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COASTAL  
WETLANDS  
OF THE  
CONTINENTAL  
UNITED STATES

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*the trouble fringe*

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**COASTAL  
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## Introduction

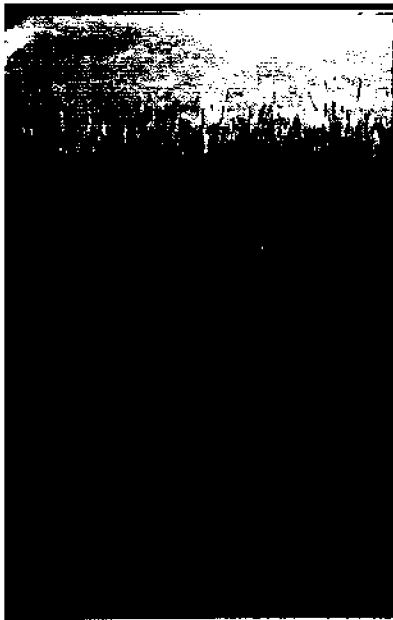
In the ecologist's language, wetlands are known as *ecotones*, or transitional areas, sandwiched between permanently flooded deep-water environments and well-drained uplands. At one edge they are predominantly aquatic and at the other mostly dry. The boundaries of each are often subtle, like the blurred border of green between bleeding blue and yellow dyes in a fabric. Typically, ecotones are richer than either adjacent habitat because they have attributes of both. They often contain more plants and animals, and may produce more organic material than either adjacent habitat.

In the last 50 years, ecologists have discovered that wetlands in natural ecosystems perform a number of important roles. They help to moderate extreme floods, help to maintain the desirable qualities of water, and are home to many unusual plants and commercially important animals like shrimp and crayfish. At the same time, wetlands are vulnerable systems, easily filled or drained for other uses, and they are rapidly disappearing. Beginning in the 1970s, wetland protection began to be written into federal and state laws. These statutes required a clear definition of wetlands.

The three common characteristics of all wetland definitions are: (1) Wetlands are periodically flooded or at least saturated to or near the surface with water. (2) Wetlands have unique soils (hydric soils) that differ from those of adjacent uplands. (3) Wetlands support plant species adapted to wet conditions (hydrophytes), and do not support vegetation intolerant of flooding.



Cypress knees, Lac des Allemands, Louisiana.  
Photo: Ronald Paille, Louisiana Sea Grant.



Cattails are common along the Atlantic and Pacific coasts  
Photo: C. C. Lockwood

As the tide moves inland, its amplitude increases while at the same time its water freshens. Wetlands in this zone are tidal but the water is fresh. In contrast, on coasts with low tidal energy such as the Gulf coast, the tide diminishes inland. Water levels rise and fall in a more unpredictable manner as a result of winds that raise water levels when they blow from the ocean and lower water levels when they blow from the land. In arid regions, not enough fresh water enters estuaries to support freshwater marshes.

### Coastal Wetlands

Coastal wetlands fringe the shoreline of the United States, with major occurrences along the margins of the Gulf of Mexico and the south Atlantic coast. Coastal wetland ecosystems are organized and integrated by the water that flows through them. Each coastal system includes both the wetlands immediately along the ocean and those lining the rivers and bays that drain into that part of the coast. The entire hydrologic unit functions as one entity. Fresh river water, upland runoff, and local rainfall flow seaward through the system, and sea water, pulsed by the tides, flows inland. The central basin, or estuary, is a mixing zone between fresh and saline waters. *Freshwater marshes* and *freshwater forested wetlands* occur farthest inland, where rain and river water dominate seawater. At the seaward edge of the basin, wetlands are regularly flooded by tidal waters, and large expanses of tidal *salt marshes* occur. In south Florida and the western coast of the Gulf of Mexico, salt marshes are sometimes replaced by saline forested wetlands called *mangroves*.

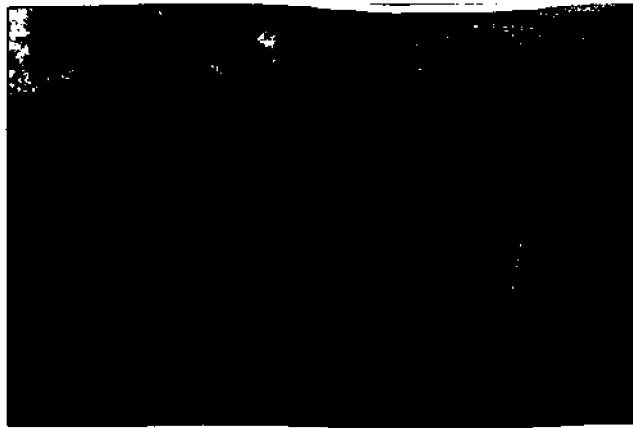
*Freshwater wetlands* are typically found at the inland portions of coastal ecosystems where river discharge is high. Fresh marshes can be tidally influenced or nontidal. Many wetland basins along the Atlantic coast are funnel shaped, and tidal water moving up the funnel from the coast is forced into ever narrowing channels. As the

The characteristic flooding of the soil surface in wetlands stresses most plants because it depletes the soil oxygen they require to survive. Of the hundreds of thousands of vascular plants that inhabit the planet, only a small percentage can survive much flooding. These are the wetland plants. A typical coastal freshwater marsh is characterized by only about 50 species of vascular plants. On the Gulf coast, the dominant freshwater marsh plants include maiden cane, arrowheads, and spike rushes. On the Atlantic coast, pick erebweed, wild rice, and cattails are common. On the Pacific coast, cattails and bulrushes dominate.

*Freshwater forested wetlands.* It is not clear why freshwater marshes are replaced by trees in some areas. Perhaps a firmer substrate allows trees to grow, or a different flooding regime is required for tree seed germination. At any rate, forested wetlands are common features of coastal basins. Although relatively diverse by wetland standards, the number of species is also limited because flooding limits the amount of oxygen in the soils. There are two broad types of forested wetlands. Deep-water areas that are

Top: Wild rice is commonly found on the south Atlantic coast  
Photo: USFWS  
Bottom: Arrowheads in flower  
Atchafalaya delta, Louisiana  
Photo: Ronald Paille, Louisiana Sea Grant





Bottomland hardwood swamps in Louisiana's Atchafalaya basin are flooded for part of each year. Photo: © C. C. Lockwood.

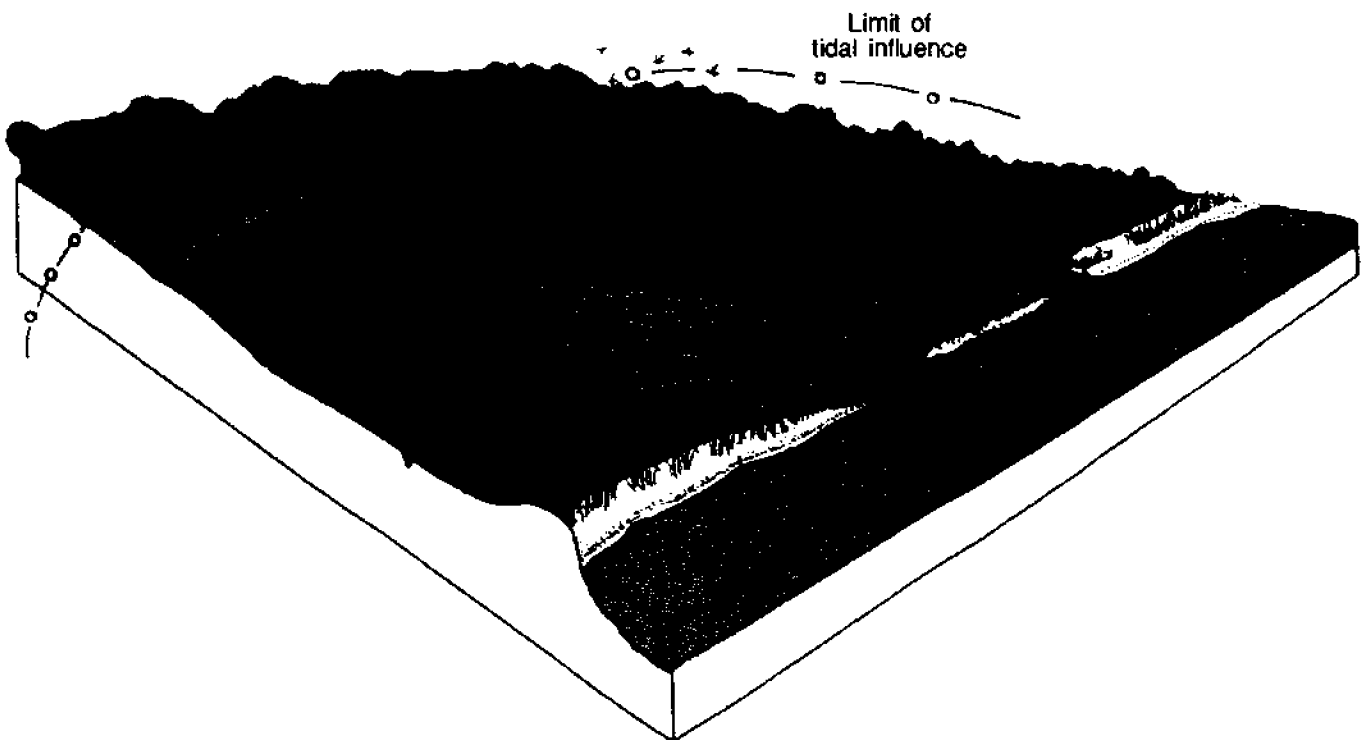
flooded most of the time are dominated by bald cypress and water tupelo or by pond cypress and black gum. Less frequently flooded areas, especially the floodplains of rivers, are dominated by willows, cottonwood, several species of oak, water hickory, green ash, and red maple.

*Salt marshes.* Salt marshes are flooded for varying periods by saline or brackish water. Lower marsh elevations are typically flooded on every tidal cycle: twice a day on the Atlantic and Pacific coasts, once a day on the Gulf coast. This environment is, therefore, characterized by twin stresses, flooding and salt. Of the plants that can survive flooding, few

can also survive the salinities associated with salt marshes. These few species, for example, salt marsh cordgrass or oyster grass (*Spartina alterniflora*) and black needlerush (*Juncus roemerianus*), are extremely successful, probably because they have little competition from other plants. Salt marsh salinities vary from nearly fresh to very salty, depending on the amount of rainfall and freshwater inflow. The saltier the water, the fewer plant species there are.

*Mangroves.* The only trees that can withstand the dual stresses of flooding and salt are tropical mangroves; in the United States they occur only in south Florida and, in stunted form, along the western Gulf coast. In south Florida, three mangrove species are common: *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), and *Laguncularia racemosa* (white mangrove). The vigor of the trees reflects the degree of environmental stress, with the tallest trees along the banks of flowing creeks, and stunted ones in stagnant water where oxygen is most limited.

#### CONCEPTUAL DIAGRAM OF COASTAL MARSH ZONES



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# Ecology, Functions, and Values of Coastal Wetlands

Wetlands are among the most important ecosystems on earth. Three hundred million years ago, the swampy environment of the Carboniferous period produced and preserved most of the fossil fuel on which we now depend. Today, wetlands continue to provide us with valuable services. They are sometimes described as "the kidneys of the landscape" for their function as removers of wastes from both natural and human sources. They form natural reservoirs, storing flood waters and minimizing the damage from severe storms. And they "store" biotic diversity, providing a home for a wide variety of important plants and animals. Finally, they produce and export food for a number of commercially important coastal fish and wildlife species.

Unlike rocky coasts, which have remained unchanged for millions of years, most coastal marshes are measurably different from the way they were a few hundred or thousand years ago. Wetlands occur where marine or river sediments settle into shallow water and build a platform on which marsh plants can grow. At any time, the elevation of the marsh surface is a balance between land building upward from sediment deposition, and land subsiding from consolidation of marsh sediments and the sinking of the land mass. This balance may be affected by many factors—a change in the water supply that carries the sediments, a change in the sediment supply, or even

Red mangrove at Rabbit Key, Florida.  
Photo: © C.C. Lockwood.



Salt marshmallow. Photo: © C.C. Lockwood.

a change in elevation of the marsh relative to the surrounding water (for example, a global rise in sea level), which in turn changes the frequency and depth of flooding.

These possibilities for wetland change emphasize the dynamic nature of wetlands. To a large extent, the characteristics of wetlands and the manner in which they function are determined by what is happening in the areas surrounding those wetlands. To understand why this is so, we must understand how hydrology (patterns of water flow) controls wetland sediment supply and erosion, the availability of oxygen and thus the organisms that depend on that oxygen, the nutrient supply and biological production, and the channels of access by migratory animals.

## Wetland Hydrology

Water is the life's blood of coastal wetland ecosystems. Most wetland processes are determined



Great blue heron in marsh.  
Photo: © C.C. Lockwood



The muskrat is a permanent resident in the coastal marshes of the Blackwater National Wildlife Refuge, Maryland. Photo: USFWS.

by the depth, duration, frequency, and energy of flooding water. When water rises and covers a marsh, it replaces air in the soil, leaving much less oxygen available to the plants and animals. The oxygen deficiency in the soil restricts soil microorganisms to those that can use chemicals other than oxygen in their metabolism. Microorganisms able to do this are the sulfate-reducing bacteria. These bacteria can substitute the sulfate in seawater for the oxygen that is normally used to derive energy from food. The end product of this process, hydrogen sulfide, has the characteristic rotten-egg odor noticeable when the soil in a salt marsh is disturbed.

The influence of water is not limited to its effect on the oxygen supply in the sediments. Water is also the vehicle that transports materials such as nutrients and sediments into and out of wetlands. We have discussed briefly how suspended sediments transported by water are vital in the formation and continuing existence of a marsh. These same waters, when focused into shallow depressions, scour tidal channels. A typical salt marsh is interlaced with a network of tidal channels.

The same flooding waters carry plant-nourishing nutrients into the marsh. Scientists have found that in Atlantic coast salt marshes, the greater the tidal amplitude, the more productive the marsh. This relationship has been termed the *tidal subsidy*. Large tides carry more water and nutrients into the marsh than small ones and thus stimulate plant growth. The subsidy is, in effect, a natural fertiliza-

tion that makes many salt marshes as productive as the most vigorous agricultural croplands.

Coastal ecosystems receive virtually all the water flowing off the continental United States—waters carrying sediments, fertilizers, and pesticides from the nation's farms; waters containing the treated and untreated sewage from thousands of communities across the country; and waters contaminated with heavy metals and exotic organic chemicals from thousands of factories along the nation's rivers, lakes, and estuaries. Coastal wetlands detoxify some of these materials, transform inorganic nutrients to less damaging organic forms, and bury others in their sediments.

For decades it has been recognized that flooding waters carry organic materials out of coastal marshes to serve as food for fish and shellfish in adjacent waters. In Louisiana, after high spring floods sweep through the marshes, the adjacent waters are rich with "coffee grounds," decaying organic material from the marshes, which support a dense population of small, bottom-dwelling invertebrates. This mixture is a rich source of food for the small migrating fish and shellfish that are in the estuary during this time of year. Small fish and shellfish also get much of their food by foraging on the marsh surface itself when it is flooded.

#### Wetland Food and Food Chains

Coastal wetlands are perhaps best known for their support of migratory birds, fish, and shellfish. From this point of view, the wetlands might be

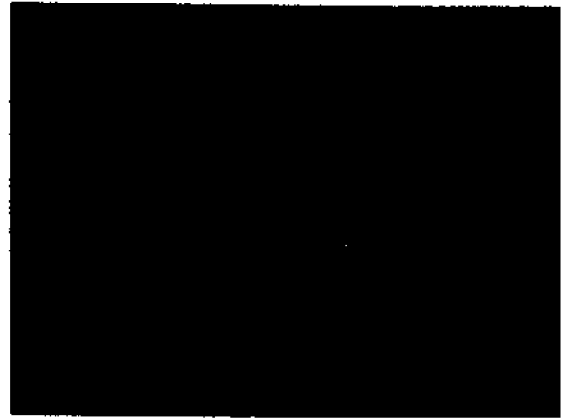
thought of as a resort, visited seasonally for its excellent food. Each visitor to the resort stays for a while to enjoy the good meals and then moves on. Each species is genetically programmed with "standing reservations," so that it returns year after year at the same time. And each shares the resort with others, but not always at the same time.

The coastal wetlands of the northern Gulf of Mexico illustrate this analogy. Wading birds, grackles, and blackbirds dominate during the summer. Teal and pintail ducks visit during late fall, move on to South America for the winter, then stop again on the way north in the spring. Other ducks, such as canvasbacks and redheads, spend the entire winter in Gulf coastal marshes, flying to Canada in the spring to nest and returning to the Gulf coast again in late fall. Migratory songbirds stop by only briefly in fall and spring on their travels to and from South America.

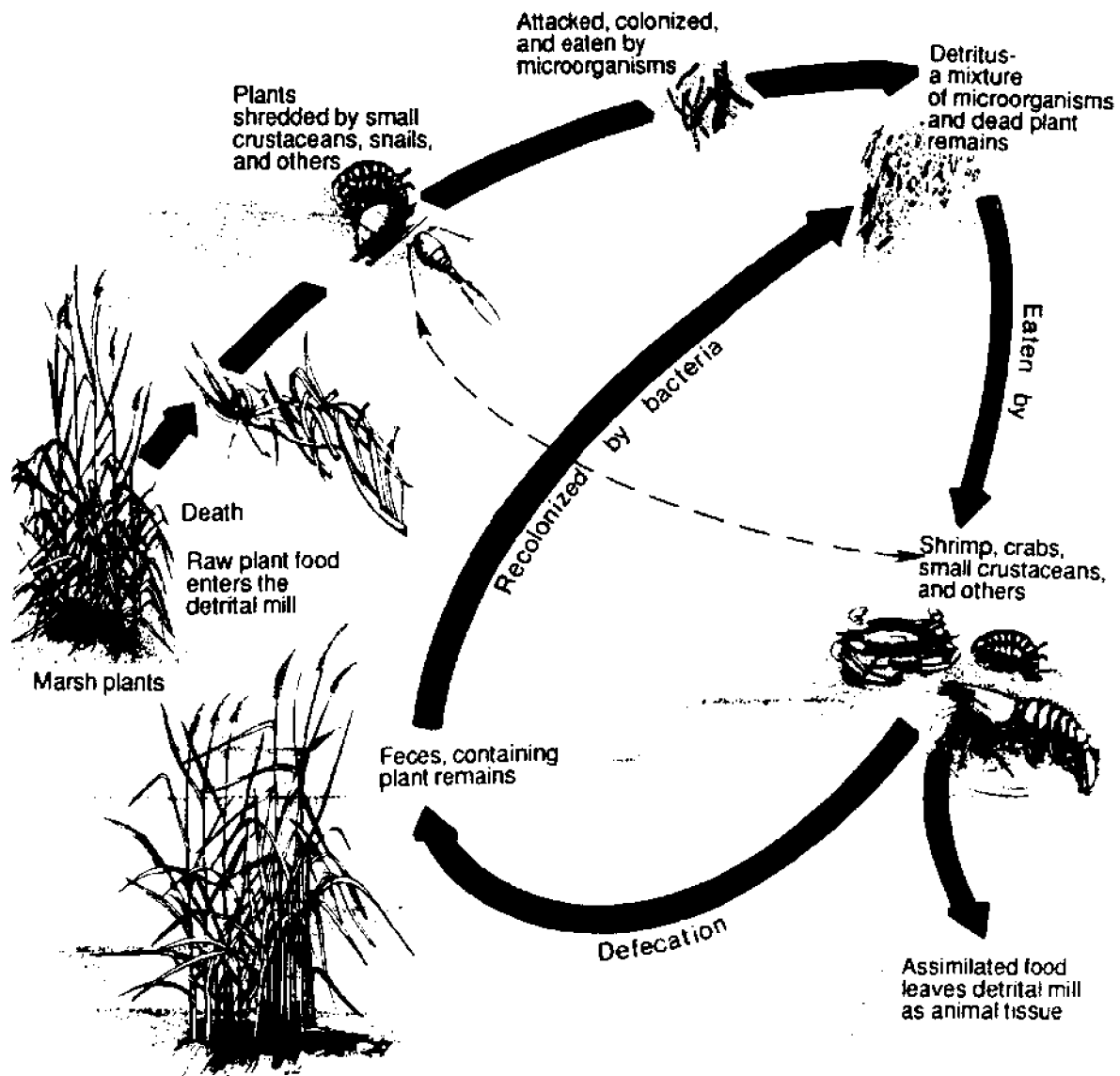


Fish and shellfish similarly share the resource, shuttling between the estuary and the adjacent ocean. Croaker, brown shrimp, white shrimp, spotted sea trout, red drum, menhaden, and striped bass all use the marsh and adjacent estuary as a nursery, usually spawning in the ocean, moving into the estuary as juveniles, and leaving as young adults. Like the birds, their reservations are for different times of the year and different parts of the estuary.

In addition to these periodic visitors, coastal marshes also support their own permanent animal residents. The largest are two rodents, the muskrat and, in the south, the nutria (introduced from South America). Both are vegetarians. Alligators are also found in the south, preferring fresh marshes. Many birds, such as herons, ibises, and bitterns, are also year-round residents, especially in the south. Small fish abound in the marsh when it is flooded and retreat to



Deer in the Aransas National Wildlife Refuge, Texas.  
Photo by C.C. Lockwood.



Marsh grasses support the detrital food web. Small animals shred the dead grass, enabling microorganisms to colonize it and break it down chemically so that other animals can assimilate it and grow. Their waste products are recolonized by microbes and the cycle is repeated.



Reekery. Photo: © C.C. Lockwood.

permanent ponds and tidal creeks during low water. Most marsh consumers, however, are small invertebrates that live out their lives buried in the sediments.

What about the kitchen of this unusual resort? It is distinguished by its abundance of food and by its unique "soup recipe." Earlier we discussed reasons for the high productivity of coastal wetlands. Salt marsh grasses, although often limited to one species in a given area, are more productive than any cultivated meadow. The fresh marshes farther inland are more diverse, offering an array of plants. In both the salt and fresh marshes, grasses are garnished with algae that grow on the moist lower stems and on the soil surface. Birds and animals enjoy the seeds and succulent roots and tubers of freshwater marsh plants. On the whole though, there is little evidence of extensive grazing on living marsh plants—especially in salt marshes.

What is the famous soup? All the evidence suggests that the primary food of the marsh is a mixture of decaying plant material, bacteria, algae, and small invertebrates. The decaying plant material, or *detritus* (from the Latin word for worn down or disintegrated), is broken down in what is termed the *detrital mill*. The "mill" works by both physical action (waves, tides, and currents) and biological action (shredding by animals and microbial decomposition).

Detritus food webs are distinct from grazing food webs (in which animals eat live plants) in three major ways. First, bacteria, fungi, and other microbes play an important role, colonizing the broken bits of plant material and breaking down fibrous cellulose, which is not digestible by most animals. Second, because most decomposition occurs on or in the sediments, the scavenging animals are predominantly bottom dwellers—for example, microscopic wormlike

nematodes, tiny crustaceans, and bottom-feeding fish and shellfish. These animals eat decaying plant material, strip microbes from the plant fibers, digest them, and then excrete the plant remains in fecal pellets that can be colonized again by microorganisms.

Finally, tides, storms, and especially the larger bottom-dwelling invertebrates aid in breaking down detrital particles so that they can be more readily decomposed. The animals do this by shredding the plant particles during feeding. Ecologists have estimated that excluding invertebrates from the decaying plant material would reduce the decomposition rate by as much as 30 to 50 percent.

#### Wetland Values

The term *value* is human centered. Wetlands are valuable because in socioeconomic terms, they produce a number of goods and services for people. The primary "goods" include commercial harvests of timber, shrimp, fish, crabs, crayfish, and fur. Ducks, geese, deer, and game fish are recreational "crops" from wetlands. Services provided by wetlands include water filtration and protection of communities from floods and severe storms. The term *heritage value* has been used to describe the importance of wetlands as educational resources, as repositories of biodiversity, as sources of aesthetic experience, and as, simply, an existing natural phenomenon.

The importance of the goods that wetlands produce has been extensively documented. For example, 90 percent of the Gulf coast fishery (including shellfish) depends on estuaries and wetlands during some part of its life cycle. This fishery is the largest in the country, supporting thousands of people directly and indirectly. As another example, in the best years, 700,000 waterfowl are produced in the marshes bordering the southern states.

It is harder to document the value



Coastal wetlands are popular sites for birdwatching.  
Photo: Jane Rohling.

of the services provided by wetlands, partly because not all wetlands function in the same way or at the same level of efficiency. Nevertheless, numerous studies show that wetlands remove sediments, nutrients, and toxins from the water. As a result, wetlands are now being created and used for final treatment of domestic sewage from a number of small cities. Economic studies show that this process can be less expensive and just as efficient as the construction and operation of a tertiary treatment plant.

Wetlands along rivers draining into coastal zones provide flood protection by detaining water from heavy rains, thus reducing peak flows downstream. Coastal wetlands provide flood protection during severe storms and hurricanes by diminishing the amount of water that travels inland with the storm

surge. Wetlands also trap sediments, limiting erosion. Estuarine channels bordered by wetlands erode much more slowly than unvegetated banks.

Although difficult to quantify, the heritage value of wetlands is receiving increasing attention. Wetlands are used extensively for nonconsumptive recreation such as wildlife observation, nature photography, and canoeing. Wetlands are also tremendously valuable as reserves of biological diversity. For example, wetlands comprise more than half of the areas identified as critical habitat under provisions of the Endangered Species Act.

It has been tempting to apply an economic value to wetlands in order to make easier decisions about alternate uses of the resource. In a number of studies, coastal wetlands have been

valued from as little as \$10 per acre to over \$100,000 per acre. Each method of evaluating wetlands focuses on different criteria and all methods are imprecise at best and misleading at worst.

To be useful, any wetland valuation method must address a number of questions. First, the evaluator must decide on which *wetland use(s)* the evaluation will focus. This is not a technical question that can be answered objectively; it involves an element of preference. The evaluator must also decide whether the wetland will be used in its natural condition or in a modified condition, say to enhance fisheries, attract waterfowl, or purify water.

Secondly, the evaluator must decide how to evaluate the *wetland system as a whole*. The value of a wetland is more than its value for fisheries or for hunting, yet many of the wetland's services are typically ignored because they are difficult to put into monetary terms.

Thirdly, the evaluator must address the *contextual value* of the individual wetland. Wetlands are part of larger basin ecosystems; therefore, the valuation method must address the relative scarcity of that wetland type in the basin as a whole, the upstream or downstream systems that depend on that wetland, and the role of the wetland in the pattern of the landscape.

Finally, the valuer must address the issue of wetlands as a *common property resource*. By this, we refer to the products and services of wetlands that belong to the public as a whole rather than to the individual wetland owner. For example, the shrimp and crabs supported by wetlands are harvested by fishermen in the estuary or ocean, not by the owner of the wetland. Similarly, the flood protection service of a wetland is not primarily received by the owner on site, but by people living many miles downstream or inland.

Typically, the owner of a salt marsh may lease a wetland for several

dollars an acre to fur trappers or hunters. It is easy to understand, then, why an offer to buy for urban residential development or to lease for oil exploration may be attractive to an owner, even though the public value of the wetlands thus destroyed may be many times that of the money the

owner receives. Much of the debate over wetland protection and regulation revolves around this discrepancy between the wetland's value to the landowner and its value to the public at large.



Working with marsh grasses in both field and greenhouse, wetland scientists have gained valuable insights into the roles of salinity, subsidence, and waterlogging in marsh loss. Such information is vital in designing comprehensive plans for wetland management. Photo: Ken Varden, Louisiana Sea Grant.

Residential development in Florida.  
Photo: James Johnston, USFWS.

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# Status and Trends of Coastal Wetlands



Coastal wetlands in the lower 48 states cover more than 26 million acres (see table). This acreage includes about 5.5 million acres of salt marshes and mangroves immediately along the coast and more than 20 million acres of freshwater marshes and forested wetlands along the rivers and estuaries that drain into the oceans. Although coastal ecosystems account for only about 9 percent of the land area in the lower 48 states, this zone includes about 30 percent of the wetlands in these states.

Losses of wetlands since the United States was colonized in the 1700s have been tremendous. The U.S. Fish and Wildlife Service estimates that about 220 million acres of wetlands existed in the contiguous United States in colonial times. Today, only about 103 million acres, or 47 percent of those wetlands remain. Statistics for the coastal zone only do not exist, but one coastal state, California, has lost more than 90 percent of its original wetlands. Florida and Louisiana, the two states with the greatest original

COASTAL WETLAND ACREAGE IN THE CONTINENTAL U.S.\*

	Salt Marsh	Fresh Marsh	Forested Wetlands**	TOTAL WETLANDS
Atlantic Coast	1,651,900	1,490,600	8,410,900	11,553,400
Gulf of Mexico	2,496,600	2,751,100	8,211,800	13,459,500
Pacific Coast	121,900	291,200	757,100	1,170,200
<b>Total</b>	<b>4,270,400</b>	<b>4,532,900</b>	<b>17,379,800</b>	<b>26,183,100</b>

\*excludes Alaska, the Great Lakes, and Hawaii

\*\*includes mangroves

Source: National Oceanic and Atmospheric Administration, National Ocean Service, Office of Oceanography and Marine Assessment, Strategic Assessment Branch.



California has lost over 90 percent of its wetlands. Here, development encroaches on wetlands near Cerritos Channel, Long Beach.  
Photo: Lauma Jerkevics

Land cover for 1950 and 1982 for Tampa Bay, Florida, depicting land, wetland, and seagrass changes. Source: USFWS National Wetlands Research Center and National Wetlands Inventory; Florida Department of Natural Resources; Marine Research Institute

acres of wetlands, have both lost about 46 percent of those wetlands (a combined total of almost 17 million acres).

Between the 1950s and the 1970s, losses of coastal marshes and mangroves were especially heavy, largely because the public did not view these habitats as valuable, and post-World War II urban, residential, and industrial development in the coastal zone was booming. For example, the airports at Boston, New York, and New Orleans were all built on wetlands. By the mid 1970s, over half of our original salt marshes and mangrove forests had been destroyed. In the freshwater marshes and forested wetlands, drainage and clearing for agriculture and silviculture were major causes of loss. Since the mid 1970s, loss rates have slowed, largely because of the passage of a variety of federal and state laws designed to protect wetlands.

### Population Growth and Urban Development

Directly or indirectly, the major threat to coastal wetlands is the pressure of population growth. Over half of the nation's people live and work within coastal counties that encompass less than 10 percent of the U.S. land mass. The population of coastal counties is five times greater than that of noncoastal counties nationwide, and the coastal counties along the Atlantic Ocean are 10 times more densely populated than inland counties.

This dense population puts enormous pressure on all natural resources, including wetlands. Historically, the rate of coastal wetland loss has been directly proportional to population density. People directly destroy wetlands for urban development and indirectly destroy wetlands by water flow modifications, pollution, and energy exploration and extraction.

### Hydrologic Modification

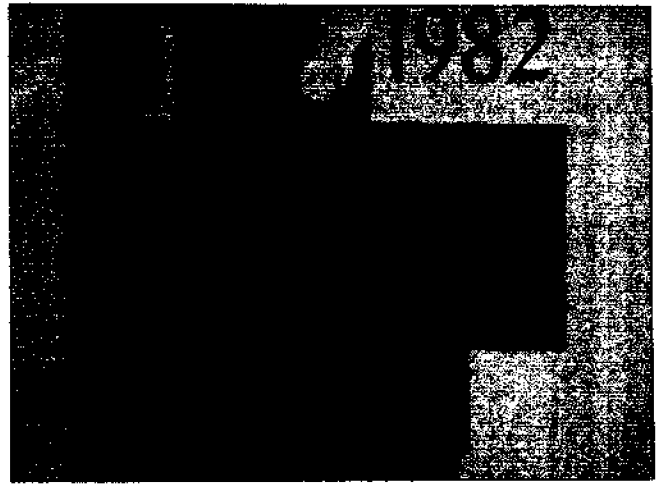
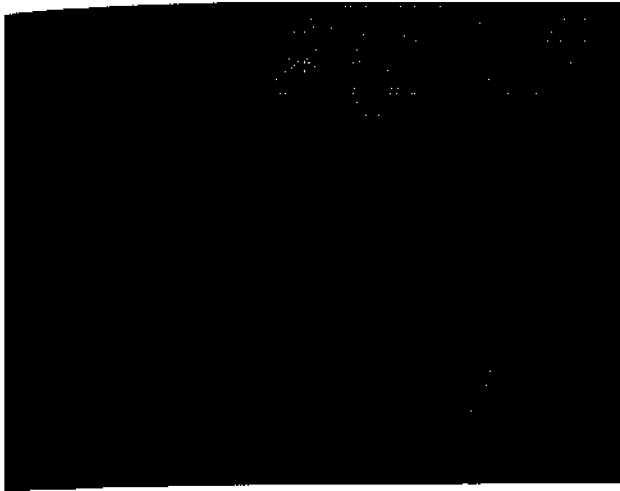
Perhaps the least recognized but most insidious threat to coastal wetlands has been extensive hydrologic modifications, which indirectly damage wetlands by changing their flooding regimes. The U.S. Army Corps of Engineers has been given the federal responsibility for flood control. Responding to urban growth in flood-prone areas, the Corps constructed levees along most major rivers. These levees prevent spring floods from reaching the adjacent wetlands. Inland, dams and reservoirs have reduced the water and sediment supply to the coastal marshes. Around the periphery of many estuaries, a dense network of small canals has been dug to speed water off urban and agricultural land. The result is that water, with its vital load of nutrients and sediment, bypasses the wetlands instead of flowing over them.

The Corps of Engineers also has responsibility for navigation and in this capacity has dredged thousands of miles of canals, often across coastal wetlands and estuaries. In Louisiana and other areas along the Gulf coast,

an extensive network of canals for access to subsurface oil, gas, and sulfur deposits has also been dredged in the coastal wetlands by private interests. These canals are generally straight and deep and are efficient conduits for both fresh water flowing downstream and tidal pulses, which can bring saltwater much farther inland. As a result, coastal wetland flooding patterns change and salt marshes migrate inland.

### Agricultural Activities

The history of agriculture in coastal wetlands is a fascinating one. In the mid 1800s, wetlands were considered wastelands, good only when drained for cultivation. The federal government, however, was not anxious to incur the expense of drainage, so in the Federal Swamp Land Acts of 1845, 1850, and 1860, it ceded to 12 coastal and three inland states all land then unfit for cultivation because of flooding. These lands were to be used for flood control and, where feasible through the construction of levees and by draining, for agriculture. The states acquired 26.3 million acres of land in this way, but by the turn of the century, retained only about 5 percent of them. The rest was sold to private individuals, often at prices far below estimated values. Ironically, these new owners promptly applied pressure through their representatives in Congress to floodproof the land. The taxpayer footed the bill for drainage, lost millions of acres of wetlands, and is now in the position of



buying parcels back at inflated prices.

Coastal wetlands have been used for agriculture for centuries. The high marshes of the New England coast were used extensively for cattle grazing and for native hay production. In South Carolina, farmers took advantage of the tidal pulse of fresh water in coastal wetlands to manage them for rice production, an extremely profitable occupation during the nineteenth and early twentieth centuries. Many of these old rice fields are still identifiable and some are now managed for migratory waterfowl.

In Louisiana, large rectangular ponds are all that remain of earlier attempts to turn coastal marshes into sugar cane fields. The marshes were leveed and drained with enormous coal or wood-fired pumps, the ruins of which are still standing. However, the farmers failed to consider two factors: first, organic soils exposed by draining rapidly subside and, second, Gulf hurricanes are relatively frequent and severe. Subsidence lowered the land, making it increasingly expensive to drain, and hurricanes breached the levees, flooding the fields. Few marsh sugar cane fields remain in Louisiana today.

#### Water Pollution

Water pollution may not be the most dramatic threat to coastal wet-

lands but it is probably the most difficult to control. Water pollution sources fall into two categories, *point* and *nonpoint*. Point sources are identifiable discharges from a pipe or other single source that can be quantified, monitored, and, presumably, controlled. The U.S. Environmental Protection Agency requires that permits be issued limiting pollutants in these discharges. Examples of point-source discharges include outfalls from sewage treatment plants, paper mills, and industrial plants. Nonpoint-source discharges result from land runoff. They do not originate from discrete sources and therefore are not easy to control. Examples include urban street runoff and farm runoff that contains manure, fertilizers, and pesticides.

Both point and nonpoint sources of pollution may be located many miles upstream from the coastal wetlands that they influence; sometimes they originate in another state and, thus, another jurisdiction from the affected wetlands. Furthermore, any one discharge may involve only small amounts of chemicals that are rapidly diluted to unmeasurable concentrations in the receiving stream, but when multiplied many times or in combination with other chemicals, these small discharges may form significant concentrations that have detrimental biological effects. Only recently has

the issue of *cumulative impact* management begun to receive serious attention.

#### Case Studies of Wetland Loss

**San Francisco Bay.** San Francisco is considered by many to be the major U.S. estuary most modified by human activities. Although the first Spanish soldiers and missionaries arrived in the bay area in 1769, San Francisco remained a relatively isolated frontier town until gold was discovered in the Sierra Nevada foothills in 1848. In just two years, the population grew from fewer than 400 to over 25,000. By 1900, most of the marshes in the bay were gone.

The causes of wetland loss and estuary modification are numerous. From 1853 to 1884, gold miners used a high-pressure water jet to wash the gold from ore deposits in sluiceways. This hydraulic mining process washed tens of millions of cubic meters of sediment and debris into the bay annually, filling huge portions of Suisun, San Pablo, and Central bays. In 1884, hydraulic mining was stopped by court order, but it took decades for the sediments deposited over the previous 30 years to be flushed from the river channels.

Agriculture was another major cause of wetland loss. By the 1920s, almost all the freshwater marshes in the

delta area, at the confluence of the Sacramento and San Joaquin rivers, were diked and converted to farmland. The diking and filling of tidal marshes for fodder fields continued until the 1970s.

In the South Bay, diking for salt production in evaporation ponds began in 1856 and continues today. About two million tons of salt are produced annually in the bay area.

At the same time that wetland diking and filling were progressing, fresh water entering the bay was being diverted through a system of dams, reservoirs, and canals. Today, about 40 percent of the historic freshwater flow is diverted for irrigation and municipal consumption; another 24 percent of the volume of "fresh water" entering the bay today is composed of agricultural, industrial, and domestic wastewater. This has enormous implications for the remaining wetlands, and many indeed have poor water quality and reduced productivity. Most of the remaining tidal marshes are isolated and there is little opportunity for wetland expansion because of numerous dikes and urban development.

*Louisiana.* Enormous losses have occurred recently in wetland habitats along the Gulf of Mexico, especially in coastal Louisiana. In the last century, 790,000 acres of coastal wetlands were converted to agricultural, urban, and industrial use. Between 1956 and 1978, about 680,960 acres of wetlands deteriorated into open water. The U.S. Army Corps of Engineers estimates that before the year 2040, nearly 1,000,000 additional acres of wetlands will be lost, an area larger than the state of Rhode Island.

The causes of this wetland loss are both natural and human induced. In much of coastal Louisiana, wetlands formed on delta deposits from sediments in flood waters of the Mississippi River. Over the last 7,000 years, the Mississippi River has changed course at least four times. When the river changed courses, sediments left in the abandoned delta lobes compacted and sank under their own weight, causing the marsh to deteriorate. Until relatively recent times, this natural marsh deterioration in abandoned delta

lobes was offset by marsh formation in the newest, active delta lobe.

But when the 900-mile levee system along the Mississippi River was completed in the early twentieth century to protect growing towns from flooding, the sediment-laden river water could no longer spill over the banks to deposit its load of silt in the wetlands. Thus, new marsh accretion rates could no longer offset marsh deterioration in abandoned delta lobes. River water is now contained in the main channel of the river and the sediments needed to build and maintain the wetlands are shunted directly into the Gulf of Mexico.

Because southern Louisiana is an extremely flat plain, small changes in land elevation relative to water level can result in large changes in the amount of wetland. An action or event that lowers the marsh surface by as little as an inch may cause widespread marsh deterioration. The withdrawal of oil, gas, water, salt, and sulfur from near-surface deposits can contribute to land subsidence, lowering the marsh surface and drowning the marshes. Worldwide sea level rise, although small (6 to 12 inches per hundred years), may also be contributing to marsh drowning.

Wetland loss from sediment starvation and marsh drowning has been accelerated and exacerbated by other human activities in the coastal zone. An extensive network of canals for navigation and for oil and gas exploration has been dredged in coastal Louisiana. The dredging of canals directly destroys wetlands by converting them to open water and spoil piles. Spoil piles block marsh flooding and draining and thus increase sediment deficits in the marshes. Waterlogging in undrained marshes leads to increased plant stress and lower productivity. Canals may funnel saltwater into previously brackish or freshwater marshes, changing the plant community and perhaps ultimately causing the plants to die. Canals may also shunt

fresh water containing nutrients and sediments vital to plant productivity through the wetland system, bypassing the wetland plain itself.

Solutions to Louisiana's wetland loss problem will require a comprehensive plan of action, incorporating both large-scale federal actions and local wetland management.



Louisiana's productive coastal marshes are rapidly eroding into open ponds and lakes, a loss that threatens the survival of the state's renewable natural resources. Photo: Louisiana Sea Grant.



COASTAL  
WETLANDS  
OF THE  
CONTINENTAL  
UNITED STATES

# Coastal Wetland Management and Protection



The success of coastal monitoring and replanting programs depends on the efforts of citizen volunteers  
Photo: Florida Phosphate Industries, Inc.

As we have seen, there have been many causes for the loss of our coastal wetlands, and until relatively recently, public indifference and government policies encouraged that loss. Fortunately, this situation has changed. Recent polls show that an overwhelming majority of Americans want to preserve and protect wetlands, even if it means additional cost to them. The federal government and most coastal states have implemented a variety of programs specifically directed toward wetland management and protection.

## Wetland Protection Programs

The cornerstone of the federal effort to regulate wetlands is the so-called "404 program," Section 404 of the Clean Water Act. Under 404, the discharge of dredged or fill material into waters of the United States, including most wetlands, requires a permit from the U.S. Army Corps of Engineers. The Corps is required to issue a public notice of a permit application to inform citizens about the proposed project and solicit their opinions on it. Other government

agencies and interested organizations can also provide their comments. The Corps bases its decision to grant a permit on a review of environmental impacts, using standard guidelines developed in cooperation with the Environmental Protection Agency, and the balance between the public costs and benefits of the proposed project.

Many activities that damage or destroy wetlands have not been regulated under the 404 program because they do not involve the discharge of dredged or fill material. Some of these activities may be included under the program in the future.

The U.S. Army Corps of Engineers, Environmental Protection Agency, Soil Conservation Service, and Fish and Wildlife Service use criteria for delineating "jurisdictional wetlands" based on the three primary characteristics of wetlands (flooded or saturated site, hydric soils, and wetland plants present) discussed at the beginning of this publication. Jurisdictional wetlands are those subject to regulation under the 404 program and other

federal statutes. Some in the agricultural, forestry, and development communities have suggested that regulated wetlands should be more narrowly defined.

Another approach to wetland protection is to buy the wetland property and set it aside. Various federal and state programs and some private conservation organizations (such as the Nature Conservancy) purchase wetlands or easements on wetlands for wildlife refuges, parks, and wilderness areas.

Recently, governments have developed programs that provide economic incentives for wetland preservation and disincentives for wetland destruction. For example, the federal tax code allows landowners who sell or donate their wetlands to the government or to a qualified wetland conservation organization to claim the value as a charitable deduction on their federal income tax returns. The "swampbuster" provision of the Food Security Act of 1985 creates disincentives for draining wetlands for cropland by eliminating most farm program benefits to owners producing commodity crops on wetlands drained after

1985. Recent amendments to the swampbuster provisions have changed the "trigger" for withholding benefits from planting commodity crops to draining the wetland. Voluntary efforts by farmers have also helped to slow the rate of wetland loss from agricultural practices in recent years.

#### Public Responsibility

Our coastal wetlands cannot survive the next century unless more citizens take personal responsibility for wetland conservation. Wetlands provide benefits and values for all people; they are trust resources that we all must work to protect.

As citizens, we can work together in many ways to slow wetland loss and degradation. Be aware of what is happening in your community that affects wetlands. Support wetland conservation by government agencies and conservation organizations. Encourage the use of upland sites rather than wetlands for development. Participate in the 404 review process by commenting on a proposed project if it is appropriate. If you are able, buy a federal duck stamp because the proceeds go toward wetland acquisi-

tion. Donate to conservation agencies that try to acquire wetlands, participate in a coastal cleanup program, or volunteer to help state and federal agencies monitor coastal ecosystems. Along the Chesapeake Bay and in Rhode Island, North Carolina, and the Pacific Northwest, volunteers collect data to help scientists and managers answer questions about the quality of our coastal systems and monitor efforts to restore degraded systems.

Although most coastal wetlands are owned by private citizens, we cannot expect them to pay for all the public benefits provided by wetlands. Therefore, we must encourage our legislators to find ways to make wetland conservation and management economically attractive for the individual landowner.

There is no question that we are entering the twenty-first century more aware than ever of the problems of our environment, but we cannot wait until tomorrow to protect our coastal resources. Time will quickly tell whether America's love affair with the coast will spell the demise or salvation of her wetlands.



Willetts at Ding Darling National Wildlife Refuge, Florida. Photo. Jane Rohling.