Texas
Wetland Resources

Wetlands cover about 7.6 million acres of Texas—a decrease of about 52 percent from the State's original wetland acreage (Dahl, 1990). Wetlands have considerable environmental and economic value. In river basins, wetlands provide flood attenuation, bank stabilization, and water-quality maintenance. The tourist industry benefits from the scenic beauty of the State's many and diverse wetlands, which afford opportunities for recreational activities that include hunting, fishing, bird watching, nature photography, camping, and hiking. Coastal wetlands (fig. 1) are essential to maintaining important fish and shellfish population and habitat, which in turn provide an economic benefit from the recreational and commercial harvesting of these resources (Tiner, 1984).

Wetlands provide important wildlife habitat. For example, about 90 percent of overwintering waterfowl in the High Plains inhabit playa lake wetlands (Nelson and others, 1983). Statewide riparian and coastal wetlands provide stopover, feeding, and breeding grounds to migratory waterfowl and habitat to nonmigrating wildlife. Among the migrants from Canada that stop at riparian wetlands and overwinter in wetlands along the Texas coast are snow geese, Canada geese, and whooping cranes (an endangered species). Some of the migratory ducks that reside on coastal marshes are American widgeon, mallard, green-winged teal, and blue-winged teal. The mottled duck is a common year-round resident on coastal marshes (Britton and Morton, 1989).

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 Texas 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 Texas are described below.

Figure 1. Wetlands in Welder Flats Coastal Preserve. The preserve was established to manage sensitive and productive estuarine wetlands and protect the endangered whooping cranes that overwinter there. *(Photograph by B.D. Jones, U.S. Geological Survey.)*

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.

Most Texas wetlands are palustrine; estuarine wetlands are next in area. Lacustrine, riverine, and marine wetlands are ecologically significant but cover a smaller area. The most extensive wetlands are the bottom-land hardwood forests and swamps (forested and scrub-shrub wetlands) of East Texas (the part of the State east of about 96 degrees longitude); the marshes (emergent wetlands), swamps, and tidal flats (unconsolidated-shore wetlands) of the Gulf of Mexico coast; the playa lakes of the High Plains; and the small, shallow, inland depressional basins called potholes found in coastal areas from Brownsville to Port O'Connor.

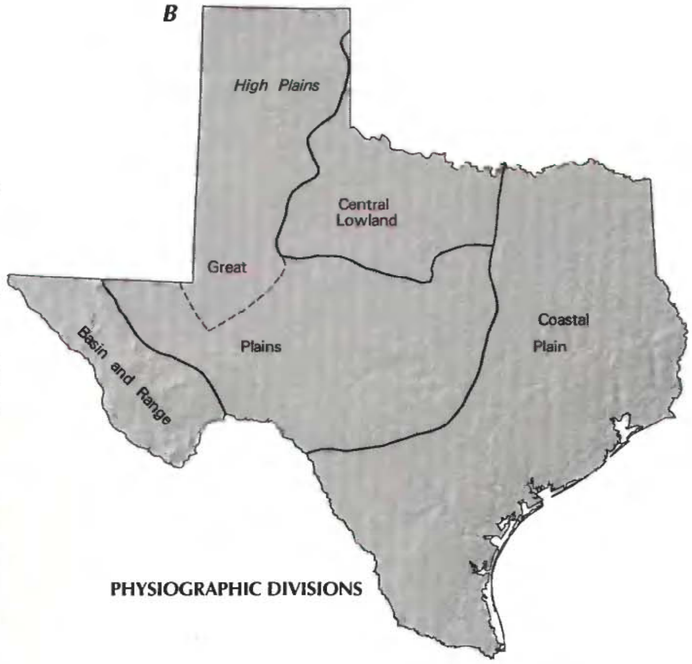
Most of the State's wetlands are palustrine bottom-land hardwood forests and swamps, and most of these are in the flood plains of East Texas rivers. A recent inventory estimated that, as of the early 1980's, forested wetlands in the State consisted of about 6,068,000 acres, including 5,973,000 acres of bottom-land hardwood forest and other riparian vegetation and 95,000 acres of swamp (Frye, 1987). East Texas contains about 71 percent of the forested wetlands, and the remaining 29 percent is located along rivers and streams throughout the rest of the State.

Data from LANDSAT images taken from 1972 through 1980 provided the basis for the preceding acreage estimates. The use of the LANDSAT images enabled the Texas Parks and Wildlife Department to determine the distribution and types of forested wetlands. Five principal vegetative groups were determined. They include (1) cottonwood-hackberry-salt cedar brush/woods, (2) pecan-elm forest, (3) water oak-elm-hackberry forest, (4) willow oak-water oak-blackgum forest, and (5) bald cypress-water tupelo swamp (McMahan and others, 1984).

Texas coastal wetlands—wetlands that are either on the coast, in or adjacent to estuaries, or in or near the tidal reaches of the rivers—extend the entire length of the coast. Palustrine wetlands, such as swamps and fresh marshes, occupy the flood plains and line the shores of tidal freshwater reaches of sluggish coastal rivers. Pothole wetlands are small, circular bodies of water fringed by emergent vegetation. The pothole wetlands are found inland from the coast and generally contain freshwater. Estuarine wetlands such as salt marshes (emergent wetlands) and tidal flats (mostly unconsolidated-shore, unconsolidated-bottom, and aquatic-bed wetlands) form in tidal reaches of rivers and in sounds and bays, where the salinity of the water can range from slightly more salty than freshwater to nearly as salty as seawater.

A recent inventory of coastal wetlands performed by the National Oceanic and Atmospheric Administration (NOAA) (Field and others, 1991) estimated the area covered by fresh marsh to be 530,300 acres. Estuarine wetlands comprised most of the coastal acreage—710,300 acres. Of the estuarine wetlands, 432,100 acres

B



A

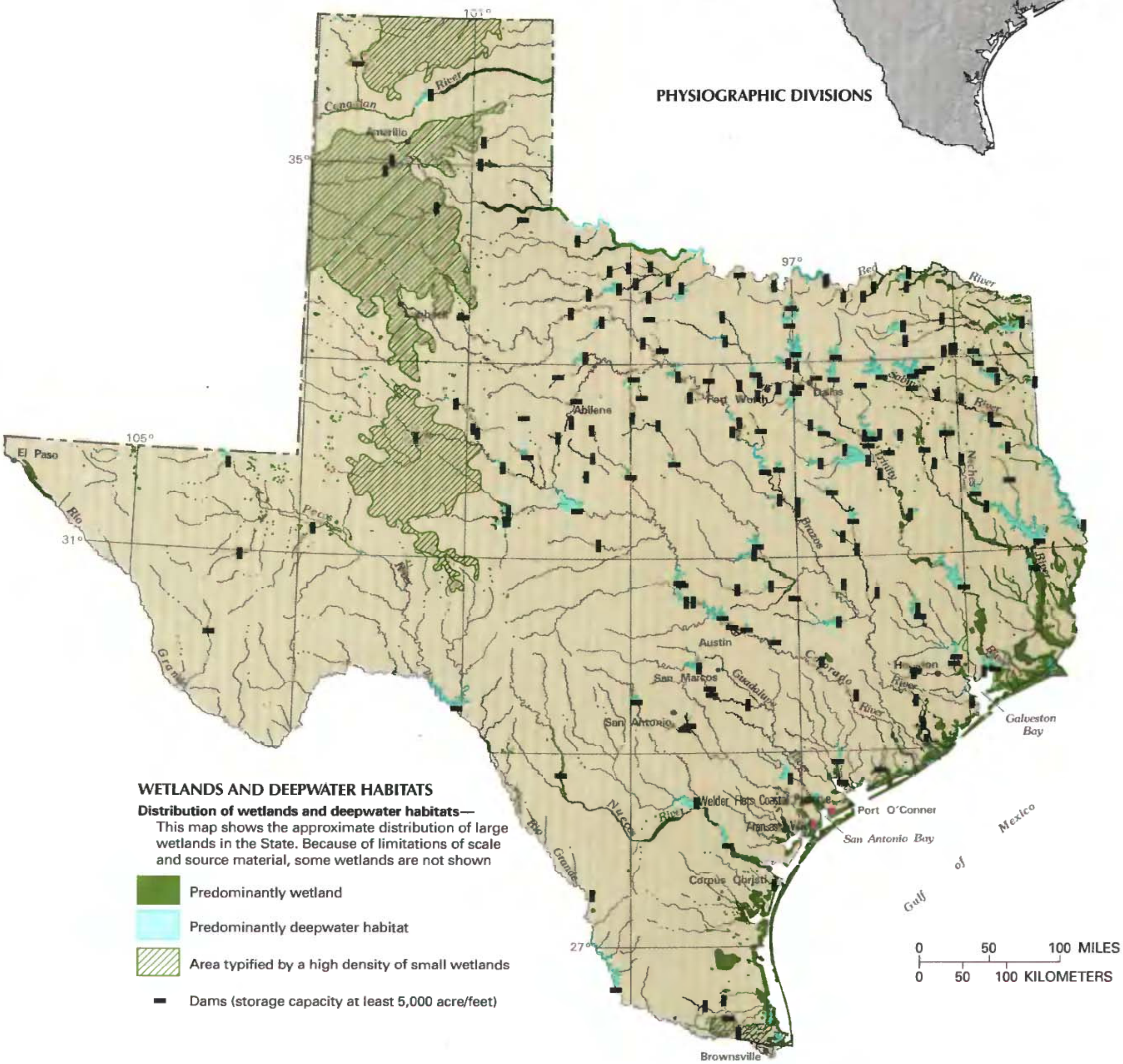


Figure 2. Wetland distribution in Texas and physical and climatological features that control wetland distribution in the State. ***A***, Distribution of wetlands and deepwater habitats. ***B***, Physiography. *(Sources: A, T.E. Dahl, U.S. Fish and Wildlife Service, unpub. data, 1991. B, Physiographic divisions from Fenneman, 1946; landforms data from EROS Data Center.)*

were salt marsh, 275,300 acres were tidal flats, and 2,900 acres were forested or scrub-shrub wetlands. The acreage summaries were produced using a grid-sampling procedure and wetland maps from the National Wetland Inventory project of the FWS (Tiner, 1984).

The Welder Flats Coastal Preserve (fig. 1) consists of approximately 1,400 acres of wetlands adjacent to San Antonio Bay (Texas Parks and Wildlife Department, 1990). These wetlands are a part of a dynamic estuarine system that has developed in response to the physical, chemical, and biological processes of the Guadalupe River–San Antonio Bay estuary. The wetlands consist of salt marshes, submersed vegetation known as seagrass beds (aquatic beds), nonvegetated mud and sand flats, and shallow saltwater ponds and lagoons. Welder Flats is near the Aransas National Wildlife Refuge, which provides critical shelter and plant food for a large variety of bay waterfowl, estuarine fishes, and bottom-dwelling organisms. It is also an overwintering area for endangered whooping cranes, a migration stopover for shorebirds, and a roosting and foraging area for nonmigrating wildlife.

The State's playa lakes are predominantly within the High Plains. The natural landscape is grassland except along the southeastern border of the area of playa lakes, where it becomes grassland and forest. The playa lakes, which range from dry lakebeds to shallow lakes, have been estimated to total 296,000 acres, or about 4 percent of Texas' wetland area (Guthery and Bryant, 1982). The estimated 20,000 or more playa lakes range in size from about 1 acre to more than 100 acres and in salinity from freshwater to saline. The freshwater playas are numerous, small to medium in size, and serve as zones of recharge to the underlying aquifer (Osterkamp and Wood, 1987). The saline playas are fewer, larger, and are areas of discharge from the underlying aquifer. The density of playa lakes is generally highest in the central part of the High Plains (Nelson and others, 1983).

The playas can be dry for extended periods. In wet conditions, the playa wetlands are either shallow lakes having little or no vegetation or lakes having aquatic vegetation (Nelson and others, 1983). Most of the playas are palustrine wetlands. However, playa lakes that exceed 20 acres are classified as lacustrine wetlands.

HYDROLOGIC SETTING

Wetlands form where there is a persistent water supply at or near the land surface. The location and persistence of the water supply is affected by many factors, such as climate, physiography, and hydrology.

Precipitation and runoff rates in Texas vary annually and with location and season. The average annual precipitation in the State ranges from about 8 inches at El Paso in the Basin and Range Province to about 56 inches in the lower Sabine River valley in the Coastal Plain of extreme eastern Texas (fig. 2*B* and 2*C*). The wettest seasons are spring and late summer (Jones, 1991). Evaporation is highest in West Texas and is lowest in East Texas (fig. 2*D*). In West Texas, annual lake evaporation is 4 to 5 times annual precipitation, whereas in East Texas, annual precipitation approaches annual evaporation. The areas with the highest annual precipitation and lowest evaporation are also the areas that have the most wetlands. East Texas contains more than one-half of the wetland acres in the State.

Bottom-land hardwood or flood-plain forests in East Texas are diverse wetland ecosystems dominated by woody vegetation (Wilkinson and others, 1987). These wetlands form in alluvial sediments deposited in flood plains when streams overflow their banks. The wetlands are maintained by fluctuating water levels resulting from flooding, by stream meanders that retard flow, and by the adaptation of woody vegetation to an environment in which the roots are in organic soils that are inundated or saturated during the growing season.

In East Texas, abundant precipitation and annual flooding in the seven major river basins cause fluctuation of water levels in stream channels, bottom lands, flood plains, and backwater areas, which promotes the development and maintenance of forested wetlands. Other conditions conducive to wetland development and maintenance in East Texas are low evaporation rates, shallow ground water, many springs, and nutrient-rich, clayey bottom-land soils.

The estuaries of the Gulf of Mexico coast were formed when water from melting glaciers caused sea level to rise and inundate

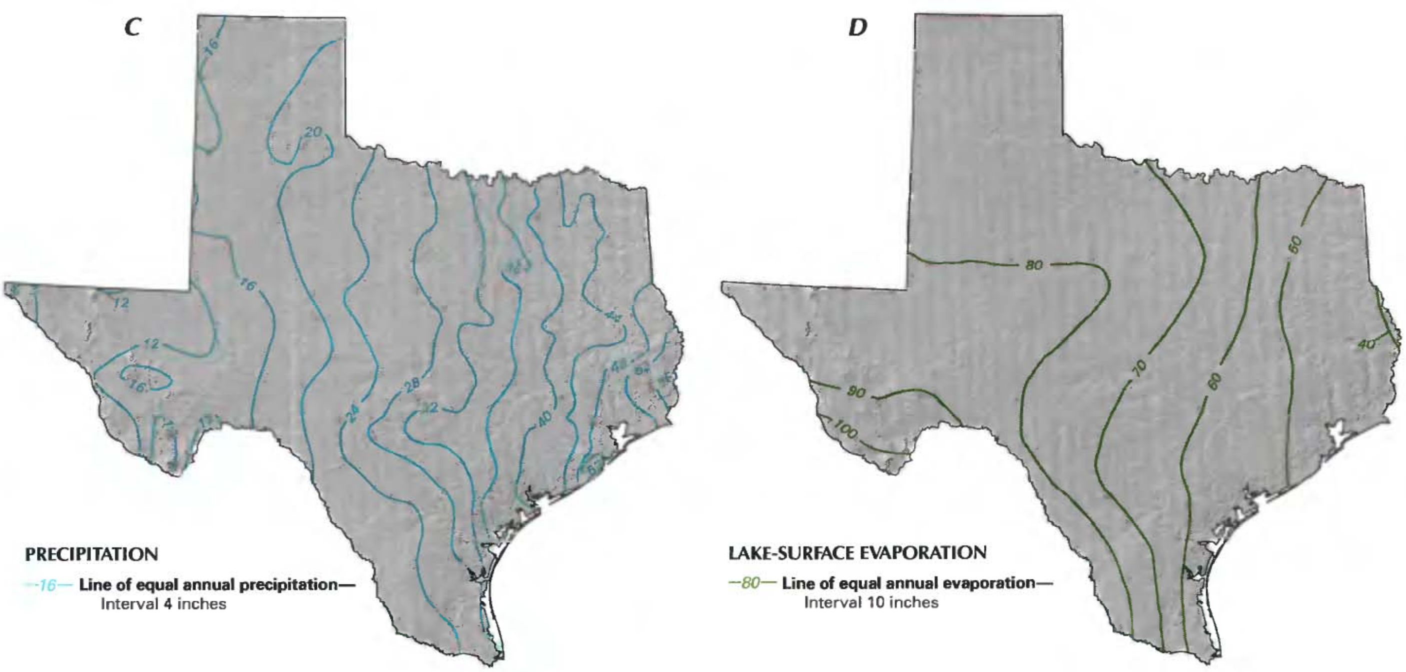


Figure 2. Continued. Wetland distribution in Texas and physical and climatological features that control wetland distribution in the State. ***C***, Average annual precipitation. ***D***, Average annual gross lake-surface evaporation. *(Sources: C, Woodward, 1986. D, Kane, 1967.)*

coastal river valleys. These drowned valleys were separated from the open sea by barrier islands, forming the bays and lagoons of the present shoreline. The bays and lagoons became shallow as they received sediment from rivers and wind to form estuaries. A variety of habitats develop in an estuary. Each habitat's ecological characteristics are the result of the stability of the substrate, rates of sediment accumulation or erosion, water depth, current flow, and other variables (Britton and Morton, 1989). The salinity of coastal wetlands depends upon whether the source of most of the water entering the estuary is from ocean tides or inland streams.

The soils that support wetlands on the coast have level to depressed relief and low permeability. These soils typically are poorly drained and have a high clay content and a moderate to high water-holding capacity (Barrera and Kelly, 1990).

Rainfall along the coast ranges from 56 inches per year in the subhumid east to 26 inches per year in the semiarid south at the Mexico border. Other principal factors in the climate of the coast are windspeed and direction. Wind, in combination with rainfall, evaporation, humidity, and temperature, affects most of the natural coastal processes. Evaporation generally exceeds precipitation in summer owing to high winds and temperatures. During fall and winter, there is generally a water surplus because of lower temperatures and increased rainfall from tropical storms. Severe tropical storms cause flooding of tidal flats, streams, and hummocky, wind-blown depressions that have poor drainage. Flooding from these tropical storms also results in widespread ponding and development of a shallow water table in the wind-deposited sand overlying older deposits that have very low permeability.

The playa lakes of the High Plains typically are shallow depressions that have a large surface area relative to the volume of water contained in them. Consequently, most playa lakes have a small storage capacity. Osterkamp and Wood (1987) stated that playa lakes form in the Great Plains wherever surface depressions collect water. The lakes enlarge as a result of dissolution of carbonates by water infiltrating the unsaturated zone above the underlying aquifer and subsequent subsidence of the lakebed. There is no general agreement on the origin of saline lakes; however, the source of the salinity might be the concentration by evaporation of shallow ground water that discharges from the underlying aquifer (Wood and Jones, 1990).

The playa-lake area has topography classified as either smooth plains, irregular plains, or tablelands (Nelson and others, 1983). Smooth plains are largely on upland terrain, and irregular plains and tablelands are mostly on lowland terrain. Because of the flatness of the terrain, there is generally little stream drainage; consequently, playa lakes collect most of the surface runoff. Water probably is removed from playa lakes by evaporation that can range as high as 96 to 112 inches per year (Nelson and others, 1983) and by slow leakage to the ground-water system (Osterkamp and Wood, 1987). The playa-lake beds generally have a layer of clay that retards movement of water from the playa lakes to the underlying aquifer.

Annual precipitation in the playa-lake area ranges from 15 inches along the western edge of the High Plains to 21 inches along the eastern edge. On average, more than an inch of rain falls each month between April and October. Windspeeds can range between 40 and 60 miles per hour for as long as a day in March, April, and May. Extreme winter temperatures range from –8°F in the south to –18°F in the north. Extreme summer temperatures range from 109°F to 112°F (Nelson and others, 1983).

TRENDS

The FWS has estimated that from the 1780's to the 1980's, wetland acreage in Texas decreased by 52 percent—from about 16 million to about 7.6 million acres (Dahl, 1990). Wetlands of every type have been affected. Some of these losses can be attributed to natural causes, but a large percentage were caused by human activities. In rural agricultural areas, losses can be attributed to conversion to cropland, declining water levels due to pumpage for irrigation, and overgrazing of wetland vegetation by livestock, which can increase erosion and evaporation. In urban areas, wetland losses occur because of encroachment by residential and commercial construction and industrial development. Wetland degradation has resulted from the discharge of inadequately treated sewage and industrial waste into wetlands. Other activities that can cause wetland losses are filling, water diversion, drainage and river channelization, clearcutting, burning, lowering or disturbing the shallow water table, and the construction of dams, reservoirs, flood-control ditches, levees, irrigation canals, and barge and ship canals. In recent years, several State agencies have begun to develop wetland plans and strategies to reduce wetland losses (Texas Parks and Wildlife Department, 1988).

Bottom-land-hardwood-forest acreage has declined from about 16 million acres in early Texas history (Kier and others, 1977) to about 5.9 million acres (Frye, 1987), a 63 percent loss. A study by the Texas A&M University Remote Sensing Center conducted in the early 1980's indicated that some areas of eastern and southeastern Texas had wetland increases, and some areas had decreases (R.G. Frye, Texas Parks and Wildlife Department, written commun., 1985). The FWS has reported, on the basis of U.S. Forest Service (FS) statistics, that commercial bottom-land forests decreased by 18 percent between 1935 and 1975 and by 10 percent between 1975 and 1985 (U.S. Fish and Wildlife Service, 1984). Lake and reservoir construction, based on the Texas Water Plan to meet projected water needs, would further reduce these wetlands by about 262,000 acres if the 44 reservoirs proposed by the plan were constructed (Texas Department of Water Resources, 1984).

Some of the fresh and salt marshes along the Gulf of Mexico coast have been lost because of dredging, agricultural drainage, and industrialization and urbanization. On the basis of estimates of coastal-wetland area (fresh and salt marshes) made in 1956 and 1980 (Texas Parks and Wildlife Department, 1988), the estimated loss in wetland acreage was about 35 percent during that period. Seagrass beds in the Galveston Bay estuarine system decreased from about 2,500 acres in the 1950's to about 700 acres in 1989 (White and others, 1993). The decrease was attributed to Hurricane Carla, land-surface subsidence, and human activity. A study of six coastal counties found a 41 percent loss in pothole wetlands from 1955 to 1979 (Spiller and French, 1986). Most of the loss was attributed to conversion to agriculture. It also is probable that many of the remaining coastal wetlands have been degraded by land subsidence, saltwater intrusion, and pollution from industry, shipping, and urbanization (D.W. Moulton, Texas Parks and Wildlife Department, written commun., 1990).

The playa lakes of the High Plains have been affected by intense cultivation and irrigation for the last 50 years. It has been estimated that about 90 percent of the playas have been modified (W.W. Wood, U.S. Geological Survey, written commun., 1994), and that more than two-thirds of the larger playas (10 acres or more) have been modified drastically (Guthery and Bryant, 1982). However, no comprehensive estimates of acreage losses exist for the playa-lakes area. Losses of other types of wetlands, such as freshwater springs and riparian wetlands, have occurred throughout the State.

Some land-use practices have led to the creation of new wetlands or the enlargment of existing wetlands. Rice farming near the gulf coast might have contributed to increases in wetland acreage, and construction of lakes and reservoirs undoubtedly has increased the acreage of lacustrine wetlands. However, those gains cannot offset the losses of wetland acreage, function, and value that have occurred in the State.

Table 1. Selected wetland-related activities of government agencies and private organizations in Texas, 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	...	•	...	...	...	...
Forest Service	•	...	•	•	•	•
Natural Resources Conservation Service	...	•	•	...	•	•
Department of Commerce						
National Oceanic and Atmospheric Administration	•	...	...	...	•	•
Department of Defense						
Army Corps of Engineers	•	•	•	•	•	•
Military reservations	•	...	...	...	...	...
Department of the Interior						
Fish and Wildlife Service	•	...	•	•	•	•
Geological Survey	...	...	...	...	•	...
National Biological Service	...	...	...	...	•	...
National Park Service	•	...	•	•	•	•
Environmental Protection Agency	•	...	...	•	•	...
STATE						
Department of Agriculture	...	...	...	...	•	...
Department of Transportation	...	...	•	...	•	...
Forest Service	...	...	...	...	•	...
General Land Office	...	...	•	•	...	•
Parks and Wildlife Department	•	•	•	•	•	•
Railroad Commission	...	•	...	...	...	...
Water Development Board	...	•	...	...	...	...
SOME COUNTIES AND LOCAL GOVERNMENTS	•	•	...	...	...	...
PRIVATE ORGANIZATIONS						
Ducks Unlimited	•	...	•	...	•	•
National Audubon Society	...	...	•	...	...	...
The Conservation Fund	...	...	...	•	...	...
The Nature Conservancy	•	...	•	•	•	•
Trust for Public Land	...	...	...	•	...	...

CONSERVATION

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

Federal wetland activities.—Development activities in Texas 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 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 NOAA are eligible for Federal funding and technical assistance through the Coastal Zone Management Act.

Federal agencies that have public land under their jurisdiction are responsible for the proper management of any wetlands that exist on these lands. In Texas, the FS manages about 636,000 acres of forested land and riparian habitat and about 148,600 acres of grassland (Dallas Morning News, 1992). About 8,500 acres of this land is estimated to be wetlands. The FS goal is to provide for healthy, diverse, and productive ecosystems that will sustain a variety of public benefits now and in the future.

The FWS manages about 396,000 acres in 14 National Wildlife Refuges in Texas. About 228,000 acres of this land is estimated to be wetlands (D.W. Moulton, Texas Parks and Wildlife Department, written commun., 1990). The FWS mission is to conserve, protect, and enhance fish, wildlife, and their habitats.

The NPS manages about 260,000 acres of land in Texas, and more than 99,000 acres of this land is protected waterfowl habitat (D.W. Moulton, Texas Parks and Wildlife Department, written commun., 1990). Regional water-resource coordinators are responsible for wetlands programs within their respective regions. The mission of the NPS is to conserve, preserve, and manage resources of the lands in the National Park system.

State wetland activities.—Several State agencies participate in managing natural resources. Agencies whose responsibilities include some aspect of wetland conservation and a brief description of their activities follow:

The Texas Railroad Commission is responsible for the regulation of surface coal mining and oil and gas production and transport. The regulations are oriented toward production stabilization and include prevention of pollution of wetlands.

The Texas Department of Transportation is responsible for avoiding damage to wetlands while constructing roads and bridges. They also are responsible for acquiring upland disposal areas for maintenance material from the Gulf Intracoastal Waterway.

The Texas Forest Service and Texas Department of Agriculture are involved in wetlands primarily in an advisory capacity to landowners. The agencies assist private owners in the management of forested land and use of land in crop production, including land containing wetlands.

The Texas Water Development Board prepares the State Water Plan and administers funds for reservoir construction and flood control. The State Water Plan must consider the effect of upstream development on bays and estuaries.

The Texas Natural Resource Conservation Commission regulates the allocation of State waters. The effects on fish and wildlife must be considered in permit application for allocations of 5,000 acre-feet or more. The Commission is involved in the process for granting permits for draining, channelizing, levee improvement, construction of wastewater-treatment facilities, and wastewater discharge. The degradation of waters and wetlands in the State is considered in all permit applications.

The Texas General Land Office has management responsibility for 15 large bays totaling over 1.5 million acres. The Land Office manages State lands and leases and grants easements to these lands under rules and regulations that require protection of natural resources, including fish and wildlife habitats.

The Texas Parks and Wildlife Department manages the State Park system, which features many wetland habitats. The Department acquires lands for the preservation, management, and study of wildlife. It also conducts research on management practices for waters and wetlands necessary to promote and sustain fisheries. As the State agency responsible for fish and wildlife, it reviews permit applications submitted to Federal and other State permitting agencies and evaluates their impact on wildlife habitat.

Counties and local wetland activities.—Counties and cities in Texas differ greatly in their commitment to the protection of wetland resources. A few municipalities, such as Austin and San Marcos, have implemented watershed-development controls to protect water quality and riparian wetlands. Some counties and cities have acquired wetlands in order to protect them.

Private wetland activities.—Private organizations have an important function as advocates of wetland conservation and protection. Texas has many private groups that inform the public, organize citizen groups, and lobby governments for the protection of wetlands. The Conservation Fund, National Audubon Society, The Nature Conservancy, and Trust for Public Land have programs for the purchase of wetlands for preservation. These lands can be transferred to State or Federal ownership or, in some cases, may remain in private ownership. Groups that provide information, education, evaluation, and technical help to both public and private owners of wetlands include Ducks Unlimited, Galveston Bay Foundation, Sierra Club, and the Texas Committee on Natural Resources.

References Cited

Barrera, T.A., and Kelly, Nivra, 1990, Wetland creation and enhancement on private lands along the mid to lower gulf coast of Texas under the north American waterfowl management plan: U.S. Fish and Wildlife Service Report CCSU–9002–CCS, 62 p.

Britton, J.C., and Morton, Brian, 1989, Shore ecology of the Gulf of Mexico: Austin, University of Texas Press, 289 p.

Cowardin, L.M., Carter, Virginia, Golet, F.C., and LaRoe, E.T., 1979, Classification of wetlands and deepwater habitats of the United States: U.S. Fish and Wildlife Service Report FWS/OBS–79/31, 131 p.

Dahl, T.E., 1990, Wetlands—Losses in the United States, 1780's to 1980's: Washington, D.C., U.S. Fish and Wildlife Service Report to Congress, 13 p.

Dallas Morning News, 1992, 1990–91 Texas Almanac: Dallas, Texas Monthly Press, 607 p.

Fenneman, N.M., 1946, Physical divisions of the United States: Washington, D.C., U.S. Geological Survey special map, scale 1:7,000,000.

Field, D.W., Reyer, A.J., Genovese, P.V., and Shearer, B.D., 1991, Coastal wetlands of the United States—An accounting of a valuable national resource: Washington, D.C., National Oceanic and Atmospheric Administration and U.S. Fish and Wildlife Service cooperative publication, 59 p.

Frye, R.G., 1987, Current supply, status, habitat quality and future impacts from reservoirs, *in* McMahan, C.A., and Frye, F.G., eds., Bottomland hardwoods in Texas—Proceedings of an interagency workshop on status and ecology, May 6–7, 1986, Nacogdoches, Tex.: Texas Parks and Wildlife Report PWD–RP–7100–133–3/87, p. 24–28.

Guthery, F.S., and Bryant F.C., 1982, Status of playas in the southern Great Plains: Wildlife Society Bulletin, v. 10, no. 4, p. 309–317.

Jones, B.D., 1991, Texas floods and droughts, *in* U.S. Geological Survey, National water summary 1988–89—Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 513–520.

Kane, J.W., 1967, Monthly reservoir evaporation rates for Texas, 1940 through 1965: Texas Water Development Board Report 64, 111 p., 7 pls., scale 1:5,000,000.

Kier, R.S., Garner, L.E., and Brown, L.F., Jr., 1977, Land resources of Texas—A map of Texas lands classified according to natural suitability and use considerations: University of Texas at Austin, Bureau of Economic Geology, 42 p., 4 map sheets, scale 1:500,000.

McMahan, C.A., Frye, R.G., and Brown, K.L., 1984, The vegetation types of Texas—Including cropland: Texas Parks and Wildlife Department, PWD Bulletin 7000–120, 40 p., map, scale 1:1,000,000.

Nelson, R.W., Logan, W.J., and Weller, E.C., 1983, Playa wetlands and wildlife on the southern Great Plains—A characterization of habitat: U.S. Fish and Wildlife Service Report FWS/OBS–83/28, 163 p.

Osterkamp, W.R., and Wood, W.W., 1987, Playa lake basins on the southern High Plains of Texas and New Mexico—Part 1, hydrologic, geomorphic, and geologic evidence for their development: Geological Society of America Bulletin, v. 99, p. 215–223.

Spiller, S.F., and French, J.D., 1986, The value and status of inland pothole wetlands in the lower Rio Grande Valley, Texas: U.S. Fish and Wildlife Service Special Report, 18 p.

Texas Department of Water Resources, 1984, Water for Texas—A comprehensive plan for the future: Texas Department of Water Resources Report G–P–4–1, 2 volumes, 72 p.

Texas Parks and Wildlife Department, 1988, The Texas wetlands plan—Addendum to the 1985 Texas outdoor recreation plan: Austin, Texas Parks and Wildlife Department, 35 p.

______1990, Welder Flats Coastal Preserve—Baseline studies report: Austin, Texas Parks and Wildlife Department [variously paged].

Tiner, R.W., Jr., 1984, Wetlands of the United States—Current status and recent trends: Washington, D.C., U.S. Fish and Wildlife Service, 59 p.

U.S. Fish and Wildlife Service, 1984, Texas bottomland hardwood preservation program: Albuquerque, N. Mex., U.S. Fish and Wildlife Service, 378 p.

White, W.A., Tremblay, T.A., Wermund, E.G., Jr., and Handley, L.R., 1993, Trends and status of wetland habitats in the Galveston Bay system, Texas: U.S. Fish and Wildlife Publication GBNEP–31, 225 p.

Wilkinson, D.L., Schneller-McDonald, Karen, Olson, R.W., and Auble, G.T., 1987, Synopsis of wetlands functions and values—Bottomland hardwoods with special emphasis on eastern Texas and Oklahoma: U.S. Fish and Wildlife Service Biological Report 87(12), 131 p.

Wood, W.W., and Jones, B.F., 1990, Origin of saline lakes and springs on the southern High Plains of Texas and New Mexico, *in* Gustavson, T.C., ed., Geological framework and regional hydrology—Upper Cenozoic Blackwater Draw and Ogallala Formation, Great Plains: Austin, Tex., Bureau of Economic Geology, p. 193–208.

Woodward D.G., 1986, Texas surface-water resources, *in* National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, p. 431–440.

FOR ADDITIONAL INFORMATION: District Chief, U.S. Geological Survey, 8011 Cameron Road, Building A, Austin, TX 78754; Regional Wetland Coordinator, U.S. Fish and Wildlife Service, 500 Gold Avenue, SW, Room 4012, Albuquerque, NM 87103

Prepared by
B.D. Jones,
U.S. Geological Survey