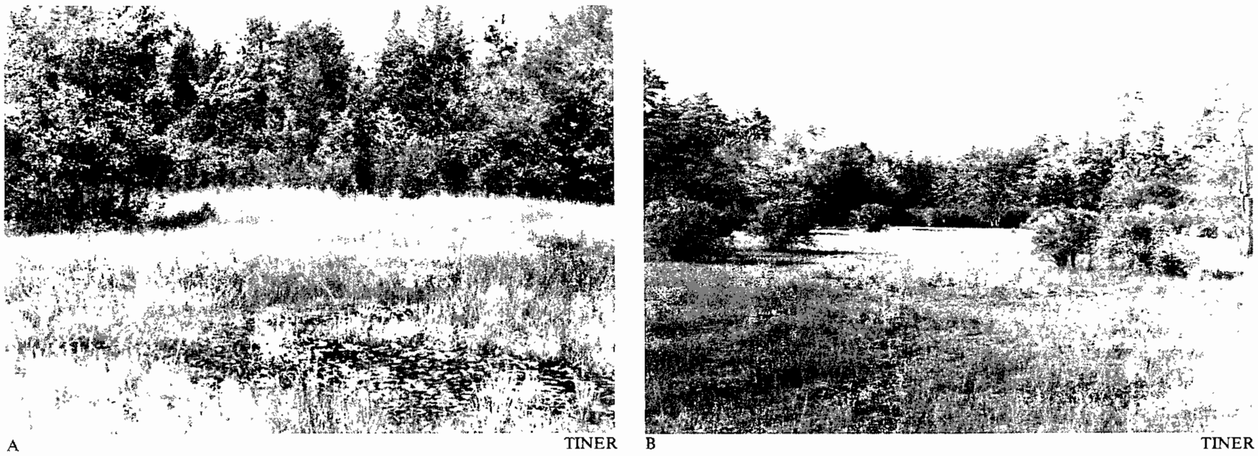

Figure 30. Examples of palustrine emergent wetlands in southern New Jersey: (a) mixed emergents with aquatic bed and (b) spikerush marsh, with grasses and highbush blueberry.

with less than 1000 acres remaining. Today, shrub thickets of leatherleaf and highbush blueberry and maple-gum or white cedar swamps have replaced many former savannas.

Outside of the Pine Barrens in southern New Jersey, emergent wetlands are dominated by rice cutgrass, cattails, soft rush, water willow, burreeds, purple loosestrife, common reed, woolgrass, and others. Common emergent plants include pickerelweed, arrow arum, St. John's-worts, bedstraw (*Galium* sp.), tussock sedge, other sedges, smartweeds, blue flag, foxtail grass, soft-stemmed bulrush, jewelweed, swamp milkweed, boneset, three-way sedge, arrowheads, tearthumbs, and beggar-ticks. Shrubs and low trees may also be present, such as buttonbush, arrowwood, common elderberry (*Sambucus canadensis*), sweet gum (*Liquidambar styraciflua*), and red maple.

On coastal islands, other types of palustrine emergent wetlands are found. Where natural primary and secondary dunes have survived development, freshwater marshes exist in wet swales between the dunes. Martin (1959) observed three major communities on Island Beach State Park: (1) broad-leaved cattail dominance type, (2) marsh fern dominance type, and (3) rose mallow dominance type. Minor communities were dominated by swamp milkweed, flat sedge, and salt marsh hay. Numerous mixed communities were also reported. Harshberger (1900) also noted the high variability between different interdunal wetlands. Other common plants included lowland broomsedge, sedges, umbrella sedges (*Cyperus filicinus* and *C. grayii*), spikerush (*Eleocharis erythropoda*), thoroughwort (*Eupatorium album*), marsh St. John's-wort (*Triadenum virginicum*), Canada rush, soft rush, evening primrose (*Oenothera perennis*), cinnamon fern, royal fern, reed, Pennsylvania smartweed (*Polygonum pensylvanicum*), and common three-square (Small and Martin 1958). Common reed-dominated marshes 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, willows, horsetails (*Equisetum* spp.), nightshade (*Solanum dulcamara*), poison ivy, swamp rose and water primrose (*Ludwigia decurrens*) may also occur.

Palustrine Scrub-Shrub Wetlands

Palustrine scrub-shrub wetlands are shrub swamps dominated by woody vegetation less than 20 feet (6m) in height. The dominant shrubs in northern New Jersey include speckled alder (*Alnus rugosa*), smooth alder (*A. serrulata*), willows (*Salix sericea* and others), buttonbush, silky dogwood, northern arrowwood (*Viburnum recognitum*), southern arrowwood, meadowsweet, steeplebush, highbush blueberry, swamp rose, Allegheny blackberry, and sapling red maple. Other important shrubs in this area are sweet pepperbush (*Clethra alnifolia*), swamp azalea (*Rhododendron viscosum*), winterberry (*Ilex verticillata*), poison sumac, red osier dogwood (*Cornus stolonifera*), poison ivy, and maleberry (*Lyonia ligustrina*). Sweet gale (*Myrica gale*) and mountain holly (*Nemopanthus mucronata*) may be common locally in the northwestern corner of the State as observed in High Point State Park by Niering (1953).

In the southern region, red maple, southern arrowwood and high bush blueberry are still common dominants, but other woody plants often predominate in shrub wetlands including bayberry (on barrier islands), leatherleaf, staggerbush (*Lyonia mariana*), sweet pepperbush, swamp azalea, shrubby St. John's-wort, sheep laurel, dangleberry (*Gaylussacia frondosa*), dwarf huckleberry (*Gaylussacia dumosa*), fetterbush, big cranberry, and sapling trees of pitch pine, Atlantic white cedar (*Chamaecyparis thyoides*), and gray birch (*Betula populifolia*). Other shrubs of local importance are inkberry, chokeberries, withe-rod, possum haw (*Viburnum nudum*), and smooth alder. Examples of the community structure of scrub-shrub wetlands are shown in Table 19.

The wettest shrub wetlands may be dominated by buttonbush in the north and by leatherleaf and dense St. John's-wort in the south. Buttonbush is characteristic of semipermanently flooded wetlands and the wettest seasonally flooded ones. It is also found in freshwater tidal wetlands along the coastal plain, where it is often intermixed with emergent vegetation. Leatherleaf tends to predominate in southern shrub bogs which are seasonally flooded and saturated throughout the year, while it is much less common in northern New Jersey (Figure 31). It also grows along the margins of many ponds in the Pine Barrens and occurs with sedges in savannas (McCormick 1970b). Dense St. John's-wort is also common in these wet savannas (Harshberger 1916).

Other seasonally flooded shrub swamps throughout the State may be characterized by highbush blueberry (Figure 32) and sapling red maple or by alders and willows in northern New Jersey or by Atlantic white cedar, staggerbush, big cranberry and others in the south. Common associates in northern areas include bluejoint, purple loosestrife, soft rush, tussock sedge and other sedges, broad-leaved cattail, marsh fern, arrow arum, rice cutgrass, rose mallow, reed canary grass, arrow-leaved tearthumb, and peat mosses. Further south, sedges, soft rush, arrow arum, peat mosses and marsh fern remain common, but other plants become increasingly important in shrub swamps. They include woolgrass, chain ferns (*Woodwardia* spp.), lowland broomsedge, spikerushes, cinnamon fern (*Osmunda cinnamomea*), royal fern, bayonet rush, three-way sedge, cottongrass, sundews (*Drosera* spp.),

Table 19. Examples of palustrine scrub-shrub wetland communities in New Jersey.

Dominance Type (Water Regime)	**Associated Vegetation**		**Location**
Buttonbush (Semipermanently Flooded)	Shrubs:	Steeplebush, Red Maple	Morris County
	Herbs:	Arrow Arum, Soft Rush, Woolgrass, Blue Flag, St. John's-wort, Tussock Sedge, False Nettle, Arrow-leaved Tearthumb	
	Others:	Duckweed	
Red Maple (Seasonally Flooded)	Shrubs:	Steeplebush, Highbush Blueberry, Smooth Alder, Poison Sumac, Gray Birch, Maleberry, Black Chokeberry, Southern Arrowwood	Passaic County
	Herbs:	Marsh Fern, Cinnamon Fern, Tussock Sedge, Boneset, Sweet Flag, Marsh St. John's-wort, Sweet White Violet, Sensitive Fern	
	Others:	Peat Moss and other mosses	
Highbush Blueberry/ Swamp Azalea/ Sweet Pepperbush (Seasonally Flooded)	Shrubs:	Red Maple	Morris County
	Herbs:	Arrow Arum, St. John's-wort, Tussock Sedge	
	Others:	Peat Moss	
Smooth Alder (Seasonally Flooded)	Shrubs:	Red Maple, Swamp Rose, Willow, American Elm, Silky Dogwood, Cherry, Arrowwood	Sussex County
	Herbs:	Sweet Flag, Skunk Cabbage, Sensitive Fern, Manna Grass, Spikerush, Blue Flag, Mint	
Silky Dogwood (Seasonally Flooded)	Herbs:	Rice Cutgrass, Arrow-leaved Tearthumb, Thoroughwort	Union County
Red Maple (Seasonally Flooded)	Shrubs:	Southern Arrowwood, Silky Dogwood, Alder, Willow, Highbush Blueberry, Poison Sumac	Monmouth County
	Herbs:	Jewelweed, Boneset, Sensitive Fern, Tussock Sedge, Broad-leaved Cattail, Woolgrass, Seed-box, Spotted Joe-Pye-weed, Smartweed, Marsh Fern, Goldenrod, Arrow-leaved Tearthumb	
	Others:	Climbing Hempweed	
Red Maple (Seasonally Flooded)	Shrubs:	Dangleberry, Sheep Laurel, Leatherleaf, Big Cranberry, Sweet Bay, Bayberry, Serviceberry	Burlington County
	Herbs:	Cinnamon Fern, Sedges, Virginia Cottongrass, Soft Rush, Thoroughwort, Spikerush, Arethusa	
	Others:	White Water Lily, Bladderwort	
Highbush Blueberry/ Sheep Laurel (Seasonally Flooded)	Trees:	Red Maple	Burlington County
	Shrubs:	Pitch Pine, Inkberry, Wintergreen, Big Cranberry	
	Herbs:	Woolgrass, Bracken Fern, Aster	
	Others:	Peat Moss, Haircap Moss	
Leatherleaf (Saturated)	Trees:	Pitch Pine, Red Maple	Burlington County
	Shrubs:	Highbush Blueberry, Inkberry	
	Herbs:	Virginia Chain Fern	
	Others:	Peat Moss	
Pitch Pine/Sheep Laurel/ Atlantic White Cedar (Saturated)	Shrubs:	Highbush Blueberry, Swamp Azalea	Ocean County
	Others:	Greenbriar	

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Figure 31. Leatherleaf wetland in southern New Jersey. Saplings of Atlantic white cedar are growing along the edge of this scrub-shrub wetland.

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Figure 32. Highbush blueberry is abundant throughout the State.

and St. John's-worts. These plants, which may dominate emergent wetlands, are especially abundant in mixed shrub-emergent wetlands.

Jervis (1963) described a mixed wetland type in northern New Jersey as the "sedge-shrub community." Here, shrubs like red maple, alder, buttonbush, swamp rose, steeplebush and silky dogwood had colonized the tussocks of the tussock sedge. Tiner (1980) also observed mixed emergent and shrub wetlands in the Passaic River Basin. Composition of these communities was quite variable, although red maple saplings with tussock sedge, purple loosestrife or bluejoint were most common. Other communities were well-mixed with numerous shrubs and herbs, including alders, dogwoods, willows, common elderberry, swamp rose, red maple, steeplebush, meadow-sweet, poison sumac, southern arrowwood, tussock sedge, cattail, marsh fern, tearthumbs, sensitive fern, asters, St. John's-worts, cinnamon fern, soft rush, goldenrods, blue-joint, woolgrass, New York ironweed, fringed loosestrife (*Lysimachia ciliata*), blue flag, reed canary grass, purple loosestrife, horsetail, sedges, crowfoots, mints (*Mentha* spp.), wild millet (*Echinochloa* spp.) and blue vervain.

Olsson (1979) described several shrub wetland communities of the Pine Barrens, while Montgomery and Fairbrothers (1963) compared a northern New Jersey sphagnum bog with one from the Pine Barrens. The southern bog (Bennett Bog, 149 species) had much higher plant diversity than the northern bog (Utterton Bog, 43 species). Interestingly, only 9 plants, including sweet pepperbush, swamp azalea, red maple, highbush blueberry and big cranberry, were common to both areas. These data confirmed claims that boreal plants near their southern range limit may be restricted to northern New Jersey bogs, while Pine Barrens bogs possessed southern species which have reached their northern limit.

Niering (1953) studied a leatherleaf-dominated northern bog in Sussex County. Associated shrubs included bog rosemary (*Andromeda glaucophylla*), bog laurel (*Kalmia polifolia*), sheep laurel, and big cranberry. Small trees of black spruce (*Picea mariana*) and larch (*Larix laricina*) were scattered on the bog mat. Rigg (1940) compared New Jersey shrub bogs with others in the United States.

In the northern half of the State, silky dogwood, meadowsweet, steeplebush, and Allegheny blackberry may reach their maximum abundance in temporarily flooded wetlands. Their southern counterparts are sheep laurel and pitch pine saplings.

Van Vechten and Buell (1959) found Allegheny blackberry, common elderberry, multiflora rose (*Rosa multiflora*) and silky dogwood on temporarily flooded floodplains of the Millstone River. Jervis (1963) reported a similar shrub wetland having a mixture of meadowsweet, steeplebush, Allegheny blackberry, silky dogwood, and goldenrods from Troy Meadows in Morris County.

Shrub wetlands are also present on barrier islands. Here, common shrubs are highbush blueberry, bayberry, big cranberry, and sea myrtle. Representative plant communities have been described by Martin (1959). All of these communities lie in depressions between sand dunes where the water table is near the surface. The highbush blueberry and bayberry communities are probably the most common types. Common associates within blueberry wetlands are poison ivy, sheep laurel, and common greenbriar (*Smilax rotundifolia*), while less abundant plants include bayberry, Canada serviceberry (*Amelanchier canadensis*), swamp rose, marsh fern, cinnamon fern, and royal fern.

Palustrine Forested Wetlands

Palustrine forested wetland is the most abundant and widely distributed wetland type in the State. Most swamps 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 taller than 20 feet (6m). Figure 33 shows examples of these wetlands.

Figure 33. Examples of palustrine forested wetlands: northern N.J. (a) red maple swamp and (b) silver maple floodplain wetland; southern N.J. (c) Atlantic white cedar swamp (background) and (d) red maple swamp.

New Jersey's forested wetlands have received much attention from botanists and ecologists. Most studies have been conducted in the Pine Barrens (Stone 1911; Harshberger 1916; Little 1950, 1951; Bernard 1963; McCormick 1955, 1970b, 1979; Givnish 1971; Olsson 1979; Ehrenfeld and Gulick 1981; Ehrenfeld 1983). Considerable work has also centered on the floodplains of central and northern New Jersey (Buell and Wistendahl 1955; Wistendahl 1958; Van Vechten and Buell 1959; Jervis 1963; Buchholz 1981). Few studies, however, relate to northern forested wetlands (Heusser 1949; Niering 1953; Tiner 1980). General differences between northern and southern forested wetlands were reported by Robichaud and Buell (1973). Wetland communities are extremely diverse and complex and vary widely with changes in local characteristics.

Forested Wetlands of Northern New Jersey

The vast majority of wooded swamps in northern New Jersey are deciduous forested wetlands, with evergreen forested wetlands generally restricted to the northernmost areas, especially Sussex County. Red maple swamps are the predominant wetland type in this part of the State. In many instances, other trees are often intermixed and may appear as co-dominants in certain wetlands. These trees include white ash (*Fraxinus americana*), silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*), black willow (*Salix nigra*), sycamore (*Platanus accidentalis*) and sweet gum. Less dominant trees which may be locally abundant are slippery elm (*Ulmus rubra*), American elm (*Ulmus americana*), black cherry (*Prunus serotina*), black gum (*Nyssa sylvatica*), swamp white oak (*Querus bicolor*), ironwood (*Carpinus caroliniana*), gray birch, and yellow birch (*Betula alleghaniensis*). Conifers like larch, black spruce, hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) are rather limited in their distribution and abundance.

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 20). In most wetlands, other trees are found in varying numbers with red maple, often near the edges of the swamp. Robichaud and Buell (1973) observed that yellow birch was the prime associate of red maple in northern New Jersey swamps, while in central New Jersey, yellow birch was generally replaced by elm, pin oak, swamp white oak, and silver maple. These trees join black gum, ash, and red maple as the most common wetland trees. A shrub understory characterizes red maple swamps, with several species important: highbush blueberry, swamp azalea, winterberry, spicebush (*Lindera benzoin*), silky dogwood, and alders. Spicebush is very abundant in forested wetlands of the Piedmont region (Robichaud and Buell 1973) and its yellow blossoms are evident in early spring. Snowberry (*Symphoricarpos albus*) appears to be associated with the drier (temporarily flooded) red maple swamps. Numerous emergents form the herbaceous stratum of forested wetlands. Some of the more common emergents are skunk cabbage, jewelweed, marsh marigold (*Caltha palustris*), clearweed (*Pilea pumila*), false hellebore (*Veratrum viride*), tussock sedge, other sedges, asters, bugleweeds, beggar-ticks, smartweeds and tearthumbs, jack-in-the-pulpit (*Arisaema triphyllum*), goldenrods, false nettle, spring beauty (*Claytonia virginica*), cinnamon fern, royal fern, and sensitive fern. With long periods of soil saturation and surface water ponding, peat mosses often form dense mats on the forest floor. In general, many red maple swamps are flooded for long periods early in the growing season, while the soil remains saturated for most of the year. They represent the wettest of the forested wetlands in northern New Jersey.

Niering (1953) described a red maple-yellow birch swamp in Sussex County. Associated trees included black ash (*Fraxinus nigra*), white ash, basswood (*Tilia americana*), tulip tree (*Liriodendron tulipifera*), ironwood and hop-hornbean (*Ostrya virginiana*). Important shrubs were highbush blueberry, southern arrowwood, and nannyberry (*Viburnum lentago*). Cinnamon fern, tussock sedge and skunk cabbage were abundant, as was peat moss in wetter depressions. Other swamps were dominated by red maple and black gum, with white pine or hemlock sparsely intermixed. Common shrubs included highbush blueberry, swamp azalea, alders, and gray birch.

The driest (temporarily flooded) of the forested wetlands are represented by red maple, pin oak, sweet gum, white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), swamp white oak, ironwood and beech (*Fagus grandifolia*, probably var. *caroliniana*). Several shrubs forming the shrub understory include spicebush, highbush blueberry, southern arrowwood, snowberry, Japanese honeysuckle (*Lonicera japonica*), and brambles (*Rubus* sp.). Greenbriar (*Smilax* sp.) is also common. Canada mayflower (*Maianthemum canadense*) and trout lily (*Erythronium umbilicatum*) are locally abundant in these wetlands, while other emergents include may apple (*Podophyllum peltatum*), false nettle, sedges, wild garlic (*Allium* spp.), avens (*Geum* spp.), spinulose shield fern (*Dryopteris spinulosa*), and clubmosses (*Lycopodium* spp.). Haircap moss (*Polytrichum* spp.) and partridgeberry (*Mitchella repens*) may occur in scattered patches on the ground. These wetlands have a seasonal high water table and may be flooded annually for short periods early in the growing season. Infrequent flooding or surface water ponding may be observed after snow melt, spring rains, heavy summer storms or during the winter.

Forested wetlands often border major rivers and streams. They occur on the low-lying inner floodplain behind natural levees. Microrelief determines the duration of

Table 20. Examples of palustrine forested wetland communities in northern New Jersey.

Dominance Type (Water Regime)	**Associated Vegetation**	**Location**
Red Maple (Seasonally Flooded)	Trees: American Elm, Slippery Elm, Pin Oak, White Ash, Beech Shrubs: Silky Dogwood, Spicebush, Elderberry, Barberry, Brambles Herbs: Smartweed, Meadow-rue, Sensitive Fern, Sedge, False Nettle, Goldenrods, Stinging Nettle, Bugleweed, Broad-leaved Cattail, Arrow-leaved Tearthumb Others: Mosses	Morris County
Red Maple (Seasonally Flooded)	Trees: Slippery Elm, White Ash, Swamp White Oak Shrubs: Spicebush, Elderberry, Multiflora Rose, Pin Cherry, Common Winterberry, Silky Dogwood, Southern Arrowwood Herbs: Jewelweed, Avens, Nightshade, Tussock Sedge, Dock, New York Aster, Spikerush, Willowherb, Tearthumbs, Rice Cutgrass, Beggar-ticks, Jack-in-the-pulpit, Skunk Cabbage, Fringed Loosestrife Others: Poison Ivy, Virginia Creeper	Bergen County
Red Maple (Seasonally Flooded)	Trees: Black Gum Shrubs: Highbush Blueberry, Spicebush, Swamp Azalea, Sweet Pepperbush, Serviceberry Herbs: Cinnamon Fern, Royal Fern, Skunk Cabbage, Tussock Sedge, Sedge, Goldthread, Violet, Canada Mayflower Others: Virginia Creeper, Grape	Passaic County
White Ash (Seasonally Flooded)	Trees: Sweet Gum Shrubs: Silky Dogwood, Elderberry Herbs: Wood Reed, Jack-in-the-pulpit, False Nettle, Jewelweed, Bushy Aster, Clearweed, Sedges, Arrow-leaved Tearthumb, Thoroughwort, Calico Aster, Turtlehead Others: Poison Ivy	Middlesex County
Red Maple (Temporarily Flooded)	Trees: White Pine Shrubs: Highbush Blueberry, Southern Arrowwood, Serviceberry, Cherry, Swamp Rose, Meadowsweet, Partridgeberry Herbs: Canada Mayflower, Sedges, Wood Fern, Sensitive Fern, Sedge, Jewelweed, Bedstraw	Passaic County
Red Maple (Temporarily Flooded)	Trees: American Elm, Sycamore, Black Cherry, River Birch, Swamp White Oak Shrubs: Spicebush Herbs: Wild Garlic Others: Greenbriar, Virginia Creeper, Grape	Essex County
Pin Oak/Red Maple (Temporarily Flooded)	Trees: White Oak, White Ash, Shagbark Hickory, Slippery Elm, Cottonwood Shrubs: Southern Arrowwood, Japanese Honeysuckle, Privet Herbs: Sedge, Avens, Blue Flag, Wild Garlic, Aster, Grasses Others: Greenbriar, Mosses	Somerset County
Silver Maple (Temporarily Flooded)	Shrubs: Elderberry Herbs: Fairy Aster, Wood Nettle, Clearweed, White Grass, Wood Reed, Sedge, False Nettle, Avens, Bugleweed, Giant Ragweed, Sweet White Violet, Smartweeds Others: Poison Ivy	Somerset County
Atlantic White Cedar (Saturated)	Trees: Red Maple, Hemlock, Pitch Pine, Black Gum, Gray Birch Shrubs: Highbush Blueberry, Rose Bay, Swamp Azalea, Mountain Holly, Common Winterberry, Sheep Laurel Herbs: Sedge, Goldthread, Cinnamon Fern, Skunk Cabbage, Starflower Others: Peat Moss and other mosses	Sussex County

flooding which affects plant community composition. The lowest areas are seasonally flooded, while slightly higher levels are only temporarily flooded. A mixed forest community characterizes these wetlands. Important trees include silver maple, white ash, sycamore, red maple, pin oak, swamp white oak, black willow, elms, black gum, box elder (*Acer negundo*), basswood, ironwood, and river birch (*Betula nigra*). Wistendahl (1958) found 17 tree species in Raritan River floodplain wetlands. Bitternut (*Carya cordiformis*), beech, and red oak (*Quercus rubra*) were among these trees. He described the inner floodplain as a series of shallow sloughs forming a network of low areas and noticed that trees did not grow in the slough itself, with the exception of box elder and river birch. Numerous shrubs comprised a shrub understory, with spicebush, snowberry, meadowsweet, alder, silky dogwood, barberry (*Berberis thunbergii*), and poison ivy being common. Spicebush was the dominant shrub along the Raritan River (Buell and Wistendahl 1955; Wistendahl 1958). Typical floodplain emergents on the wetland floor included avens, goldenrods, asters, rice cutgrass, reed canary grass, wood nettle (*Laportea canadensis*), wood reed (*Cinna arundinacea*), clearweed, jewelweed, violets (*Viola* spp.), Virginia smartweed (*Polygonum virginianum*), false nettle, smartweeds, and beggar-ticks. Common vines were poison ivy, Japanese honeysuckle, wild grape (*Vitis* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and bittersweet (*Celastrus scandens*).

Evergreen forested wetlands are of minor importance in northern New Jersey being limited to the northernmost areas. Sussex County possesses most of these wetlands. Niering (1953) described a mixed hemlock-red maple swamp. Other important trees were Atlantic white cedar, yellow birch, black spruce and black gum. He noted that the oldest hemlocks and cedars were 90 and 140 years old, respectively. Rose bay (*Rhododendron maximum*) formed dense thickets in heavily shaded areas. Other shrubs were smooth winterberry (*Ilex laevigata*), winterberry, mountain holly, highbush blueberry, and smooth alder. In more open areas, swamp azalea, speckled alder and spicebush occurred. Herbs were widely scattered, with cinnamon fern, wild calla (*Calla palustris*) and skunk cabbage being most common. Belling (1977) found white pine, hemlock, black gum, red maple, and larch associated with Atlantic white cedar in southeastern New York.

Forested Wetlands of Southern New Jersey

Three types of forested wetlands are prevalent in southern New Jersey: (1) hardwood swamps, (2) Atlantic white cedar swamps, and (3) pitch pine lowland forests. Forested floodplain wetlands also occur along Inner Coastal Plain rivers. Soil type and water regime were reported by Bernard (1963) as the most important factors influencing vegetation in southern New Jersey. Human activities, particularly timber cutting, and natural events such as fire have played an important role in shaping the vegetation of the Pine Barrens (McCormick 1979). Table 21 presents examples of forested wetland communities in southern New Jersey.

Hardwood swamps are the most abundant forested wetland type. As in the north, red maple dominates most of these wetlands. Black gum and sweet gum are frequent co-dominants or locally dominant. Common associate trees in wetter swamps include sweet bay (*Magnolia virginiana*), Atlantic white cedar, and ash. Tulip tree, American holly (*Ilex opaca*), sassafras (*Sassafras albidum*), gray birch and willow oak (*Quercus phellos*) are frequently found at drier sites. Pitch pine is widely distributed ranging from seasonally flooded to temporarily flooded swamps (Ledig and Little 1979). Robichaud and Buell (1973) noted that sweet gum and tulip trees become more dominant in southernmost areas. Loblolly pine (*Pinus taeda*) was found in a Cape May County wetland by Bernard (1963). This may represent the northernmost location for this species. The shrub understory of hardwood swamps is often a dense thicket of sweet pepperbush, highbush blueberry, swamp azalea, fetterbush, black huckleberry (*Gaylussacia baccata*), dangleberry, and southern arrow-wood. Other important shrubs are leatherleaf, inkberry, spicebush, smooth alder, other blueberries (*Vaccinium pallidum*), winterberry, staggerbush, maleberry, service-berries (*Amelanchier* spp.), chokeberries, and sheep laurel. Mountain laurel (*Kalmia latifolia*) and bayberry are infrequently associated with drier forested wetlands. When a dense shrub understory exists, emergent plants are scarce. In most wetter swamps, emergents include tussock sedge, rice cutgrass, skunk cabbage, beggar-ticks, cinnamon fern, royal fern, arrow-leaved tearthumb, St. John's-worts, and three-way sedge. Peat mosses are scattered in patches on the forest floor in these wetlands. Drier swamps have goldenrods, Joe-Pye-weeds, white grass (*Leersia virginica*), meadow rue (*Thalictrum* sp.), and bracken fern (*Pteridium aquilinum*). Sensitive fern, chain ferns, jewelweed, bedstraws, and false nettle occur under variable water regimes. Common greenbriar is particulary common in the drier wetlands. It is also generally limited to the edges of wetter swamps, while bamboo-vine (*Smilax laurifolia*) occurs frequently in the swamp interior. Other important vines in forested wetlands are poison ivy, Virginia creeper, Japanese honeysuckle, wild grape, and trumpet creeper (*Campsis radicans*). Bernard (1963) described several hardwood swamp communities for Cape May County, while Ehrenfeld and Gulick (1981) examined tree and shrub strata in Pine Barrens swamps. Plant community differences between swamps in disturbed and undisturbed areas are discussed by Ehrenfeld (1983). Minor vegetation associated with Pine Barrens swamps has also been described (Little 1951). Other significant studies include Harshberger (1916), McCormick (1955, 1970b, 1979) and Olsson (1979).

Table 21. Examples of palustrine forested wetlands in southern New Jersey.

Dominance Type (Water Regime)	Associated Vegetation	Location
Red Maple (Seasonally Flooded)	Trees: Sweet Bay, Black Gum Shrubs: Southern Arrowwood, Brambles, Serviceberry, Winterberry Herbs: Cinnamon Fern, Thoroughwort, Grasses	Mercer County
Red Maple/Sweet Gum (Seasonally Flooded)	Trees: River Birch, American Holly Shrubs: Southern Arrowwood, Sweet Pepperbush Herbs: Sensitive Fern, Arrow-leaved Tearthumb, Smartweeds, Rice Cutgrass, Bedstraw, Jewelweed, St. John's-wort, Arrow Arum, Spotted Joe-Pye-weed, False Nettle	Cumberland County
Atlantic White Cedar (Seasonally Flooded)	Trees: Black Gum Shrubs: Fetterbush, Highbush Blueberry, Swamp Azalea, Red Maple, Alder, Sweet Pepperbush, Dangleberry, Big Cranberry Herbs: Smartweed, Arrow Arum, Virginia Cottongrass, Sedges, Spatulate-leaved Sundew Others: Peat Moss and other mosses	Ocean County
Atlantic White Cedar/ Red Maple (Seasonally Flooded)	Trees: None Shrubs: Southern Arrowwood, Swamp Rose, Sweet Pepperbush, Bayberry, Winterberry, Swamp Azalea Others: Poison Ivy	Burlington County
Pitch Pine (Seasonally Flooded)	Trees: Red Maple, Atlantic White Cedar, Sweet Bay Shrubs: Maleberry, Swamp Azalea, Sweet Pepperbush, Highbush Blueberry Herbs: Cinnamon Fern Others: Peat Moss	Atlantic County
Red Maple (Temporarily Flooded)	Trees: Black Gum Shrubs: Sweet Pepperbush, Southern Arrowwood, Spicebush, Japanese Honeysuckle, Swamp Azalea, Elderberry Herbs: Jewelweed, Spotted Joe-Pye-weed, Sensitive Fern, New York Fern, Smartweed, White Grass, Royal Fern, Cinnamon Fern Others: Greenbriar, Poison Ivy	Camden County
Red Maple (Temporarily Flooded)	Trees: Sweet Bay, Sweet Gum, White Oak, Red Oak Shrubs: American Holly, Sweet Pepperbush, Southern Arrowwood Herbs: Cinnamon Fern Others: Poison Ivy, Greenbriar	Cape May County
White Oak/Sweet Gum (Temporarily Flooded)	Trees: Red Maple, Black Cherry, Beech, Sassafras, Ironwood, Swamp White Oak, Pin Oak, Shagbark Hickory Shrubs: Highbush Blueberry, Southern Arrowwood, Huckleberry Herbs: Sedges, Wrinkled Goldenrod, Canada Mayflower	Mercer County
Pitch Pine (Temporarily Flooded)	Trees: Sassafras, Gray Birch, Red Maple Shrubs: Highbush Blueberry, Sweet Pepperbush Herbs: Virginia Chain Fern Others: Common Greenbriar	Gloucester County
Pitch Pine/Black Gum/ Red Maple (Temporarily Flooded)	Trees: Sweet Bay, Gray Birch Shrubs: Sweet Pepperbush, Highbush Blueberry, Sheep Laurel, Swamp Azalea, Inkberry, Common Winterberry Herbs: Cinnamon Fern, Bracken Fern Others: Greenbriar	Atlantic County
Red Maple/Sweet Gum/ Pitch Pine (Temporarily Flooded)	Trees: American Holly, Sassafras, Black Gum, Sweet Bay, Red Oak Shrubs: Highbush Blueberry, Sweet Pepperbush, Swamp Azalea, Wintergreen, Partridgeberry, Mountain Laurel Herbs: Bracken Fern Others: Greenbriar	Cumberland County

Atlantic white cedar dominates many forested wetlands along Pine Barrens watercourses. In general, they form a band less than 1,000 feet wide, but some stands exceed one mile in width (McCormick 1979). These cedar swamps represent only 2% (or 21,450 acres) of the Pinelands National Reserve (Roman and Good 1983). While the hardwood swamps are largely represented by a mixture of co-dominant trees, many cedar swamps have a nearly solid canopy of Atlantic white cedar. This dense canopy precludes establishment of a thick shrub layer, typical of hardwood swamps. Instead, scattered trees and shrubs are found including red maple, sweet bay, black gum, sweet pepperbush, fetterbush, highbush blueberry, dangleberry, inkberry, and swamp azalea. In more open canopies, these plants and others are more abundant and red maple can co-dominate. Herbaceous species are not prevalent, but those present include chain ferns, cinnamon fern, sedge (*Carex collinsii*), bladderworts (*Utricularia* spp.), purple pitcher plant, sundews, swamp pink (*Helonias bullata*), and partridgeberry (McCormick 1979; Olsson 1979). Orchids occur in cedar swamps, including dragon's mouth (*Arethusa bulbosa*), swamp pink (*Calopogon pulchellus*), green rein orchid (*Platanthera clavellata*), white fringed orchid (*P. blephariglottis*), and rose pogonia (*Pogonia ophioglossoides*) (Harshberger 1916). Little (1951) found some emergent plants that were not found in hardwood swamps: rose pogonia, purple pitcher plant, round-leaved sundew (*Drosera rotundifolia*), starflower (*Trientalis borealis*) and twining bartonia (*Bartonia paniculata*). In addition, he reported that the rare curly grass fern (*Schizaea pusilla*) is restricted to cedar swamps. McCormick (1979) observed that this fern is widely distributed throughout cedar forests. Wintergreen (*Gaultheria procumbens*) occurs on the cedar hummocks (Roman and Good 1983). Peat mosses cover much of the ground, while liverworts and reindeer moss (*Cladonia incrassata*) are found on logs and tree bases (Olsson 1979). Forman (1979) noted that bryophyte cover increased with soil moisture and that cedar swamps had the greatest moss coverage of all Pine Barrens habitats. Harshberger (1916), Little (1950), and Givnish (1971) have examined the ecology of Pine Barrens cedar swamps.

Pitch pine lowlands are among the driest wetlands in southern New Jersey. Although pitch pine dominates some seasonally flooded wetlands, it is most abundant in temporarily flooded situations associated with the seasonally high water table of the Pine Barrens (Figure 34). Pitch pine lowlands typically represent transitional areas between the white cedar and hardwood swamps and the dry upland. They comprise about 10% of the Pinelands National Reserve (Roman and Good 1983). While pitch pine forms almost the entire forest canopy, red maple and black gum may often be intermixed and sometimes co-dominant forming mixed deciduous-evergreen forested wetlands. In southernmost areas, sweet gum becomes an important community component. Other trees are scattered throughout this lowland complex including Atlantic white cedar, sassafras, gray birch, American holly, and willow oak. Other oaks, such as scrub oak (*Quercus ilicifolia*), may be common at drier sites (McCormick 1979). A shrub understory may be well developed in pitch pine wetlands. McCormick (1979) reported more than 20 species of shrubs and woody vines. Important shrubs are dangleberry, sweet pepperbush, highbush blueberry, swamp azalea, sheep laurel, leatherleaf, wintergreen, fetterbush, winterberry, black huckleberry, dwarf huckleberry, and inkberry. Leatherleaf forms a dense low thicket in the wetter areas. Less common shrubs include staggerbush, mountain laurel, alder, serviceberry, southern arrowwood, chokeberry, bayberry, and partridgeberry. Common vines are greenbriars (*Smilax glauca* and *S. rotundifolia*). Herbaceous vegetation is variable and may cover 30% of the ground (McCormick 1979). Numerous ferns can be found, i.e., bracken, chain, cinnamon, royal and sensitive ferns. Other significant emergents include turkeybeard (*Xerophyllum asphodeloides*), lowland broomsedge, sundews, cowwheat (*Melampyrum lineare*), sedges and orchids (McCormick 1979; Olsson 1979). Peat mosses may exist in wetter depressions. Olsson (1979) noted several plants associated with recent disturbance: sand myrtle (*Leiophyllum buxifolium*) with drainage, turkeybeard with fire, and bracken and cinnamon ferns with clearing or burning.

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Figure 34. Pitch pine occurs in a wide variety of habitats both wet and dry. Here it is growing in a seasonally flooded wetland.

Lacustrine Wetlands

The Lacustrine System is principally a deepwater habitat system of lakes, reservoirs and deep ponds. Wetlands are generally limited to shallow waters and exposed shorelines like in the Riverine System. While algae are probably more abundant in these waters, the vascular macrophytes are usually more readily observed. A variety of life forms can be recognized, including: (1) free-floating plants, (2) rooted vascular 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. Fairbrothers and Moul (1965) have discussed the ecology of aquatic vegetation in New Jersey and a list of common aquatic plants is presented as Table 22.

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, and water shield. Duckweeds (*Lemna* spp., *Spirodela polyrhiza*, *Wolffia* spp. and *Wolffiella* spp.) comprise the free-floating beds. Bladderworts (*Utricularia* spp.) are also free-floating, but are typically submerged. Submergent aquatic beds are less conspicuous. Lacustrine submergent plants include pondweeds, naiads (*Najas* spp.), wild celery, waterweeds (*Elodea* spp.), coontail (*Ceratophyllum demersum*), fanwort (*Cabomba caroliniana*), and the algal stoneworts (*Nitella* spp.).

Soft water lakes with a pH between 6.8 and 7.4 may be characterized by pondweeds, naiads, wild celery, and manna grasses (*Glyceria* spp.), with bladderworts, white water lilies and water milfoils (*Myriophyllum* spp.) also abundant. By contrast, hard water lakes (pH 8-8.8) frequently have a border of emergent plants, e.g., cattails, burreeds, bulrushes and common reed (Fairbrothers and Moul 1965). Renlund (1953) noted that many plants such as muskgrass (*Chara* spp.), water shield, quillwort (*Isoetes* spp.) and purple loosestrife may be limited to northern and central New Jersey, while others are more frequent in southern and central lakes, e.g., yellow-eyed grass, arrowheads and bladderworts. Purple loosestrife, however, is now abundant in some southern New Jersey marshes (N. Good, pers. comm.).

Nonpersistent Emergent Wetlands

Emergent wetlands frequently form along the shorelines of lakes. Common nonpersistent plants include arrowheads, three-way sedge, spikerushes, pipeworts, burreeds, rushes, smartweeds, manna grasses, pickerelweeds and arrow arum. In addition to these species, persistent plants like cattails, water willow, buttonbush, and leatherleaf may comprise all or part of the lacustrine boundaries. These persistent wetlands, however, fall within the Palustrine System according to Cowardin and others (1979) as discussed earlier.

Rare and Endangered Wetland Plants

New Jersey is located in a rather unique position along the East Coast which greatly affects its plant associations and diversity. The State includes both the southern limit of the Northern Hardwoods Forest and the northern tip of the Southeastern Mixed Forest (Bailey 1978). As a result, a large number of plants occur at the limit of their natural range, with many plants having a quite restricted distribution in New Jersey. In the Pine Barrens alone, 15% of the flora is composed of plants reaching their northern or southern range limit (McCormick 1970b). Fifty-four species have been identified as threatened or endangered plants of the Pinelands in the Comprehensive Management Plan (N.J. Pinelands Commission 1980).

Although New Jersey does not have an official state list of endangered and threatened plants, a total of 338 rare plants were identified for the State in a recent Fish and Wildlife Service sponsored survey (Snyder and Vivian 1981). Of these plants, 249 species (or 64%) grow in wetland or aquatic habitats. Another 7 species may be associated with wetlands, but available habitat information was inconclusive. For additional information, the reader is referred to Snyder and Vivian (1981).

To date, only one New Jersey plant has been officially listed by the Service as an endangered species, under protection of the Federal Endangered Species Act. The small-whorled pogonia (*Isotria medeoloides*) is in danger of extinction throughout all or a significant portion of its range. It is typically associated with mixed deciduous upland forest, but is found occasionally in wetlands along freshwater streams.

Interestingly, 23 of the 25 plants currently under review as being Federally endangered or threatened (likely to become endangered within the foreseeable future) throughout all or a significant part of their range in the United States occur in New Jersey wetlands (Table 23). Of these, 15 species are associated with the Pine Barrens.

Summary

Plant composition of New Jersey'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

Table 22. Plants of freshwater lakes, ponds and slow moving rivers and streams (from Fairbrothers and Moul 1965). Scientific names are listed as they appeared in this reference.

Scientific Name	Common Name	Scientific Name	Common Name
Acorus calamus	Sweet Flag	*Potamogeton perfoliatus*	Pondweed
Alisma subcordatum	Water Plantain	*Potamogeton pusillus*	Small Pondweed
Anacharis canadensis	Waterweed	*Potamogeton robbinsii*	Pondweed
Anacharis nuttallii	Waterweed	*Potamogeton* spp.	Pondweeds
Bidens beckii	Water Marigold	*Proserpinaca palustris*	Mermaid Weed
Bidens bidentoides		*Proserpinaca pectinata*	Mermaid Weed
Brasenia schreberi	Water Shield	*Ranunculus aquatilis*	White Water Crowfoot
Cabomba caroliniana	Fanwort	*Ranunculus circinatus*	Water Crowfoot
Calamagrostis canadensis	Bluejoint	*Ranunculus longirostris*	White Water Crowfoot
Callitriche heterophylla	Water Starwort	*Sagittaria australis*	Arrowhead
Callitriche terrestris	Water Starwort	*Sagittaria eatoni*	Arrowhead
Callitriche verna	Water Starwort	*Sagittaria engelmanniana*	Arrowhead
Carex langinosa	Woolly Sedge	*Sagittaria latifolia*	Broad-leaved Arrowhead
Ceratophyllum demersum	Coontail	*Sagittaria graminea*	Arrowhead
Cicuta maculata	Water Hemlock	*Sagittaria rigida*	Arrowhead
Cladium mariscoides	Twig Rush	*Sagittaria subulata*	Arrowhead
Eleocharis obtusa	Spike Rush	*Sagittaria teres*	Arrowhead
Glyceria striata	Manna Grass	*Saururus cernuus*	Lizard's Tail
Heteranthera dubia	Water Star Grass	*Scirpus acutus*	Hard-stemmed Bulrush
Juncus marginatus	Rush	*Scirpus americanus*	Three-square
Juncus militaris	Bayonet Rush	*Scirpus fluviatilis*	River Bulrush
Juncus repens	Rush	*Scirpus olneyi*	Three-square
Juncus subtilis	Rush	*Scirpus paludosus*	Bulrush
Juncus pelocarpus	Rush	*Scirpus smithii*	Bulrush
Lemna minor	Duckweed	*Scirpus subterminalis*	Swaying Rush
Lemna perpusilla	Duckweed	*Scirpus torreyi*	Bulrush
Lemna trisulca	Duckweed	*Scirpus validus*	Soft-stemmed Bulrush
Lemna valdiviana	Duckweed	*Sium suave*	Water Parsnip
Lobelia cardinalis	Cardinal Flower	*Sparganium americanum*	Burreed
Myosotis laxa	Forget-me-not	*Sparganium eurycarpum*	Large Burreed
Myriophyllum humile	Water Milfoil	*Spirodela polyrhiza*	Big Duckweed
Myriophyllum heterophyllum	Water Milfoil	*Utricularia biflora*	Bladderwort
Myriophyllum spicatum	Water Milfoil	*Utricularia cornuta*	Bladderwort
Najas flexilis	Bushy Pondweed	*Utricularia fibrosa*	Bladderwort
Najas gracillima	Bushy Pondweed	*Utricularia geminiscapa*	Bladderwort
Najas guadalupensis	Bushy Pondweed	*Utricularia gibba*	Bladderwort
Nuphar advena	Spatterdock	*Utricularia inflata*	Bladderwort
Nuphar microphyllum	Yellow Pond Lily	*Utricularia intermedia*	Bladderwort
Nuphar variegatum	Yellow Pond Lily	*Utricularia juncea*	Bladderwort
Nymphaea odorata	White Water Lily	*Utricularia minor*	Bladderwort
Nymphaea tuberosa	White Water Lily	*Utricularia purpurea*	Purple Bladderwort
Nymphoides cordata	Floating Heart	*Utricularia resupinata*	Bladderwort
Orontium aquaticum	Golden Club	*Utricularia vulgaris*	Bladderwort
Peltandra virginica	Arrow Arum	*Vallisneria americana*	Wild Celery
Pontederia cordata	Pickerelweed	*Wolffia* spp.	Duckweeds
Potamogeton crispus	Crimped-leaf Pondweed	*Wolffiella* spp.	Duckweeds
Potamogeton diversifolius	Pondweed	*Xyris caroliniana*	Yellow-eyed Grass
Potamogeton nodosus	Riverweed	*Zizania aquatica*	Wild Rice

wetlands where forested swamps abound. Even within major vegetative classes of wetlands, significant differences in community structure are observed. These variations are largely due to several factors including water regime (hydrology), soil type, human activities (e.g., drainage, timber harvest, filling and water pollution) and natural events like fire. Consequently, a wide variety of wetland plant communities exist within the State and they represent an essential part of its landscape diversity and natural heritage.

Table 23. List of New Jersey plants under review for Federal listing as endangered species. Wetland habitats have been identified where applicable.

Scientific Name	Common Name	Occurs in Wetland	Pine Barrens Associate	Wetland Habitats
Aeschynomene virginica	Sensitive Joint Vetch	X	X	Tidal flats and marshes
Amaranthus pumilus	Sea-beach Pigweed	X	X	Sea beaches
Calamovilfa breviplis	Sand Grass	X	X	Freshwater wetlands
Cardamine longii	Long's Bitter Cress	X		Salt marshes
Carex barrattii	Barrett's Sedge	X	?	Freshwater wetlands
Carex polymorpha	Variable Sedge			N/A
Eriocaulon parkeri	Parker's Pipewort	X		Shallow water and freshwater tidal flats
Eupatorium resinosum	Pine Barrens Boneset	X	X	Freshwater wetlands
Euphorbia purpurea	Darlington's Spurge	X		Freshwater forested wetlands
Gentiana autumnalis	Pine Barren Gentian	X	X	Freshwater wetlands
Helonias bullata	Swamp Pink	X	X	Freshwater wetlands
Isoetes eatonii	Eaton's Quillwort	X		Freshwater ponds and lakes
Juncus caesariensis	New Jersey Rush	X	X	Freshwater wetlands
Lobelia boykinii	Boykin's Lobelia	X		Freshwater ponds and forested wetlands
Micranthemum micranthemoides	Nuttall's Micranthemum	X		Freshwater tidal wetlands
Muhlenbergia torreyana	Torrey's Muhly	X	X	Freshwater forested wetlands
Narthecium americanum	Bog Asphodel	X	X	Freshwater wetlands
Panicum hirstii	Hirst's Panic Grass	X	X	Freshwater wetlands
Polemonium vani-bruntiae	Jacob's Ladder	X		Freshwater wetlands
Rhexia aristosa	Awned Meadow Beauty	X	X	Freshwater ponds and acid bogs
Rhynchospora knieskernii	Knieskern's Beaked Rush	X	X	Freshwater wetlands
Schizaea pusilla	Curly Grass Fern	X	X	Freshwater wetlands
Schwalbea americana	Chaffseed		X	N/A
Scirpus longii	Long's Bulrush	X	X	Freshwater marshes
Trollius laxus subspecies *laxus*	Spreading Globe-flower	X		Freshwater wetlands

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CHAPTER 7.
Wetland Values

Introduction

New Jersey's wetlands have been traditionally used for hunting, trapping, fishing, cranberry and blueberry harvest, timber and salt hay production, and livestock grazing. These uses tend to preserve the wetland integrity, although the qualitative nature of wetlands may be modified, especially for salt hay, blueberry, and cranberry production and timber harvest. Human uses are not limited to these activities, but also include destructive and often irreversible actions such as drainage for agriculture and filling for industrial or residential development. In the past, many people considered wetlands as wastelands whose best use could only be attained through "reclamation projects." To the contrary, wetlands in their natural state provide a wealth of values to society (Table 24). These benefits can be divided into three basic categories: (1) fish and wildlife values, (2) environmental quality values, and (3) socioeconomic values. The following discussion emphasizes the more important values of New Jersey's wetlands, with significant national values also mentioned. Roman and Good (1983) have summarized wetland values for the Pinelands. For an indepth 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 Service has created and maintains a wetland values database which records abstracts of over 2000 articles (Stuber 1983).

Fish and Wildlife Values

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

Fish and Shellfish Habitat

Coastal and inland wetlands in New Jersey are important fish habitats. Estuarine wetlands are also essential habitats for shrimp, crabs, oysters and clams.

Approximately two-thirds of the major U.S. commercial fishes depend on estuaries and salt marshes for nursery or spawning grounds (McHugh 1966). Among the more familiar wetland-dependent fishes are menhaden, bluefish, fluke, white perch, sea trout, mullet, croaker, striped bass, and drum. Forage fishes, such as anchovies, killifishes, mummichogs, and Atlantic silversides, are among the most abundant estuarine fishes. Between Manasquan and Cape May, Wang and Kernehan (1979) found 40 estuarine spawning fishes and 136 species using estuaries as nursery grounds. Significant nursery habitat for striped bass is now limited to the Hudson River and the South River (U.S. Fish and Wildlife Service and National Marine Fisheries Service 1982). Striped bass production in the Delaware River continues to approach zero, while historically it was a major spawning habitat.

Coastal wetlands are also important for shellfish including bay scallops, grass shrimp, 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). Blue crabs and grass shrimp are abundant in tidal creeks of salt marshes. Estuarine aquatic beds, in general, also provide important cover for juvenile fishes and other estuarine organisms (Good, *et al.* 1978).

Freshwater fishes also find wetlands essential for survival. In fact, nearly all freshwater fishes can be considered wetland-dependent because: (1) many species feed in wetlands or upon wetland-produced food, (2) many fishes use wetlands as nursery grounds and (3) almost all important recreational fishes spawn in the aquatic portions of wetlands (Peters, *et al.* 1979). Chain and grass pickerels are common throughout New Jersey (Hastings 1979) as are basses, crappies, bluegills, bullheads and carp. Hastings and Good (1977) found 17 species of fishes abundant in the freshwater tidal marshes of Woodbury Creek. Alewife and blueback herring use these types of wetlands as spawning and nursery grounds (Good, *et al.* 1975; Simpson, *et al.* 1983b). White perch commonly occur in freshwater tidal segments of Pine Barrens streams (Hastings 1979). The American shad spawns in freshwater streams. Historically, shad were abundant in the Delaware River system, but habitat losses and pollution have jeopardized their existence in New Jersey. A total of 19 shad spawning runs have been eliminated in the State. Today, the shad is a State-threatened species (N.J.D.E.P. and U.S.S.C.S. 1980). Thirty-six fishes have been reported in Pine Barrens streams, with 16 identified as characteristic species, including sunfishes, yellow bullhead, pirate perch, shiners and darters (Hastings 1979). Aquatic beds are recognized as important habitats for these latter species and the black-banded sunfish is especially abundant in dense beds.

Table 24. 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

Waterfowl and Other Bird Habitat

In addition to providing year-round habitats for resident birds, wetlands are particularly important as breeding grounds, overwintering areas and feeding grounds for migratory waterfowl and numerous other birds (Figure 35). Both coastal and inland wetlands are valuable bird habitats. Leck (1975) has described New Jersey's birds and their habitats.

Salt marshes along the Atlantic coast are used for nesting by birds such as laughing gulls, Forster's terns, sharp-tailed sparrows, clapper rails, black ducks, blue-winged teals, willets, marsh hawks, and seaside sparrows. Smooth cordgrass marshes are principal nesting areas for the clapper rail (Widjeskog and Shoemaker 1981). Wading birds like herons, glossy ibises, and egrets also feed and nest in and adjacent to New Jersey's coastal wetlands. The U.S. Fish and Wildlife Service (Erwin and Korschgen 1979) has identified nesting colonies of coastal water birds in New Jersey and other northeastern states. The State-threatened short-billed marsh wren and savannah sparrow also depend on brackish water marshes (N.J.D.E.P. and U.S.S.C.S. 1980).

Atlantic coastal marshes are important feeding and stopover areas for migrating snow geese, peregrine falcons, shorebirds and wading birds. Intertidal mudflats are principal feeding grounds for migratory shorebirds (e.g., oystercatchers, ringed plovers and knots), while swallows can often be seen feeding on flying insects over the marshes.

New Jersey salt marshes are also prime wintering grounds for 300,000 to 450,000 waterfowl including black ducks, snow geese, scaup, Atlantic brant, Canada geese and mallards in the Atlantic Flyway. Brant feed heavily on sea lettuce and other estuarine aquatic beds, while black ducks eat marsh invertebrates, especially the salt marsh snail. Pintails and canvasbacks overwinter in the Hackensack Meadowlands (Hackensack Meadowlands Development Commission 1975).

Forty-eight species of birds have been reported nesting in New Jersey's freshwater tidal marshes, including redwing blackbirds, long-billed marsh wrens, least bitterns, clapper rails, American goldfinches, swamp sparrows, Indigo buntings, common yellowthroats, yellow warblers, Traill's flycatchers, wood ducks, green herons, and common gallinules (Hawkins and Leck 1977). Many of these birds utilize nontidal wetlands as well for nesting. McCormick (1970) found 119 species of birds at Tinicum Marsh, a tidal freshwater marsh outside of Philadelphia.

New Jersey's inland wetlands serve as important nesting, feeding and resting areas for other resident and migrating birds. From 40-45 nesting species were observed in hardwood swamps of southern New Jersey, while fewer species were noted in mixed hardwood-cedar wetlands and pure Atlantic white cedar swamps (Wander 1980). Great crested flycatchers, pine warblers, towhees, chickadees, titmouses, prothonotary warblers, scarlet tanagers, vireos, acadian flycatchers, ovenbirds, black and white warblers, catbirds, common yellowthroats, brown creepers, hooded warblers and black throated green warblers were among the most important breeding birds. This study suggested that swamp size was somewhat less important than vegetative composition in determining avian diversity. Leck (1979) also identified eastern wood pewee, wood thrush, parula warbler, yellow warbler, redstart, and song sparrow as other breeding birds of cedar swamps. American bitterns, various waterfowl, long-billed marsh wrens, redwings, swamp sparrows and song sparrows nest in freshwater marshes, while veeries and yellowthroats utilize forested wetlands and wet thickets, respectively. More than 30 species breed in northern cedar swamps near High Point State Park (Leck 1975). In the Great Swamp National Wildlife Refuge, wetland nesting birds include green heron, least bittern, American bittern, Canada goose, mallard, black duck, green-winged teal, blue-winged teal, wood duck, Virginia rail, sora, common gallinule, American woodcock, long-billed marsh wren,

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Figure 35. Migratory birds depend on wetlands: (a) black duck, (b) Canada geese, (c) American bittern, and (d) yellow warbler.

common yellowthroat and swamp sparrow. The wood duck is an important resident of forested wetlands where it nests in cavities of dead trees or in man-made nesting boxes. During migration, freshwater wetlands are important to many birds passing through New Jersey, especially for American woodcock (A. Petrongolo, pers. comm.).

Wetlands are, therefore, 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 breeding, feeding or resting.

Furbearer and Other Wildlife Habitat

Muskrat and beavers are the most important furbearers in New Jersey and they depend on wetlands. Muskrats are more abundant and wide ranging, inhabitating both coastal and inland marshes (Figure 36). By contrast, beavers tend to be restricted to inland wetlands, and are most abundant in Sussex County (Ferrigno 1984). In the Pine Barrens, beaver help perpetuate white cedar by feeding on hardwoods (Little 1950). Other wetland-utilizing furbearers include river otter, mink, raccoons, skunks, foxes, and weasels. Smaller mammals also frequent wetlands such as

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Figure 36. The muskrat is a common resident of freshwater marshes.

marsh and swamp rabbits, rice rats, numerous mice, meadow voles, bog lemmings and shrews, while large mammals may also be observed. White-tailed deer depend on white cedar swamps in the Pine Barrens and evergreen forested wetlands in northern New Jersey for winter shelter and food (Little 1950; Person 1983). They also use pitch pine lowlands for cover and breeding areas in winter (N.J.D.E.P. 1981).

Besides the animals previously mentioned, other forms of wildlife make their homes in wetlands. Reptiles (i.e., turtles and snakes) and amphibians (i.e., frogs and salamanders) are important residents. Turtles are most common in freshwater marshes and ponds. The more important ones nationally are the painted, spotted, Blanding's, map, pond, musk and snapping turtles (Clark 1979). In Pine Barrens wetlands, ten turtles may be found: bog, common snapping, eastern box, eastern mud, eastern painted, eastern spiny softshell, red-bellied, spotted, stinkpot and wood turtle (Conant 1979). The State-endangered bog turtle and State-threatened wood turtle depend on freshwater wetlands (N.J.D.E.P. and U.S.S.C.S. 1980). Along the coast, the diamond-backed terrapin is a common denizen of salt marshes.

Many snakes also inhabit wetlands, with water snakes being most abundant throughout the U.S. (Clark 1979). In Pine Barrens wetlands, several snakes can be found, including the black rat snake, eastern king snake, eastern worm snake, northern black racer, northern red-bellied snake, northern water snake, queen snake and rough green snake (Roman and Good 1983). The State-threatened northern pine snake and State-endangered timber rattlesnake also occur there. Garter snakes are probably common in New Jersey's inland wetlands.

Nearly all of the approximately 190 species of amphibians in North America are wetland-dependent, at least for breeding (Clark 1979). Frogs occur in many freshwater wetlands and common frogs include the bull, green, leopard, mink, pickerel, wood and chorus frogs and spring peepers. For the Pine Barrens, Conant (1979) lists Fowler's toad, northern spring peeper, green frog, and southern leopard frog as abundant and eastern spadefoot and carpenter frog as common. He also reports that the State-endangered Pine Barrens treefrog is declining and is presently threatened by any drop in water table levels. Many salamanders use temporary ponds or wetlands for breeding, although they may spend most of the year in uplands. Common Pine Barrens salamanders include marbled salamander, red-backed salamander, and northern red salamander (Conant 1979). 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 gum pond (less than 100 feet wide) in Georgia (Wharton 1978). In New Jersey, rare and State-endangered amphibians include the Pine Barrens treefrog, southern gray treefrog, blue-spotted salamander, eastern tiger salamander, eastern mud salamander and long-tailed salamander (N.J.D.E.P. and U.S.S.C.S. 1980).

Environmental Quality Values

Besides providing habitat for fish and wildlife, wetlands play a less conspicuous but essential role in maintaining high environmental quality, especially for aquatic habitats. They do this in a number of ways, including purifying natural waters by removing nutrients, chemical and organic pollutants, and sediment, and producing food which supports aquatic life.

Water Quality Improvement

Wetlands help maintain good water quality or improve degraded waters in several ways: (1) nutrient removal and retention, (2) processing chemical and organic wastes, and (3) reducing sediment load of water. Wetlands are particularly good water filters because of their locations between land and open water. Thus, they can both intercept runoff from land before it reaches the water and help filter nutrients, wastes and sediment from flooding waters. Clean waters are important to humans as well as to aquatic life.

First, wetlands remove nutrients, especially nitrogen and phosphorus, from flooding waters for plant growth and help prevent eutrophication or over-enrichment of natural waters. New Jersey's freshwater tidal wetlands are important in reducing nutrient and heavy metal loading from urban runoff in the upper Delaware River estuary (Simpson, *et al.* 1983c). It is, however, possible to overload a wetland and thereby reduce its ability to perform this function. Every wetland has a limited capacity to absorb nutrients and individual wetlands differ in their ability to do so.

Wetlands have been shown to be excellent removers of waste products from water. Sloey and others (1978) summarize the value of freshwater wetlands at removing nitrogen and phosphorus from the water and address management issues. They note that certain wetland plants are so efficient at this task that some artificial waste treatment systems are using these plants. For example, the Max Planck Institute of Germany has a patent to create such systems, where a bulrush (*Scirpus lacustris*) is the primary waste removal agent. Numerous 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). New Jersey's freshwater tidal wetlands may be valuable as tertiary treatment systems (Whigham and Simpson 1976). It must, however, be recognized that individual wetlands have a finite capacity for natural assimilation of excess nutrients and research is needed to determine this threshold (Good 1982).

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 discharge treated sewage into marsh waters. On a daily basis, it was shown that this marsh removes from flooding waters: 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.

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 3 miles of swamp, the river's water quality was 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). In New Jersey, Durand and Zimmer (1982) have demonstrated the capacity of Pine Barrens wetlands to assimilate excess nutrients from adjacent agricultural land and upland development

Wetlands also play a valuable role in reducing turbidity of flooding 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 absorbed nutrients, pesticides, heavy metals and other toxins which pollute our Nation's waters (Boto and Patrick 1979). Depressional wetlands should retain all of the sediment entering them (Novitski 1978). In Wisconsin, watersheds with 40% coverage by lakes and wetlands had 90% less sediment in water than watersheds with no lakes or wetlands (Hindall 1975). Creekbanks of salt marshes typically support more productive vegetation than the marsh interior. Deposition of silt is accentuated at the water-marsh interface, where vegetation slows the velocity of water causing sediment to drop out of solution. In addition to improving water quality, this process adds nutrients to the creekside marsh which leads to higher density and plant productivity (DeLaune, *et al.* 1978).

The U.S. Army Corps of Engineers has investigated the use of marsh vegetation to lower turbidity of dredged disposal runoff 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 Capobianca 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 heavy concentrations of heavy metals (e.g., 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 are among the most productive ecosystems in the world and some types of wetlands may be the highest, rivaling our best cornfields (Figure 37). Wetlands 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 seeds of marsh plants, especially in winter, while muskrat eat cattail tubers and young shoots.

Although direct grazing of wetland plants may be considerable in freshwater marshes, their major food value to most aquatic organisms is reached upon death when plants fragment to form "detritus." This detritus forms the base of an aquatic food web that supports higher consumers, e.g., commercial fishes. 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., anchovies, sticklebacks, killifishes, and silversides) 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 food web for New Jersey estuaries is presented as Figure 38. Thus, wetlands can be regarded as the farmlands of the aquatic environment where great volumes of food are produced annually. The majority of non-marine aquatic animals also depend, either directly or indirectly, on this food source.

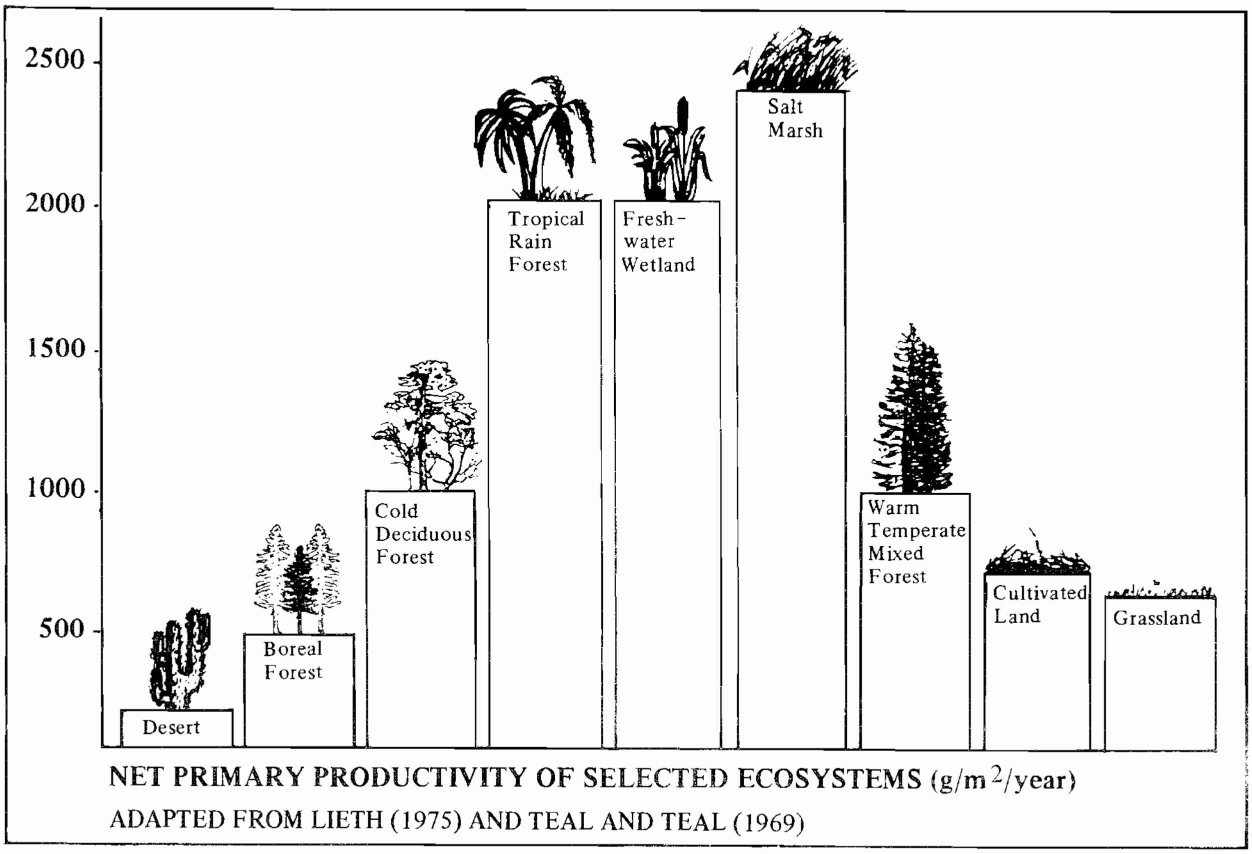

Figure 37. Relative productivity of wetland ecosystems in relation to other ecosystems (redrawn from Newton 1981). Salt marshes and freshwater wetlands are among the most productive ecosystems.

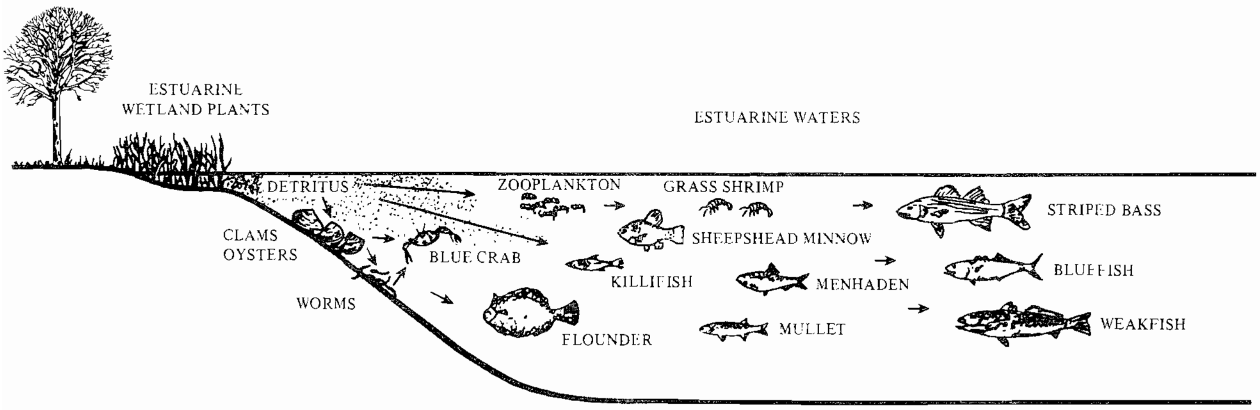

Figure 38. Simplified food pathways from estuarine wetland vegetation to commercial and recreational fishes of importance to humans.

Socio-economic Values

The more tangible benefits of wetlands to society may be considered socio-economic values and they include flood and storm damage protection, erosion control, water supply and ground-water recharge, 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, thereby protecting downstream property owners from flood damage. After all, such flooding has been the driving force in creating these wetlands to begin with. This flood storage function also helps to slow the velocity of water and lower wave heights, 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 a period of time and slowly release 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. Although Fusillo (1981) has demonstrated this situation for the Pine Barrens (Figure 40), it is more applicable to northern New Jersey where flooding problems are prevalent.

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 Administration reduce flood losses from urban land, 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 1970's, 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% 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

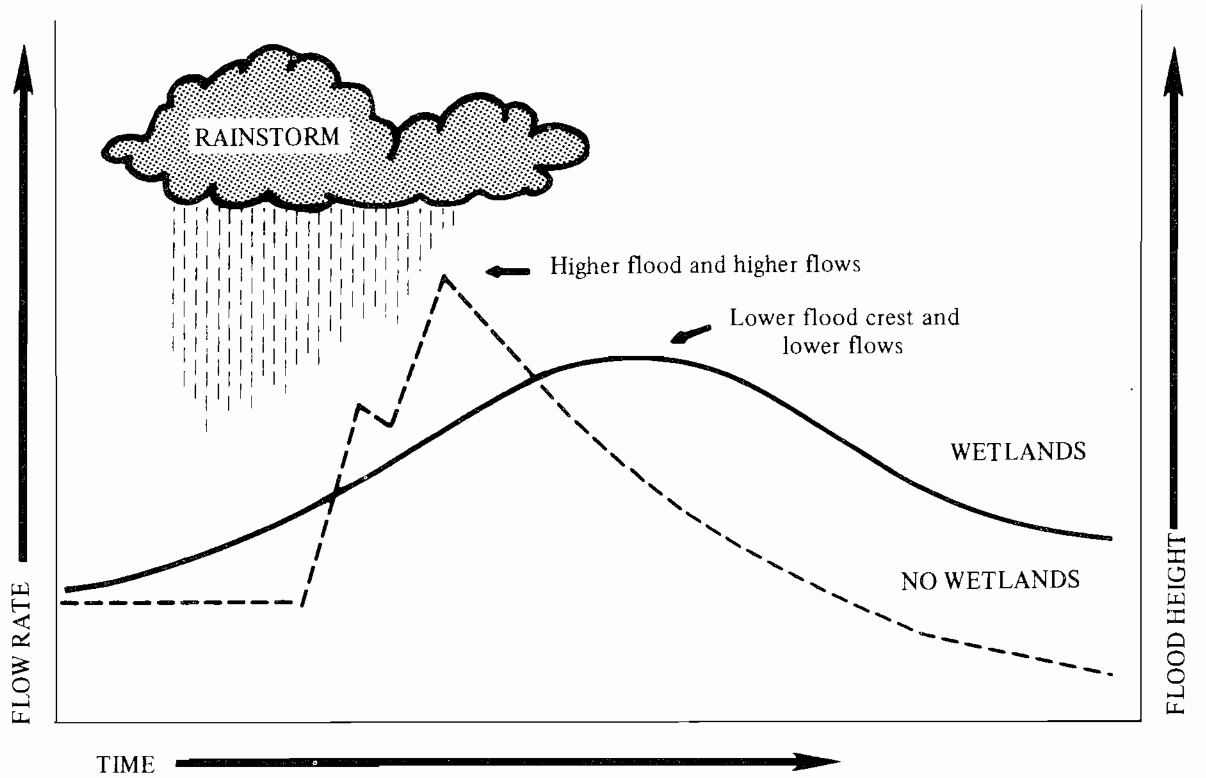

Figure 39. Wetland value in reducing flood crests and flow rates after rainstorms (adapted from Kusler 1983).

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 in the future (U.S. Army Corps of Engineers 1979). A Wisconsin study projected that floods may be lowered as much as 80% in watersheds with many wetlands compared with similar basins with little or no wetlands (Novitski 1978). Pothole wetlands in the Devils Lake basin of North Dakota store nearly 75% of the total runoff (Ludden, *et al.* 1983).

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

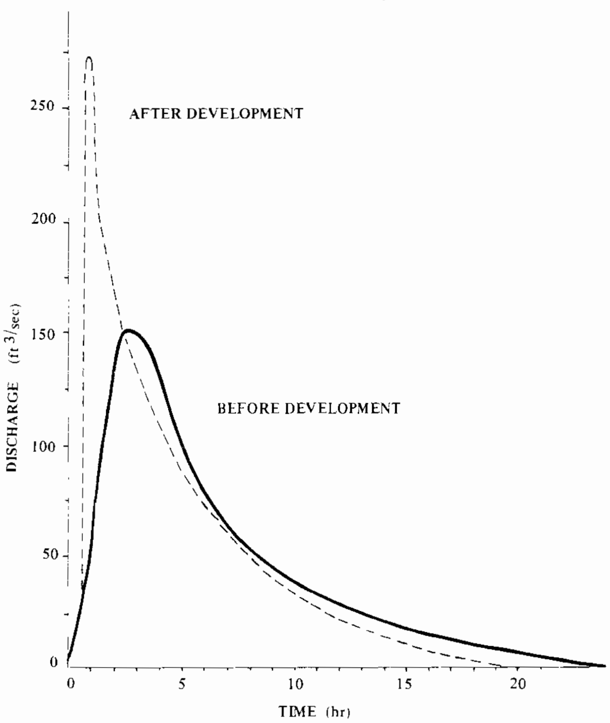

Figure 40. Urban development increases peak discharge in rivers. Comparison of unit hydrographs from a Pine Barrens subwatershed - before and after development (redrawn from Fusillo 1981).

North Dakota watershed (Malcolm 1978; Malcolm 1979). Even northern peat bogs reduce peak rates of streamflow from snow melt and heavy summer rains (Verry and Boelter 1979). Destruction of wetlands through floodplain 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 through binding with its 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 river banks. 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 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% of wetlands may be valuable potential sources of drinking water, since at least 60 municipalities have public wells in or very near wetlands (Motts and Heeley 1973). 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 New Jersey and other states and wetland protection could be instrumental in helping to solve current and future water supply problems.

Ground-water Recharge

There is considerable debate over the role of wetlands in ground-water recharge, i.e.,their 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. In general, most researchers believe that wetlands do not 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 Pine Barrens may contribute to ground-water recharge (Ballard 1979). Depressional 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). Floodplain 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 hayed in many places for winter livestock feed. During other seasons, livestock graze directly in many New Jersey wetlands. Along Delaware Bay, many New Jersey tidal marshes have been impounded for producing salt hay. These and other products are harvested for human use and provide a livelihood for many people.

In the 49 continental states, an estimated 82 million acres of commercial forested wetlands exist (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 in $8 billion. These southern forests have been harvested for over 200 years without noticeable degradation, thus they can be expected to produce timber for many years to come, unless converted to other uses. Atlantic white cedar is the most profitable timber product from New Jersey's wetlands, but cedar stands are decreasing (Little 1950).

Many wetland-dependent fishes and wildlife are also utilized by society. Commercial fishermen and trappers make a living from these resources. From 1956 to 1975, about 60% of the U.S. commercial landings were fishes and shellfishes 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, commercial fishing and shellfishing in New Jersey are valued at $217 million, $180 million, and $158 million, respectively (Bonsall 1977). Nationally, furs from beaver, muskrat, mink, nutria, and otter yielded roughly $35.5 million in 1976 (Demms and Pursley 1978). Louisiana is the largest fur-producing state and nearly all furs come from wetland animals. In New Jersey where muskrat dominates the harvest, furbearers produce an annual value of $3.5 million (Kantor 1977).

Many wetlands in southern New Jersey are cultivated to produce cranberries and highbush blueberries (Figure 41). Blueberry agriculture actually began in New Jersey at Whitesbog in 1916 and during the 1970's, the blueberry crop yielded a gross income of between $8-$14 million per year. Nationally, the State is second only to Michigan in blueberry production (P. Eck, pers. comm.). New Jersey also ranks third in the Nation in cranberry production which is valued at about $3.5 million annually (Applegate, *et al.* 1979). In addition, berries produced naturally in Pine Barrens and other wetlands in the State are harvested locally for personal consumption.

Although not as important in New Jersey as for some others states (e.g., 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

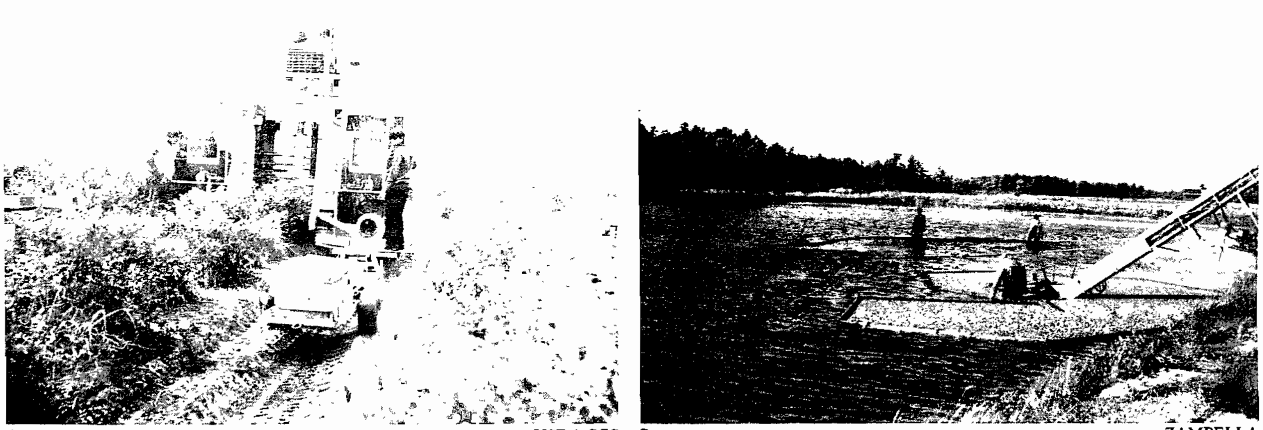

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Figure 41. Blueberries and cranberries are important natural products cultivated in wetlands: (a) blueberry harvest and (b) cranberry harvest.

Department of Commerce 1982). In 1982, an estimated 138,000 New Jersey residents purchased hunting licenses and they spent nearly 3 million person-days hunting wildlife (Snyder and Herrighty 1983). About 22% of these hunters participated in waterfowl hunting. Saltwater recreational fishing has increased dramatically over the past 20 years, with half of the catch represented by wetland-associated species. In 1979, nearly 1 million people, including 662,000 residents, fished in New Jersey's coastal waters. Estuarine-dependent fishes, i.e., fluke, bluefish, winter flounder and weakfish, were the most important species caught (N.J.D.E.P. 1982). Moreover, nearly all freshwater fishing is dependent on wetlands. In 1975 alone, sportfishermen 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 and 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 evaluate or place a dollar value upon. Nonetheless, it is a very important one because in 1980, 28.8 million people (17% of the U.S. population) took special trips to observe, photograph or feed wildlife. Moreover, about 47% 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 microorganism from 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 affected by present antibiotics (Moore 1981). This represents a significant medical discovery. If these wetlands were destroyed or grossly polluted, this discovery 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, therefore, in the public's best interest to protect wetlands to preserve these values for themselves and future generations. This is particularly important to a densely populated state like New Jersey where extensive wetlands have already been lost, making the remaining wetlands even more valuable as public resources.

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CHAPTER 8.

New Jersey Wetland Trends

Introduction

Although conservation-minded government agencies, private groups and individuals have recognized the importance of wetlands to fish and wildlife, New Jersey's wetlands have been largely viewed as natural lands best suited for conversion to other uses such as agriculture, industrial sites and residential housing. Many of the alternative uses require the physical destruction of wetlands and the public values they naturally provide. Other uses alter the character or quality of a wetland, but do not destroy all of its natural values. For example, diking of coastal marshes along Delaware Bay for salt hay production has disrupted their ecology and estuarine productivity, yet these wetlands still provide wildlife habitat and function as wetland in other ways. The following discussion addresses factors causing wetland changes and presents available information on the amount of wetland change in New Jersey. 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 actions. These forces interact to cause wetland gains and losses as well as to degrade and improve their quality. In general, the overall effect in New Jersey 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 New Jersey (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 waste 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, natural succession, the hydrologic cycle, sedimentation, 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 wetlands through permanent flooding. Along the New Jersey coastline, it is allowing estuarine wetlands to invade former forested wetlands. Natural succession and fire typically change the vegetation of a wetland, usually with no net loss or gain in wetland acreage. The hydrologic cycle represents the natural cycle of wet and dry periods over time. During dry periods, wetlands are particularly vulnerable to drainage and filling. Deposition of water-borne sediments along rivers and streams often leads to formation of new wetlands, while erosion removes wetland acreage. The activities of beavers create or alter wetlands by damming stream channels. Thus, natural forces act in a variety of ways to create, modify and destroy wetlands.

Human Actions

Human actions have a significant impact on wetlands. Unfortunately, many human activities are destructive to natural wetlands, either by converting them to agricultural or other lands or by degrading their quality. Key human impacts in New Jersey include drainage for agriculture;

channelization for flood control; filling for housing, highway, industry and sanitary landfills; dredging for navigation channels, harbors and marinas; reservoir construction; timber harvest; ground-water 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 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 New Jersey to improve their value to waterfowl. Wetland protection efforts, such as Federal and State wetland regulation 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 New Jersey'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.

Quantitative Changes

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

Drainage of wetlands for pasturage or crop production has altered many of the State's wetlands. Muckland farming (e.g., onions, cabbage and lettuce) in northern New Jersey and blueberry and cranberry cultivation in the Pine Barrens have been particularly significant uses of wetlands. Other important crops grown in drained wetlands include corn, soybeans, hay, small grains, summer vegetables and sod. Agricultural drainage has affected many types of wetlands, e.g., freshwater tidal marshes (Good, *et al* 1976; Ferrigno, *et al.* 1973), forested wetlands (McCormick 1970; Markley 1979), and freshwater marshes (Jervis 1963; Robichaud and Buell 1973). Counties experiencing significant wetland conversions to agriculture may include Atlantic, Burlington, Hunterdon, Mercer, Middlesex, Monmouth, Ocean, Somerset, Sussex and Warren. Agriculture has been abandoned in many drained wetlands and these areas have potential for wetland rehabilitation. Many areas are naturally reverting to woodland and whether they will become forested wetland depends on how permanent the drainage is and on restoration efforts. It is quite possible that many of these areas could once again become forested wetlands. In the future, agricultural impacts may be limited to abandoned farmed wetlands, although blueberry cultivation in the Pine Barrens may utilize additional wetland acreage.

Filling of wetlands is probably the greatest threat to New Jersey's wetlands. Many municipalities outside of the Pinelands Natural Reserve encourage wetland filling by zoning wetlands for residential, commercial or industrial development. Although filling has recently accelerated throughout the State, it is not a new threat to New Jersey wetlands. For example, in the late 1800's large tracts of the Hackensack Meadowlands were drained and then filled for railroad terminals and factories (Harshberger and Burns 1919). More recently, the Meadowlands have been partly filled for a sports complex and a section of the New Jersey Turnpike. At one point, filling in this area was occurring at a rate of 30,000 tons per week (Robichaud and Buell 1973). In general, filling of wetland for industrial and residential uses increased after World War II. Increasing population raised demand for land for housing and businesses particularly in northern New Jersey and along the Atlantic coast. Urbanization probably took its greatest toll of wetlands in coastal counties and Morris and Middlesex Counties since the 1950's. By contrast, northeastern counties, i.e., Bergen, Essex, Hudson, Passaic and Union, probably experienced heaviest losses prior to that time. Interstate highway development, such as Routes 80, 287, and 280, directly impacted many acres of wetlands by filling and by fragmenting large wetland complexes in northern New Jersey. This transportation network also spawned accelerated urban development of wetlands in affected areas. Significant wetland losses within the Passaic River Basin have been partly responsible for escalating flood damages (Figure 42). In the central basin alone, nearly half of the wetlands were destroyed between 1940 and 1978 (Photographic Interpretation Corporation 1978). During this period, Passaic County lost 14.5% of its wetland acreage to housing, reservoir construction, and industrial and commercial development (Tiner, *et al.* 1984).

Although the Pine Barrens generally have not experienced heavy urbanization like more northern areas, residential developments east of the Garden State Parkway are impacting wetlands (Andropogon Associates 1980). Lagoonal housing developments in estuarine wetlands often extend into adjacent hardwood swamps. In addition, scattered small-scale developments within the Pine Barrens are having an adverse impact on its wilderness quality. Fragmentation of large wetland complexes and other ecosystems jeopardizes wildlife populations dependent on these large areas. This situation has been occurring throughout New Jersey.

Other significant adverse direct impacts on wetlands include reservoir and recreational lake construction, and

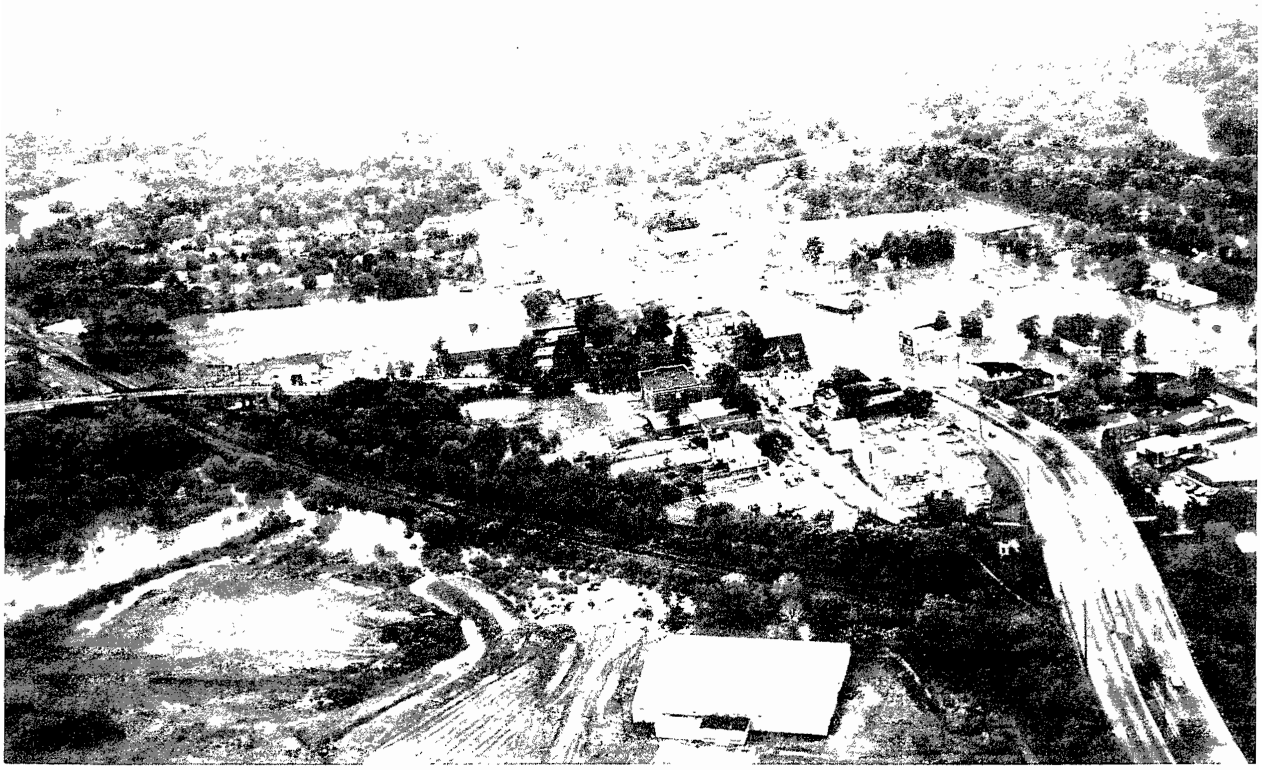

Figure 42. Increased urban development of wetlands has heightened flood damages, especially in northern New Jersey communities.

channel dredging and associated material disposal (e.g., Atlantic intracoastal waterway and Delaware River). Man-made lakes and reservoirs throughout the State have been created from wetlands and adjacent upland. Examples of former wetlands include Lake Mohawk and Steeny Kill Lake in northern New Jersey (Waksman, *et al.* 1943; Niering 1953). In southern areas, abandoned cranberry bogs have been cleared and flooded, creating residential lakes like Presidential Lakes, Lebanon Lakes, and Fawn Lake (McCormick 1970).

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 source) discharges such as urban and agricultural runoff.

Logging operations in forested wetlands in New Jersey may alter the character or plant composition of utilized wetlands. Historically, Atlantic white cedar swamps were the most extensive forested wetland type in the Pine Barrens, but recent logging practices have substantially reduced cedar acreage between 1970 and 1979 (N.J. Pinelands Commission 1980). Select or small-tract cutting practices have converted many cedar swamps to hardwood swamps.

Water pollution and disposal of hazardous and other wastes have degraded many wetlands. Urbanization has often increased sedimentation and nutrient levels in streams, thereby affecting wetland 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. Robichaud and Buell (1973) observed less plants growing along the polluted Whippany River than were found on the edge of Troy Brook in northern New Jersey. Ehrenfeld (1983) documented the loss of sensitive Pine Barrens plants in developed drainages in southern New Jersey. About 25% of the species observed in pristine areas disappeared in developed basins. Elevated hydrogen ion concentration (pH), resulting from increased nutrients, and increased flooding associated with urbanization were particular problems for these native species.

Coastal Wetland Losses

Coastal wetland losses were tremendous prior to the establishment of the Wetlands Act of 1970 which provided strong control of uses of tidal wetlands. Although most of the State's remaining tidal marshes are in the southern region, northern New Jersey once possessed vast acreages of estuarine marshes. These wetlands were probably the first of the coastal wetlands to be subjected to extensive filling. Their location within the New York City metropolitan area, proximity to harbor waters, and the relative ease of filling these wetlands made them especially vulnerable to development. As previously mentioned, large areas of the Hackensack Meadowlands were filled in the late 1800's. Available 1925 soil survey information for northern New Jersey (Lee, *et al.* 1925) identified 31,296 acres of tidal marsh. Approximately 50 years later, less than 8,000 acres remained, amounting to a loss of about 75% of these coastal wetlands. Extensive filling has eliminated most of northern New Jersey's estuarine marshes, especially in Newark, Elizabeth, and Jersey City.

More recently, development focused on coastal marshes in southern New Jersey. Between 1953 and 1973, nearly 25% of the State's tidal marshes were filled or diked, with heaviest losses in Cumberland, Ocean, Salem, Atlantic, and Cape May Counties (Table 26; Ferrigno, *et al.* 1973). Filling for houses, roads, industry and sanitary landfills had the greatest impact, resulting in a loss of 28,386 acres or 11% of the tidal marshes. Dredge and fill developments converted thousands of acres of coastal wetlands to finger canal residential areas (Figure 43). Examples of these developments can be found in Beach Haven West, Forked River, Tuckerton and elsewhere along large coastal bays and barrier islands. Filling of freshwater tidal wetlands along the Delaware River and other rivers has extirpated or seriously reduced populations of several plants (Ferren and Schuyler 1980). Since the early 1970's, coastal wetland losses have been greatly reduced by the Wetlands Act of 1970 and the Federal Clean Water Act. Prior to 1970, annual losses averaged 3,200 acres, but since then losses have been reduced to about 50 acres per year (JACA Corporation 1982).

Statewide Wetland Losses

Information on statewide wetland losses does not exist, although good data are available on coastal marsh losses (Ferrigno, *et al.* 1973). Shaw (1982) has reported losses and proposed developments for some of the larger wetlands in northern New Jersey, while Tiner and others (1984) identified wetland changes in Passaic County between 1940 and the mid-1970's. A comparison between the results of the National Wetlands Inventory (NWI) and the Soil Conservation Service's (SCS) soil surveys provides an interesting perspective on the State's wetland losses. Such comparison does, however, have limitations due to differences in mapping techniques, but it is nonetheless useful for showing trends.

Comparing the NWI data with the SCS data for hydric soils, a tremendous difference, amounting to a potential loss of 200,000 wetland acres, was detected. This figure equates to roughly 20% of the State's wetland resources. Moreover, the figure is probably conservative for at least two reasons: (1) Essex and Hudson Counties are not included in this number and (2) the soil surveys are relatively recent and do not reflect the original extent of hydric soils or wetlands. On a county basis, losses were even more startling. Twelve counties may have lost more than 25% of their wetlands (Table 27), with five losing

Table 26. Losses of tidal marshes between 1953 and 1973 (Ferrigno, *et al.* 1973). These figures include losses by filling and impoundment construction.

County	1953 Marsh Acreage	1973 Marsh Acreage	Marsh Acreage Lost	% Lost
Atlantic	48,141	43,157	4,984	10.4
Bergen	4,986	2,438	2,548	51.1
Burlington	8,980	8,428	552	6.1
Camden	553	29	257	46.5
Cape May	50,204	41,921	8,283	16.5
Cumberland	54,018	43,018	11,000	20.4
Essex	613	0	613	100.0
Gloucester	7,118	3,674	3,444	48.4
Hudson	4,171	1,623	2,548	61.1
Mercer	796	796	0	0.0
Middlesex	5,355	3,374	1,981	37.0
Monmouth	3,811	2,021	1,790	47.0
Ocean	37,007	26,078	10,929	29.5
Salem	34,877	24,549	10,328	29.6
Union	2,420	0	2,420	100.0

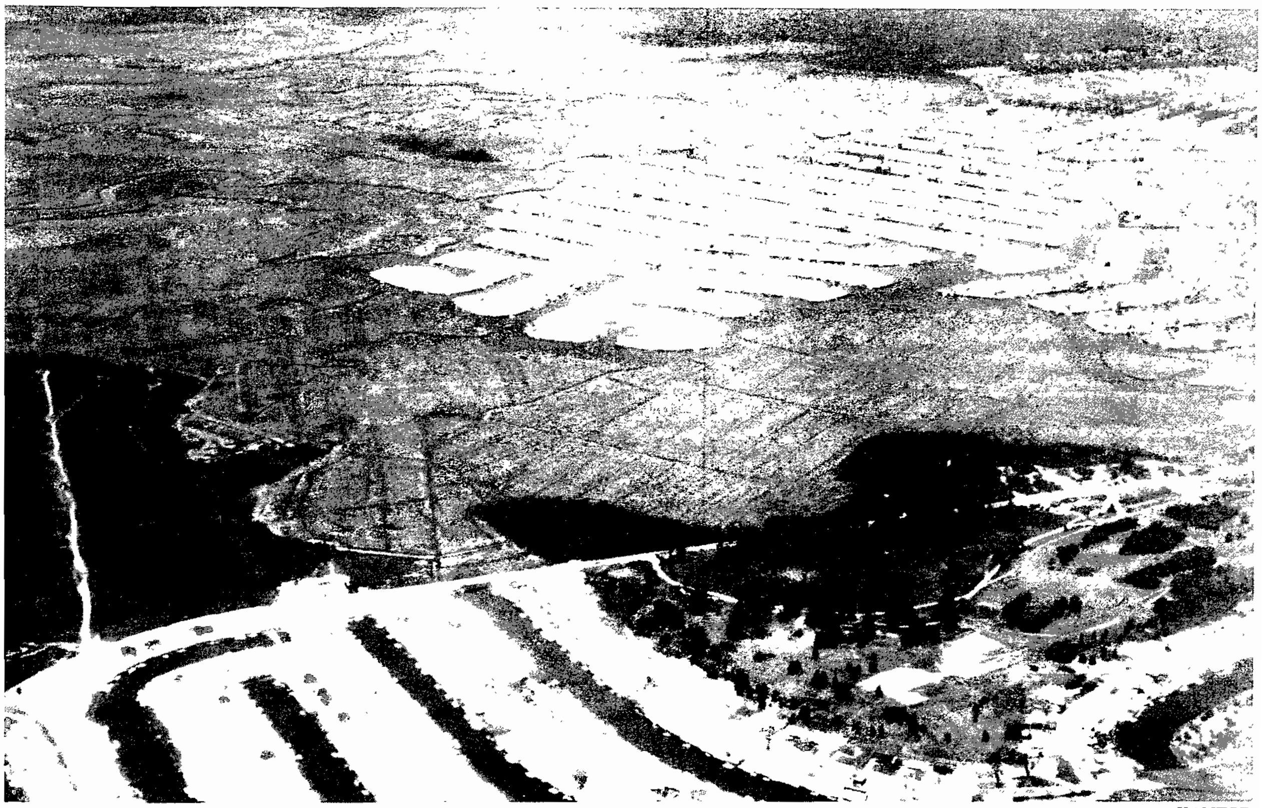

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Figure 43. Prior to the 1970's, many estuarine wetlands were filled for residential housing and other development. Since passage of the Wetlands Act in 1970, losses of tidal marshes have been greatly reduced.

Table 27. Comparison between NWI results and SCS hydric soil statistics for 19 counties in New Jersey, excluding Essex and Hudson Counties. Note: NWI statistics do not include flats, aquatic beds, open water, or beach/bars because such areas were not mapped as a soil type by SCS soil surveys.

County	SCS Hydric Soils (acres)	NWI Wetlands (acres)	Difference (acres)	Change
Atlantic	132,920	127,930	− 4,990	− 4%
Bergen	8,930	8,882	− 48	− 1%
Burlington	114,470	132,804	+ 18,334	+ 16%*
Camden	24,595	19,727	− 4,868	− 20%
Cape May	70,800	74,071	+ 3,271	+ 5%*
Cumberland	98,400	88,180	− 10,220	− 10%
Gloucester	45,420	33,569	− 11,851	− 26%
Hunterdon	15,650	4,537	− 11,113	− 71%
Mercer	25,883	11,291	− 14,592	− 56%
Middlesex	34,160	21,488	− 12,672	− 37%
Monmouth	56,290	24,676	− 31,614	− 56%
Morris	54,069	38,481	− 15,587	− 29%
Ocean	104,630	96,428	− 8,202	− 8%
Passaic	13,490	4,639	− 8,851	− 66%
Salem	77,760	56,140	− 21,620	− 28%
Somerset	15,109	10,558	− 4,551	− 30%
Sussex	67,670	28,764	− 38,906	− 57%
Union	3,530	2,627	− 903	− 26%
Warren	21,760	11,680	− 10,080	− 46%

* Increase in wetland highly unlikely, the positive difference is probably related to better resolution (increased detail) of NWI and not to a gain in wetland acreage.

more than half: Hunterdon, Passaic, Mercer, Sussex, and Monmouth. Comparative data suggest a 16% and 5% increase in wetland acreage for Burlington and Cape May Counties, respectively. The positive differences, however, probably reflect differences in mapping techniques (i.e., increased mapping resolution for the wetlands inventory), since there was no reason for such an increase. Despite limitations in comparing actual numbers of NWI findings with SCS statistics, significant wetland losses undoubtedly took place. Inland wetlands probably accounted for at least 80% of all losses, with coastal marshes representing the remainder.

Future Outlook

While substantial wetland losses have occurred, wetlands remain abundant, particularly in southern New Jersey. This may be related to the fact that population growth has focused on a few areas, i.e., New York metropolitan area, Camden, Trenton and more recently in Ocean County (Robichaud and Buell 1973). This growth pattern left many areas in a natural state.

Future losses in coastal wetlands and in inland wetlands of Pinelands should be significantly reduced through existing laws and regulations, i.e., Wetlands Act of 1970 and the Pinelands Comprehensive Management Plan (N.J. Pinelands Commission 1980). The Pinelands alone contain about half of the State's inland wetlands. The fate of the Hackensack Meadowlands lies in the hands of the Hackensack Meadowlands Development Commission, whose prime objective is promoting economic growth. The Commission's master plan includes filling 1,196 acres of Hackensack wetlands during the next 20 years (JACA Corporation 1982).

Many uses of inland wetlands outside of these areas are regulated by the U.S. Army Corps of Engineers through the Clean Water Act of 1977 or in rare instances by local municipalities through wetland protection ordinances. Yet, many inland wetlands outside of the Pinelands are not receiving adequate protection (Figure 44). A bill to regulate uses of these freshwater wetlands has been introduced into the State legislature in 1983 and 1984. If this bill or a similar version is passed, tools to better manage New Jersey's inland wetlands will be in place. If not, then wetland filling can be expected to continue, with numerous northern New Jersey wetlands destroyed within the next 10 years. Proposed developments already have been planned for all or part of Lee Meadows, Bog and Vly Meadows, Long Meadows, Black Meadows and numerous other wetlands (Shaw 1982).

Water quality problems will also continue to affect the quality of 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 New Jersey's waterways, urban and agricultural runoff (non-point sources) continues to degrade water quality. Soil erosion from upland development causes sedimentation and water quality problems for streams and adjacent wetlands. Perhaps establishing a buffer zone around wetlands would help better maintain the ecological integrity of the State's waters and wetlands. Roman and Good (1983) have proposed a buffer zone delineation model to accomplish this in the Pinelands and the buffer zone concept has been incorporated into the State's freshwater wetlands protection bill.

USDA SCS

Figure 44. Many freshwater wetlands remain vulnerable to development pressures.

Summary

Available information on wetland trends for the State suggest that New Jersey may have lost at least 20% of its wetland resources since the mid-1900's. While agriculture may have played the primary role in wetland alteration in in the distant past, the most significant recent cause is urbanization. Filling wetlands for houses, industry, and business offices has been accelerating since the 1950's. The Wetlands Act of 1970 in combination with the Federal regulations under Section 10 of the River and Harbor Act and Section 404 of the Clean Water Act have served to protect coastal wetlands, yet inland wetland losses have continued despite Federal jurisdiction (see following chapter for further discussion). In order to protect inland wetlands (outside of the Pinelands) and their public values, new initiatives must be taken. Strengthened Federal regulations and a New Jersey bill to regulate uses of these wetlands are first steps toward accomplishing this goal.

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CHAPTER 9.

Wetland Protection

Introduction

A variety of techniques are available to protect our remaining wetlands, including 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**. Tabachnik (1980) specifically addresses protection of New Jersey's inland wetlands. Opportunities also exist for private initiatives by individual landowners, groups, and corporations to help in conserving our Nation's wetlands. Private options for land preservation are reviewed by Rusmore and others (1982).

Wetland Regulation

Several Federal and State laws regulate certain uses of many New Jersey wetlands. The more significant ones include the River and Harbor Act of 1899 and the Clean Water Act of 1977 at the Federal level. At the State level, the Wetlands Act of 1970, the Waterfront Development Law of 1914, the Coastal Area Facility Review Act of 1973, the Pinelands Protection Act of 1979 and the Flood Hazard Area Control Act of 1979 all contribute to wetland protection. 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 laws are outlined in Table 28.

The foundation of Federal wetland regulation is Section 10 of the River and Harbor Act and Section 404 of the Clean Water Act. Federal permits for many types of construction in wetlands are required from the U.S. Army Corps of Engineers, but normal agricultural and silvicultural activities are exempt from permit requirements. The Service plays an active role in the permit process by reviewing permit applications and making recommendations based on environmental considerations, under authority of the Fish and Wildlife Coordination Act. Although the Federal laws in combination apply to virtually all of the State's wetlands, the U.S. Army Corps of Engineers' 1982 regulations for Section 404 of the Clean Water Act reduced its effectiveness for protecting wetlands. In particular, the widespread use of "nationwide permits" and the lack of strong enforcement were major weak points (U.S. Fish and Wildlife Service 1984). Under the nationwide permit system, there is no required reporting or monitoring system, consequently there is no record of wetland loss and no effort to promote environmental or other public interest concerns. In New Jersey, many wetlands lie above designated headwaters or exist in isolated basins and were, therefore, not protected under the 1982 regulations. Numerous lawsuits were filed nationwide against the Corps by concerned environmental organizations over the 1982 regulatory changes. Under a recent out-of-court settlement agreement (National Wildlife Federation v. Marsh), the Corps issued new regulations in October 1984 requiring closer Federal and State review of proposals to fill wetlands. Implementation of these new regulations needs to be monitored to assess their effectiveness of protecting wetlands.

State laws have generally worked well to protect wetlands in certain areas of the State, especially in tidal waters and the Pinelands (Figure 45). Since its passage in 1970, the Wetlands Act has reduced annual losses of tidal wetlands from about 3,200 acres to about 50 acres (JACA Corporation 1982). Approximately 3,800 acres of tidal wetlands in northern New Jersey are regulated under the Waterfront Development Act (M. Hochman, pers. comm.). The Coastal Area Facility Review Act protects wetlands in the designated coastal zone from large facilities such as housing developments of 25 or more units. Approximately 300,000 acres of freshwater wetlands are regulated through the Pinelands Comprehensive Management Plan. The Flood Hazard Area Control Act has a high potential for protecting wetlands from residential and commercial developments. Presently, increased attention is given in project reviews to environmental and flood storage values of wetlands. The real test of this Act's effectiveness will be seen in the future.

In addition to these major laws, other governmental authorities have a role in wetland protection. The Hackensack Meadowlands Development Commission controls the use of approximately 5,000 acres of wetland in Hudson and Bergen Counties. The Delaware River Basin Commission has authority over wetlands generally 25 acres or greater in size within the Basin. A comprehensive plan for water resources development and uses has been prepared which specifies an environmental impact statement requirement for wetland alterations in these areas and a public interest determination. The N.J. Department of Environmental Protection has a number of policies and programs that help conserve wetlands besides the regulatory programs mentioned. One of particular importance is the 201 Water Quality Construction Grants Program. This program has recently become quite effective at deterring construction of houses and other buildings in wetlands. Proposed developments are not approved to tie into existing Federally-financed sewer lines if wetlands are adversely impacted.

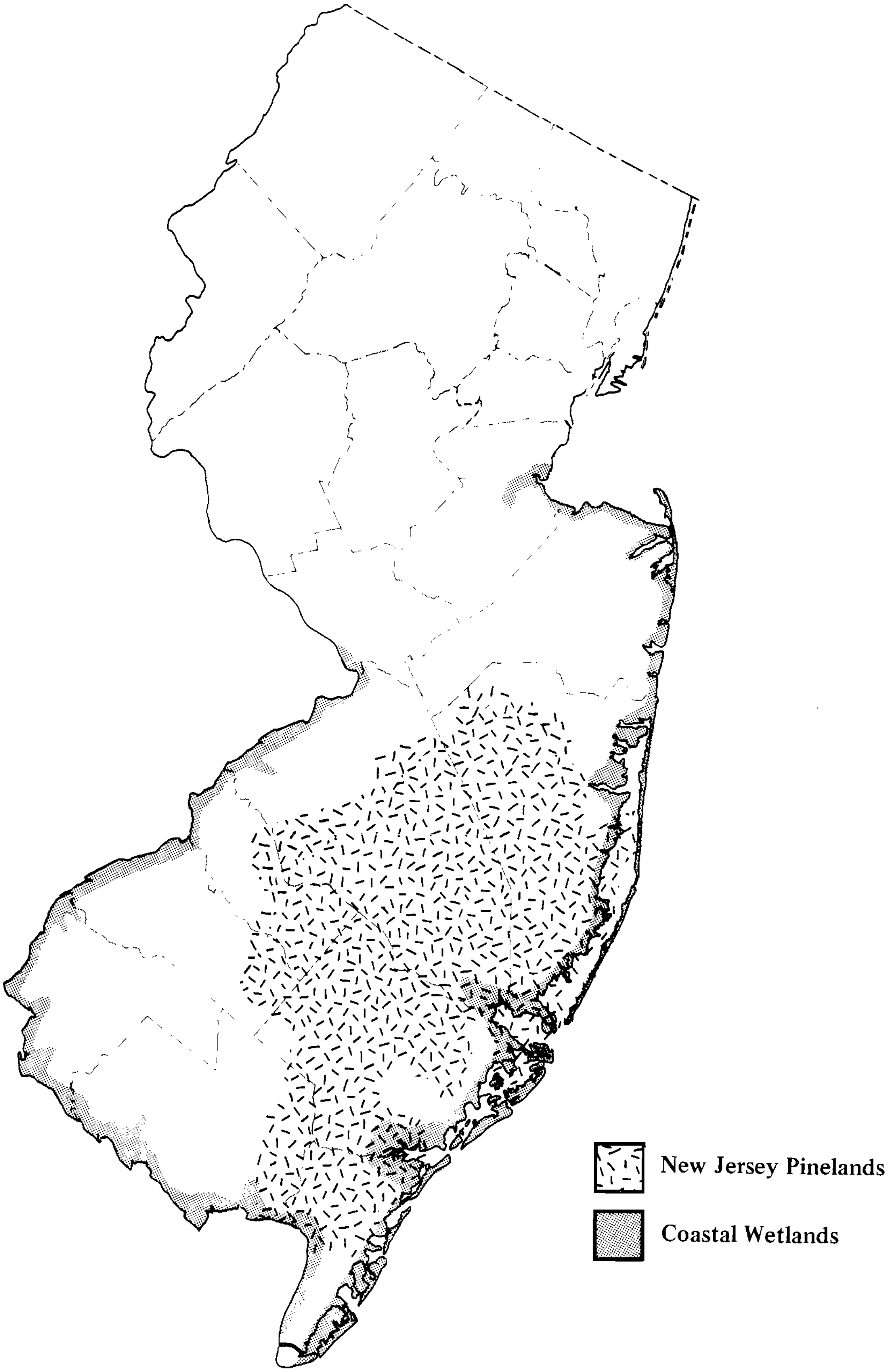

Figure 45. General extent of major State wetland protection efforts. Coastal wetlands are protected under the Wetlands Act of 1970, while wetlands within the Pinelands are regulated through the Pinelands Comprehensive Management Plan.

Table 28. Summary of primary Federal and State laws relating to wetlands protection in New Jersey.

Name of Law	Administering Agency	Types of Wetlands Regulated	Regulated Activities
River and Harbor Act of 1899 (Section 10)	U.S. Army Corps of Engineers	Tidal wetlands below the mean high water mark; nontidal wetlands below the ordinary high water mark	Structures and/or work in or affecting navigable waters of the U.S., including dredging and filling
Clean Water 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 considered all waters of the U.S.	Discharge of dredged or fill material
Wetlands Act of 1970	N.J. Department of Environmental Protection	Coastal wetlands, excluding those within jurisdiction of Hackensack Meadowlands Development Commission (must appear on filed wetlands maps)	Draining, dredging, excavation or removal of materials; depositing, dumping or discharging of materials; erection of structures, or placing of obstructions
Coastal Area Facility Review Act of 1973	N.J. Department of Environmental Protection	Wetlands within the defined coastal region and where major facilities are proposed	Construction of designated "facilities" for the following purposes: electric power generation, food and food byproduct, waste incineration, paper production, public facilities and housing developments (25 or more units), agrichemical production, inorganic acids and salt manufacture, mineral products, chemical processes, storage, metallurgial processes and miscellaneous purposes (specified in the law)
Pinelands Protection Act of 1979	N.J. Pinelands Commission or municipal and county governments (upon certification of master plan and land use ordinances)	All wetlands (coastal and inland) and submerged lands within the designated Pinelands	All development in wetlands is prohibited, except as specified in Part 1 - Wetlands - of the Pinelands Comprehensive Management Plan
Waterfront Development Law of 1914	N.J. Department of Environmental Protection	Current or former tidal wetlands north of the Raritan Basin, (excluding the Meadowlands District) and all coastal wetlands in the Delaware and Raritan River Basins not regulated by the Wetlands Act	Dredging; erection of structures; landfills
Flood Hazard Control Act of 1979	N.J. Department of Environmental Protection	Wetlands within designated floodways and flood fringe	Construction, rebuilding or repair of structure or alteration within 100 yr. floodplain

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 the Fish and Wildlife Coordination Act.
Normal farming, silviculture, and ranching activities (including minor drainage); maintenance of existing structures; construction or maintenance of farm ponds, irrigation ditches or maintenance of irrigation ditches; construction of temporary sedimentation basins; construction or maintenance of farm roads, forest 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 State wildlife agency review proposed work for environmental impacts by authority of the Fish and Wildlife Coordination Act. Permits cannot be 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 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.
Continuance of commercial production of salt hay or agricultural crops; activities authorized by Dept. of Environmental Protection, Natural Resource Council, Mosquito Control Commission, Dept. of Health, or any mosquito control or other project authorized by provisions of Chap. 9 Title 26 of the Revised Statutes	Regulated wetlands are mapped. These regulations do not pertain to the Hackensack Meadowlands. DEP issues wetland order to establish wetland protection in each county.
Projects not meeting the definition of "facility"	Relates only to major facilities or developments within the defined coastal area. Requires preparation of an environmental impact statement. DEP must prepare an inventory of environmental resources in the coastal area, develop management strategies and select an appropriate environmental design.
Horticulture of native species and berry agriculture; beekeeping; forestry (subject to forestry requirements); fish and wildlife management (provided no significant adverse impact); hunting, fishing, trapping, hiking, boating, swimming or similar recreational uses; private docks, piers, moorings and boat launches (demonstrated need, no significant impact, conforms w/all State and Fed. regs); bridges, roads, trails and utility transmission/distribution facilities (subject to specified conditions)	Public hearings held prior to finalizing master plans and land use ordinances. Landowners must request approval for developments in or within 300′ of wetlands from Pinelands Commission, unless local authority is certified.
Construction of single family dwelling beyond 100′ from mean high water line; expansion of existing structure beyond 100′ from MHW line; minor changes in existing structures; navigation dredging, installation of aids to navigation, etc. by the U.S. government	Regulations amended in 1980; extends jurisdictions to adjacent upland areas within 500′ of the waterway.
Recreation, agriculture, soil conservation projects or similar uses that do not obstruct or intensify flooding	Prohibits: dumping solid wastes, processing, storage and disposal of pesticides, domestic, industrial or other hazardous waste materials; storage of materials and equipment; construction of individual septic systems; erection of structures for humans, livestock or other animals.

Recently, there has been much public concern over inland wetland losses, especially in northern New Jersey. Approximately 300,000 acres of freshwater wetlands remain largely unprotected by State laws and Federal regulation does not adequately protect these wetlands. Consequently, State legislators have submitted a bill which expands county government's authority to regulate inland wetlands.If this bill or a similar version is passed, the tools will be available to better manage and protect the State's freshwater wetlands.

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 and private environmental organizations, but the majority are privately-owned.

The Service's National Wildlife Refuge (NWR) System was established to preserve important migratory bird wetlands at strategic locations across the country. Three National Wildlife Refuges (NWR) are located in New Jersey: Great Swamp NWR (3,088 wetland acres), Forsythe NWR (Brigantine Division - 18,026 wetland acres; Barnegat Division - 9,271 wetland acres), and Supawna Meadows NWR (1,390 wetland acres). Great Swamp NWR contains only freshwater wetlands (Figure 46), while the others are nearly all estuarine marshes. Military reservations like Fort Dix, Lakehurst and Picatinny Arsenal also encompass considerable wetland acreage. The U.S. Army Corps of Engineers, New York District is considering acquisition of numerous wetlands in the Passaic River Basin for flood protection.

The State of New Jersey possesses much more wetland acreage than the Federal government. Its wildlife management areas, State parks and State forests contain

Figure 46. Great Swamp National Wildlife Refuge near Basking Ridge is part of one of the largest wetland complexes in northern New Jersey.

numerous wetlands, ponds, lakes, and streams. The N.J. Department of Environmental Protection is actively acquiring wetlands in the Pinelands National Reserve, using Federal and State funds. Acquisition efforts have focused on several watersheds including Cedar Creek, Oswego River, and Bass River. The Comprehensive Management Plan for the Pinelands recommends acquisition of 100,000 acres of land (i.e., upland and wetland). Through the Green Acres Program, additional wetland and upland habitats are acquired for conservation and recreation purposes. This program also permits acquisition of conservation easements. County and municipal parks may hold wetlands in public ownership as well.

Future Actions

Many opportunities are available to both government and the private sector to halt or slow wetland losses and enhance the quality of the remaining wetlands. Their joint efforts will determine the future course of our Nation's wetlands. Major options have been outlined below. For a more detailed discussion, the reader is referred to Kusler (1978; 1983), Tabachnick (1980), 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 staffing, surveillance and enforcement.

4. Increase wetland acquisition in selected areas.

5. Remove government subsidies that encourage wetland drainage.

6. Provide tax and other incentives to private landowners and industry to encourage wetland preservation and remove existing tax benefits that encourage wetland destruction.

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

8. Improve wetland management on publicly owned lands.

9. Increase the number of marsh creation and restoration projects, especially related to mitigation for unavoidable wetland losses by government-sponsored water resource projects. This should include enhancing existing wetlands by improving local water quality and providing buffer zones.

10. Monitor wetland changes especially with reference to effectiveness of State and Federal wetland protection efforts and periodically update the National Wetlands Inventory in problem areas.

11. Increase public awareness of wetland values and the status of wetlands through 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 ecology and public values.

Private Options:

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

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

3. Maintain wetlands as open space.

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

5. Construct ponds in uplands and manage for wetland and aquatic species.

6. Purchase Federal duck stamps to support wetland acquisition.

Robichaud and Buell (1973) raised four basic questions that 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 New Jersey's wetlands as well as its other natural resources. 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 various land uses. For example, they must understand that filling and development of wetlands and floodplains leads directly to downstream flooding problems and to other losses like fish and wildlife habitat. Public education is, therefore, vital to protecting wetlands. Private nonprofit organizations like the Association of New Jersey Environmental Commissions, American Littoral Society, N.J. Conservation Foundation, N.J. Audubon Society 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. Private corporations are often in a position to work with private nonprofit conservation organizations and government agencies to protect 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 Forsythe National Wildlife Refuge's Barnegat Division. The area will be managed by the Service for migratory birds.This is an excellent example of private and public cooperation to achieve wetland protection goals. Perhaps, private corporations in the State will now follow the AT&T example and begin to seriously consider donating wetland holdings to public agencies or nonprofit environmental organizations for conservation purposes. In New Jersey, competition for wetlands is particularly intense between developers and environmental organizations. Ways must 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 New Jersey Wetland Plants.

List of plants occurring in New Jersey's wetlands. Scientific names conform with the **National List of Scientific Plant Names** (U.S.D.A. Soil Conservation Service 1982). Although this list is comprehensive, it is not exhaustive, yet the majority of plants occurring in wetlands are listed. Sources used to compile this list are cited.

Scientific Name	Plant Common Name
Lycopodiaceae	
Lycopodium alopecuroides	Clubmoss
Lycopodium carolinianum	Clubmoss
Lycopodium inundatum	Clubmoss
Lycopodium obscurum	Ground-Pine
Selaginellaceae	
Selaginella apoda	Spikemoss
Isoetales	
Isoetes echinospora	Quillwort
Isoetes riparia	Quillwort
Equisetaceae	
Equisetum arvense	Horsetail
Equisetum fluviatile	Horsetail
Equisetum hyemale	Horsetail
Equisetum palustre	Horsetail
Ophioglossaceae	
Botrychium dissectum	Grape Fern
Botrychium virginianum	Grape Fern
Osmundaceae	
Osmunda cinnamomea	Cinnamon Fern
Osmunda claytoniana	Interrupted Fern
Osmunda regalis	Royal Fern
Schizaeaceae	
Schizaea pusilla	Curly Grass Fern
Polypodiaceae	
Pteridium aquilinum	Bracken Fern
Adiantum pedatum	Maidenhair Fern
Matteuccia struthiopteris	Ostrich Fern
Onoclea sensibilis	Sensitive Fern
Woodwardia areolata	Netted Chain Fern
Woodwardia virginica	Virginia Chain Fern
Athyrium filix-femina	Lady Fern
Thelypteris noveboracensis	New York Fern
Thelypteris simulata	Massachusetts Fern
Thelypteris thelypteroides	Marsh Fern
Dryopteris cristata	Crested Shield Fern
Dryopteris marginalis	Marginal Shield Fern
Dryopteris spinulosa	Spinulose Shield Fern
Polystichum acrostichoides	Christmas Fern
Salviniaceae	
Azolla caroliniana	Mosquito Fern
Pinaceae	
Picea mariana	Black Spruce
Tsuga canadensis	Hemlock
Larix laricina	Larch
Pinus rigida	Pitch Pine
Pinus strobus	White Pine
Pinus taeda	Loblolly Pine
Cupressaceae	
Chamaecyparis thyoides	Atlantic White Cedar
Juniperus virginiana	Red Cedar
Typhaceae	
Typha angustifolia	Narrow-leaved Cattail
Typha latifolia	Broad-leaved Cattail
Sparganiaceae	
Sparganium americanum	Eastern Burreed
Sparganium androcladum	Branching Burreed
Sparganium chlorocarpum	Green-fruit Burreed
Sparganium eurycarpum	Giant Burreed
Sparganium minimum	Small Burreed
Potamogetonaceae	
Potamogeton amphlifolius	Pondweed
Potamogeton confervoides	Tuckerman's Pondweed
Potamogeton crispus	Curly Pondweed
Potamogeton diversifolius	Waterthread Pondweed
Potamogeton epihydrus	Ribbonleaf Pondweed
Potamogeton foliosus	Leafy Pondweed
Potamogeton natans	Floatingleaf Pondweed
Potamogeton nodosus	Longleaf Pondweed
Potamogeton obtusifolius	Bluntleaf Pondweed
Potamogeton pectinatus	Sago Pondweed
Potamogeton perfoliatus	Thorowort Pondweed
Potamogeton pusillus	Baby Pondweed
Potamogeton robbinsii	Robbins Pondweed
Potamogeton strictifolius	Narrowleaf Pondweed
Ruppia maritima	Widgeon Grass
Zannichellia palustris	Horned Pondweed
Zostera marina	Eelgrass
Najadaceae	
Najas flexilis	Naiad
Najas gracillima	Naiad
Najas guadalupensis	Naiad
Alismataceae	
Alisma plantago-aquatica	Common Waterplantain
Alisma subcordatum	Subcordate Waterplantain
Sagittaria calycina	Hooded Arrowhead
Sagittaria engelmanniana	Engelmann Arrowhead
Sagittaria graminea	Grassy Arrowhead

Scientific Name	Plant Common Name
Sagittaria isoetiformis	Arrowhead
Sagittaria latifolia	Broadleaf Arrowhead
Sagittaria rigida	Bur Arrowhead
Sagittaria subulata	Owlleaf Arrowhead
Hydrocharitaceae	
Elodea canadensis	Waterweed
Elodea nuttallii	Waterweed
Vallisneria americana	Wild Celery
Gramineae	
Puccinellia pallida	Pale Manna Grass
Glyceria canadensis	Rattlesnake Manna Grass
Glyceria obtusa	Blunt Manna Grass
Glyceria septentrionalis	Eastern Manna Grass
Glyceria striata	Fowl Manna Grass
Poa palustris	Meadow Grass
Poa pratensis	Kentucky Bluegrass
Poa trivialis	Meadow Grass
Distichlis spicata	Spike Grass
Chasmanthium laxum	
Dactylis glomerata	Orchard Grass
Phragmites australis	Common Reed
Agropyron repens	Wheat Grass
Elymus virginicus	Wild Rye
Holcus lanatus	Velvet Grass
Danthonia sericea v. epilis	Wild Oat Grass
Calamagrostis canadensis	Bluejoint
Calamagrostis cinnoides	Hairyseed Reedgrass
Agrostis alba	Redtop
Agrostis scabra	Rough Bent Grass
Cinna arundinacea	Wood Reedgrass
Alopecurus pratensis	Meadow Foxtail
Phleum pratense	Timothy
Muhlenbergia sylvatica	Woodland Muhly
Muhlenbergia torreyana	New Jersey Muhly
Spartina alterniflora	Smooth Cordgrass
Spartina cynosuroides	Big Cordgrass
Spartina patens	Salt Hay Grass
Spartina pectinata	Slough Grass
Anthoxanthum odoratum	Sweet Vernal Grass
Phalaris arundinacea	Reed Canary Grass
Leersia oryzoides	Rice Cutgrass
Leersia virginica	White Grass
Zizania aquatica	Wild Rice
Digitaria sanguinalis	Finger Grass
Paspalum laeve	Field Paspalum
Panicum agrostoides	Panic Grass
Panicum amarum	Beach Panic Grass
Panicum dichotomiflorum	Fall Panicum
Panicum longifolium	Longleaf Panicum
Panicum verrucosum	Warty Panicum
Panicum virgatum	Switchgrass
Dichanthelium acicularae	Needle Panicum
Dichanthelium acuminatum	Pacific Panicum
Dichanthelium clandestinum	Deertongue
Dichanthelium dichotonum	Forked Panicum
Dichanthelium latifolium	Broad-leaved Panicum
Dichanthelium oligosanthes	Scribner Panicum
Dichanthelium scoparium	Velvet Panicum
Echinochloa crusgalli	Barnyard Grass
Echinochloa muricata	Barnyard Grass
Echinochloa walteri	Walter's Millet

Scientific Name	Plant Common Name
Setaria geniculata	Foxtail Grass
Setaria glauca	Yellow Foxtail Grass
Cenchrus tribuloides	Sandspur
Andropogon gerardii	Big Bluestem
Andropogon virginicus v. abbreviatus	Lowland Broomsedge
Schizachyrium scoparium	Little Bluestem
Sorghastrum nutans	Indian Grass
Coelorachis rugosa	Joint Grass
Cyperaceae	
Cyperus dentatus	Toothleaf Flatsedge
Cyperus erythrorhizos	Redroot Cyperus
Cyperus filicinus	Nuttall's Cyperus
Cyperus filiculmis	Slender Cyperus
Cyperus odoratus	Fragrant Flatsedge
Cyperus ovularis	Pine Barren Cyperus
Cyperus polystachyos	Many-spiked Flatsedge
Cyperus retrofractus	Rough Cyperus
Cyperus retrorsus	Cylinder Flatsedge
Cyperus rivularis	Nutgrass
Cyperus strigosus	Straw-colored Cyperus
Dulichium arundinaceum	Three-way Sedge
Eleocharis acicularis	Slender Spikerush
Eleocharis engelmanni	Engelmann's Spikerush
Eleocharis erythropoda	Creeping Spikerush
Eleocharis fallax	Creeping Spikerush
Eleocharis microcarpa	Torrey's Spikerush
Eleocharis obtusa	Blunt Spikerush
Eleocharis olivacea	Spikerush
Eleocharis ovata	Ovate Spikerush
Eleocharis palustris	Common Spikerush
Eleocharis parvula	Dwarf Spikerush
Eleocharis quadrangulata	Squarestem Spikerush
Eleocharis robbinsii	Trianglestem Spikerush
Eleocharis rostellata	Beaked Spikerush
Eleocharis smallii	Small's Spikerush
Eleocharis tenuis	Slender Spikerush
Eleocharis tricostata	Three-ribbed Spikerush
Eleocharis tuberculosa	Large Tubercled Spikerush
Fimbristylis castanea	Salt Marsh Fimbristylis
Fimbristylis autumnalis	Slender Fimbristylis
Scirpus acutus	Hardstem Bulrush
Scirpus americanus	Olney Three-square
Scirpus atrocinctus	Bulrush
Scirpus atrovirens	Green Bulrush
Scirpus cylindricus	Swamp Bulrush
Scirpus cyperinus	Woolgrass
Scirpus fluviatilis	River Bulrush
Scirpus maritimus	Salt Marsh Bulrush
Scirpus microcarpus	Panicled Bulrush
Scirpus peckii	Peck's Bulrush
Scirpus pungens	Common Three-square
Scirpus purshianus	Weak Bulrush
Scirpus robustus	Salt Marsh Bulrush
Scirpus smithii	Bluntscale Bulrush
Scirpus subterminalis	Water Bulrush
Scirpus validus	Soft-stemmed Bulrush
Eriophorum tenellum	Cottongrass
Eriophorum virginicum	Virginia Cottongrass
Fuirena pumila	Umbrella-sedge
Fuirena squarrosa	Hairy Umbrella-sedge
Rhynchospora alba	White Beakrush

Scientific Name	Plant Common Name
Rhynchospora capitellata	False Bog Rush
Rhynchospora cephalantha	Capitate Beakrush
Rhynchospora chalarocephala	Loose-headed Beakrush
Rhynchospora filifolia	Bristle-leaved Beakrush
Rhynchospora fusca	Brown Beakrush
Rhynchospora glomerata	Clustered Beakrush
Rhynchospora gracilenta	Slender Beakrush
Rhynchospora macrostachya	Horned Rush
Rhynchospora microcephala	Small-headed Beakrush
Rhynchospora oligantha	Few-flowered Beakrush
Rhynchospora pallida	Pale Beakrush
Rhynchospora torreyana	Torrey's Beakrush
Cladium mariscoides	Twigrush
Scleria minor	Slender Nutrush
Scleria reticularis	Netted Razorsedge
Scleria triglomerata	Whip-grass
Scleria verticillata	Low Nutgrass
Carex alata	Wingseed Sedge
Carex albolutescens	Sedge
Carex amphibola	Sedge
Carex annectens	Sedge
Carex barrattii	Sedge
Carex bullata	Bullsedge
Carex buxbaumii	Buxbaum Sedge
Carex canescens	Silvery Sedge
Carex collinsii	Sedge
Carex comosa	Longhair Sedge
Carex exilis	Coast Sedge
Carex flaccosperma	Sedge
Carex hormathodes	Sedge
Carex howei	Howe Sedge
Carex hystricina	Bottlebrush Sedge
Carex interior	Inland Sedge
Carex intumescens	Sedge
Carex lacustris	River Sedge
Carex lanuginosa	Wooly Sedge
Carex livida	Livid Sedge
Carex lonchocarpa	Sedge
Carex lupuliformis	Hoplike Sedge
Carex lupulina	Hop Sedge
Carex normalis	Sedge
Carex paupercula	Little Sedge
Carex rostrata	Beaked Sedge
Carex scoparia	Broom Sedge
Carex squarrosa	Sedge
Carex stipata	Sawbeak Sedge
Carex straminea	Sedge
Carex stricta	Tussock Sedge
Carex trisperma	Threeseeded Sedge
Carex typhina	Sedge
Carex venusta	Sedge
Carex vesicaria	Inflated Sedge
Carex vulpinoidea	Fox Sedge
Carex walteriana	Sedge
Araceae	
Arisaema dracontium	Jack-in-the-pulpit
Arisaema triphyllum	Jack-in-the-pulpit
Peltandra virginica	Arrow Arum
Symplocarpus foetidus	Skunk Cabbage
Calla palustris	Wild Calla
Acorus calamus	Sweet Flag
Orontium aquaticum	Golden Club

Scientific Name	Plant Common Name
Lemnaceae	
Spirodela polyrhiza	Big Duckweed
Lemna minor	Duckweed
Lemna perpusilla	Duckweed
Lemna trisulca	Star Duckweed
Lemna valdiviana	Valdivia Duckweed
Wolffia columbiana	Watermeal
Wolffiella floridana	Eastern Wolffiella
Eriocaulaceae	
Eriocaulon compressum	Pipewort
Eriocaulon decangulare	Ten-angle Pipewort
Eriocaulon parkeri	Parker's Pipewort
Eriocaulon septangulare	Pipewort
Xyridaceae	
Xyris caroliniana	Carolina Yellow-eyed Grass
Xyris difformis	Southern Yellow-eyed Grass
Xyris fimuriata	Fringed Yellow-eyed Grass
Xyris montana	Northern Yellow-eyed Grass
Xyris smalliana	Small's Yellow-eyed Grass
Xyris torta	Twisted Yellow-eyed Grass
Commelinaceae	
Commelina communis	Dayflower
Commelina virginica	Dayflower
Pontederiaceae	
Pontederia cordata	Pickerelweed
Zosterella dubia	Water Star-grass
Heteranthera reniformis	Roundleaf Mud Plantain
Juncaceae	
Juncus acuminatus	Tapertip Rush
Juncus balticus	Baltic Rush
Juncus biflorus	Turnflower Rush
Juncus bufonius	Toad Rush
Juncus caesariensis	New Jersey Rush
Juncus canadensis	Canada Rush
Juncus dichotomus	Forked Rush
Juncus effusus	Soft Rush
Juncus gerardii	Black Grass
Juncus marginatus	Shore Rush
Juncus militaris	Bayonet Rush
Juncus nodosus	Knotted Rush
Juncus pelocarpus	Bog Rush
Juncus repens	Creeping Rush
Juncus scirpoides	Needlepod Rush
Juncus subtilis	Creeping Rush
Juncus tenuis	Poverty Rush
Liliaceae	
Narthecium americanum	Bog Asphodel
Tolfieldia racemosa	False Asphodel
Xerophyllum asphodeloides	Turkeybeard
Helonias bullata	Swamp Pink
Amianthium muscaetoxicum	Fly-poison
Zigadenus leimanthoides	Pine Barren Deathcamas
Veratrum viride	False Hellebore
Melanthium virginicum	Bunchflower
Allium canadense	Wild Garlic
Allium tricoccum	Wild Leek
Allium vineale	Field Garlic

Scientific Name	Plant Common Name
Lilium canadense	Turk's Cap Lily
Erythronium umbilicatum	Trout Lily
Asparagus officinalis	Asparagus
Smilacina racemosa	False Solomon's Seal
Smilacina stellata	False Solomon's Seal
Maianthemum canadense	Canada Mayflower
Polygonatum biflorum	Solomon's Seal
Medeola virginiana	Indian Cucumber-root
Smilax glauca	Greenbriar
Smilax herbacea	Greenbriar
Smilax laurifolia	Bamboo-vine
Smilax rotundifolia	Common Greenbriar
Smilax pseudochina	Greenbriar
Smilax walteri	Walter's Greenbriar
Haemodoraceae	
Lophiola americana	Gold-crest
Lachnanthes caroliniana	Redroot
Dioscoreaceae	
Dioscorea villosa	Wild Yam
Amaryllidaceae	
Hypoxis hirsuta	Star Grass
Iridaceae	
Iris prismatica	Slender Blue Flag
Iris pseudacorus	Yellow Flag
Iris versicolor	Blue Flag
Sisyrinchium angustifolium	Blue-eyed Grass
Sisyrinchium atlanticum	Blue-eyed Grass
Orchidaceae	
Cypripedium acaule	Moccassin Flower
Platanthera blephariglottis	White Fringed Orchid
Platanthera ciliaris	Yellow Fringed Orchid
Platanthera clavellata	Green Rein Orchid
Platanthera cristata	Crested Fringed Orchid
Platanthera lacera	Ragged Fringed Orchid
Platanthera nivea	Snowy Orchid
Pogonia ophioglossoides	Rose Pogonia
Calopogon tuberosus	Grass Pink
Arethusa bulbosa	Arethusa
Spiranthes cernua	Nodding Ladies' Tresses
Spiranthes praecox	Southern Ladies' Tresses
Saururaceae	
Saururus cernuus	Lizard's Tail
Salicaceae	
Populus deltoides	Cottonwood
Populus tremuloides	Quaking Aspen
Salix alba	White Willow
Salix babylonica	Weeping Willow
Salix cordata	Heart-leaved Willow
Salix discolor	Pussy Willow
Salix lucida	Shining Willow
Salix nigra	Black Willow
Salix petiolaris	Meadow Willow
Salix rigida	Heart-leaved Willow
Salix sericea	Silky Willow

Scientific Name	Plant Common Name
Myricaceae	
Myrica gale	Sweet Gale
Myrica pensylvanica	Bayberry
Juglandaceae	
Juglans cinerea	Butternut
Juglans nigra	Black Walnut
Carya cordiformis	Bitternut
Carya ovata	Shagbark Hickory
Betulaceae	
Ostrya virginiana	Hop-hornbeam
Carpinus caroliniana	Ironwood
Betula alleghaniensis	Yellow Birch
Betula lenta	Sweet Birch
Betula nigra	River Birch
Betula populifolia	Gray Birch
Alnus rugosa	Speckled Alder
Alnus serrulata	Smooth Alder
Fagaceae	
Fagus grandifolia	Beech
Quercus alba	White Oak
Quercus bicolor	Swamp White Oak
Quercus falcata	Southern Red Oak
Quercus illicifolia	Scrub Oak
Quercus michauxii	Swamp Chestnut Oak
Quercus nigra	Water Oak
Quercus palustris	Pin Oak
Quercus phellos	Willow Oak
Quercus prinus	Chestnut Oak
Quercus rubra	Red Oak
Ulmaceae	
Ulmus americana	American Elm
Ulmus rubra	Slippery Elm
Celtis occidentalis	Hackberry
Moraceae	
Morus alba	White Mulberry
Urticaceae	
Urtica dioica	Stinging Nettle
Laportea canadensis	Wood Nettle
Boehmeria cylindrica	False Nettle
Pilea pumila	Clearweed
Loranthaceae	
Phoradendron flavescens	Mistletoe
Santalaceae	
Comandra umbellata	Bastard Toad-flax
Aristolochiaceae	
Asarum canadense	Wild Ginger
Polygonaceae	
Rumex crispus	Sour Dock
Rumex obtusifolius	Bitter Dock
Rumex orbiculatus	Great Water Dock
Rumex verticillatus	Swamp Dock
Polygonum amphibium	Water Knotweed
Polygonum arifolium	Halberd-leaved Tearthumb

Scientific Name	Plant Common Name
Polygonum careyi	Carey's Smartweed
Polygonum convolvulus	Black Bindweed
Polygonum hydropiper	Common Smartweed
Polygonum hydropiperoides	Mild Waterpepper
Polygonum lapathifolium	Smartweed
Polygonum orientale	Princess-feather
Polygonum pensylvanicum	Pennsylvania Smartweed
Polygonum persicaria	Lady's-thumb
Polygonum punctatum	Water Smartweed
Polygonum ramosissimum	Bushy Knotweed
Polygonum sagittatum	Arrow-leaved Tearthumb
Polygonum scandens	False Buckwheat
Polygonum virginianum	Virginia Smartweed
Chenopodiaceae	
Chenopodium album	Lamb's Quarters
Chenopodium ambrosioides	Mexican Tea
Atriplex arenaria	Seabeach Orach
Atriplex patula	Marsh Orach
Salicornia bigelovii	Glasswort
Salicornia europaea	Glasswort
Salicornia virginica	Perennial Glasswort
Suaeda linearis	Sea-blite
Suaeda maritima	Sea-blite
Salsola kali	Saltwort
Amaranthaceae	
Amaranthus cannabinus	Water Hemp
Phytolaccaceae	
Phytolacca americana	Pokeweed
Aizoaceae	
Mollugo verticillata	Carpetweed
Sesuvium maritimum	Sea Purslane
Portulacaceae	
Claytonia virginica	Spring Beauty
Caryophyllaceae	
Stellaria longifolia	Chickweed
Honkenya peploides	Seabeach Sandwort
Sagina decumbens	Trailing Pearlwort
Ceratophyllaceae	
Ceratophyllum demersum	Coontail
Nymphaeaceae	
Cabomba caroliniana	Fanwort
Brasenia schreberi	Water Shield
Nuphar luteum	Spatterdock
Nymphaea odorata	White Water Lily
Nymphaea tuberosa	Water Lily
Magnoliaceae	
Magnolia virginiana	Sweet Bay
Liriodendron tulipifera	Tulip Tree
Ranunculaceae	
Trollius laxus	Spreading Globeflower
Coptis trifolia	Goldthread
Caltha palustris	Marsh Marigold
Ranunculus abortivus	Kidneyleaf Buttercup

Scientific Name	Plant Common Name
Ranunculus bulbosus	Bulbous Buttercup
Ranunculus cymbalaria	Seaside Crowfoot
Ranunculus flabellaris	Yellow Water Crowfoot
Ranunculus longirostris	White Water Crowfoot
Ranunculus pensylvanicus	Bristly Buttercup
Ranunculus pusillus	Dwarf Buttercup
Ranunculus repens	Creeping Buttercup
Ranunculus sceleratus	Cursed Crowfoot
Ranunculus septentrionalis	Swamp Buttercup
Ranunculus subrigidus	White Water Crowfoot
Ranunculus tricophyllus	White Water Crowfoot
Thalictrum dioicum	Early Meadow Rue
Thalictrum pubescens	Tall Meadow Rue
Clematis virginiana	Virgin's Bower
Berberidaceae	
Podophyllum peltatum	May Apple
Berberis thunbergii	Barberry
Menispermaceae	
Menispermum canadense	Moonseed
Lauraceae	
Sassafras albidum	Sassafras
Lindera benzoin	Spicebush
Cruciferae	
Cakile edentula	Sea Rocket
Cardamine bulbosa	Spring Cress
Cardamine pensylvanica	Bitter Cress
Cardamine pratensis	Cuckoo-flower
Nasturtium officinale	Water Cress
Rorippa prostrata	Water Cress
Barbarea verna	Early Winter Cress
Barbarea vulgaris	Winter Cress
Alliaria petiolata	Garlic-mustard
Sarraceniaceae	
Sarracenia purpurea	Pitcher Plant
Droseraceae	
Drosera filiformis	Dew-thread
Drosera intermedia	Spatulate-leaved Sundew
Drosera linearis	Slender-leaved Sundew
Drosera rotundifolia	Round-leaved Sundew
Podostemaceae	
Podostemum ceratophyllum	Riverweed
Crassulaceae	
Penthorum sedoides	Ditch Stonecrop
Crassula aquatica	Pygmy-weed
Saxifragaceae	
Saxifraga pensylvanica	Swamp Saxifrage
Chrysosplenium americanum	Golden Saxifrage
Itea virginica	Virginia Sweetspire
Ribes americanum	Wild Black Currant
Hamamelidaceae	
Hamamelis virginiana	Witch Hazel
Liquidambar styraciflua	Sweet Gum
Platanaceae	
Platanus occidentalis	Sycamore

Scientific Name	Plant Common Name
Rosaceae	
Spiraea alba	Meadowsweet
Spiraea latifolia	Meadowsweet
Spiraea tomentosa	Steeplebush
Fragaria vesca	Woodland Strawberry
Fragaria virginiana	Common Strawberry
Duchesnea indica	Indian Strawberry
Potentilla palustris	Marsh Cinquefoil
Geum aleppicum	Avens
Geum canadense	White Avens
Geum laciniatum	Avens
Rubus allegheniensis	Allegheny Blackberry
Rubus argutus	Tall Raspberry
Rubus hispidus	Running Dewberry
Rubus occidentalis	Black Raspberry
Agrimonia gryposepala	Agrimony
Agrimonia parviflora	Agrimony
Sanguisorba canadensis	American Burnet
Rosa multiflora	Rose
Rosa palustris	Swamp Rose
Rosa rugosa	Seaside Rose
Rosa virginiana	Rose
Prunus pensylvanica	Pin Cherry
Prunus serotina	Black Cherry
Prunus virginiana	Choke-cherry
Aronia arbutifolia	Red Chokeberry
Aronia melanocarpa	Black Chokeberry
Amelanchier arborea	Shadbush
Amelanchier bartramiana	Bartram's Serviceberry
Amelanchier canadensis	Canada Serviceberry
Amelanchier intermedia	Shadbush
Caesalpiniaceae	
Cassia fasciculata	Partridge Pea
Cassia marilandica	Wild Senna
Leguminosae	
Trifolium pratense	Red Clover
Melilotus alba	White Sweet Clover
Melilotus officinalis	Yellow Sweet Clover
Desmodium canadense	Tick-trifoil
Desmodium paniculatum	Tick-trifoil
Aeschynomene virginica	Sensitive Joint Vetch
Strophostyles helveola	Beach Pea
Amphicarpaea bracteata	Hog Peanut
Oxalidaceae	
Oxalis stricta	Wood Sorrel
Geraniaceae	
Geranium maculatum	Wild Geranium
Linaceae	
Linum striatum	Flax
Linum virginianum	Flax
Polygalaceae	
Polygala brevifolia	Short-leaved Milkwort
Polygala cruciata	Cross-leaved Milkwort
Polygala lutea	Yellow Milkwort
Polygala nuttallii	Nuttall's Milkwort
Polygala sanguinea	Purple Milkwort

Scientific Name	Plant Common Name
Polygala verticillata	Whorled Milkwort
Euphorbiaceae	
Acalypha virginica	Copperleaf
Euphorbia polygonifolia	Beach Spurge
Callitrichaceae	
Callitriche deflexa	Water Starwort
Callitriche heterophylla	Larger Water Starwort
Callitriche stagnalis	Green Water Starwort
Limnanthaceae	
Floerka proserpinacoides	False Mermaid
Anacardiaceae	
Toxicodendron radicans	Poison Ivy
Toxicodendron vernix	Poison Sumac
Aquifoliaceae	
Ilex glabra	Inkberry
Ilex laevigata	Smooth Winterberry
Ilex opaca	American Holly
Ilex verticillata	Winterberry
Nemopanthus mucronatus	Mountain Holly
Celastraceae	
Celastrus scandens	Bittersweet
Staphyleaceae	
Staphylea trifolia	Bladdernut
Aceraceae	
Acer negundo	Box Elder
Acer rubrum	Red Maple
Acer saccharinum	Silver Maple
Balsaminaceae	
Impatiens capensis	Jewelweed
Impatiens pallida	Pale Touch-me-not
Vitaceae	
Vitis riparia	Riverbank Grape
Parthenocissus quinquefolia	Virginia Creeper
Tiliaceae	
Tilia americana	Basswood
Malvaceae	
Kosteletzkya virginica	Seaside Mallow
Hibiscus moscheutos	Rose Mallow
Hypericaceae	
Hypericum adpressum	Shore St. John's-wort
Hypericum boreale	Northern St. John's-wort
Hypericum canadense	Canada St. John's-wort
Hypericum densiflorum	Dense St. John's-wort
Hypericum denticulatum	Coppery St. John's-wort
Hypericum mutilum	Dwarf St. John's-wort
Hypericum punctatum	Spotted St. John's-wort
Triadenum virginicum	Marsh St. John's-wort
Elatinaceae	
Elatine minima	Waterwort

Scientific Name	Plant Common Name
Violaceae	
Viola blanda	Sweet White Violet
Viola conspersa	American Dog Violet
Viola cucullata	Marsh Blue Violet
Viola lanceolata	Lance-leaved Violet
Viola pallens	Northern Blue Violet
Viola papilionacea	Common Blue Violet
Viola primulifolia	Primrose-leaved Violet
Viola striata	Cream Violet
Lythraceae	
Rotala ramosior	Toothcup
Decodon verticillatus	Water Willow
Lythrum lineare	Loosestrife
Lythrum salicaria	Purple Loosestrife
Melastomataceae	
Rhexia mariana	Meadow Beauty
Rhexia virginica	Meadow Beauty
Onagraceae	
Ludwigia alternifolia	Seed-box
Ludwigia hirtella	Spindle-root
Ludwigia linearis	Narrowleaf Seed-box
Ludwigia palustris	Water Purslane
Ludwigia sphaerocarpa	Spherical-fruited Seed-box
Epilobium angustifolium	Fireweed
Epilobium ciliatum	Hairy Willowherb
Epilobium coloratum	Purpleleaf Willowherb
Epilobium hirsutum	Hairy Willowherb
Oenothera biennis	Evening Primrose
Oenothera fruticosa	Sundrops
Oenothera humifusa	Seabeach Evening Primrose
Oenothera perennis	Evening Primrose
Circaea lutetiana	Enchanter's Nightshade
Halorrhagidaceae	
Myriophyllum heterophyllum	Variableleaf Water Milfoil
Myriophyllum humile	Lowly Water Milfoil
Myriophyllum spicatum	Common Water Milfoil
Myriophyllum tenellum	Water Milfoil
Proserpinaca palustris	Marsh Mermaidweed
Proserpinaca pectinata	Cutleaf Mermaidweed
Araliaceae	
Aralia spinosa	Hercules' Club
Umbelliferae	
Hydrocotyle americana	Water Pennywort
Hydrocotyle umbellata	Water Pennywort
Sanicula gregaria	Sanicle
Sanicula marilandica	Black Snakeroot
Cryptotaenia canadensis	Honewort
Osmorhiza claytoni	Sweet Cicely
Zizia aurea	Golden Alexanders
Conium maculatum	Poison Hemlock
Sium suave	Water Parsnip
Cicuta bulbifera	Water Hemlock
Cicuta maculata	Water Hemlock
Lilaeopsis chinensis	Eastern Lilaeopsis
Ptilimnium capillaceum	Mock Bishopweed
Angelica atropurpurea	Angelica

Scientific Name	Plant Common Name
Oxypolis rigidior	Stiff Cowbane
Eryngium aquaticum	Eryngium
Cornaceae	
Cornus amomum	Silky Dogwood
Cornus foemina	Gray Dogwood
Cornus stolonifera	Red Osier Dogwood
Nyssa sylvatica	Black Gum
Clethraceae	
Clethra alnifolia	Sweet Pepperbush
Ericaceae	
Monotropa uniflora	Indian Pipe
Rhododendron maximum	Rose Bay
Rhododendron periclymenoides	Pinksterflower
Rhododendron viscosum	Swamp Azalea
Leiophyllum buxifolium	Sand Myrtle
Kalmia angustifolia	Sheep Laurel
Kalmia latifolia	Mountain Laurel
Kalmia polifolia	Bog Laurel
Leucothoe racemosa	Fetterbush
Andromeda glaucophylla	Bog Rosemary
Lyonia ligustrina	Maleberry
Lyonia mariana	Staggerbush
Chamaedaphne calyculata	Leatherleaf
Gautheria procumbens	Wintergreen
Gaylussacia baccata	Black Huckleberry
Gaylussacia dumosa	Dwarf Huckleberry
Gaylussacia frondosa	Dangleberry
Vaccinium caesariense	New Jersey Blueberry
Vaccinium cespitosum	Dwarf Bilberry
Vaccinium corymbosum	Highbush Blueberry
Vaccinium macrocarpon	Big Cranberry
Vaccinium oxycoccos	Small Cranberry
Vaccinium pallidum	Blueberry
Primulaceae	
Lysimachia ciliata	Fringed Loosestrife
Lysimachia hybrida	Loosestrife
Lysimachia nummularia	Moneywort
Lysimachia quadrifolia	Whorled Loosestrife
Lysimachia terrestris	Swamp Candles
Lysimachia thyrsiflora	Tufted Loosestrife
Lysimachia vulgaris	Garden Loosestrife
Trientalis borealis	Starflower
Plumbaginaceae	
Limonium carolinianum	Sea Lavender
Limonium nashii	Sea Lavender
Ebenaceae	
Diospyros virginiana	Persimmon
Oleaceae	
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Ligustrum vulgare	Privet
Gentianaceae	
Sabatia difformis	Marsh Pink
Sabatia dodecandra	Marsh Pink

Scientific Name	Plant Common Name
Sabatia stellaris	Marsh Pink
Gentiana autumnalis	Pine Barren Gentian
Gentiana saponaria	Soapwort Gentian
Gentianopsis crinita	Fringed Gentian
Bartonia paniculata	Twining Bartonia
Bartonia virginica	Bartonia
Menyanthes trifoliata	Buckbean
Nymphoides aquatica	Big Floating Heart
Nymphoides cordata	Little Floating Heart
Apocynaceae	
Apocynum cannabinum	Indian Hemp Dogbane
Asclepiadaceae	
Asclepias incarnata	Swamp Milkweed
Asclepias lanceolata	Milkweed
Asclepias rubra	Milkweed
Asclepias syriaca	Milkweed
Convolvulaceae	
Convolvulus sepium	Hedge Bindweed
Cuscuta compacta	Dodder
Cuscuta gronovii	Swamp Dodder
Hydrophyllaceae	
Hydrophyllum virginianum	Virginia Waterleaf
Boraginaceae	
Myosotis laxa	Forget-me-not
Myosotis scorpioides	True Forget-me-not
Hackelia virginiana	Stickseed
Mertensia virginica	Bluebell
Verbenaceae	
Verbena hastata	Blue Vervain
Verbena urticifolia	White Vervain
Labiatae	
Teucrium canadense	Germander
Scutellaria galericulata	Common Skullcap
Scutellaria integrifolia	Hyssop Skullcap
Scutellaria lateriflora	Mad-dog Skullcap
Prunella vulgaris	Self-heal
Stachys palustris	Woundwort
Stachys tenuifolia	Hedge Nettle
Pycnanthemum muticum	Mountain Mint
Pycnanthemum virginianum	Virginia Basil
Lycopus americanus	Water Horehound
Lycopus amplectens	Water Horehound
Lycopus uniflorus	One-flower Bugleweed
Lycopus virginicus	Bugleweed
Mentha arvensis	Wild Mint
Collinsonia canadensis	Horse-balm
Solanaceae	
Solanum dulcamara	Nightshade
Scrophulariaceae	
Gratiola aurea	Hedge Hyssop
Gratiola neglecta	Hedge Hyssop
Gratiola virginiana	Hedge Hyssop
Mimulus ringens	Square-stemmed Monkeyflower

Scientific Name	Plant Common Name
Lindernia dubia	False Pimpernel
Hemianthus micranthemoides	Nuttall's Micranthemum
Limosella aquatica	Mud-wort
Limosella subulata	Mud-wort
Chelone glabra	Turtlehead
Penstemon digitalis	Beard-tongue
Veronicastrum virginicum	Culver's Root
Veronica scutellata	Marsh Speedwell
Agalinis maritima	Seaside Gerardia
Agalinis purpurea	Purple Gerardia
Schwalbea americana	Chaffseed
Melampyrum lineare	Cowwheat
Bignoniaceae	
Campsis radicans	Trumpet Creeper
Catalpa speciosa	Catalpa
Conopholis americana	Squaw-root
Lentibulariaceae	
Utricularia biflora	Bladderwort
Utricularia cornuta	Horned Bladderwort
Utricularia fibrosa	Fiberous Bladderwort
Utricularia geminiscapa	Hidden-flower Bladderwort
Utricularia gibba	Humped Bladderwort
Utricularia inflata	Floating Bladderwort
Utricularia intermedia	Flat-leaved Bladderwort
Utricularia juncea	Rush Bladderwort
Utricularia macrorhiza	Common Bladderwort
Utricularia minor	Lesser Bladderwort
Utricularia purpurea	Purple Bladderwort
Utricularia resupinata	Lavender Bladderwort
Utricularia subulata	Zigzag Bladderwort
Plantaginaceae	
Plantago lanceolata	Plantain
Rubiaceae	
Mitchella repens	Partridge-berry
Cephalanthus occidentalis	Buttonbush
Galium asprellum	Rough Bedstraw
Galium tinctorium	Dye Bedstraw
Caprifoliaceae	
Viburnum acerifolium	Dockmackie
Viburnum cassinoides	Withe-rod
Viburnum dentatum	Southern Arrowwood
Viburnum lentago	Nannyberry
Viburnum nudum	Possumhaw
Viburnum opulus	Highbush Cranberry
Viburnum prunifolium	Black Haw
Viburnum recognitum	Northern Arrowwood
Sambucus canadensis	Common Elderberry
Lonicera japonica	Japanese Honeysuckle
Symphoricarpos albus	Snowberry
Cucurbitaceae	
Echinocystis lobata	Prickly Cucumber
Sicyos angulatus	Bur Cucumber
Campanulaceae	
Campanula aparinoides	Marsh Bellflower

Scientific Name	Plant Common Name
Lobeliaceae	
Lobelia canbyi	Lobelia
Lobelia cardinalis	Cardinal-flower
Lobelia nuttallii	Lobelia
Lobelia puberula	Downy Lobelia
Lobelia siphilitica	Great Lobelia
Lobelia spicata	Pale Spike Lobelia
Compositae	
Helianthus angustifolius	Swamp Sunflower
Helianthus decapetalus	Sunflower
Helianthus giganteus	Giant Sunflower
Helianthus tuberosa	Jerusalem Artichoke
Eclipta alba	Yerba-de-tajo
Rudbeckia hirta	Rough Coneflower
Rudbeckia laciniata	Cutleaf Coneflower
Helenium autumnale	Sneezeweed
Helenium flexuosum	Sneezeweed
Bidens bidentoides	Swamp Beggar-ticks
Bidens cernua	Nodding Beggar-ticks
Bidens connata	Swamp Beggar-ticks
Bidens coronata	Tickseed Sunflower
Bidens discoidea	Discoid Beggar-ticks
Bidens frondosa	Beggar-ticks
Bidens laevis	Bur Marigold
Coreopsis rosea	Tickseed
Iva frutescens	High-tide Bush
Ambrosia artemisifolia	Common Ragweed
Ambrosia trifida	Giant Ragweed
Xanthium strumarium	Cockebur
Achillea millefolium	Yarrow
Chrysanthemum leucanthemum	Ox-eye Daisy
Erechtites hieracifolia	Fireweed
Tussilago farfara	Coltsfoot
Heterotheca mariana	Golden Aster
Solidago canadensis	Canada Goldenrod
Solidago elliottii	Elliott's Goldenrod
Solidago elongata	Creek Goldenrod
Solidago fistulosa	Pine Barren Goldenrod
Solidago gigantea	Late Goldenrod
Solidago patula	Downy Goldenrod
Solidago rugosa	Wrinkled Goldenrod
Solidago sempervirens	Seaside Goldenrod
Solidago uliginosa	Bog Goldenrod
Euthamia galetorum	Narrow-leaved Goldenrod
Euthamia graminifolia	Grass-leaved Goldenrod
Aster dumosus	Bushy Aster
Aster ericoides	Heath Aster
Aster lateriflorus	Calico Aster
Aster nemoralis	Bog Aster
Aster novae-angliae	New England Aster
Aster novi-belgii	New York Aster
Aster puniceus	Swamp Aster
Aster simplex	Lowland White Aster
Aster spectabilis	Aster
Aster subulatus	Annual Salt Marsh Aster
Aster tenuifolius	Perennial Salt Marsh Aster
Aster umbellatus	Flattop Aster
Aster vimineus	Fairy Aster
Boltonia asteroides	Boltonia
Erigeron annuus	Daisy Fleabane
Baccharis halimifolia	Sea Myrtle
Pluchea camphorata	Camphorweed
Pluchea odorata	Marsh Fleabane
Pluchea purpuracens	Marsh Fleabane
Sclerolepis uniflora	
Eupatoriadelphus dubius	Joe-Pye-weed
Eupatoriadelphus fistulosus	Joe-Pye-weed
Eupatoriadelphus maculatus	Spotted Joe-Pye-weed
Eupatoriadelphus purpureus	Purple Joe-Pye-weed
Eupatorium album	Thoroughwort
Eupatorium leucolepis	White-bracted Thoroughwort
Eupatorium perfoliatum	Boneset
Eupatorium pilosum	Hairy Thoroughwort
Eupatorium resinosum	Resin Boneset
Eupatorium rotundifolium	Roundleaf Joe-Pye-weed
Eupatorium serotinum	Late Eupatorium
Mikania scandens	Climbing Hempweed
Liatris spicata	Blazing Star
Vernonia noveboracensis	New York Ironweed
Cirsium arvense	Canadian Thistle
Cirsium discolor	Thistle
Cirsium horridulum	Plumeless Thistle
Prenanthes alba	Rattlesnake-root
Prenanthes trifoliolata	Gall-of-the-earth
Lactuca biennis	Wild Lettuce
Lactuca canadensis	Canada Lettuce
Tragopogon porrifolius	Salsify

Sources*

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* see Chapter 6 for references.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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