Indiana
Wetland Resources

Wetlands cover about 813,000 acres of Indiana (Rolley, 1991)—about 3.5 percent of the State. These wetlands support rich biotic communities in freshwater settings across the State, especially in the north and southwest (fig. 1).

Wetlands have many chemical, physical, and biological functions. Wetlands trap waterborne sediments, nutrients, and toxic chemicals by filtering them out of inflowing water and storing or transforming them. The capacity of wetlands to trap sediment is particularly important in Indiana because surface erosion is a persistent, long-term result of intensive agricultural activity. Riparian (streamside) wetlands lessen the severity of floods by storing water temporarily and releasing it gradually, thus reducing flow velocity and delaying and attenuating flood peaks. Vegetation in riparian wetlands helps to maintain stream channels by stabilizing the land surface, and wetlands around lakes act as buffers to erosion from waves.

Wetlands provide habitat for waterfowl, fish, other terrestrial and aquatic animals, and a wide variety of plant life. Wetlands provide resting and feeding places on migration routes, as well as food, shelter, breeding areas, and nurseries for many animals, including species of economic interest in Indiana such as muskrat, fish, ducks, and geese. The State has listed 128 wetland-dependent plant species and over 60 wetland-dependent animal species as endangered, threatened, or of special concern (Indiana Department of Natural Resources, 1989).

In Indiana, wetlands have considerable recreational, educational, and economic value. Common activities in and surrounding wetlands are bird-watching, hiking, fishing, hunting, swimming, and boating. Wetlands are important to the fur trapping, lumbering, and tourist industries, which benefit the economy of the State.

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 Indiana 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 Indiana 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.

Most Indiana wetlands have been filled or drained. Palustrine wetlands, which are the most abundant wetlands remaining in the State, are distributed throughout Indiana in topographic depressions, between agricultural fields, and in riparian zones along rivers, streams, and lakes. Palustrine forested wetlands are the most common wetlands in Indiana.

In the early to mid-1980's, palustrine forested wetlands covered about 504,000 acres, or approximately 62 percent of the wetland area of the State (Rolley, 1991). Palustrine emergent wetlands covered about 143,000 acres (18 percent of total wetland area), and scrub-shrub wetlands covered about 42,000 acres (5 percent). Lacustrine and riverine wetlands covered about 99,000 acres (12 percent). The remaining 3 percent of the wetland area in the State contained mixed or undetermined types of wetland.

Most of the wetlands in Indiana are in the north and along river flood plains in the south, particularly the southwest (Rolley, 1991). The northeastern part of the State contains most of Indiana's natural lakes and numerous small, isolated wetlands. The northwestern part of the State includes the Indiana Dunes National Lakeshore, which is on the southern shore of Lake Michigan. Most streams and rivers in Indiana flow to the southwest, where many wetlands are located in the river flood plains of the largest river systems (Indiana Department of Natural Resources, written commun., 1993). Wetlands in the rest of the State consist of small, widely scattered wetlands and narrow wetland bands along rivers and streams and around reservoirs (Indiana Department of Environmental Management, 1991).

Indiana has many types of wetlands, most of which are vegetated. The plant composition of vegetated wetlands is determined by factors such as climate, soil type, ground- and surface-water chemistry, and the extent and duration of flooding. The predominant vegetation or specific location of a wetland frequently deter-

Figure 1. Cowles Bog in the Great Marsh, Indiana Dunes National Lakeshore. *(Photograph by R.J. Shedlock, U.S. Geological Survey.)*

mines its common name. Familiar common names for some Indiana wetlands include marsh, wet prairie, swamp, slough, bottom-land hardwood forest, flatwood, bog, fen, kettle, pothole, dune swale, muck flat, and sinkhole pond. Marshes and wet prairies are palustrine emergent wetlands that contain grasses, sedges, or cattails. Swamps, sloughs, and bottom-land hardwood forests are palustrine forested and scrub-shrub wetlands typically found along rivers. Flatwoods are palustrine forested wetlands that form on level, poorly drained soils where the water table is shallow. Bogs and fens are palustrine wetlands that are generally located in depressions in once-glaciated areas of Indiana; these wetlands generally contain grasses, other soft-stemmed plants, and peat deposits. Kettles and potholes are emergent and scrub-shrub wetlands that formed in depressions left after large blocks of ice that were embedded in glacially deposited sediments melted. Dune swales are topographic depressions among sand dunes near Lake Michigan that contain palustrine emergent or scrub-shrub wetlands. Sinkhole ponds are lacustrine wetlands located in plugged sinkholes in areas where limestone bedrock is at or near the surface.

HYDROLOGIC SETTING

The wetlands of Indiana are formed and maintained by water from precipitation, surface-water runoff, and local and regional ground-water flow systems. Wetlands generally are in topographic lows, where water from surface runoff collects and where ground water commonly discharges after periods of heavy precipitation. Fluctuations in local precipitation and evapotranspiration rates combined with local differences in geology, topography, and soil characteristics cause transient or seasonal changes in the way that ground water and surface water interact in a wetland (Meyboom, 1966; Wilcox, 1986; Winter, 1992; Phillips and Shedlock, 1993).

Precipitation in Indiana varies seasonally and geographically. Precipitation falls throughout the year but is greatest from March through July (Crompton, 1986). Annual average precipitation ranges from about 36 inches in the northeastern part of the State to about 44 inches in the south-central part. Combined loss from evaporation and transpiration is nearly uniform across the State and averages 26 inches annually. Annual surface-water runoff averages about

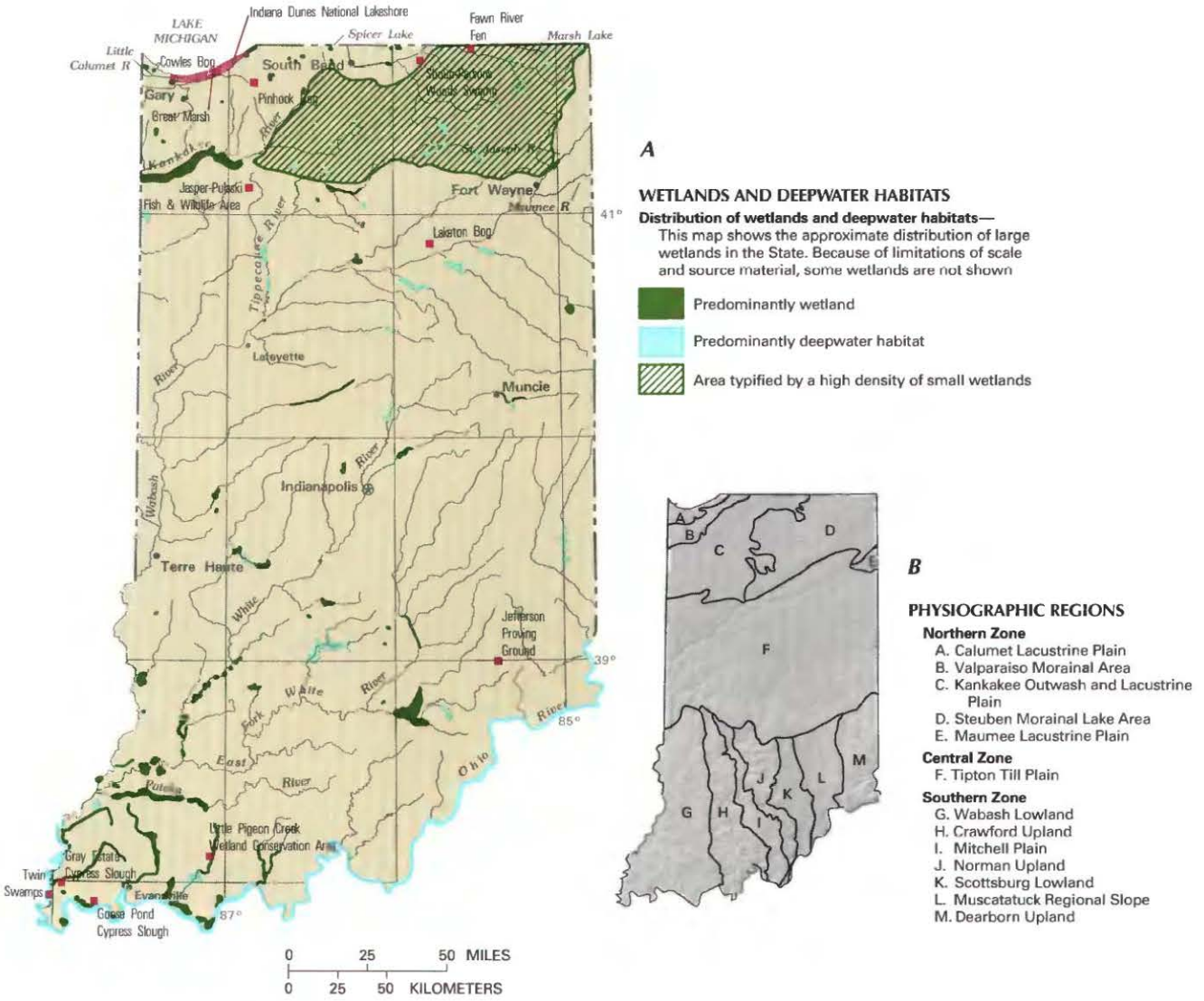

Figure 2. Wetland distribution in Indiana and physiography of the State. ***A***, Distribution of wetlands and deepwater habitats. ***B***, Physiography. *(Sources: A, T.E. Dahl, U.S. Fish and Wildlife Service, unpub. data, 1991. B, Physiographic divisions modified from Schneider, 1966; landforms data from EROS Data Center.)*

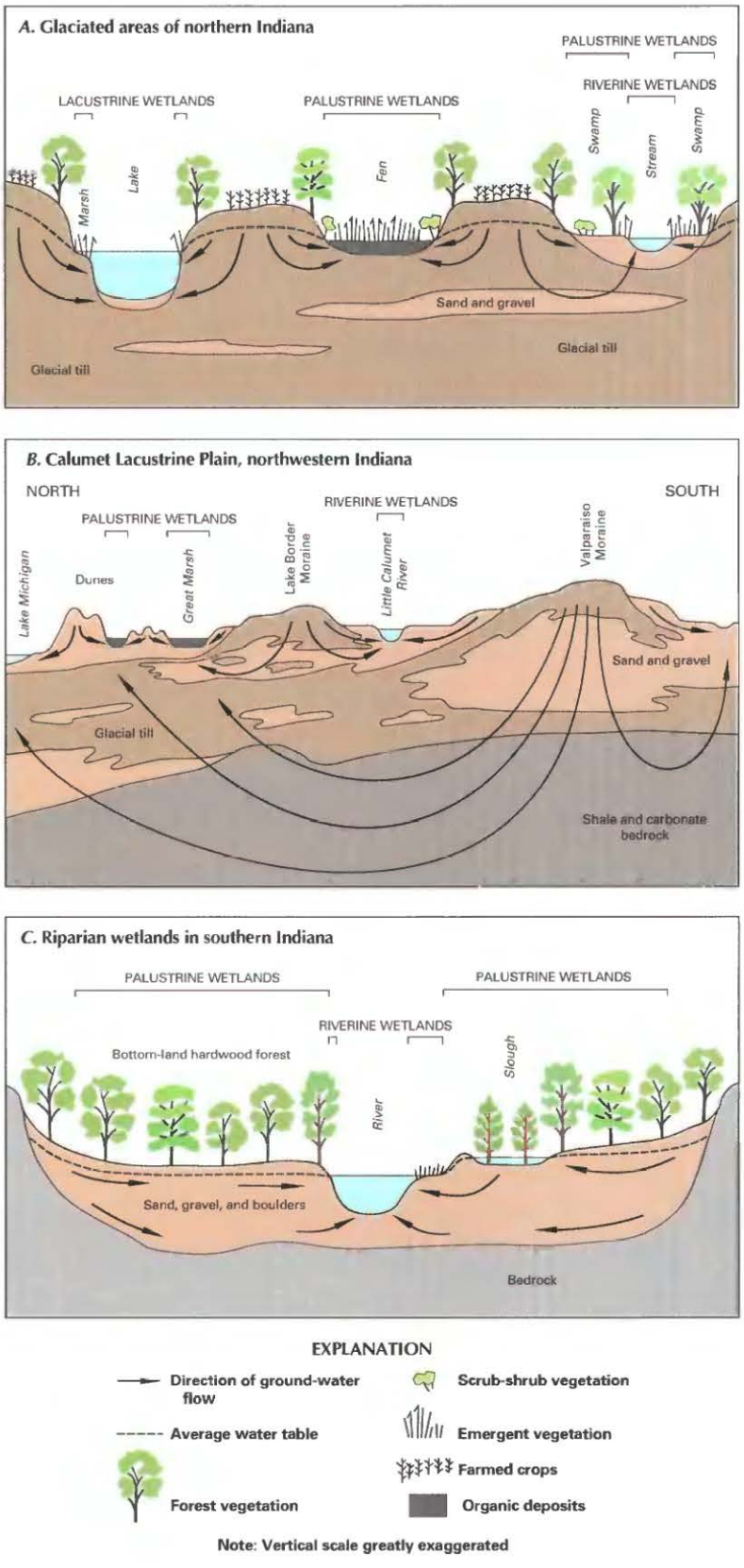

Figure 3. Generalized geohydrologic setting of common wetland types in Indiana. ***A***, Wetlands in glaciated areas of northern Indiana. ***B***, Wetlands in the Calumet Lacustrine Plain of northwestern Indiana. ***C***, Riparian wetlands in bedrock areas of southern Indiana. *(Sources: A, Modified from Hartke and others, 1975. B, Modified from Shedlock and others, 1993. C, Modified from Gallaher and Price, 1966.)*

9.0 inches, and about 3.5 inches recharges the groundwater system (Clark, 1980). The abundant precipitation is conducive to the formation and maintenance of wetlands, which were once extensive in Indiana. However, agricultural tile drains, ditches, and straightened drainages have substantially reduced the retention of water and, hence, reduced wetland area in many parts of the State.

Indiana can be divided into three broad physiographic zones based on surficial and bedrock geology (fig. 2*B*). The northern zone consists of glacial moraine and areas reworked by water from ancient and present Lake Michigan. The central zone is a flat depositional plain of low relief. The physiography of the southern zone varies and is largely controlled by underlying bedrock. Wetland hydrology differs among and within these zones.

In the northern physiographic zone, different local depositional conditions during glacial advances and retreats have resulted in a complex surficial aquifer largely composed of till. Till is a heterogeneous mixture of clay, silt, sand, gravel, and boulders that is deposited directly by and underneath a glacier. The surficial aquifer in the northern zone is connected to deeper aquifer systems in places where the till is thin or missing (Shedlock and others, 1993). Wetlands in this zone generally are in low, poorly drained areas that have standing water (fig. 3*A*).

The northern zone has five physiographic units: the Valparaiso Morainal Area, the Steuben Morainal Lake Area, the Calumet Lacustrine Plain, the Kankakee Outwash and Lacustrine Plain, and the Maumee Lacustrine Plain (fig. 2*B*). Most of the wetlands that remain in Indiana are in the Valparaiso Morainal Area and the Steuben Morainal Lake Area. These physiographic units have irregular topography and as much as 200 feet of relief; numerous small, poorly integrated streams; and many closed depressions containing lakes and wetlands, including kettles, fens, and bogs. Water is supplied to these wet areas by precipitation, surface-water runoff and, except in bogs, shallow ground-water flow (fig. 3*A*). Notable wetlands in these areas are Spicer Lake, Marsh Lake, Laketon Bog, Pinhook Bog, and Fawn River Fen.

The Calumet Lacustrine Plain, Kankakee Outwash and Lacustrine Plain, and Maumee Lacustrine Plain have flat terrain and once contained extensive wetlands in glacial lakes and outwash plains. Land in these physiographic units has been nearly completely ditched and drained. Remaining wetlands in these units are mainly in riparian areas. The exception is the Calumet Lacustrine Plain, which contains extensive wetlands in and around the Indiana Dunes National Lakeshore (fig. 3*B*). In the Calumet Lacustrine Plain, major changes in the level of Lake Michigan occurred as the glaciers receded. Shoreline dune complexes formed sequentially approximately parallel to the modern lakeshore. Each new dune line prevented drainage from the south from reaching the lake directly, resulting in the development of a complex wetland system. The wetland system includes Cowles Bog (fig. 1), the largest peatland in Indiana. Peatlands form in depressions where there is poor drainage, standing water, and water chemistry not conducive to plant decay. Plant remains eventually fill the original depression and sometimes rise above the surrounding land surface, forming a peat mound.

Cowles Bog, which is sustained in part by ground water and therefore is by definition a fen, is an example of this process (Wilcox and others, 1986; Shedlock and others, 1993). The wetlands in the Indiana Dunes are the only wetlands in the State where a detailed long-term study (Shedlock and others, 1993) has been completed. The hydrology of both the riparian and the sand-dune wetlands in the Calumet Lacustrine Plain is controlled by precipitation and groundwater flow, primarily in shallow flow systems.

The central physiographic zone (fig. 2*B*) consists of one unit—the Tipton Till Plain, which is a nearly flat to gently rolling glacial plain of sandy and silty outwash sediments. At the extreme western edge of the plain, the Wabash River and its tributaries have cut as deep as 150 feet through the glacial deposits into bedrock. The Tipton Till Plain has been almost entirely drained for agricultural purposes. Remaining wetlands are in stream channels, along the edges of reservoirs, and in small, shallow depressions between agricultural fields. These wetlands are maintained by precipitation and local and regional ground-water flow.

The southern physiographic zone (fig. 2*B*) was partly covered by glaciers. There, the surficial aquifer consists of regolith and sedimentary deposits of glacial origin. Regolith is unconsolidated, mostly fine-grained material composed of fragmental, weathered bedrock and alluvium overlying unweathered bedrock. The southern zone has seven physiographic units: the Wabash Lowland, the Crawford Upland, the Mitchell Plain, the Norman Upland, the Scottsburg Lowland, the Muscatatuck Regional Slope, and the Dearborn Upland. Topography and soils differ considerably among the units and are primarily controlled by the type of underlying bedrock.

Most of the wetlands in the southern physiographic zone are in riparian areas along streams and rivers. These wetlands are maintained by precipitation and local shallow flow systems (fig. 3*C*). Some of the largest remaining wetlands in Indiana are in the Wabash and Scottsburg Lowlands and on the Muscatatuck Regional Slope. These wetlands are in the flood plains, confluences, and backwater areas of the Wabash, Patoka, White, and Ohio Rivers and their tributaries. Notable among these are the flatwoods in the tributaries of the East Fork of the White River, located in the Jefferson Proving Grounds; Little Pigeon Creek Wetland Conservation Area; Twin Swamps; and the Gray Estate and Goose Pond Cypress Sloughs. Unusual wetlands in this zone include those in the Wabash Lowland that have formed in long, narrow surface depressions between spoil piles in areas mined for coal. Also unusual are the sinkhole wetlands and ponds in the Mitchell Plain, formed where vertical solution zones in the carbonate bedrock have become plugged with soil and other debris, and water from precipitation and surface runoff has collected. Additionally, the Jasper–Pulaski Fish and Wildlife Area is a congregating area and migratory rest stop for eastern greater sandhill cranes.

TRENDS

In the 1780's, before settlement by Europeans, wetlands covered about 5.6 million acres (24 percent) of Indiana (Indiana Department of Natural Resources, 1989). At that time, and continuing to the present in some communities, wetlands were categorized as wastelands that could be made more useful by filling and draining. Federal and State laws encouraged these activities (Read, 1993). By the early 1980's, more than 85 percent of the original wetlands in Indiana had been destroyed, and only about 813,000 acres of wetlands remained (Rolley, 1991). About 85 percent of vegetated-wetland losses resulted from conversion of wetlands for agricultural purposes (Indiana Department of Natural Resources, 1989).

Agricultural, industrial, and residential-development interests in Indiana still encourage stream channelization and ditching, draining, filling, diking, dredging, and damming of wetlands. In addition to the direct loss of wetlands, the biological value of many natural wetlands has been degraded by contamination by excess nutrients, sediments, and toxic chemicals as well as by the spread of nonnative plant species that can eliminate native species. The loss and degradation of wetlands and resulting adverse effects on fish and wildlife populations have reduced recreational opportunities and the economic benefits that outdoor recreation can bring to local communities (Indiana Department of Natural Resources, written commun., 1993).

About 1 to 3 percent of Indiana's remaining wetlands are lost each year, primarily because of drainage for agricultural purposes (Indiana Division of Fish and Wildlife, written commun., 1993). A survey of wetlands in the northern one-third of Indiana indicated that by 1987, more than 10 percent of the wetlands in aerial photographs taken between 1981 and 1984 of the northern physiographic zone and Wabash River watershed had been drained (Indiana Department of Natural Resources, 1989).

Construction of flood-control reservoirs in the 1960's and 1970's doubled the acreage of open water by permanently flooding riparian zones along rivers. Lacustrine wetlands replaced the naturally occurring riverine and palustrine wetlands in the process. In fact, approximately 70 percent of existing lacustrine wetlands and 13 percent of palustrine wetlands in Indiana developed as the result of damming or excavation (Rolley, 1991). In addition, some new wetlands have formed in reclaimed and unreclaimed spoil areas in coal-mining zones. However, wetland losses in Indiana have been far greater than wetland gains.

To slow the rate of wetland loss, recent State and Federal laws require or encourage wetland protection or creation. For example, wetlands have been created by the establishment of compensatory wetland mitigation sites, especially for transportation-related projects. Regulations require that 3 acres be created for each acre destroyed, but the actual success rate is probably much lower (Indiana Department of Natural Resources, 1989). The Indiana tax code encourages wetland protection for sites larger than 10 acres. Some farmers have used provisions in Federal wetlands-related legislation to consolidate existing wetlands and create new ones (Indiana Department of Natural Resources, 1989). Some municipalities are invoking waste- and stormwater-management regulations to encourage the protection and development of wetlands. River Basin Commissions, notably those of the Kankakee, Maumee, and St. Joseph Rivers, are encouraging or pursuing wetland restoration as a flood-control measure that would have the added benefit of recreation potential. In addition, the Indiana Department of Natural Resources, FWS, and the Natural Resources Conservation Service (NRCS; formerly known as the Soil Conservation Service) have restored more than 600 wetlands totaling 3,000 acres and constructed many other wetlands under the Partners for Wildlife program. Wetland protection efforts are adversely affected by limited public understanding of wetland values, lack of information on wetland distribution and abundance in the State, and insufficient and unenforced legislation (Indiana Department of Natural Resources, written commun., 1993).

CONSERVATION

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

Federal wetland activities.—Development activities in Indiana 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

Table 1. Selected wetland-related activities of government agencies and private organizations in Indiana, 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						
Department of Environmental Management	•	•	...	...	...	•
Department of Natural Resources	•	•	•	•	•	•
Indiana Geological Survey	...	...	...	...	•	...
Indiana University						
School of Public and Environmental Affairs	...	...	...	...	•	•
Purdue University						
Department of Forestry and Natural Resources	...	...	...	...	•	•
State Highway Administration	...	...	•	...	•	•
SOME COUNTY AND LOCAL GOVERNMENTS	•	•	...	•	...	•
PRIVATE ORGANIZATIONS						
Ducks Unlimited	•	...	•	•	•	...
Hoosier Environmental Council	•	...	...	...	...	...
Izaak Walton League	...	...	•	•	•	...
Save the Dunes Council	•	...	•	...	...	...
Sierra Club	...	...	...	...	•	...
The Nature Conservancy	•	...	...	•	•	...

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 (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 NRCS 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 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.

State wetland activities.—Currently (1993), no Indiana law specifically regulates activities in wetlands, although the Department of Natural Resources is developing a State wetland conservation plan under a grant from the EPA. The scheduled completion date for the plan is mid-1995. Regulation and management of Indiana wetlands are performed under the Indiana Water Pollution Control Law, sections 401 and 404 of the Federal Clean Water Act, the Indiana Flood Control Act, the Indiana Preservation of Lakes Statute, the Indiana Nature Preserves Act, and the Indiana Wetland Conservation Program. The Indiana Department of Environmental Management and the Indiana Department of Natural Resources are the principal State agencies that administer the laws and associated permit programs.

The Indiana Water Pollution Control Law gives the Department of Environmental Management authority to protect wetlands, which are defined as "waters of the State" for this purpose. Section 401 of the Federal Clean Water Act authorizes the Department of Environmental Management's water-quality certification program. Corps section 404 dredge-and-fill applications are reviewed both by the Department of Environmental Management to determine whether the proposed activities will adversely affect water quality and by the Department of Natural Resources for comment on potential environmental impacts and habitat disturbance. The Indiana Flood Control Act requires a Construction in the Floodway Permit from the Department of Natural Resources in order to construct within the floodway of a river or stream and its adjacent wetlands. The Indiana Preservation of Lakes Statute requires a permit from the Department of Natural Resources to change the water level or alter the shoreline or bed of a public freshwater lake. The Indiana Nature Preserves Act established the Division of Nature Preserves within the Department of Natural Resources; the Division is responsible for the inventory, acquisition, dedication, management, and protection of significant natural areas throughout the State, including wetlands, but the program's strict criteria eliminate many wetlands from consideration. The Division of Fish and Wildlife of the Department of Natural Resources administers the Indiana Wetland Conservation Program, which also protects and manages "significant" wetlands in 20 areas (totaling 5,409 acres) acquired by donation, by purchase, or as compensation for loss resulting from permit violation.

Other State wetland-management activities of the Division of Fish and Wildlife include several projects in partnership with Federal, other State, and private agencies to conserve and restore wet-

lands for wildlife habitat. In addition, the Division administers recreation and conservation areas directly and performs management activities in about 364,000 acres, mostly lakes and rivers.

County and local wetland activities.—Several counties are developing wetland programs. For example, LaGrange County in northeastern Indiana is developing a water-treatment process that uses created wetlands to protect its natural lakes and streams.

Private wetland organization activities.—Several private organizations in Indiana are active in the development of wetland regulations, policy planning, advocacy, land acquisition and management, environmental education, and research. A few of the many private organizations active in wetlands issues in the State are The Nature Conservancy, whose primary wetland activities are acquisition, preservation, and management of wetland areas and associated watersheds; the Sierra Club, which has established the Wetlands Project, an information network to connect individuals, groups, and agencies working on wetland conservation and restoration; Ducks Unlimited, which supports the conservation and creation of waterfowl habitat; and the Izaak Walton League, the Save the Dunes Council, and the Hoosier Environmental Council, which support public education and efforts to enact wetland protection legislation.

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