Delaware
Wetland Resources

Wetlands cover about 17 percent of Delaware (Tiner and Finn, 1986). These wetlands support rich biotic communities in freshwater, brackish-water, and saltwater settings across the State. Some of the most familiar wetlands in Delaware are the tidal marshes along Delaware Bay (fig. 1).

Wetlands have many chemical, physical, and biological functions. In Delaware, wetlands trap waterborne sediments, nutrients, and toxic chemicals by filtering inflowing water and storing or transforming the filtrate. Coastal-zone and flood-plain wetlands mitigate the effects of flooding caused by runoff and tides by reducing flow velocity, storing water temporarily, and releasing it gradually. Vegetation in riparian wetlands maintains stream channels by stabilizing the land surface, and tidal wetlands act as buffers against storm tides and waves, thus impeding erosion. One of the most important functions of wetlands is habitat for waterfowl, terrestrial and aquatic animals, and a wide variety of plant life. Wetlands provide food, shelter, resting and feeding places on migration routes, breeding areas, and nurseries for many animals including species of particular economic interest in Delaware such as muskrat, fish, ducks, and geese. Many rare and endangered plant species are adapted to hydrologic conditions present only in wetlands, especially freshwater wetlands.

Delaware's wetlands have considerable recreational and economic value. They provide outdoor educational and recreational opportunities, including activities such as bird watching, hiking, and canoeing. In addition, wetlands in Delaware support the hunting, fur trapping, commercial and sport fishing, lumbering, and tourist industries.

TYPES AND DISTRIBUTION

Wetlands are lands transitional between terrestrial and deepwater habitats where the water table usually is at or near the land surface or the land is covered by shallow water (Cowardin and others, 1979). The distribution of wetlands and deepwater habitats in Delaware is shown in figure 2*A*; only wetlands are discussed herein.

Wetlands can be vegetated or nonvegetated and are classified on the basis of their hydrology, vegetation, and substrate. In this summary, wetlands are classified according to the system proposed by Cowardin and others (1979), which is used by the U.S. Fish and Wildlife Service (FWS) to map and inventory the Nation's wetlands. At the most general level of the classification system, wetlands are grouped into five ecological systems: Palustrine, Lacustrine, Riverine, Estuarine, and Marine. The Palustrine System includes only wetlands, whereas the other systems comprise wetlands and deepwater habitats. Wetlands of the systems that occur in Delaware are described below.

System	Wetland description
Palustrine	Nontidal and tidal-freshwater wetlands in which vegetation is predominantly trees (forested wetlands); shrubs (scrub-shrub wetlands); persistent or nonpersistent emergent, erect, rooted herbaceous plants (persistent- and nonpersistent-emergent wetlands); or submersed and (or) floating plants (aquatic beds). Also, intermittently to permanently flooded open-water bodies of less than 20 acres in which water is less than 6.6 feet deep.
Lacustrine	Nontidal and tidal-freshwater wetlands within an intermittently to permanently flooded lake or reservoir larger than 20 acres and (or) deeper than 6.6 feet. Vegetation, when present, is predominantly nonpersistent emergent plants (nonpersistent-emergent wetlands), or submersed and (or) floating plants (aquatic beds), or both.
Riverine	Nontidal and tidal-freshwater wetlands within a channel. Vegetation, when present, is same as in the Lacustrine System.
Estuarine	Tidal wetlands in low-wave-energy environments where the salinity of the water is greater than 0.5 part per thousand (ppt) and is variable owing to evaporation and the mixing of seawater and freshwater.
Marine	Tidal wetlands that are exposed to waves and currents of the open ocean and to water having a salinity greater than 30 ppt.

Figure 1. Estuarine wetlands on Cedar Creek at Slaughter Beach, Delaware. These are tidal wetlands typical of those found along Delaware Bay. *(Photograph by Evelyn M. Maurmeyer, Coastal and Estuarine Research, Inc.)*

Palustrine wetlands are the most abundant wetlands in Delaware, comprising 132,000 acres in 1983, or about 59 percent of the wetland area in the State (Tiner, 1985). Palustrine wetlands are distributed throughout the State in topographic depressions and in riparian zones along rivers and streams. In 1983, estuarine wetlands covered 89,800 acres in Delaware, or about 40 percent of the wetland area in the State. Estuarine wetlands occur along the shores of Delaware Bay and the Delaware River and behind the barrier beaches of the Atlantic Coast. Other types of wetland comprise less than 1 percent of Delaware's wetland area. In 1983, the State had about 650 acres of riverine wetland, 140 acres of lacustrine wetland, and 540 acres of marine wetland (mostly beaches and sandbars along the Atlantic Coast).

Delaware is a small State, but it contains many different types of wetlands. The plant composition of vegetated wetlands is determined by factors such as climate, soil type, ground-water and surface-water chemistry, salinity, and the extent and duration of flooding. The predominant vegetation or specific location of a Delaware wetland frequently determines its common name. For example, inland bays are natural coastal features that contain both palustrine and estuarine emergent wetlands, and such wetlands occur in Rehoboth, Indian River, and Little Assawoman Bays. Palustrine and estuarine emergent wetlands can be found in impoundments modified by constructed levees and managed by water-control structures. Salt and brackish marshes are predominantly estuarine emergent wetlands characterized by vegetation tolerant of brackish to salty

water; small scrub-shrub wetlands commonly are associated with the landward margins of salt marshes. Interdunal swales (dune slacks) are topographic depressions among sand dunes on the Atlantic Coast that contain palustrine emergent or scrub-shrub wetlands. Palustrine forested wetlands in Delaware include Atlantic white cedar swamps, cypress swamps, and flood-plain forests, both tidal and nontidal. Delmarva bays (small, closed topographic depressions) commonly contain seasonally flooded palustrine emergent, scrub-shrub, or forested wetlands. Delmarva bays and associated wetlands also are known as whale wallows; loblollies; flatwoods depressions; and intermittent, temporary, vernal, woodland, or coastal-plain ponds.

The Delaware Department of Natural Resources and Environmental Control has established five wetland categories for the State based on relative functions and values of the State's wetlands. Category I wetlands provide exceptional value or unique biotic assemblages and include Delmarva bays, dune slacks, Atlantic white cedar swamps, and cypress swamps. Category II wetlands are those generally considered permanently to seasonally wet or those that provide significant habitat or biotic values. Category III wetlands include temporarily flooded wetlands and all wetlands not included in another category. Category IV wetlands consist of farmed wetlands. Category V wetlands are all wetlands created from nonwetland areas for purposes other than mitigation and include drainage ditches, farm ponds, stormwater-retention basins, and borrow pits.

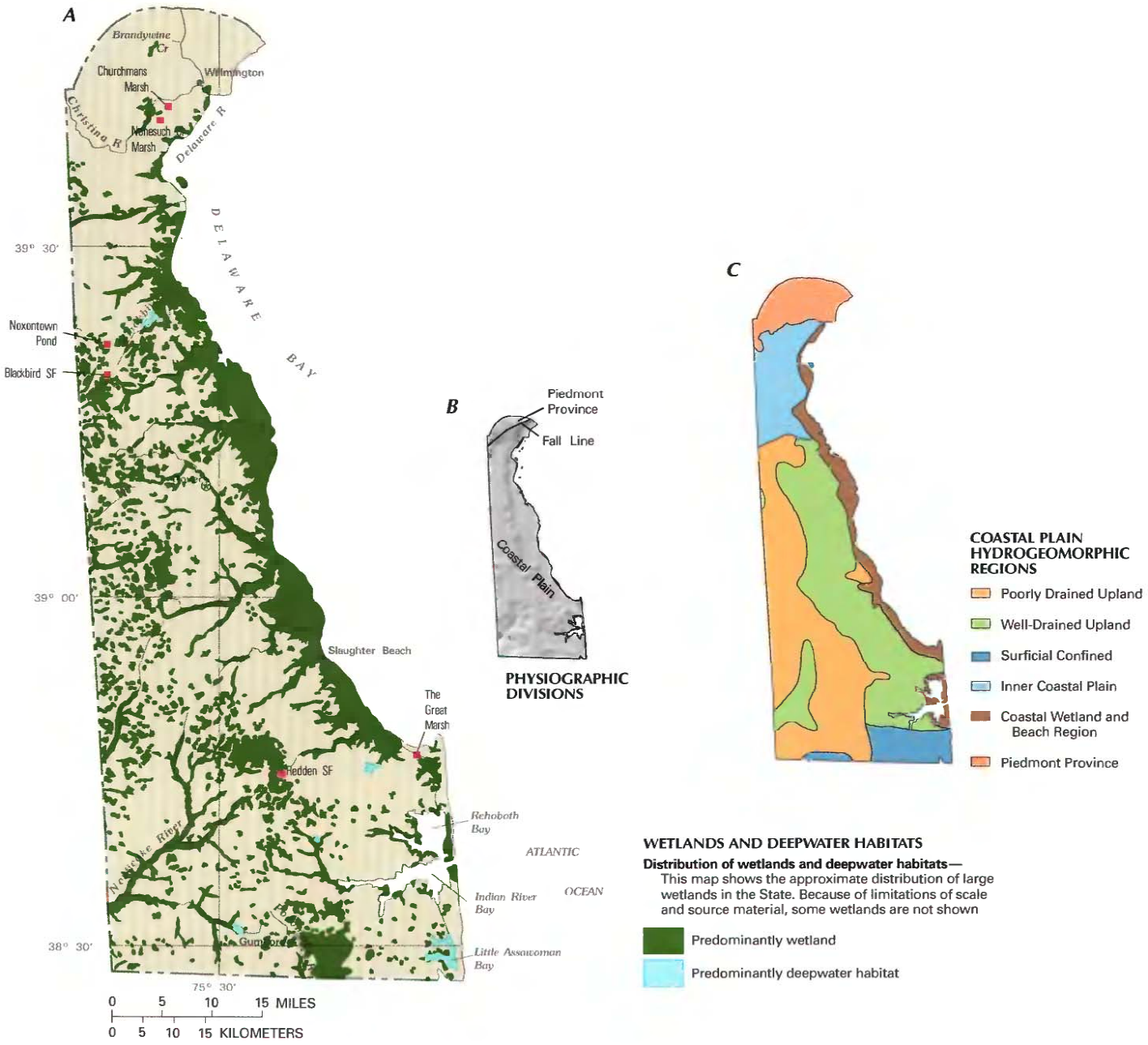

Figure 2. Wetland distribution in Delaware and physical features that control wetland distribution in the State. ***A***, Distribution of wetlands and deepwater habitats. ***B***, Physiography. ***C***, Hydrogeomorphic regions in the Coastal Plain of Delaware. *(Sources: A, T.E. Dahl, U.S. Fish and Wildlife Service, unpub. data, 1991. B, Landforms data from EROS Data Center; divisions from Spoljarik and Jordan, 1966. C, Shedlock and others, 1993.)*

HYDROLOGIC SETTING

In Delaware, water in small, nontidal wetlands is supplied by direct precipitation, surface runoff from precipitation, and localized, shallow ground-water-flow systems recharged by precipitation. Larger wetlands (tidal and nontidal) also can interact with regional ground-water-flow systems. The primary source of water in tidal wetlands is tidal inundation, although runoff and ground-water discharge can be important secondary sources. Water from surface runoff can collect in topographic lows, where ground water commonly discharges after periods of greater-than-normal precipitation. These hydrologic conditions are conducive to the formation and maintenance of wetlands.

Abundant precipitation (an annual average of 43 inches) (Simmons, 1986) and extensive tidal zones in Delaware Bay and the Atlantic Ocean provide ample water for wetlands in Delaware. Fluctuations in local precipitation and evapotranspiration rates combine with local differences in geology, topography, soil characteristics, and tides to create transient or seasonal changes in the local interactions of ground water and surface water in wetlands (Winter, 1992; Phillips and Shedlock, 1993). In general, mid-October to early April (nongrowing season) is a period of ground-water recharge, with high rates of precipitation and low rates of evapotranspiration. Mid-April to mid-October (growing season) is characterized by high rates of evapotranspiration and declining water levels (Johnston, 1973).

Delaware is in two physiographic provinces: the Coastal Plain and the Piedmont Province (fig. 2*B*). Geology, topography, and soils in the two provinces differ considerably; the types and distribution of wetlands in each province reflect this difference. Figure 3*A*–3*C* is a generalization of wetland hydrology in Delaware.

Coastal Plain.—Ninety-three percent of Delaware, including more than 94 percent of its wetland area, is in the Coastal Plain. All of the estuarine wetlands in the State are in this relatively flat province (Tiner, 1987), which rises from below sea level only to about 100 feet above sea level. The Coastal Plain is underlain by an extensive and locally complex surficial aquifer that has a wide range of depth, porosity, and permeability (Andres, 1987; Talley, 1987). Wetlands in the Coastal Plain generally intersect the surficial aquifer.

Coastal Plain wetlands are supported by precipitation, surface runoff, flooding from streams, and ground-water discharge. Recharge of the ground-water system in the Coastal Plain is mainly by infiltration of precipitation in interstream areas (Heath, 1984), and discharge results from evapotranspiration and by seepage to streams, estuaries, wells, ditches, and the ocean. Both local and regional ground-water flow may help sustain wetlands, especially in low-lying areas near the coast, which contain extensive, mainly emergent wetlands. Forested wetlands occur primarily in bottom lands along stream channels, especially in headwater areas. The width of these forested wetlands in streamside and upland areas commonly has been reduced by ditching and the conversion of land to agricultural use.

Regional differences in the configuration and geohydrologic properties of sedimentary deposits in the Coastal Plain are reflected by differences in topography, soils, degree of stream incision, the configuration of the water table, and the paths of ground-water flow. These characteristics, which affect the distribution of wetlands in the landscape, have been used to divide the Coastal Plain on the Delmarva Peninsula into hydrogeomorphic regions (Shedlock and others, 1993). In Delaware, there are five hydrogeomorphic regions (fig. 2*C*): the Poorly Drained Upland, the Well-Drained Upland, the Surficial Confined, the Inner Coastal Plain, and the Coastal Wetland and Beach. Each of these regions contains wetlands.

The Poorly Drained Upland lies along the drainage divide separating the Chesapeake Bay drainage basin to the west from the drainage basins of Delaware Bay and the Atlantic Ocean. This region is hummocky, has low relief, and has many seasonally flooded forested wetlands and small, sluggish streams in poorly defined, low-gradient, shallowly incised valleys (fig. 3*A*) (Shedlock and others, 1993). About 43 percent of the region is forested, including the topographic depressions, which have poorly drained soils and typically contain wetlands. Forests are interspersed with agricultural fields that are in areas of higher elevation than the forests. The water table in this region is shallow and has a relatively large seasonal fluctuation. Local ground-water-flow patterns are directly affected by the depth of the water table and can differ with seasonal precipitation, even to the extent of changing direction, so that wetlands where ground water is discharged in wet periods can become areas of ground-water recharge during dry periods (Phillips and Shedlock, 1993). Typical wetlands in this region are seasonally saturated, forested wetlands. Examples include the wetlands in Redden State Forest, which have poorly defined topographic boundaries (typical of the southern part of this region), and the small wetlands in Blackbird State Forest, which are contained within Delmarva bays (typical of the northern part of this region).

The Well-Drained Upland occurs in a north-south trending band in eastern Delaware and in an area in the southern part of the State around the headwaters of the Nanticoke River. This region is flat to gently rolling and has higher relief than the Poorly Drained Upland (fig. 3*A*). Streams are deeply incised, particularly tidal streams and their tributaries. About 28 percent of the Well-Drained Upland is forested, primarily in riparian (streamside) zones, which include most of the wetlands in the region. The rest of the region is covered by agricultural fields. Typical wetlands in the region include the palustrine forested wetlands along the Nanticoke River.

The Coastal Wetland and Beach region extends southward along the coast of Delaware from the Delaware River to the Delaware-Maryland border. This region is very flat and has dunes along the Atlantic Coast (fig. 3*A*). The surficial aquifer is composed of a variety of sediments that were deposited in several coastal settings, including beach, dune, and tidal marsh. The water table is generally within a few feet of the land surface because of geohydrologic conditions and because the land-surface altitude is near sea level. Wetlands in this region have complex hydrology because of the geologic setting and because of the interactions between tides and ground-water discharge. Extensive wetlands in low-lying areas form as shallow embayments, salt marshes, and tidal and nontidal freshwater marshes and swamps. Examples of wetlands in the Coastal Wetland and Beach region include the large marshes in Indian River Bay, the Great Marsh (an extensive tidal marsh along Delaware Bay), and the freshwater and brackish tidal marshes along Blackbird Creek.

The Surficial Confined region occupies two small areas of southern Delaware. The landscape is flat, except for a number of low, sandy ridges (relict dunes) that rise above their surroundings (fig. 3*B*). This region is physiographically similar to the Poorly Drained Upland. Geohydrologic conditions in the upper sand unit of the aquifer are the cause of the poor drainage conditions and widespread presence of wetlands in the Surficial Confined region (Shedlock and others, 1993). Extensively ditched agricultural lands have been converted from former wetland. About 55 percent of the area in this region is still in large tracts of woodlands that occur in uplands between streams and in wetlands in riparian zones. Examples of wetlands in the Surficial Confined region include the remnant of a large cypress swamp located east of Gumboro and the forested wetlands along the Pocomoke River.

The Inner Coastal Plain is in northern Delaware. There is considerable topographic relief in this region, and streams are well incised in their lower reaches (fig. 3*C*). Land use in this region is heterogeneous. There has been considerable development of the northeastern section, which is mostly urban. The northwestern section of the region is forested, and the southern section has mixed

agricultural and residential usage. Wetlands in the Inner Coastal Plain occur in riparian zones, especially in the tidal reaches of the Christina River, in forested areas, and in small, discontinuous areas. Examples of wetlands in the region include Churchman's Marsh, a tidal emergent wetland; Nonesuch Creek Marsh, an emergent wetland whose tidal flow is restricted by tide gates; and the small, nontidal, palustrine wetlands around Noxontown Pond.

Piedmont Province.—The Piedmont Province occupies the northern 6 percent of the State and contains only 2 percent of Delaware's total wetland area (Tiner and Finn, 1986). The gently rolling hills of this province range in altitude from near sea level to about 450 feet. The Piedmont Province is underlain by folded and faulted igneous and metamorphic bedrock overlain by a regolith of variable thickness. Regolith, which underlies the land surface nearly everywhere in this province, is a layer of unconsolidated, mostly fine-grained material composed of fragmental, weathered bedrock and alluvium overlying unweathered bedrock. Wetlands in the Piedmont Province occur along riparian valleys and other low areas of the ground surface, which commonly occur over fracture zones in the bedrock. Water is more likely to collect and be discharged in these depressions than in other areas because fracture zones are major pathways of ground-water movement (Heath, 1984).

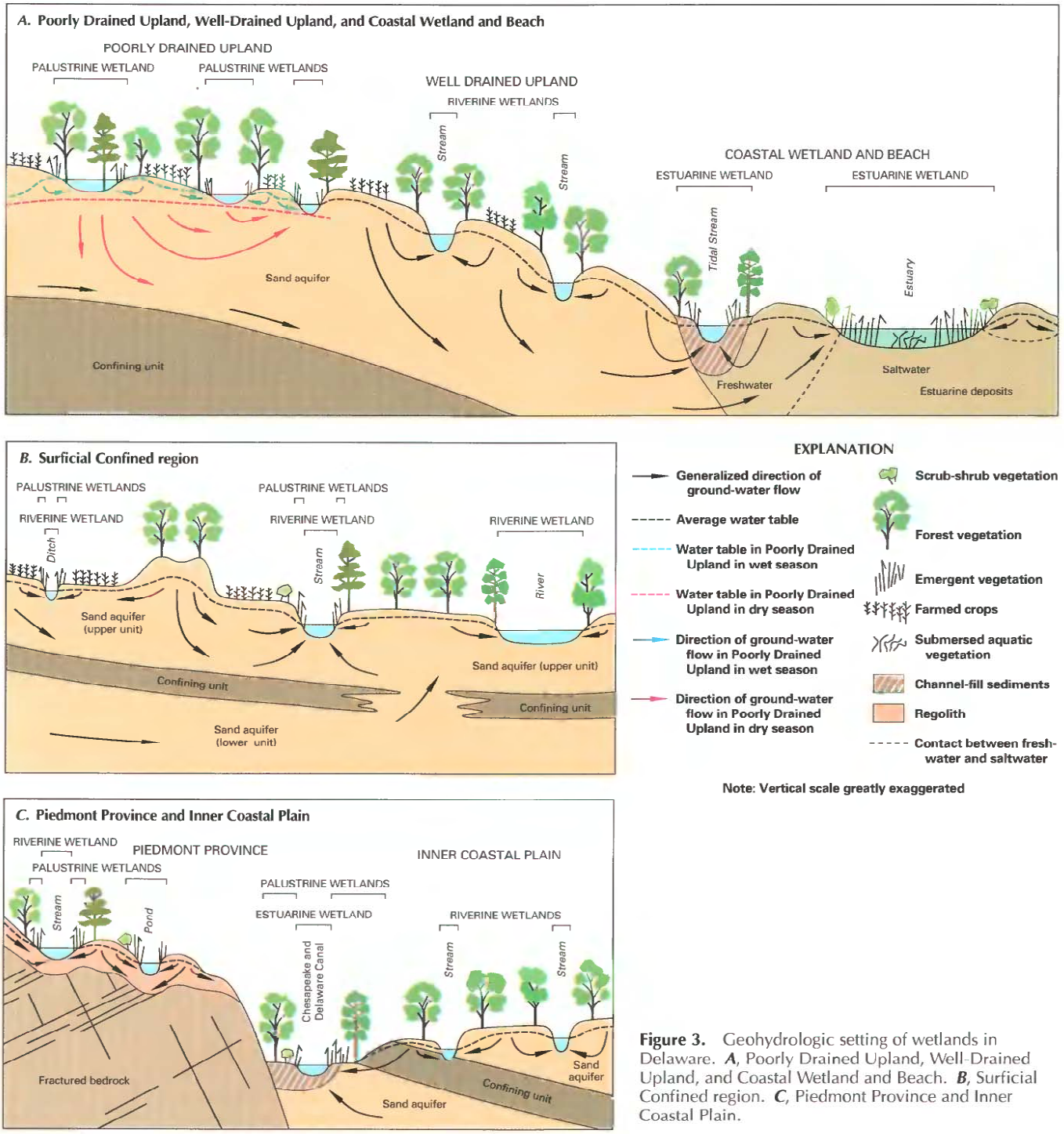

Figure 3. Geohydrologic setting of wetlands in Delaware. ***A***, Poorly Drained Upland, Well-Drained Upland, and Coastal Wetland and Beach. ***B***, Surficial Confined region. ***C***, Piedmont Province and Inner Coastal Plain.

Recharge of the ground-water system in the Piedmont Province is by infiltration of precipitation, mostly in the uplands (Heath, 1984); however, most precipitation in this province is transported to surface depressions and streams by overland runoff. In forested areas, water seeps into the soil layer and moves through it laterally to discharge into streams and, by evapotranspiration, into the atmosphere. Some water moves below the soil zone to the water table in the regolith. The water seeps from the regolith into the underlying bedrock or discharges to surface-water bodies (fig. 3*C*). Much of the ground water available to wetlands in this region is stored in the regolith (Metzgar, 1973).

Types of wetlands in the Piedmont Province include flood-plain emergent marshes, seeps, and excavated farm ponds. Notable among wetlands in this province are the forested wetlands along Brandywine Creek.

TRENDS

In the 1780's, about 480,000 acres (36 percent) of Delaware was wetland (Dahl, 1990). By the mid-1980's, 223,000 wetland acres remained—a loss of about 54 percent since the 1780's. The estimated annual loss of all types of wetland between 1955 and 1981 was 1,600 acres (Tiner, 1987). Both human activities that adversely affect water quality and natural phenomena have contributed to widespread wetland loss and degradation.

Major causes of vegetated nontidal wetland loss have been channelization and ditching (about 55 percent), direct conversion to agriculture (28 percent), urbanization (12 percent), and pond creation (5 percent) (Tiner, 1987). Major causes of vegetated tidal wetland loss have been urbanization (63 percent), inundation by submersion, dredging, or impoundment (24 percent), and pond creation (6 percent). Small areas of wetland have been formed in recent times, especially by inadvertent flooding during road construction, by pond construction and, most recently, by the establishment of compensatory wetland-mitigation sites. Properly managed shallow ponds and impoundments do not usually result in wetland losses but rather in conversions from drier to wetter types of wetlands; they can even yield net increases in wetland value with the change in function. New wetlands also have formed on washover fans and flood tidal deltas along coastal areas as well as on former upland areas inundated by rising sea levels.

Implementation of the 1973 State Wetlands Act and the 1972 Federal Clean Water Act markedly reduced the rate of human-caused tidal wetland loss. The estimated annual tidal wetland loss between 1954 and 1973 was 444 acres (Lesser, 1971); between 1973 and 1979 the estimated annual rate of tidal-wetland loss was 20 acres (Hardisky and Klemas, 1983). Recent rates of nontidal-wetland loss have not been accurately quantified.

CONSERVATION

Many government agencies and private organizations participate in wetland conservation in Delaware. The most active agencies and organizations and some of their activities are listed in table 1.

Federal wetland activities.—Development activities in Delaware wetlands are regulated by several Federal statutory prohibitions and incentives that are intended to slow wetland losses. Some of the more important of these are contained in the 1899 Rivers and Harbors Act; the 1972 Clean Water Act and amendments; the 1985 Food Security Act; the 1990 Food, Agriculture, Conservation, and Trade Act; the 1986 Emergency Wetlands Resources Act; and the 1972 Coastal Zone Management Act.

Section 10 of the Rivers and Harbors Act gives the U.S. Army Corps of Engineers (Corps) authority to regulate certain activities in navigable waters. Regulated activities include diking, deepening, filling, excavating, and placing of structures. The related section 404 of the Clean Water Act is the most often-used Federal legislation protecting wetlands. Under section 404 provisions, the Corps issues permits regulating the discharge of dredged or fill material into wetlands. Permits are subject to review and possible veto by the U.S. Environmental Protection Agency, and the FWS has review and advisory roles. Section 401 of the Clean Water Act grants to States and eligible Indian Tribes the authority to approve, apply conditions to, or deny section 404 permit applications on the basis of a proposed activity's probable effects on the water quality of a wetland.

Most farming, ranching, and silviculture activities are not subject to section 404 regulation. However, the "Swampbuster" provision of the 1985 Food Security Act and amendments in the 1990 Food, Agriculture, Conservation, and Trade Act discourage (through financial disincentives) the draining, filling, or other alteration of wetlands for agricultural use. The law allows exemptions from penalties in some cases, especially if the farmer agrees to restore the altered wetland or other wetlands that have been converted to agricultural use. The Wetlands Reserve Program of the 1990 Food, Agriculture, Conservation, and Trade Act authorizes the Federal Government to purchase conservation easements from landowners who agree to protect or restore wetlands. The Consolidated Farm Service Agency (formerly the Agricultural Stabilization and Conservation Service) administers the Swampbuster provisions and Wetlands Reserve Program. The Natural Resources Conservation Service (formerly the Soil Conservation Service) determines compliance with Swampbuster provisions and assists farmers in the identification of wetlands and in the development of wetland protection, restoration, or creation plans.

The 1986 Emergency Wetlands Resources Act and the 1972 Coastal Zone Management Act and amendments encourage wetland

Table 1. Selected wetland-related activities of government agencies and private organizations in Delaware, 1993

[Source: Classification of activities is generalized from information provided by agencies and organizations. •, agency or organization participates in wetland-related activity; ..., agency or organization does not participate in wetland-related activity. MAN, management; REG, regulation; R&C, restoration and creation; LAN, land acquisition; R&D, research and data collection; D&I, delineation and inventory]

Agency or organization	MAN	REG	R&C	LAN	R&D	D&I
FEDERAL						
Department of Agriculture						
Consolidated Farm Service Agency	...	•	...	...	...	...
Natural Resources Conservation Service	...	•	•	...	•	...
Department of Commerce						
National Oceanic and						
Atmospheric Administration	...	•	...	...	•	•
Department of Defense						
Army Corps of Engineers	...	•	•	...	•	•
Department of the Interior						
Fish and Wildlife Service	•	...	•	•	•	•
Geological Survey	...	...	...	...	•	...
National Biological Service	...	...	...	...	•	...
National Park Service	•	...	•	•	•	•
Environmental Protection Agency	...	•	...	...	•	•
STATE						
Delaware Geological Survey	...	...	...	...	•	...
Department of Natural Resources and						
Environmental Control	•	•	•	•	•	•
State Highway Administration	...	...	•	...	•	•
University of Delaware						
College of Marine Studies	...	...	...	...	•	•
SDME COUNTY AND LOCAL GOVERNMENTS	•	•	...	•	...	•
PRIVATE ORGANIZATIONS						
The Nature Conservancy	•	...	...	•	•	...
Delaware Wild Lands, Inc.	•	...	•	•	...	...
Delaware Nature Society	•	...	...	•	•	...
Ducks Unlimited	•	...	•	•	•	...

protection through funding incentives. The Emergency Wetland Resources Act requires States to address wetland protection in their Statewide Comprehensive Outdoor Recreation Plans to qualify for Federal funding for State recreational land; the National Park Service provides guidance to States in developing the wetland component of their plans. Coastal States that adopt coastal-zone management programs and plans approved by the National Oceanic and Atmospheric Administration are eligible for Federal funding and technical assistance through the Coastal Zone Management Act.

State wetland activities.—Delaware's State Wetlands Act, enacted in 1973, protects coastal tidal wetlands, including some freshwater wetlands along tidal rivers, and requires a permit from the Department of Natural Resources and Environmental Control for many activities in these wetlands. A proposed freshwater (nontidal) wetlands statute would establish a State-run nontidal-wetlands regulatory program based on five categories of wetlands. This would be part of a comprehensive statewide management program and is intended to result in the assumption of authority for the Federal section 404 program by the State. The Department of Natural Resources and Environmental Control also administers section 401 of the Federal Clean Water Act, providing regulatory control in wetland areas in terms of effects on surface-water-quality standards. The coastal-zone management program in Delaware bars the development of heavy manufacturing industry within 2 miles of the State's coastline where wetlands are abundant, while allowing the development of light industry and the expansion of preexisting industry under a permit system. Permits are also required for substantial changes to the character of beach or open-water areas. The Subaqueous Lands Act and the Beach Preservation Act regulate activities in tidal and nontidal subaqueous navigable waters and within the coastal dune systems along the Atlantic Ocean and Delaware Bay.

Private wetland activities.—Private organizations with interests in wetlands in Delaware are active in the development of regulations, policy planning, advocacy, land acquisition and management, environmental education, and research. A few of the many such organizations in the State are The Nature Conservancy, the Delaware Nature Society, Delaware Wild Lands, Inc., the Sierra Club, Ducks Unlimited, and the Brandywine Conservancy.

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