Pennsylvania
Wetland Resources

Wetlands cover about 2 percent of Pennsylvania (Tiner, 1990). Although once regarded as wastelands, wetlands now are recognized as ecologically and economically valuable ecosystems. Fish and wildlife use these highly productive areas for feeding, breeding, nesting, and refuge. More than 80 percent of the animals on Pennsylvania's list of endangered and threatened species depend on wetlands during their life cycle (Brooks, 1990). Wetlands also are home to most of Pennsylvania's rare, threatened, or endangered plants (Pennsylvania Department of Environmental Resources, 1988). The Long Pond area of Tunkhannock Creek (fig. 1) has the State's largest known concentration of endangered species (Roger Latham, University of Pennsylvania, written commun., 1993).

Wetlands trap suspended sediments and organic and inorganic contaminants in soils and plant tissue, thus enhancing water quality. Wetland vegetation also retards erosion by decreasing water velocity and increasing soil stability. During floods, riparian (streamside) wetlands regulate streamflow by temporarily storing floodwater and then slowly releasing it to the stream or river, greatly reducing flooding downstream. Of particular interest in Pennsylvania is the use of constructed wetlands as an effective passive treatment of coal-mine drainage, which can be highly acidic and contain elevated concentrations of iron, manganese, sulfate, aluminum, and other trace elements (Hedin, 1989). Constructed wetlands also are used to reduce nutrient loads from agricultural drainage.

Figure 1. Wetland at Tunkhannock Creek near Long Pond. This wetland contains the State's largest known concentration of endangered plants and animals. *(Photograph by Annette C. Heist, U.S. Geological Survey.)*

Wetlands are productive ecosystems, yielding a large amount of plant material for both wildlife and human consumption. Products harvested from wetlands include cranberries, blueberries, and wild rice. Pennsylvania's tourist industry benefits from the recreational opportunities that wetlands provide, including hunting, fishing, boating, and camping. Many wetland areas throughout the State also provide educational opportunities for schools and the general public.

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 Pennsylvania 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 Pennsylvania are described below.

System	Wetland description
Palustrine	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	Wetlands within an intermittently to permanently flooded lake or reservoir. Vegetation, when present, is predominantly nonpersistent emergent plants (nonpersistent-emergent wetlands), or submersed and (or) floating plants (aquatic beds), or both.
Riverine	Wetlands within a channel. Vegetation, when present, is same as in the Lacustrine System.

About 1.4 percent (404,000 acres) of Pennsylvania's land surface is covered by wetlands. About 97 percent of these wetlands are palustrine, about 2 percent are lacustrine, and 1 percent are riverine. Pennsylvania's 392,000 acres of palustrine wetlands consist of 178,000 acres of deciduous and evergreen forested wetlands, 62,000 acres of open water, 52,000 acres of emergent wetlands, 49,000 acres of deciduous and evergreen scrub-shrub wetlands, 25,000 acres of mixed deciduous scrub-shrub and emergent wetlands, and 26,000 acres of other types (Tiner, 1990). Pennsylvania wetlands are known by a variety of local names, the most common of which are swamp (forested wetland) and marsh (emergent wetland typically dominated by sedges and grasses). Many of Pennsylvania's palustrine wetlands line major rivers or surround lakes and reservoirs. Peatlands (wetlands that have organic soils, such as bogs and fens) are common in mountainous or glaciated areas and commonly contain sphagnum moss, tamarack or black spruce trees, a variety of low trees and shrubs, or sedges, grasses, and other herbaceous plants.

About 42 percent of Pennsylvania wetlands are in the glaciated parts of the northwestern and northeastern corners of the State (Tiner, 1990). Wetlands in the northwest are primarily deciduous forested and scrub-shrub wetlands. Those in the northeast are primarily deciduous and evergreen forested wetlands. Most of the central and southern parts of the State were not glaciated. In the nonglaciated parts of the State, wetlands are most commonly associated with the headwaters and flood plains of streams (Brooks and others, 1987). The largest area of lacustrine wetlands (5,650 acres)

is along the Lake Erie shoreline. Minor amounts of tidal riverine wetlands are along the Delaware River in southeastern Pennsylvania.

HYDROLOGIC SETTING

Wetland characteristics are determined by the balance between inflow and outflow of water, surface contours of the land, soil type, and geology (Mitsch and Gosselink, 1986). Topographic depressions caused by glacial or stream-related processes, areas with impermeable substrates that prevent infiltration of water into the ground, and areas where the water table is near the surface provide ideal conditions for wetland formation. Wetlands commonly form at groundwater discharge sites where permeable rocks intersect the land surface or at the base of slopes where the water table intersects the land surface (Novitzki, 1989).

Wetlands are most densely distributed in the northwestern and northeastern parts of the State, which were glaciated at least twice and possibly three times (fig. 2*B*). The latest glaciation occurred between 18,000 and 22,000 years ago. Glacial scouring and deposition left surface depressions and impermeable soils that are ideal for wetland development (Bushnell,1989). Outside the glaciated

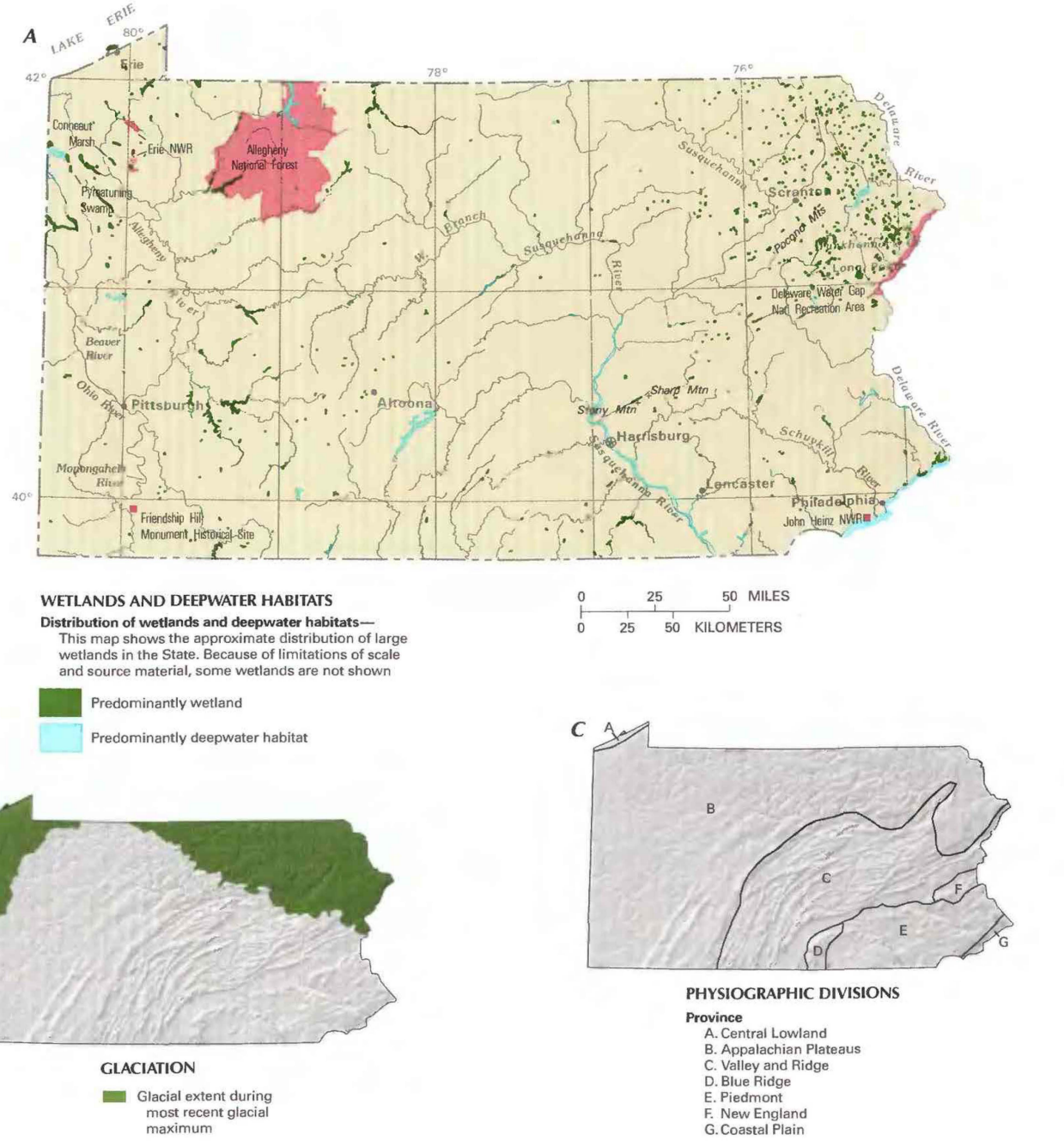

Figure 2. Wetland distribution in Pennsylvania and physical features that control wetland distribution in the State. ***A***, Distribution of wetlands and deepwater habitats. ***B***, Extent of most recent glaciation. ***C***, Physiography. *(Sources: A, T.E. Dahl, U.S. Fish and Wildlife Service, unpub. data, 1991. B, Pennsylvania Bureau of Topographic and Geologic Survey, 1989. C, Physiographic divisions from Fenneman, 1946; landforms data from EROS Data Center.)*

areas, wetlands typically are associated with streams and rivers. Some wetlands gain moisture from stream flooding, whereas others are fed by ground water and drain into streams. Riparian wetlands develop when lateral erosion and deposition widen a river valley or when accumulated sediment fills and flattens a valley. In riparian areas, a depositional substrate of silt, mud, and clay and the shallow water table near a river combine to create ideal conditions for the formation of small lakes and swamps. However, many of the large rivers in Pennsylvania are in deep, narrow valleys and lack extensive riparian areas (Bushnell, 1989).

Pennsylvania has abundant precipitation. Average annual precipitation ranges from about 36 inches in the north and west to about 48 inches in the east. Precipitation in eastern Pennsylvania is distributed evenly throughout the year, whereas the western part of the State receives most of the precipitation in the spring and summer. Statewide, an average of about 25 inches of the annual precipitation returns to the atmosphere by evaporation or transpiration (Wetzel,1986).

Pennsylvania lies in parts of seven physiographic provinces (fig. 2*C*): the Central Lowland, Appalachian Plateaus, Valley and Ridge, New England, Blue Ridge, Piedmont, and Coastal Plain. Each province has unique characteristics that control the distribution and types of wetlands.

Central Lowland.—The Central Lowland is underlain mainly by sedimentary rocks, including sandstone, shale, dolomite, and limestone (Krothe and Kempton, 1988). The region includes areas of both thick and thin glacial till, which is a mixture of clay, sand, and boulders deposited by a melting glacier. The low permeability of the glacial till allows the formation of wetlands in depressions and low-lying areas. The region is flat to gently sloping except where cut by streams. Most of the streams in the Central Lowland of Pennsylvania flow northward to Lake Erie. The streams have steep gradients and flow over or have cut deeply into bedrock, resulting in few associated wetlands (Richards and others, 1987). Lacustrine wetlands associated with Lake Erie comprise nearly two-thirds of total wetland acreage in this part of the State (Tiner and Anderson, 1986).

Appalachian Plateaus.—The Appalachian Plateaus Province is underlain by interbedded shale, sandstone, and some limestone (Bushnell, 1989). The rocks of this province are gently folded to nearly flat-lying. Fracturing and jointing are common (Seaber and others, 1988). The northeastern and northwestern parts of the province have been glaciated.

In the nonglaciated areas, palustrine wetlands have formed in riparian areas along the major rivers and streams. Some wetlands also are present in and around impoundments. Locally, small wetlands are present on hilltops where clayey soils and shale support shallow water tables. Wetlands also form along the valley sides and heads of streams where erosion has exposed aquifers or where joints break the continuity of confined aquifers (Bushnell, 1989).

In the northwestern part of the province, before glaciation, rivers flowed north to Lake Erie (Leggette, 1936). Advancing ice blocked the north-flowing rivers, forming lakes and forcing drainage southward. Present drainage patterns were created as ice melted and glacial sediments were carried in south- and southeast-sloping channels. The largest wetlands in this area, including Conneaut Marsh and Pymatuning Swamp, developed on the glacial sediments that filled deep, preglacial valleys. Numerous smaller wetlands also formed in the irregular, hummocky topography of the end and ground moraines, which are landscape features formed by glacially formed sediments (Bushnell, 1989).

In the glaciated northeast, wetlands are associated mainly with end and ground moraines and have developed as lakes, swamps, and peatlands in glacially scoured depressions (Bushnell, 1989). Many wetlands also were formed by the damming of preglacial valleys by glacial debris. In addition, "kettle-hole" lakes were created where large blocks of ice remained after glacial retreat and melted to form spring-fed lakes that have no surface inlet or outlet.

Peatlands in the Pocono Mountains of northeastern Pennsylvania are the southernmost peatlands of recent glacial origin and are considered rare habitats in Pennsylvania (Brooks and others, 1987). Peatlands can develop where drainage is slow and where precipitation normally exceeds evapotranspiration. Fens and bogs are two types of peatlands found in Pennsylvania. Fens are fed by mineral-rich ground water. Bogs are fed mostly or entirely by rainwater and, as a result, are mineral poor. The process of peat formation follows a general evolution. Clay from glacial tills accumulates on the bottom of ponds, trapping the organic material. Under the oxygen-poor conditions in the bottom substrate, slow decomposition allows the formation of peat. As peat accumulates, the pond shrinks and a marsh commonly forms. As more peat accumulates, the surface of the peatland rises to such an extent that the substrate is saturated, but there is little standing water. At that stage, trees, shrubs, and sphagnum moss become common. Eventually, as the accumulating peat brings the land surface above the water table, shrubs and trees advance until a scrub-shrub or forested wetland is formed. Flooding of the peatland by natural or artificial changes in drainage will cause the peatland to return to a marsh. If the water table is lowered for any sustained period of time, the soils will undergo aeration, and the organic content of the soil will decrease (Cameron, 1970).

Valley and Ridge Province.—The Valley and Ridge Province is underlain mainly by sedimentary rocks, including sandstone, conglomerate, shale, siltstone, dolomite, and limestone, that are tilted and folded (Seaber and others, 1988). The structure and weathering pattern of the rocks combine to yield the characteristic alternating valley and ridge topography. Some of the limestone valleys have an extensive karst or underground drainage system that precludes extensive wetland development (Bushnell, 1989). In contrast, limestone outcrops along the western edge of the province are the source of many springs and seeps that supports wetlands. Most wetlands are associated with the Susquehanna River and its tributaries (Bushnell, 1989), especially in the upper, glaciated regions of the river.

An unexpected wetland lies in a valley between the peaks of Sharp Mountain and Stony Mountain, about 15 miles northeast of Harrisburg. The wetland lies along the axis of a syncline that is underlain by resistant beds of rock that have low permeability (Bushnell, 1989). The wetland consists of forested and emergent wetlands that contain sphagnum moss, swamp azalea, red maple, and black gum.

New England Province.—The New England Province is an area of high hills and ridges that are composed principally of metamorphic rocks, and igneous rocks, and limestone (Wood and others, 1972). Because the province has steep topography and is well drained, few wetlands have formed there. Most wetlands are in riparian areas along the Delaware River.

Blue Ridge and Piedmont Provinces.—The Blue Ridge and Piedmont Provinces are underlain by fractured-rock, water-table aquifers. Deformed igneous and metamorphic rocks, commonly mantled with weathered rock and soil, characterize the bedrock of the region (LeGrand, 1988). The Piedmont Province also has gently dipping beds of sedimentary rock. The region has small groundwater units, each confined to a small basin in which a perennial stream flows. Ground water flows continuously toward streams and discharges as small springs and as channel seepage into the streams (LeGrand, 1988). Most wetlands are in stream valleys where the water table is near the land surface. Others are in upland areas where there are clayey, impermeable soils or local ground-water discharge (Bushnell, 1989).

Coastal Plain.—The Coastal Plain, limited to the southeastern edge of Pennsylvania, is underlain mainly by permeable soils

composed of sand, silt, and clay (Meissler and others, 1988). Most wetlands in this area are associated with the Delaware River and its riparian areas. Approximately 19 percent of the freshwater tidal marshes and flats in the Delaware River Basin are in this province within Pennsylvania (Tiner and Wilen, 1988), including the largest freshwater tidal marsh in the State, the John Heinz National Wildlife Refuge at Tinicum.

TRENDS

The U.S. Fish and Wildlife Service has estimated that, from the 1780's to the 1980's, wetland area in Pennsylvania decreased by more than one-half (Dahl, 1990). Activities such as conversion to cropland, channelization, forestry, mining, urban development, and the construction of impoundments have contributed to widespread wetland loss or degradation.

Between 1956 and 1979, Pennsylvania lost about 28,000 acres (nearly 7 percent) of its vegetated wetlands. More than one-half of the vegetated wetland losses took place in the northeastern (9,700 acres) and northwestern (4,600 acres) parts of the State. The leading cause of losses was conversion to ponds, lakes, and reservoirs (46 percent); farmland (17 percent); urban land (14 percent); and other land uses, mostly by channelization and drainage (23 percent) (Tiner, 1990). Peat mining in the Pocono Mountains region also has contributed to the loss of wetlands (Timer, 1987). After peat has been removed from the wetland, the area commonly is converted to a pond or lake.

The loss of vegetated wetland by conversion to pond wetland cannot be interpreted as a simple "no net loss" exchange. The importance of the gain in pond acreage in terms of fish and wildlife species, as well as the impact on wetland functions such as flood and erosion control, has not been adequately assessed. In contrast, the loss of vegetated wetlands is known to cause the loss of valuable fish and wildlife species as well as of other ecological and economical benefits (Tiner and Finn, 1986).

The Delaware River estuary and Lake Erie coastal zones contain habitats that are rare in Pennsylvania, and small losses of wetlands there could be significant. In Pennsylvania, the Delaware River estuary coastal zone consists of approximately 50 square miles along the Delaware River south of Philadelphia. Although only 129 acres of emergent wetlands have been lost in the Delaware River estuary coastal zone since the mid-1970's, this represented a 22-percent loss for the area. Major causes were the construction of a sewage-treatment plant and highway construction (Tiner,1990).

The Lake Erie coastal zone consists of approximately 63 square miles in the Lake Erie area. There were no significant changes in wetland acreage in the Lake Erie coastal zone between the mid-1970's and 1986 (Tiner, 1990). However, between 1986 and 1989, approximately 50 acres of wetlands were lost. Most of those losses (91 percent) were due to housing construction (Smith and Tiner, 1992).

CONSERVATION

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

Federal wetland activities.—Development activities in Pennsylvania 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.

Table 1. Selected wetland-related activities of government agencies and private organizations in Pennsylvania, 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						
Federal						
Consolidated Farm Service Agency	..	•	...	..	...	...
Forest Service	•	...	•	•	•	•
Natural Resources Conservation Service	...	•	•	...	•	•
Department of Commerce						
National Oceanic and Atmospheric Administration	...	•	...	...	•	...
Department of Defense						
Army Corps of Engineers	•	•	•	•	•	•
Department of the Interior						
Bureau of Mines	...	..	•	..	•	...
Fish and Wildlife Service	•	..	•	•	•	•
Geological Survey	...	...	...	...	•	...
National Biological Service	...	...	...	...	•	..
National Park Service	•	...	•	•	•	•
Environmental Protection Agency	...	•	...	...	•	•
STATE						
Department of Environmental Resources						
Bureau of Dams, Waterways, and Wetlands	•	•	•	...	•	•
Bureau of Forestry	•	...	•	•	•	•
Bureau of Land and Water (Coastal Zone management)	•	...	...	...	•	•
Bureau of State Parks	•	...	•	...	...	•
Department of Transportation	...	...	•	..	•	•
Pennsylvania Fish and Boat Commission	•	...	...	...	...	...
Pennsylvania Game Commission	•	...	•	...	...	...
Pennsylvania State University	...	...	...	...	•	...
Other State universities	..	...	...	...	•	...
COUNTY AND LOCAL						
Some county and local governments	•	•	...	•	..	..
Some county conservation districts	•	•	...	...	•	•
PRIVATE ORGANIZATIONS						
The Nature Conservancy	•	...	...	•	...	...
Pennsylvania Academy of Natural Sciences	...	...	...	...	•	...
Western Pennsylvania Conservancy	•	...	•	•	•	•

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 (EPA), 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 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 (NPS) provides guidance to States in developing the wetland component of their plans. Coastal and Great Lakes 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.

Federal agencies are responsible for the management of wetlands on public land under their jurisdiction. The FWS manages two wildlife refuges in Pennsylvania, the John Heinz National Wildlife Refuge at Tinicum and the Erie National Wildlife Refuge. The U.S. Forest Service manages about one-half million acres of land in the Allegheny National Forest. The NPS manages 11 sites in Pennsylvania, including the Delaware Water Gap National Recreation Area. Wetlands are inventoried on these lands as part of resource management plans developed for each park. The U.S. Bureau of Mines has been involved in research into the creation of wetlands for the passive treatment of acid-mine drainage. One such experimental wetland was created by the U.S. Bureau of Mines and the NPS on the Friendship Hill National Historic Site.

State wetland activities.—The Pennsylvania Department of Environmental Resources' Bureau of Dams, Waterways, and Wetlands, is the principal State agency responsible for wetland regulation. Wetlands are regulated as "bodies of water" under the Dam Safety and Encroachments Act of 1978. The wetland regulations are found at 25 Pa. code Chapter 105, Dam Safety and Waterway Management, amended October 31, 1991. Virtually any structure or activity that in any manner changes, expands, or diminishes the course, current, or cross section of any wetland requires a chapter 105 permit in addition to any Federal permits that are required for the project.

Pursuant to section 305(b) of the Clean Water Act, the Department of Environmental Resources submits to the EPA and the U.S. Congress a biennial assessment of the State's surface-water quality, including that of wetlands. The Department's Bureau of Land and Water Division of Coastal Zone Management conducts a yearly wetlands monitoring program in the Delaware River estuary and Lake Erie coastal zones.

The Bureau of State Parks and the Bureau of Forestry inventory wetlands as part of their resource-management plans. Monies from the Land and Water Conservation Fund are used by the Department of Community Affairs, the Department of Environmental Resources, the Fish and Boat Commission, the Game Commission, and the Historical and Museum Commission for planning, acquisition, and development of outdoor recreation areas, including wetlands. Land acquisition also is made possible through the Recreational Improvement and Rehabilitation Act and the Federal Land and Water Conservation Fund.

County and local wetland activities.—Most regulation of activities in wetlands is carried out through State and Federal laws. However, some county and local governments are involved in the protection of wetland resources through zoning, regulating, and land acquisition. Some county conservation districts manage public and private lands that contain wetlands.

Private wetland activities.—Private organizations in Pennsylvania are involved in wetland activities that include policy planning, land acquisition and management, research, and public education. Some of the organizations active in Pennsylvania are The Nature Conservancy and the Western Pennsylvania Conservancy (land acquisition and management), the Sierra Club and Chesapeake Bay Foundation (policy planning and education), and the Pennsylvania Academy of Natural Sciences (research). About 50 conservancy organizations throughout the State work to protect and preserve natural lands, including wetlands, on a local level.

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