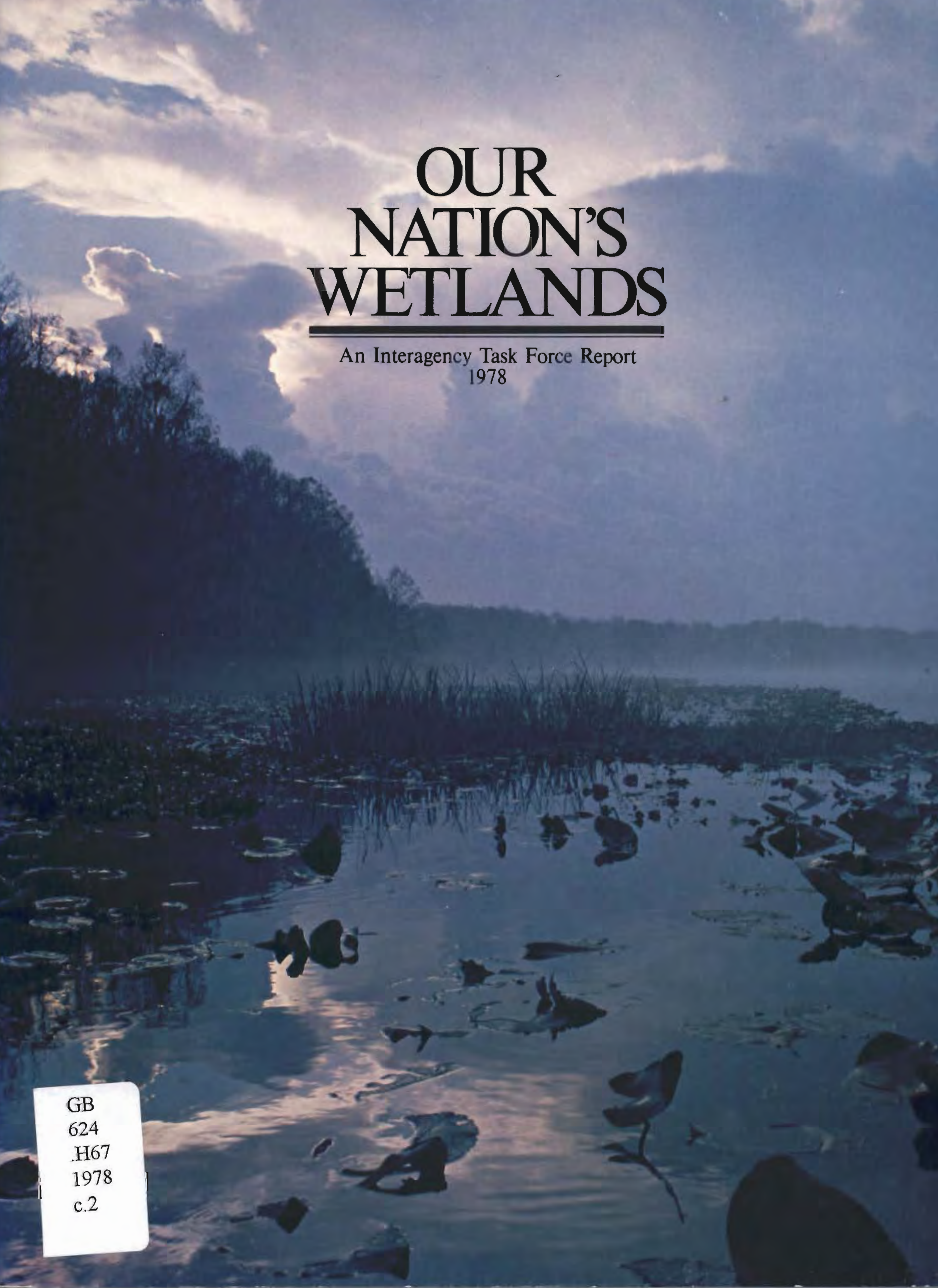

OUR NATION'S WETLANDS

An Interagency Task Force Report
1978

Cover: *Marshy bank of the pristine Suwannee River, which drains over 10,000 square miles of Florida and southern Georgia*

Title Page: Phragmites communis, *a marsh grass that often grows in disturbed areas*

Contents Page: *Palms, vines, and Spanish moss, Wassaw Island, Chatham County, Georgia*

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OUR NATION'S WETLANDS

AN INTERAGENCY
TASK FORCE REPORT

U.S. Department of Agriculture
Forest Service
Soil Conservation Service

U.S. Department of the Army
U.S. Army Corps of Engineers

U.S. Department of Commerce
National Marine Fisheries Service

U.S. Environmental Protection Agency

U.S. Department of the Interior
Fish and Wildlife Service

Coordinated by the
Council on Environmental Quality

1978

Written by Elinor Lander Horwitz

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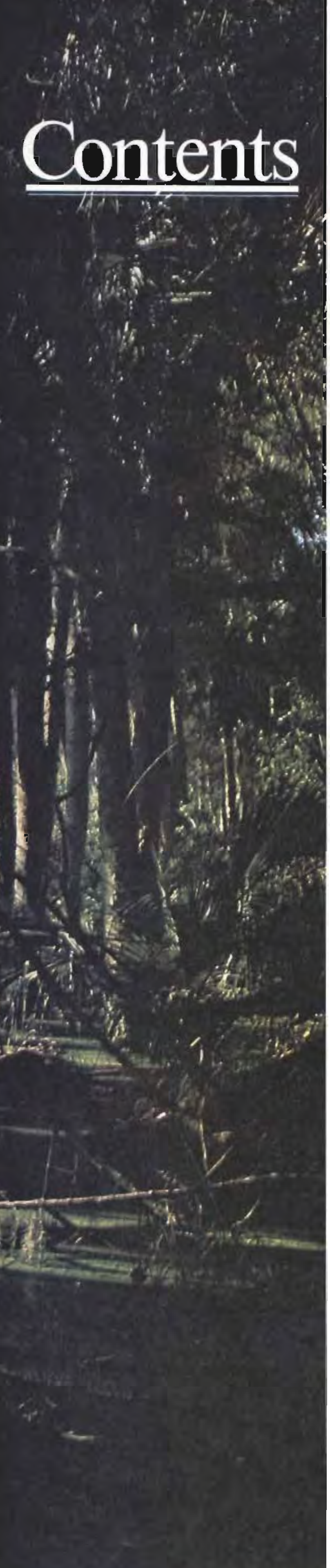
Illustrated by Richard Brown



Contents

Preface

This booklet was written in an attempt to provide a broad and balanced review of the status of our nation's wetlands. It was inspired by the widely felt need for a publication which would provide lay readers with a scientific, social, and political understanding of our current wetland policies and concerns.

Widespread public awareness of the importance of guarding our wetland heritage was stimulated by Congressional debates on Section 404 of the Federal Water Pollution Control Act as well as by recent state legislation. President Carter's 1977 Environmental Message made wetland protection an executive priority and a matter of national policy. And yet controversies which have arisen in recent years over regulation of wetland areas remain incomprehensible to many of the men and women whose actions and choices will determine future wetland policy. Scattered newspaper and magazine articles on the subject are often misleading. Because laws limiting alteration of natural resources inevitably involve questions of public good as opposed to private gain and because scientific investigation into wetland functions is still in its early stages, the issue has given rise to emotional overstatement and lavish misrepresentation from all factions.

How are wetlands formed? How do various wetland types differ? What useful functions do they serve in their natural state? How much wetland acreage have we lost? How much do we need? Why have wetlands, throughout our history, been altered or destroyed—and how are we to evaluate alternative uses? What efforts are currently being made to conserve our wetland resources? Few people today question the general concept that our previously unappreciated wetlands should now be protected, but there remain many difficult questions about how protection and proper use are to be accomplished. We hope that this booklet may provide useful background information and a guide to further reading on the range of wetland topics now being discussed by scientists, legislators, and concerned citizens.

Skunk cabbage, New England

CHAPTER ONE
Where We Stand

The early settlers on this continent found a land of extraordinary physical beauty and fertility. Sparkling wild rivers coursed through mature forests, the woods teemed with game, and fish thrived in estuaries and the pure waters of mountain lakes. To the colonists the abundance of nature seemed limitless. In their efforts to ensure their own survival, the very notion of conservation—as a practical concept or as a philosophical ideal—would have seemed absurd. Their challenge was to contend with natural forces while clearing the forests, taming the rivers with levees and dikes, and hunting wild creatures.

Today we know that the gifts of clean water, fertile land, and bountiful energy supplies are not inexhaustible. Through design, accident, and ignorance, we have polluted our waters and desecrated our landscape. We have destroyed nonreplaceable natural resources and damaged others irreversibly. In our pursuit of food, of homes, of sport, of feathers for our caps, we have brought a long list of animals to the brink of extinction, including the officially venerated Bald Eagle and such wetland-dependent creatures as the American crocodile and alligator, the sea cow, the whooping crane, and the Mississippi sandhill crane. In a day we can destroy or modify natural phenomena which evolved over centuries or millenia. But we have learned—and are still discovering, that altering nature often involves crucial trade-offs. Our sense of pride in the technology that enables us to make the desert bloom and bring forth yearround crops, to run roads over mountain tops, to alter a watercourse, or to build vast international airports on swampland has been shaken. This is not to say that we have not benefited from our technology, but we now know that we must balance our economic, social, and environmental goals.

Over this decade there has grown an increasing awareness of the need for making conscious, informed choices about further modification of the natural environment. Inland and coastal wetlands—only yesterday considered useless—are now seen as valuable endangered natural resources. Estimates of irreversibly altered or destroyed wetlands in the 48 continental states have already reached 40 percent.[1] Hundreds of thousands of acres of former inland wetlands are now among our most highly productive croplands and timberlands. Many former coastal

Cattails and water lilies, Powers Lake, Connecticut marshes and swamps are sites for vacation homes and marinas. Other wetlands are used as dumping grounds.

Evaluating all these uses is not easy. Clearly it is blatantly wasteful to turn a productive wetland into a dump. But it is harder to assign relative values to leaving a wetland in its natural state or using it for luxurious waterfront dwellings. Still more difficult is balancing the values between natural wetland and highly productive cultivated farmland. The results of past practices, recent scientific discoveries, and our changing priorities must all weigh in decisions on how much to conserve of the remainder of our wetland heritage—for the benefit of society as a whole and for the use and enjoyment of future generations.

We do know that wetlands are vital fish and wildlife habitats. Two-thirds of the commercially important fish and shellfish harvested along the Atlantic and in the Gulf of Mexico depend on coastal estuaries and their wetlands for food sources, for spawning grounds, for nurseries for the young or for all these critical purposes[2]; for the Pacific coast, the figure is almost one-half.[3] Wetlands provide essential resting, wintering, and nesting grounds for many species of migratory waterfowl, other waterbirds, and many songbirds. They are among the most productive ecosystems in the world. They are important in maintenance of ground water supplies and water purification. Marshes and swamps along coasts, rivers, and lakes protect shorelines and banks from erosion. Wetlands also have the capacity to store floodwaters temporarily and in some instances to reduce the volume and severity of floods.

The less tangible values of wetlands may be classified as recreational, educational, scientific, and aesthetic. It is curious that the sight of tall marsh grasses dipping and bending with the wind and the currents have been so little admired until recent years by any except a few naturalists and artists. The poets have offered us images with which we can readily express our wonder at the magnitude of the oceans and the mountains, but apparently they have been defeated by the fact that so few words rhyme with "swamp." Many of us who readily grasp the importance of preserving forests, sand dunes, and lakes for their aesthetic values alone remain blind to the less obvious charms of a healthy marsh bordered by deep yellow marsh marigolds or a swamp in which ospreys nest high in the cypresses.

Alteration of wetland areas began in the early history of the country as farmers routinely drained swamps and marshes for use as farmland. In most inland areas agricultural motives for wetland alteration still prevail, but along the coastlines, wetlands have most often been sacrificed to marina development, to summer homes, and to industry. The coast is densely populated: More than one-half the U.S. population lives in the counties bordering the oceans, the Gulf of Mexico, and the Great Lakes, and millions more vacation by the sea.

With greater affluence and increased population, the pressures for development of wetlands—for agricultural production, for highways, for residential and commercial building sites, for ports, for marinas, for parking lots, for industries and powerplants which require large quantities of cooling water—seem destined to increase. What do we know today about the structure, functions, and uses of wetlands in their natural state that can aid in assessing the ecological, economic, and social consequences of further wetland development? How can we work with and use these resources to our benefit?

The whooping crane (right), once nearly extinct, is now carefully protected as an endangered species. Below, a common loon and marsh vegetation at Lake Itasca, Minnesota, source of the Mississippi River.

CHAPTER TWO

Defining Wetlands

To begin at the beginning, what *are* wetlands? The word appears more and more often in newspaper and magazine articles, but it is only vaguely understood by most people. Although "wetlands" has been used by field biologists and duck hunters for at least half a century, only recently has it appeared in high school biology texts. Even today it cannot be found as a heading in the standard encyclopedias on which we rely as easily available sources of information. Is a river a wetland? If a salt marsh is a wetland, how about an inland bog? Is that a wetland too, and if so, why?

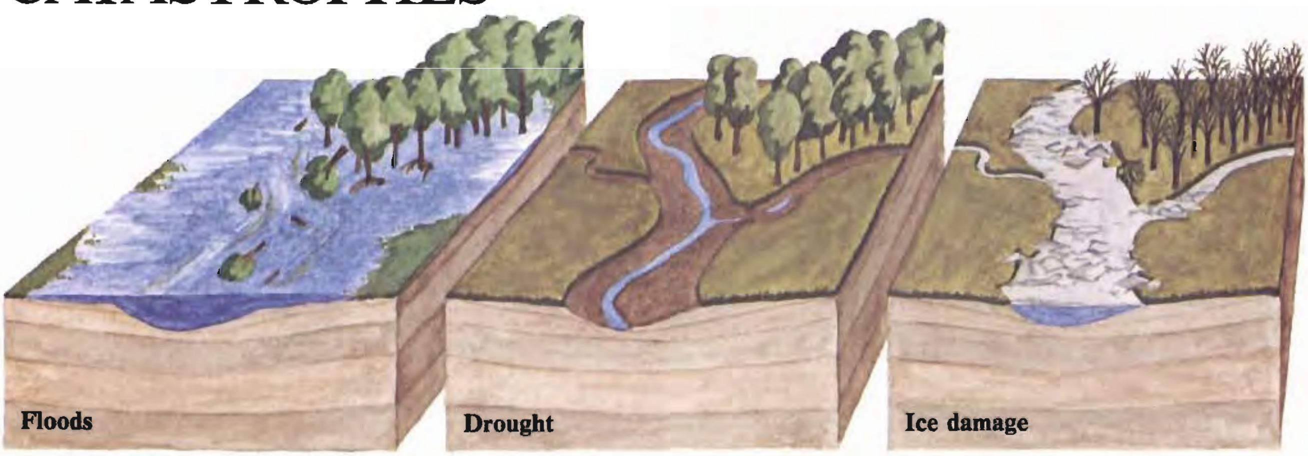
Wetlands are often described in terms of what they are not. They must not be viewed as dry land although they may or may not always be flooded. They lie between the sea and the land or at the mouth of the river or at the edge of the lake or in low-lying fields, and because they are part of a continuous landscape which merges from wet to dry, it is no easy matter to determine precisely where they begin and where they end—a matter of concern to government agencies seeking to regulate wetland use.

The official definition of wetlands used by the U.S. Army Corps of Engineers in its regulatory program is similar to the definition which appears in the Executive order signed by President Carter in May 1977 (see Appendix D). It describes wetlands as areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support—and that under normal circumstances do support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. The U.S. Fish and Wildlife Service (FWS) of the Department of the Interior is currently conducting a nationwide survey of wetlands that will update the one carried out in the 1950's. The FWS wetland classification system identifies in positive terms "[t]he single feature that most wetlands share [as] soil that, at least periodically, is saturated with water." A "wetland" is then described as "land where water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface." [4] This new description of wetlands is broader than the one used by the two federal regulatory agencies.

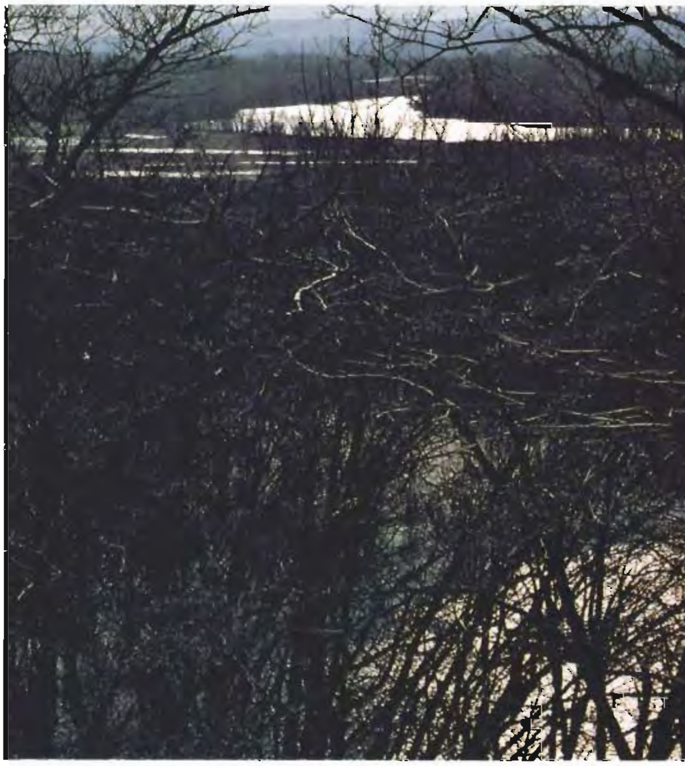
Included within these broad limits is a wide variety of lands which are continuously submerged or

Sedges border a pond at the Santinoni Preserve in New York's Adirondack Mountains

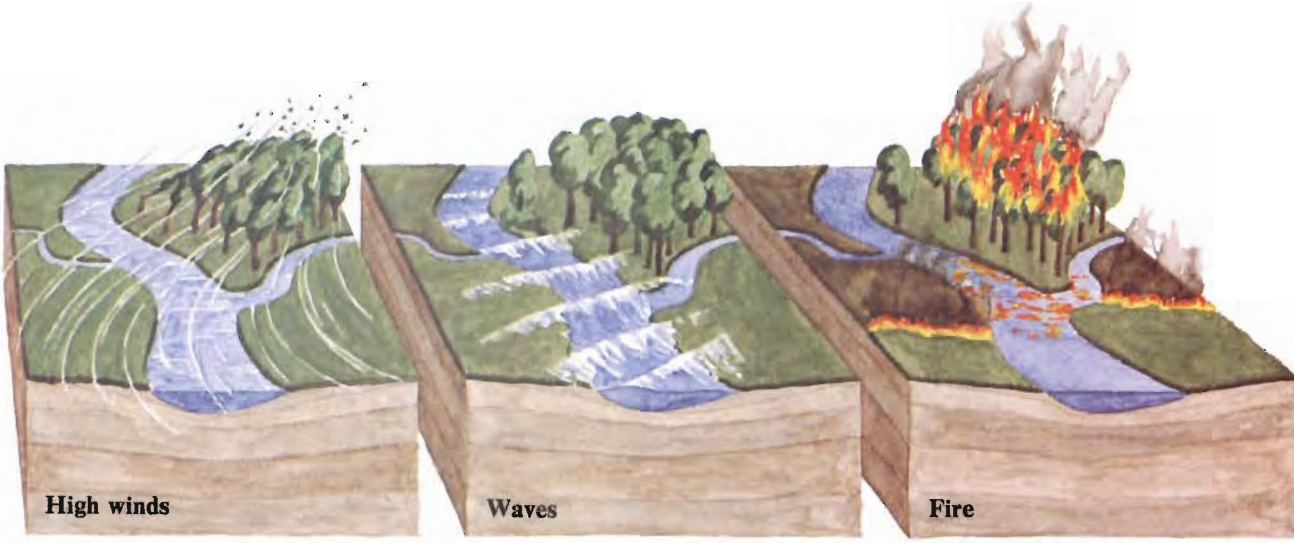
NATURAL CATASTROPHES



Wetlands are exposed to natural catastrophes characteristic of both land and water. These extremes are to a large degree responsible for the development and evolution of many wetlands. Although severe conditions may damage or destroy some wetlands, natural extremes are essential to the existence of others, such as the seasonally flooded bottomlands of the Connecticut River (right).



are intermittently inundated by seasonal river flooding or normal tidal action. Most are readily identifiable by the presence of typical emergent vegetation —plants which are rooted in the soil but are thrusting through the surface of the water—or by varying amounts of submerged and floating plant life. The depth, duration, chemistry, temperature of the water, and in coastal marshes the reach of the tide determine the types of plant life found in a given wetland. These physical and chemical features determine the types of vegetation and the wide array of fish, mollusks, birds, crustaceans, insects, worms, and tiny organisms which find food and shelter in the substrate and within the vegetation. If marked alteration of water quality or quantity occurs, death of plant and animal life or the appearance of dif-



ferent species testifies to the change of environment.

Wetlands are located at the interface between the land and water and are subject to extreme natural events. Floods, drought, winter ice, high winds, waves, violent storms, and hurricanes are important factors which help shape these ecosystems. In short, the wetlands have evolved with natural catastrophe as a partner.

Kinds of Wetlands

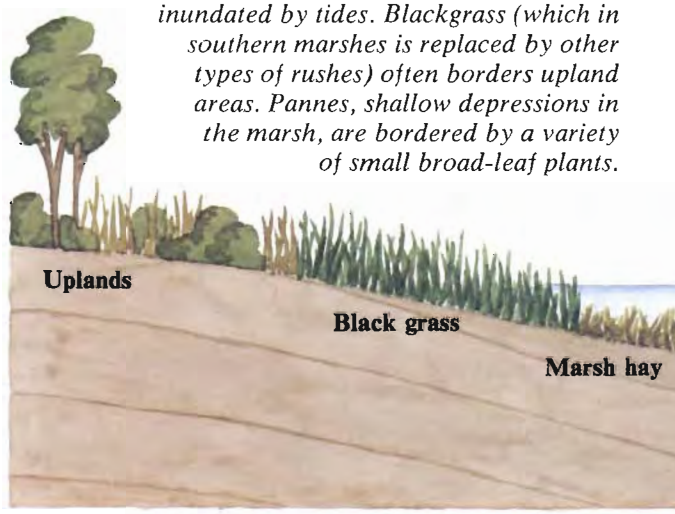
The commonly used designations for different types of coastal and inland wetlands include salt marsh, freshwater marsh, swamp, wet meadow, bog, fen, and pothole. Shallow ponds in which sunlight penetrates to produce emergent plant life are often classified as wetlands. However, in its National Wetland Inventory the U.S. Fish and Wildlife Service now classifies wetlands accordings to measurable physical features because popular terms categorizing wetlands vary from one region to another.

Wetlands may be coastal or inland; they may be located beyond the pulse of the tide or—even though far from the seacoast—they may be tidally influenced. Salt marshes stretch in an almost continuous chain of undulating grasses along the Atlantic coast and are particularly luxuriant in the mid-Atlantic and south Atlantic regions. Salt marshes are also abundant along the Gulf of Mexico and the coast of Alaska. On the Pacific coast, where the continental shelf is narrow and the interface of land and water is steeply sloping and rocky, they are found in relatively isolated areas. Although they account for less than 10 percent of our total wetlands,[5] saltwater marshes and swamps have recently received concentrated attention from scientists and legislators because so often they have been altered

SALT MARSHES and MANGROVE SWAMPS

The map (above left) shows salt marsh distribution; red areas in south Florida indicate location of mangrove swamps. , Above: a young mangrove in a Florida estuary. Right: a broad tide creek meanders through a Connecticut salt marsh.

In a typical salt marsh of the northeastern coast (below), cordgrass grows at the lowest part of the marsh, and marsh hay occupies slightly higher areas that are less frequently inundated by tides. Blackgrass (which in southern marshes is replaced by other types of rushes) often borders upland areas. Pannes, shallow depressions in the marsh, are bordered by a variety of small broad-leaf plants.



or destroyed for purposes now judged "not in the public interest."

Salt marshes are vegetated by salt-tolerant plants —predominantly cordgrass and marsh hay on the east coast. The coarse, high cordgrass grows at the seaward edge of the marsh. On the higher landward part of the salt marsh where inundation is less frequent, the shorter, denser marsh hay takes over.

On the west coast a different species of cordgrass grows by the sea, with glasswort on the higher marsh. Salt marshes are also found at great distances from the tidal influence of the sea, as far inland as Utah and the Dakotas, where soils with a high salt content predominate and evaporation is high.

Mangrove swamps are saltwater wetland systems which cover vast areas of the southern part of Florida. The mangrove is of great ecological importance. Its many-branched root system emerges from the soil, providing support for the trees and forming impenetrable tangles of growth at the edge of tidal creeks. Mangroves are among the few woody plants which can tolerate the undiluted salinity of the open sea. Their "prop roots" are areas of attachment for

FRESHWATER MARSHES

Distribution of freshwater marshes (above). Blue-green color denotes prairie pothole region (page 14). Below: frost-edged blades of a sedge tussock.

large communities of estuarine and marine organisms which feed on the nutrient material released by the bacterial decomposition of mangrove leaves that fall into the water below.

Freshwater wetlands account for over 90 percent of our total wetland acreage.[6] Freshwater marshes are most often covered with shallow water. The water level rises in periods of heavy rainfall and heavy river runoff and recedes during dry periods. The marshes may be fed by ground water, by surface springs, by streams, by runoff from the surrounding terrain, by rainwater, or by all of the above. Freshwater marshes may occur inland or adjacent to the coast in low-lying depressions. Marsh vegetation is characterized by soft-stemmed plants, particularly grasses, sedges, and rushes. These plants may emerge above or float on the surface, or they may be totally submerged; they include such common plants as waterlilies, cattails, reeds, arrowheads, pickerelweed, smartweed, grasses, and sedges. Wild rice grows in some northern marshes, and great ex-

Common freshwater marsh plants include (left to right) cattail, wild iris, and water lily. In background is wild rice.

SWAMPS

Northern white cedar (below) and red maple (opposite) are swamp trees of the northeastern United States. The leaves of the red maple (opposite, above) turn a brilliant crimson in autumn. Right: Maryland's Zekiah Swamp.

panses of sawgrass are common in Florida.

A swamp is a type of wetland which is often waterlogged in winter and early spring but may be quite dry in the summer. Unlike the marsh, which is marked by soft-stemmed herbaceous vegetation, the swamp is identifiable by a predominance of woody plants, including such trees as northern white cedar, eastern larch, black ash, red maple, black gum, willow, and alder in the North and the mid-Atlantic region and water oak, tupelo gum, and bald cypress in the South. In the northwestern part of the

country, swamp trees are willow and red alder. Both freshwater swamps and marshes develop in wet upland depressions, at the edges of lakes and ponds, and along the borders or floodplains of streams and rivers.

The bog, a freshwater wetland most common in the northeastern and north-central states, often forms in glaciated depressions known as kettle-hole lakes in forested regions. Because a bog has a very restricted source of drainage and therefore has almost no inflow or outflow, dead organic matter ac-

BOGS

cumulates as peat in layers which are often 40 or more feet deep. Plants which grow in the acid bog water include leather-leaf, sedges, and Labrador-tea as well as the rare insectivorous pitcher-plants, sundew, and, at the edge of the bog, Venus's-flytraps. In the North, trees bordering the bog include northern white cedar, red maple, eastern larch, and black spruce. Sphagnum moss forms thick, spongy masses on which other plants often root on the surface of bogs.

Potholes, which are primarily found in the northern Great Plains areas of Montana, western Minnesota, North Dakota, and South Dakota, are shallow depressions ranging in size from less than 1 acre to more than 100 acres. Some potholes hold water for only a few weeks in the spring or after a heavy rainfall; others are permanent ponds that dry out only during the most severe droughts. The high productivity of potholes makes these wetlands attractive habitat for migrating and breeding waterfowl and other migratory birds. The pothole area, which extends into south central Canada, was formed approximately 11,000 years ago as receding glaciers pocked the terrain with shallow basins.

Flowering bog plants include (clockwise from below center): water willow; the pitcher plant, which consumes insects; rhododendron, a large evergreen shrub; and wild calla.

Maine's Crystal Bog (opposite) is the largest unspoiled northern sphagnum-heath bog in the United States. Right: a cranberry bog at Tannersville, Pennsylvania.

Formation of Wetlands

Although some of our wetlands are geological infants which have been created in as short a span as a human lifetime, many others took thousands of years to develop. The landscape of the east coast as we see it today was formed, from the uppermost areas of New Jersey northward, by the glaciers which coursed over the northern part of the country from New England westward to Puget Sound. As the enormous ice caps moved, they scraped the land and seacoast clear of marshes, trees, and all vegetation, creating new peaks and hollows, bays, and lowlands.

When the ice caps, which contained a vast quantity of the earth's water, began to melt 10,000-12,000 years ago, the sea level rose and new marshes formed at the meeting of sea and land behind barrier beaches and islands. Semienclosed estuaries were formed where the layering by density of salt- and freshwater flow trapped and circulated sediments and nutrients and promoted lush plant growth.

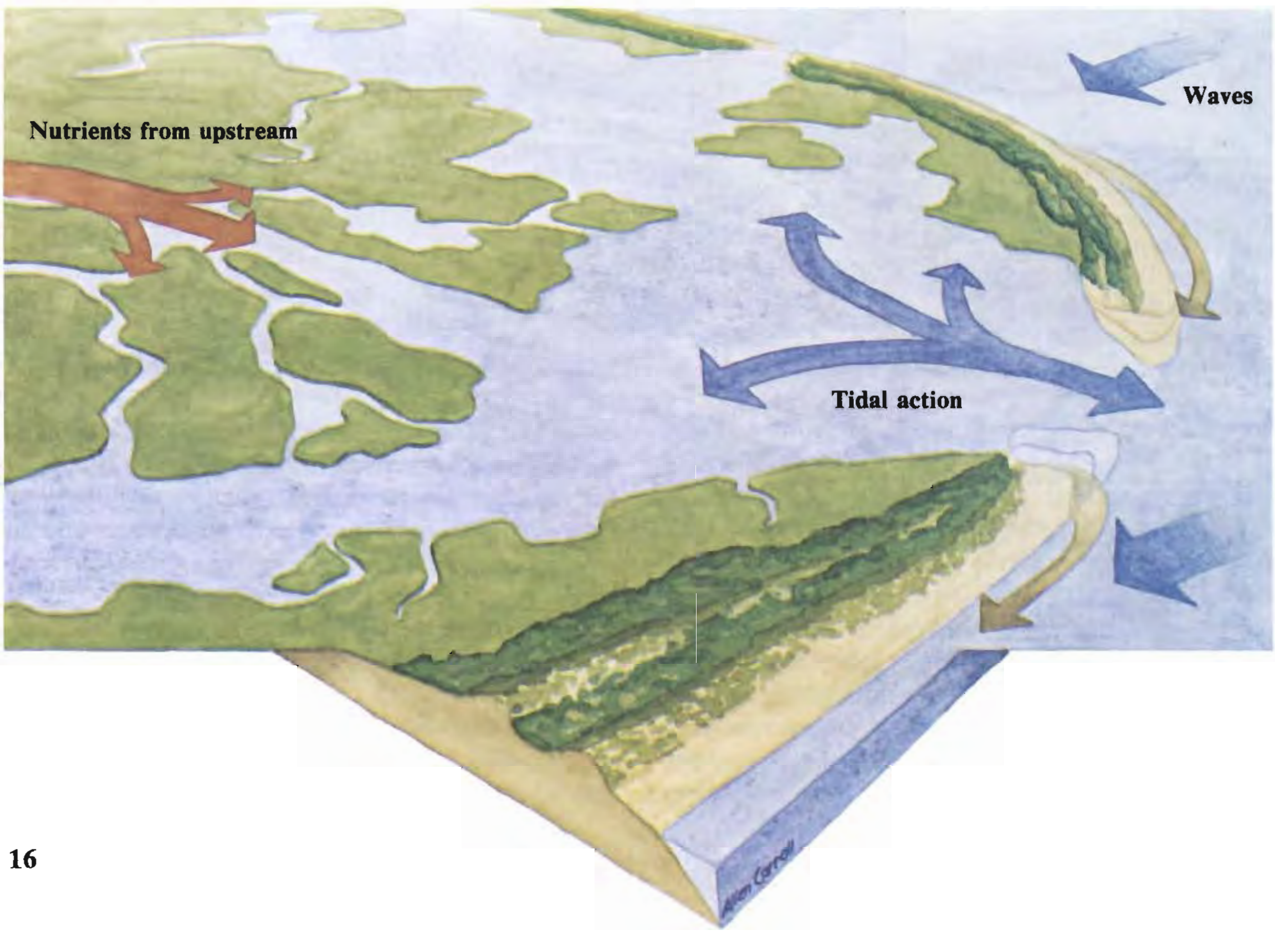
Along the unglaciated coastline of the mid-Atlantic and southern states, even denser and broader coastal marshes formed because of the relatively flat landscape, shallow water, and extensive barrier beaches and islands. As the sea level rose over the centuries, coastal marshes were inundated and pushed farther inland, and new vegetation took root in shallow areas where the sea and land met.

Coastal marshes continued to form over the decades and centuries, shaped by the contrapuntal forces of the movement of earth, water, and wind. The water cycle, by which all waters falling on the continents eventually return to the sea, links man and nature in a system in which water, an essential for all life, is absorbed, consumed, and released and is never lost. It is recycled.

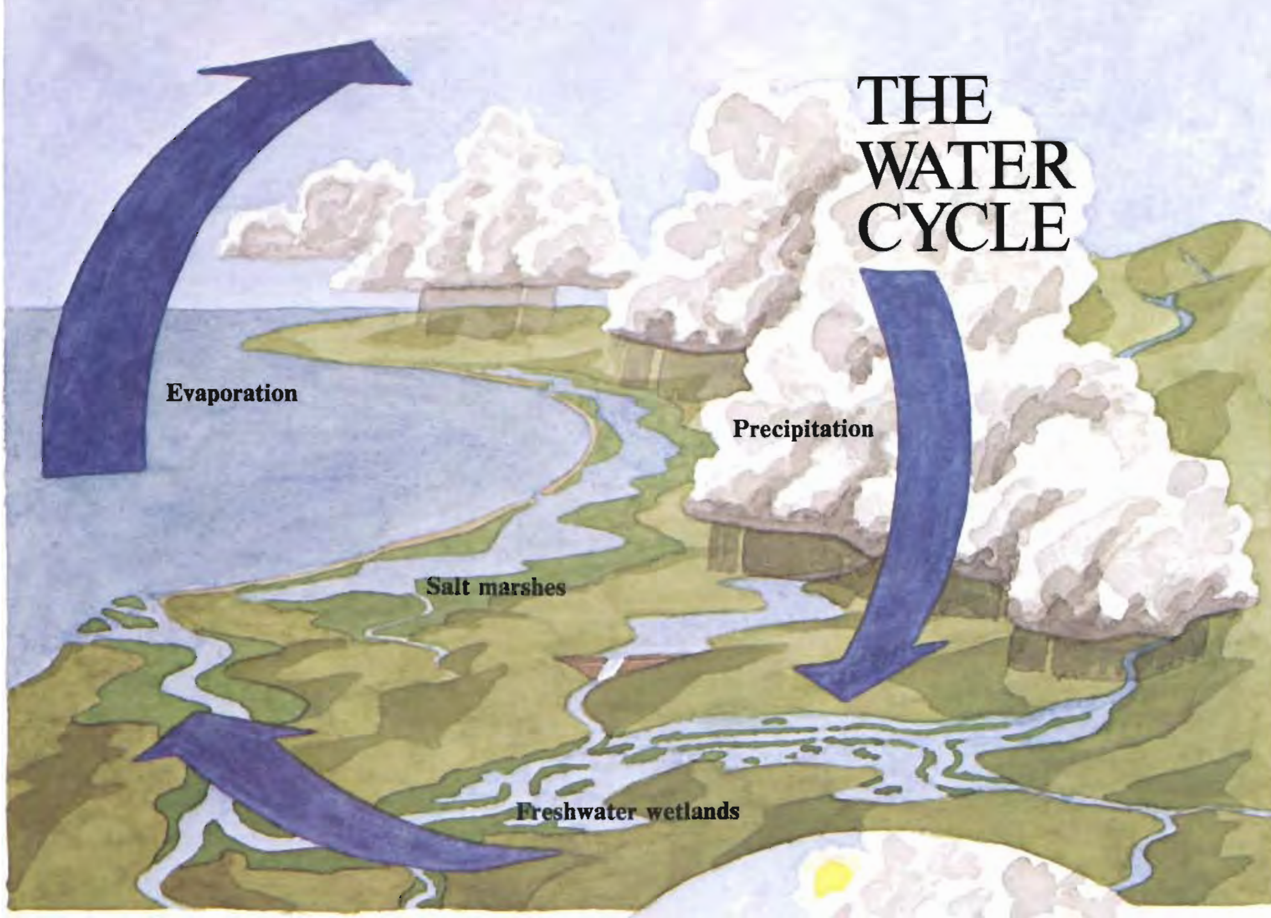
Water moves to the sea by underground flow, channeled flow, or simply over the land surface, and as it moves, it carries soil and eroded rock and other materials. Coastal marshes begin to form as silt is carried downriver or over land to the estuaries, where freshwater flows into the sea and the penetrating sunlight permits photosynthesis to occur. As plants begin to grow, their roots and rhizomes interweave to form a network which holds the soil deposits firm against the eroding force of the tide. Barrier beaches protect the marshes from the full force of incoming tides and storm waves so that plants are not uprooted or ground to extinction.

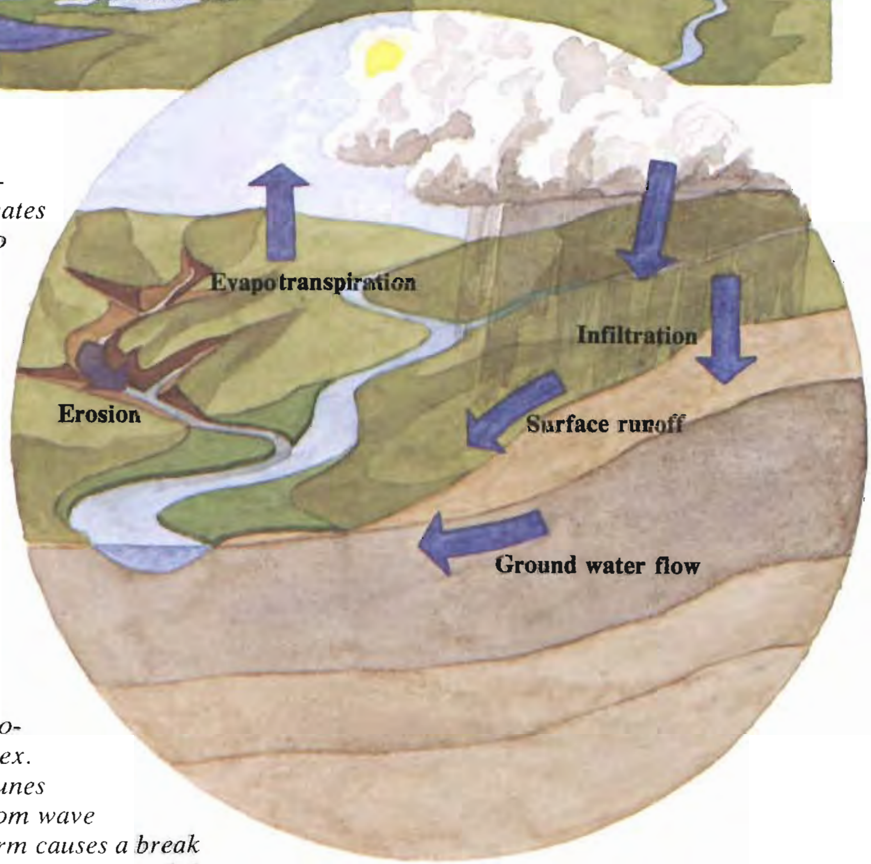
The flushing action of the tides, counteracting siltation from dry land, is an essential physical process in maintaining the integrity of coastal marshes. If a severe storm washes away barrier beaches, a delicate balance is upset.

On the Louisiana coast where channels have been constructed, the movement of silt and sediment is impeded and tidal processes are eroding the marshes. The opposite problem exists where unimpeded siltation eventually turns coastal marshes into barrier islands, beaches, and dry land. This change occurs in coastal and inland areas protected from the counterforce of the wind and waters which flush silt, decayed plant matter, and trapped sediments out to sea. Joppatown, Maryland, was a bustling tobacco port in the 18th century, but as land was cleared and farmed, topsoil eroded into the protected harbor. Today 2 miles of dry land separate the early 18th century mooring posts from navigable waters.[7]



THE WATER CYCLE





Water is constantly circulated in a sun-powered system in which water evaporates from the ocean and land and returns to the earth as precipitation. When water reaches the earth, it may immediately evaporate again, or it may be taken up by plants, where it is either incorporated into plant tissues or released to the atmosphere through transpiration. Much of the water quickly enters streams and rivers as surface runoff; some of it filters through the soil to the water table. Wetlands occur where the water table is at or just below the surface.

Barrier beaches and salt marshes (opposite) form a dynamic ecological complex. The constantly shifting beaches and dunes protect adjacent estuarine wetlands from wave and storm damage. When a severe storm causes a break in the barrier beach, old marshland may be destroyed, but sediments are deposited on which new marshes may form. Tides and currents carry nutrients and organisms between ocean and marshes.

CHAPTER THREE
Wetland Functions

An ecosystem is a unit of plants, animals, and their physical and chemical environment in which no one part exists independently of the others. The tidal wetlands and the estuary—where a stream's freshwater mixes with the saltwater of the sea—form a distinctive ecosystem in which plants and animals exist with each other and with the nonliving environment in a complex system of interdependencies.

The Food Web

Within the estuary and the marshes lives a fascinating diversity of creatures ranging in size and development from one-celled zooplankton to migrant birds and fish; permanent residents such as oysters, clams, blue crabs, and mussels; land animals which forage at the edge of the water; and even such marine mammals as the dolphin and the manatee. All are bound together in a web of energy transfers known as food chains.

The source of the energy needed by all plants and animals to sustain life is the sun, but only plants have the capacity to transform the sun's energy into food through photosynthesis. This energy, in the form of plant material, carbohydrates, fats, and proteins, then becomes available to the entire animal world, including people. Although in freshwater marshes many tender, succulent plants attract fish, ducks, and even deer, generally only about 10 percent of the waxy, tough cordgrass of the saltwater marsh is grazed directly.[8] Most of the cordgrass falls into the water, where it is broken down into detritus by bacteria and other microorganisms which live in the nutrient-rich waters. In mangrove swamps, the basis of the food chain is the leaf of the mangrove, which falls into the water, decomposes, and is circulated by intertidal currents.

Energy continues to flow as creatures feed on each other. As detritus is carried through the marsh, it is consumed by microorganisms, by fiddler crabs, by the larvae of marsh insects, and by mussels, clams, and other creatures which are then ingested by even larger animals. The energy from the sun which was harnessed by marsh vegetation reaches people as we consume the oysters and fish which feed in the estuary—or their predators which live in

Wind-blown "cowlicks" of salt marsh hay

The Canada goose and the diamondback terrapin are conspicuous members of the tidal marsh food web. Below: a young green rock crab at the marsh's edge.

the coastal waters.

The estuary offers a veritable smorgasbord for the fish which visit seasonally and for those which enter with the tides. Their prey includes the mud-dwelling insects, worms, mollusks, and crustaceans and the young of other species which use the estuary as a nursery because of the abundance of food and the shelter of shallow water and grasses. As fish and shellfish which feed in the estuary swim into deeper waters, larger predatory fish await them. Birds also find a variety of food in and near the marshes. Hawks sweep the area in search of smaller birds and mice. The clapper rail hunts small fish, fiddler crabs, insects, and snails in the vegetation along the edges of the marsh.

Inland marshes also teem with life. Red-winged blackbirds nest in cattails and shrubs and fly out, displaying their gaudy epaulets, to feed on grain, snails, beetles, and grubs. Foraging herons stretch their long necks to snatch fish, frogs, or small crustaceans swimming about in the shallow waters, and kingfishers watch at the water's edge. Raccoons, which like people will feast on either plant or animal matter, prowl the marsh at dusk. Newly hatched ducklings take to the water where they conceal themselves from predators among the bordering plants.

Wetland Productivity

The species which feed in estuaries and tidal marshes inhabit one of the most extraordinarily fertile of all environments. Studies of Georgia salt marshes by ecologist Eugene Odum show that they produce 10 tons of organic material per acre per year, a figure that Odum compares with our most fertile hayfields, from which we harvest only 4 tons annually.[9] Odum has found that the estuaries produce fully as much growth as tropical jungles and 20 times as much plant material (biomass) as the open ocean.[10]

Grasses grow abundantly in the tidal marshes where they are constantly supplied with nutrients which are circulated, recycled, and retained. As freshwater flows from land to estuary, it carries minerals from eroded rocks, from fertilizer, and from leaves and other garden and urban debris. These substances are trapped in the water circulation patterns of the estuary and mixed with other organic nutrients from decaying animal and vegetable matter. Marsh plants use these chemicals in combination with sunlight to produce more plant material. In the South, where grasses have a longer growing season, productivity is higher than in the North.

The estuary and tidal marshes are extraordinary natural systems in which tidal energy circulates nutrients, animals feed on plants and on each other, and excess nutrients are washed out to feed the organisms which live offshore. The crop is automatically cultivated and stored within the system, requiring neither human investment nor labor.

Although naturally occurring marsh crops do not reach the table—with some exceptions like wild rice and cranberries—plants of various wetlands contribute directly to the human economy. Until recent times, marsh hay was harvested by farmers, and today it is still cut and used for mulch in some areas of the country. Other marsh grasses are used in chair caning and basketmaking. Peat and sphagnum moss for agricultural and garden use come from bogs. Reeds have been used as bedding and thatching material in other countries. Valuable timber, particularly bald cypress, tupelo, and northern white cedar, grow naturally in wetland areas.

A primary measure of wetland productivity is fish yield. Of the 10 fish and shellfish most valuable commercially—shrimp, salmon, tuna, oysters, menhaden, crabs, lobsters, flounders, clams, and haddock—only tuna, lobsters, and haddock are not estuarine dependent.[11] The highest-ranking commercial species in terms of quantity is menhaden, a wetland-dependent fish valued not for human consumption but for its oil, which is used in tanning leather, in paint and varnish, insect spray, and soap, and in fertilizer, animal feed, and fish food. The average annual harvest of menhaden for the 5 years 1969-73 was 1.9 billion pounds.[12]

Figures on wetland-dependent fish yields have been the subject of numerous studies. The Georgia Game and Fish Commission estimated the per acre yield of freshwater wetland fish at 75 pounds.[13] In Connecticut's marshy Niantic River, the annual scallop harvest is 15,000 bushels, amounting to 300 pounds per acre per year, which exceeds the beef yield on excellent grazing grounds.[14]

Wetland productivity also includes waterfowl. The offspring of the 10-12 million ducks that breed

Raccoon

annually in the 48 conterminous states are direct products of wetlands and other aquatic areas. Some 60-70 percent of these waterfowl breed in the prairie pothole region alone.[15] Millions of other water birds and shore birds are also dependent on wetlands.

Fur-bearing animals are also a part of the productivity of wetlands. Raccoons, muskrats, and nutria are trapped for their pelts and in some parts of the country are valued as food sources as well.

Wildlife Management

Today experts in the field known as "wetland management" attempt to increase wildlife production not only by conservation of wetland habitat but by techniques which provide habitat for individual species requiring individual attention. Although the stereotyped view of conservation is that the physical environment is to be left strictly *au naturel,* those involved in managing wetlands seek to control or alter some conditions in order to protect specific fauna or flora or to improve the overall diversity and productivity of many wetland areas. Wildlife management techniques include special plantings for additional food and cover, construction of boxes and artificial islands for nesting where predators have less access, and more aggressive modifications of the environment, such as creating artificial potholes and open water areas in shallow marshes dominated by reeds and cattails or manipulating water levels in marshes to encourage fish and wildlife reproduction and growth of "desirable" plant and animal foods. Previously drained marshes and bottom land forests have been restored to create habitat for waterfowl. Managers of publicly owned wetlands often manage them to attract migratory birds for observation by birdwatchers, naturalists, and the general public. In the unique San Simon Cienaga wetlands in the midst of the New Mexico desert, a number of wildlife management techniques have been employed to enhance production of the Mexican duck.

In many National Forests, such as the Chippewa National Forest in Minnesota, the U.S. Forest Service also reports success with fish population increases in artificially controlled fry-rearing nursery areas. Habitat enhancement at Maryland's marshy Blackwater National Wildlife Refuge has currently increased the number of visiting Canada geese from 5,000 a few decades ago to 100,000 during the November peak.[16]

Pollution Control

There is general recognition of the fact that wetlands are vital to fish and wildlife. A subject of livelier debate and growing intensity is how wetlands function as pollution filtration systems and as natural flood control mechanisms. The implications of current scientific findings for these subjects are of great interest to ecologists, planners, and engineers.

The role of wetlands in reducing the pollution levels in water has recently become one of the most compelling arguments for their preservation. Because wetland ecosystems hold nutrients, they simultaneously act as a pollution filtration system. Water arriving from such "point" sources as waste water treatment plants and from such "nonpoint" sources as runoff from agricultural fields and city streets carries a high level of pollutants, particularly excess levels of nitrogen and phosphorus. As the water circulates through a wetland, the plants take up and use these pollutants as nutrients.

A study by the Georgia Water Quality Control Board of Mountain Creek, a tributary of the Alcovy River, showed that water heavily polluted with human sewage and chicken offal was designated clean after passing through 2.75 miles of swamp forest.[17] A study of the Tinicum Marsh, located a few miles from the Philadelphia airport, measured pollutants in the broad tidal creek which transects the marsh both before it overflowed its banks into the marshes and again when the water returned to the creek after draining for 2-5 hours. Chemical and bacteriological samplings indicated that the marshes significantly improved water quality by increasing the oxygen content and by reducing the nutrient load.[18]

The natural capacity of wetlands to recycle pollutants while stimulating plant growth is being studied in a carefully controlled experiment in Gainesville, Florida. There treated sewage from a secondary treatment plant is being routed through two pond cypress domes, a freshwater wetland ecosystem.[19] The study showed that when treated sewage is added to the domes at the rate of 1 inch per week, vegetation takes up the nutrients, natural filtration through the sand removes remaining pollutants, and purified water seeps slowly into the aquifer or ground water supply. There are no figures yet on measurable increases in tree growth resulting from this extraction of nutrients, but enhancement is expected.

At the Brookhaven National Laboratory an artificial marsh-pond system is being used in an attempt to solve Long Island's two biggest problems—sewage disposal and water supply. The system treats 20,000 gallons of sewage daily from the town of Brookhaven. There is no problem of odor, and there is a notably thriving plant, fish, and shellfish population. After natural filtration, the cleansed water can be used to recharge ground water supplies.[20]

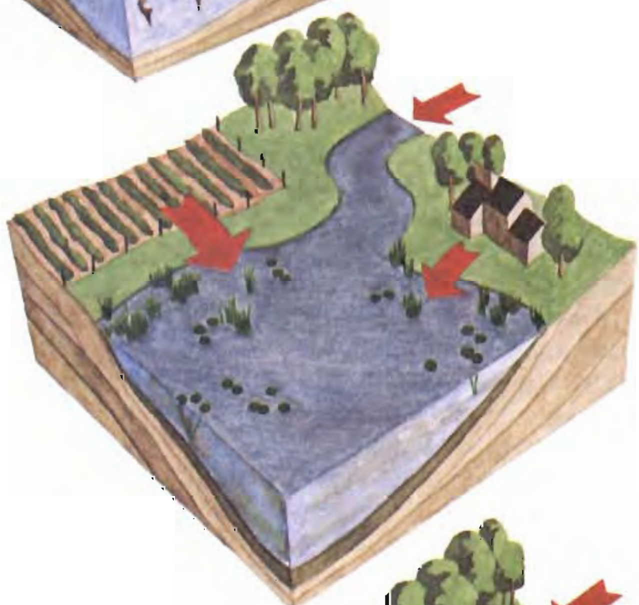
The capacity of a marsh to use pollutants for healthy plant growth is not unlimited, however. If a wetland is overburdened by pollution, it will eventually be severely changed, particularly if the waters are contaminated by toxic substances or poisons such as pesticides, heavy metals, and industrial chemicals. Many of these manmade poisons enter the food chain and may be passed on to people. Organic pollutants can also reduce fish and shellfish harvests, as was noted on Long Island when runoff from commercial duck farms so altered the chemistry of the nearby estuary that plant life deteriorated and oyster production markedly decreased.[21]

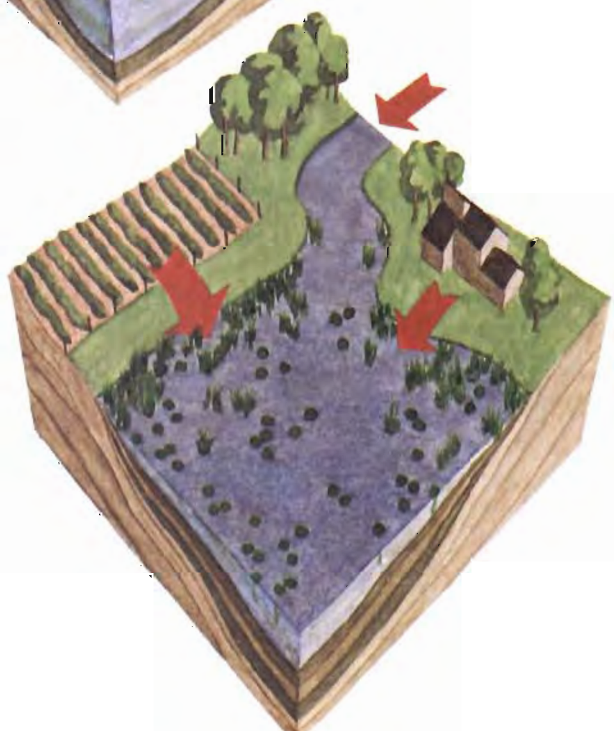
Interest currently centers on the role that river marshes play through their filtration function in

A male wood duck. Wood ducks have profited from widespread installation of nesting boxes, which provide protection from natural predators, including the raccoon.

EUTROPHICATION

Eutrophication, a natural aging process in lakes, may be accelerated by pollution. In a natural situation, nutrients entering the lake from upstream and from surrounding uplands support a slowly evolving system of plants and animals. Sewage, fertilizers and other pollutants increase the nutrients entering the lake. As the growth of algae and other plants increases, oxygen levels go down and fish die. Sedimentation allows aquatic plants to take over, and the lake becomes a wetland.





protecting lakes from accelerated aging. In the natural and normally slow aging process, lakes accumulate nutrients and sediments and become so shallow that plants grow and emerge through the surface. When a lake accumulates excess quantities of nutrients through natural or manmade causes, the aging process is accelerated, as evidenced by increased turbidity and the growth of algae. Oxygen levels in the water drop and fish die. The water often develops an unpleasant taste and a distinct odor, and it loses its aesthetic quality. During the eutrophic stage, the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that the algae and other microscopic plant life become superabundant, thereby "choking" the lake and causing it eventually to become a wetland.

Eutrophication may be accelerated by contaminated runoff or by waste treatment plant discharges.

But when the marshes are left relatively undisturbed, nature captures and recycles nutrients and keeps the marshes working; the result is healthy plant growth. One recent finding is that riverine marshes take up nitrogen and phosphorous, trapping them in plant tissue during the summer and fall, then withholding the nutrients when excessive algae blooms are likely to occur. The nutrients are released with high spring waters and storm surges well before the algal blooms appear. The high waters and increased stream flows dilute the nutrients, making them less accessible to nuisance plants.[22]

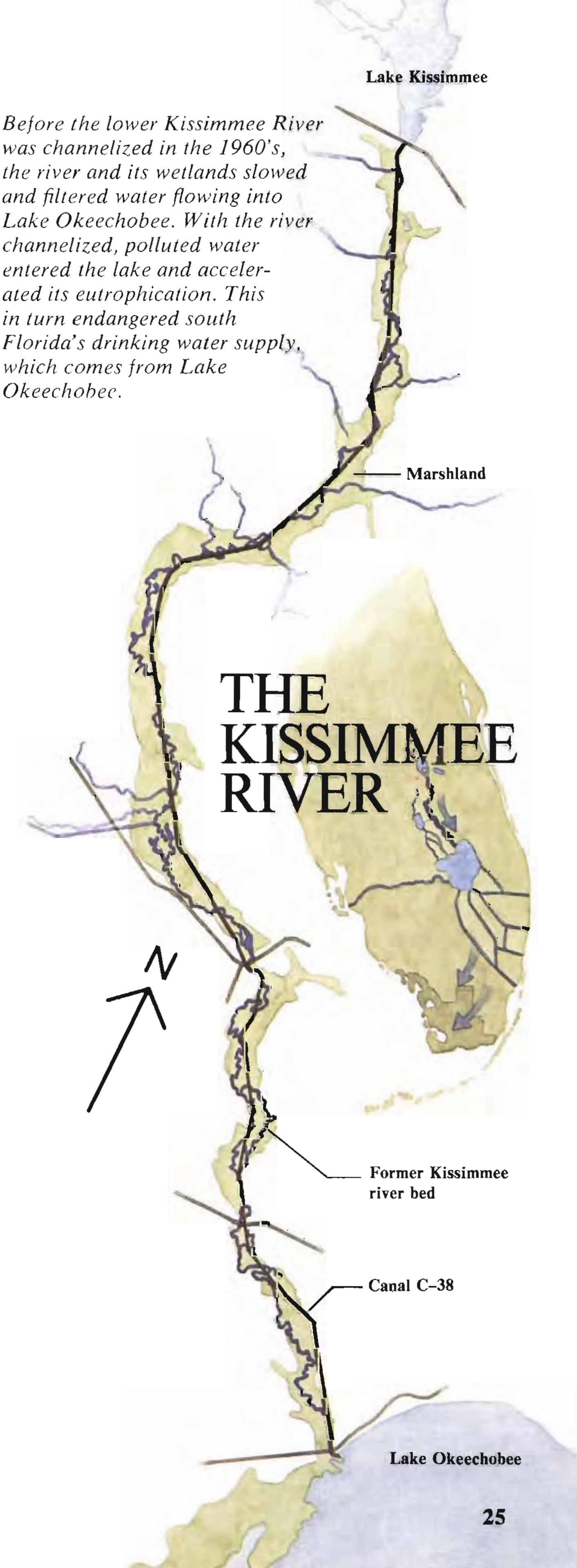
A CASE REPORT:

The Kissimmee River Canal

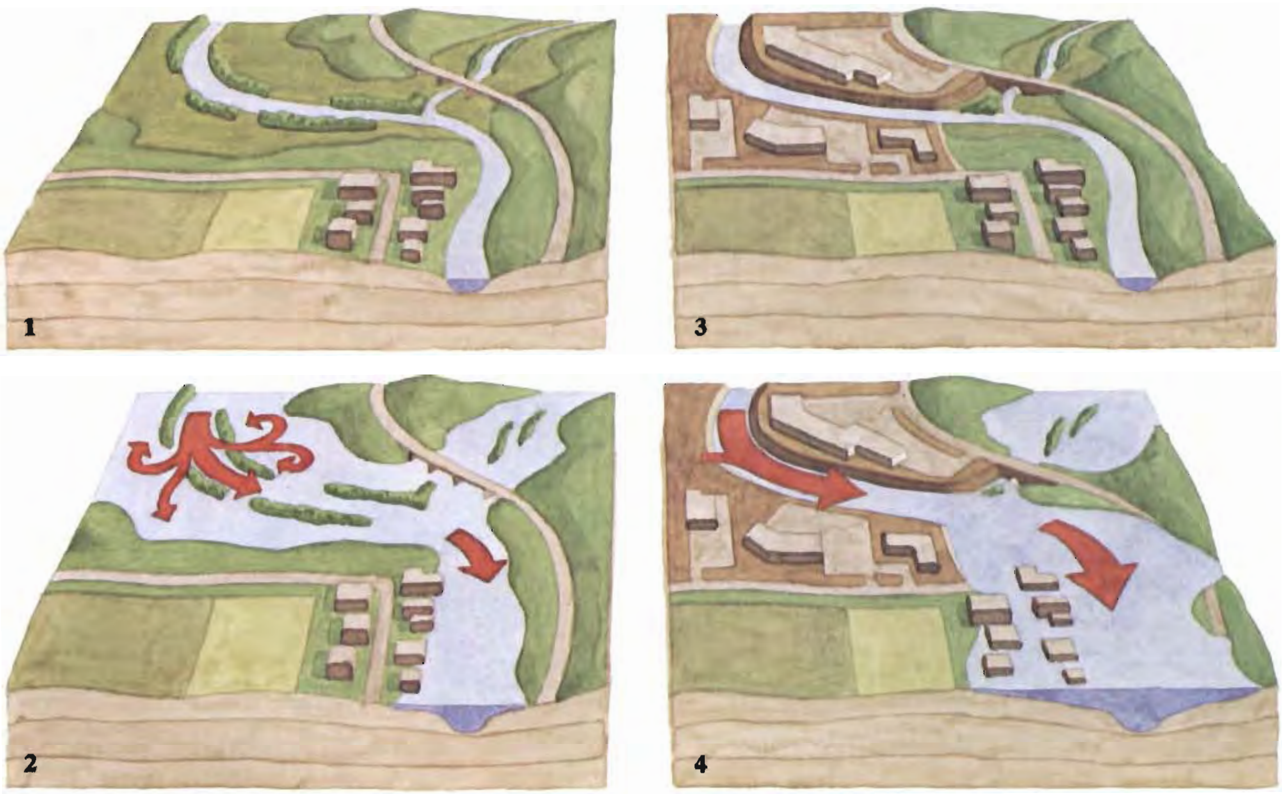
Only yesterday—before the importance of wetlands in controlling pollution was recognized—few people questioned a decision to destroy river marshes in an effort to prevent flooding of urban or agricultural areas. Lake Okeechobee acts as a massive reservoir in south central Florida. An important site for commercial and sport fishing, the lake supplies drinking water to the southern part of the state during dry seasons. In the mid-1960's the slowly meandering 100-mile Kissimmee River, which flowed south from Lake Kissimmee to Lake Okeechobee, was transformed into a 50-mile straight-cut canal at a cost of $30 million. In 1976 the Florida Legislature adopted the Kissimmee River Restoration Act,[23] which may result in replacement of the 70 million cubic yards of earth removed when engineers changed the winding river into a 30-foot-wide-by-3-foot-deep channel. The legislature did not spell out what it meant by "restoration," and a number of alternate plans are now being drawn, but it is generally agreed that as the canal now functions, it will gravely endanger drinking water quality in southern Florida by contributing to the accelerated eutrophication of Lake Okeechobee.

How did this happen? What went wrong?

Southern Florida suffered severe flooding in 1947



Before the lower Kissimmee River was channelized in the 1960's, the river and its wetlands slowed and filtered water flowing into Lake Okeechobee. With the river channelized, polluted water entered the lake and accelerated its eutrophication. This in turn endangered south Florida's drinking water supply, which comes from Lake Okeechobee.



and 1948. In the late 1950's when the plan was formulated for Canal C-38—the project designation—the canal was viewed as a routine flood prevention measure designed to move the maximum amount of water quickly, efficiently, and economically. Those who protested the plan were not water quality experts but naturalists who deplored the destruction of a beautiful winding river and predicted loss of wildlife. The Fish and Wildlife Service of the Department of the Interior recommended against the plan because of the fine bass fishing along the river and the large duck population in the river valley. Flood control seemed more urgent than the future of bass and wood ducks and the project was approved and completed.

Before channelization the winding course of the river and its 45,000 acres of wetlands slowed and filtered the passage of water on its route to Lake Okeechobee. In periods of heavy rainfall, waters were slowed even more as they overflowed a 1-mile broad, flat floodplain. After channelization the floodplains, protected from overflow, were developed for farming and cattle grazing in this predominantly agricultural area. In periods of heavy rainfall, runoff from these grazing lands was now sped into the canal and down to Lake Okeechobee without benefit of the former pollution removal services of the marshes.

Lakes in southern regions are particularly susceptible to eutrophication because of factors which cannot be controlled—warm temperatures, high light intensity, and a long growing season. A 1972 report by the University of Miami on the Kissimmee-Okeechobee Basin concluded that the canal was a major factor in accelerated lake eutrophication, with resultant water quality deterioration, and it recommended halting the discharge of all waste materials into the basin and developing a plan for reflooding the marshes of the lower Kissimmee Valley. The report estimated that a 1,500-acre marsh can use nearly all the nitrogen and one-fourth the phosphorus contained in the effluents from sewage treatment plants serving a community of 62,000 people.[24]

Plans to restore the Kissimmee River and marshes vary in their assessments of financial and engineering feasibilities. But it is hard to find anyone involved who looks with pride on Canal C-38, constructed only a decade ago when nearly everyone thought that wetlands in marshy, swampy southern Florida were the most expendable of all environments.

Wetlands frequently play an important role in natural flood protection. The preservation of wetlands upstream from developed areas (1, opposite) provides overflow areas where flood waters will do little damage. The wetlands reduce the severity of floods (2) by allowing floodwaters to spread out, by slowing their flow, and by temporarily storing water. Thus downstream floods may last longer, but they will peak at lower levels. If wetlands areas are filled and streams are channelized (3), flood waters will flow unimpeded to downstream areas (4), often causing severe damage from high velocities and flood heights.

Flood Protection

Only in the past decade or so has the role of wetlands as storm buffers been understood. A flood may be less destructive when marshes and swamps slow velocity and desynchronize peaks of tributary streams as the waters flow through their impeding vegetation and into the main stream. Their action reduces the flood peak along the main stream although it may lengthen duration of the flood.

One hydrologist likens wetlands to artificial grass:

> Let's say you have a long strip of astroturf and you tilt it up at one end and pour water down it. The astroturf isn't absorbent; it doesn't actually take up any of the water. But the water weaves in and out through the "grasses" as it goes, and it takes a long time to get to the bottom. If you then use a sheet of something like aluminum and tilt *that* up and pour water down it, the water runs right to the bottom very quickly.[25]

The capacity of wetlands to control flooding was dramatically demonstrated during severe storms in eastern Pennsylvania in 1955. Although many bridges were washed out over streams in developed areas, two survived undamaged—they were located below a large cranberry bog preserved by The Nature Conservancy.[26]

In addition to slowing the rush during storms, swamps, marshes, and bogs serve secondary purposes as well. They are often compared to sponges which "absorb" great quantities of water, but many ecologists find this comparison misleading except in the case of sphagnum mosses or certain types of Everglades peat which do in fact absorb and hold large amounts of water.

One of the most vital hydrological functions of wetlands is detention storage. At times of heavy rainfall, water flows into the marshes which overrun their margins onto a wide area of land. There the water is retained for slow release into streams; sometimes it percolates into aquifers to increase ground water supplies. It has been estimated that 1.5 million gallons of water are placed in storage with a 6-inch rise in water level when rain water is captured in a 10-acre wetland.[27]

Flood control projects, many of them carried out under federal programs for watershed improvement, mimic nature by creating artificial impoundments for the detention of water. These reservoirs are often designed for recreation as well. There is no question that wetlands do not make the best swimming pools, but they do offer their flood control services free of charge, and at the same time they perform many other valuable functions.

A CASE REPORT:

The Charles River Plan

One of the most innovative practical applications of current findings about wetland functions is the Charles River plan. Although some people still believe that engineers automatically insist on altering natural systems so that they can get on with their construction, the Corps of Engineers is responsible for devising the simplest yet the most innovative of plans for natural flood control in the Massachusetts Charles River watershed.

The plan involves acquistion of some 8,500 acres of wetlands within the Charles River Basin for the purpose of preserving their natural flood storage capacity. Additionally, the recreational and fish and wildlife benefits of the wetlands are to be preserved. The plan is expected to offer a permanent solution to the problem of inevitable flooding in areas where population pressures are leading to rapid development.

The 5-year study which resulted in this engineering design was begun in 1965 when the Congress directed the Corps of Engineers to develop a plan for controlling flood damage along the entire length of the meandering 80-mile river in eastern Massachusetts. The lower part of the river travels through highly urbanized Boston and Cambridge and empties into a harbor which at high tide has a water level higher than the river. In this city of few undeveloped absorption areas, the result is damaging flooding of roads, basements, and subway tunnels. Because Boston's once extensive Back Bay marshes are now entirely filled and the river's floodplains effectively walled, high water has nowhere to go except up. Flooding in the area was a direct result of urbanization, and the only apparent solution was to replace an old, inefficient dam with one with facilities that could pump out the tidal water.

In studying the middle and upper watershed, however, Corps engineers discovered that although previous floods had severely damaged the Boston-Cambridge area, little damage of any sort had occurred in the less developed middle and upper parts of the Charles River watershed where there never had been any flood control dams.

It was in 1968, while the studies and measurements were still being made, that in 2 days a storm added 7 inches of rain to the quantities of water from melting snow. Engineers noted that although runoff from the lower area of the river crested at the old dam within hours, the upstream crest took a full 4 days. The Corps had already estimated that channelizing only a 10-mile stretch of the river would cost $30 million and had indicated the inestimable damage to the beauty and ecological integrity of the river. The movement of water during the recent storm convinced them that the Charles River watershed had escaped a flood problem because a natural flood control system was functioning—beautifully.

Within the Charles River watershed there are 20,000 acres of undeveloped wetland amounting to 10 percent of the entire drainage area. At times of high water, these wetlands absorb the water and release it slowly after the floodwaters recede. The Corps study recommended federal acquisition of 8,500 of these acres in 17 crucially located valley sites to be kept perpetually in their natural state.

"The logic of the scheme is compelling," said the Corps final report in 1972:

> Nature has already provided the least-cost solution to future flooding in the form of extensive wetlands which moderate extreme highs and lows in stream flow. Rather than attempt to improve on this natural protection mechanism, it is both prudent and economical to leave the hydrologic regime established over the millenia undisturbed. In the opinion of the study team, construction of any of the most likely alternatives, a 55,000 acre-foot reservoir, or extensive walls and dikes, can add nothing.[28]

The plan, known as Natural Valley Storage, is now in its "construction" phase—which translates into gradual acquisition of the wetlands, currently in 525 separate ownerships. Although direct purchase is required for most federal flood control projects, in this instance some landowners who wish to may retain title to their lands while granting the government restrictive easements that will ensure retention of the land in its natural state.

The Kissimmee River canal, designed in the late 1950's, was a conventional solution to a commonplace flooding problem. A decade later the Charles River plan was based on new insights in the field of hydrology and on new sensitivity to environmental alteration.

The Value of Wetlands

In its study of the Charles River Basin, the Corps of Engineers tagged the annual flood control benefits of the Natural Valley Storage Plan at $1,203,000—"the difference between annual flood losses based on present land use and conditions" of the 8,500 acres of wetlands and "those associated with projected 1990 loss of 30 percent of valley storage."[29]

It is difficult to quantify the value of wetlands, and attempts to do so generate considerable disagreement, but because alternative approaches to engineering problems are often judged today by cost-benefit comparisons, such financial estimates are now common. Today a number of ecologists are attempting to apply accounting procedures to wetlands, making financial evaluations of the services which wetlands perform in their natural state and urging that the figures be seriously considered in decisions on uses of water resources.

Most quantifiers have concerned themselves solely with wetlands functions. Placing a dollar value on purely aesthetic delight may seem impossible to many scientists who feel on surer ground pricing wetlands in relation to damage projections or to the known commercial values of estuarine-dependent shellfish, for example.

Not everyone agrees. Ecologists debate and dispute the figures put forth by other ecologists. Economists challenge methods and results. Meanwhile, the dollar signs continue to appear in the literature. On the basis of present market value, the timber productivity of Georgia's Alcovy River system is estimated at $1,578,720 per year, or $686 per acre. Purely as a sediment accretor, the Alcovy River Swamp is valued at over $3,000 annually and the river's 2,300-acre swamp ecosystem at $1 million annually, for water quality alone.[30]

A University of Massachusetts team has developed a complex system for quantifying the value of freshwater wetlands.[31] In Massachusetts and in a number of other northeastern states, local conservation commissions of lay citizens are empowered to regulate the use of wetlands and, in some instances, to acquire land deemed important for conservation. The University work was undertaken to assist these state and local agencies in deciding whether to permit destruction or alteration of specific wetlands in their areas. A rating system was devised, based on a number of criteria, including importance in maintaining water supplies, wildlife values, and recreational and aesthetic or "visual-cultural" values. With this system and some dollar equivalents, specific wetlands can be compared. For example, the study assigned a value of $60,000 or more per acre for those wetlands that have a high water supply potential.

Other frequently cited quantifications are those of Eugene Odum, which place monetary values on South Atlantic and Gulf coast marshes and estuaries.[32] Odum based his mathematical calculations on the annual income per acre for commercial and sport fisheries, on the potential for aquaculture development and for waste assimilation, and on the total life support value (which is based on gross primary production). Odum would be the first to say that his analysis of the worth of natural systems is oversimplified but that it is a beginning.

Individual and socioeconomic considerations are always a part of determinations on how best to use natural resources. For the owner of property, the decision to convert a marsh into agricultural land or building sites invariably includes an economic choice. However, society has a stake in this choice because wetlands are a part of the aquatic system which impacts on the lives and properties of more than the individual property owner. When wetlands are voluntarily retained in their natural state, financial return is often sacrificed. Benefits which are offered to society at large in the form of waterfowl and fish production, flood control, or antipollution values do not bring measurable return to the individual property holder. However, some wetland owners may be able to realize a financial return through the use of the beneficial values of wetlands in connection with an economic activity such as forestry through government or other acquisition plans which exist for conservation purposes—or they may be eligible for programs which involve financial compensation, such as the U.S. Department of Agriculture's Water Bank. Assigning economic values to wetland functions helps society realize the value of marshes and swamps, which Dr. Odum suggests may then be preserved by government purchase, by tax relief, or by payment to owners in return for nondevelopment. Others see the primary safeguard against extensive future loss of wetlands as comprehensive and enforcible state and federal regulations based on an understanding of the importance of wetlands to the aquatic ecosystem. This view is based on the principle that society has the responsibility and right to protect water, including wetlands, from destruction and degradation for the common good and that landowners are not guaranteed the privilege of making a maximum profit from their land if it involves the irreparable loss of a part of the nation's aquatic resources to the detriment of all.

CHAPTER FOUR

Alteration of Wetlands for Agriculture and for Forestry

Agriculture in Wetlands

Although the informed farmer of today may be aware that draining wetlands has become controversial on both practical and idealistic grounds, the industrious pioneers who first cleared the land were confident that doing so was just sound practice. In the European countries from which they had emmigrated, no one questioned the wisdom of turning as much of one's "wasted" acreage as possible into useful cropland.

In 1763 George Washington was among those assigned to survey the Dismal Swamp area of Virginia and North Carolina for purposes of reclamation. Drainage projects of ambitious scope were undertaken in Delaware, Maryland, New Jersey, Massachusetts, South Carolina, and Georgia. Early attempts to reclaim wetlands for agriculture were made by digging small open ditches, but in 1835 the era of modern agricultural engineering began as the first factory for making clay tile pipe segments was opened in Seneca County, New York. By 1880 there were 1,140 tile factories in the United States, most of them located in Illinois, Indiana, and Ohio.[33]

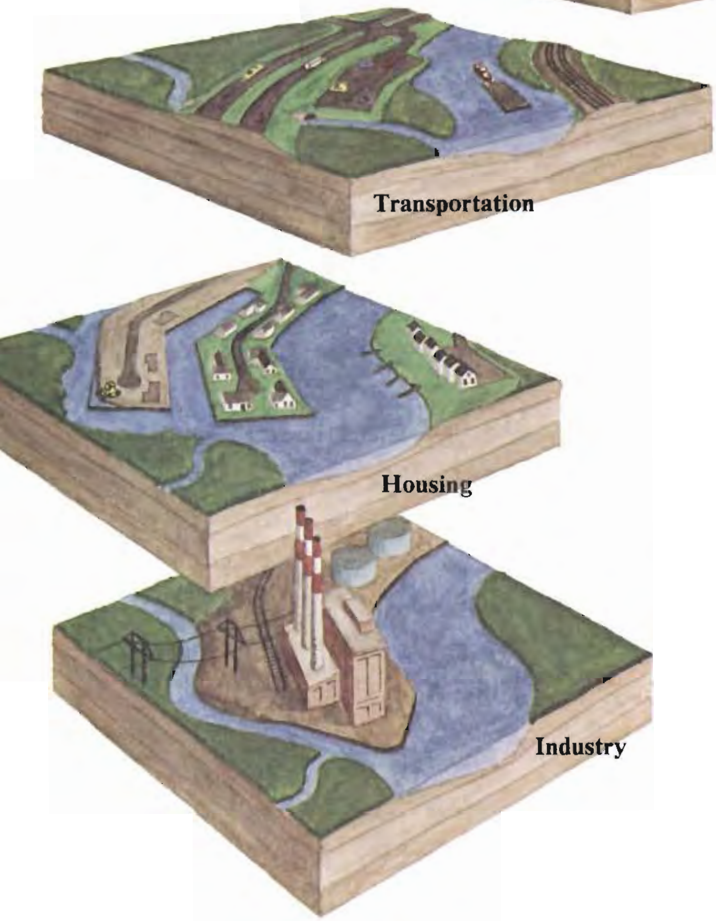
In the 19th century a number of favorable laws and subsidies further encouraged development of wetlands for agriculture. The Swamp Land Acts of 1849, 1859, and 1860 gave 65 million acres of wetlands owned by the federal government to 15 states for reclamation.[34] In the 1930's the federal government's role in land drainage was accelerated through the emergency public works programs. More recently, with the organization of new federal financing agencies and expansion of work by existing agencies, the functions have broadened. Much of the effort has been directed to improvement and renovation of existing drainage systems.

Soils having a wetness condition are identified in the Soil Conservation Service's land capability classification system. On that basis 40 percent of all soils on nonfederal lands having wetness conditions are used for cropland. These soils account for 24.4 percent of total U.S. cropland. Only 24 percent of soils on nonfederal lands with severe wetness conditions are so used, accounting for 9.4 percent of total

Cottonwood is harvested in a seasonally flooded area at Huntington Point, Mississippi.

ALTERATION OF WETLANDS

Wetlands have been altered to favor nearly all forms of human land use, including industry, housing, transportation, agriculture, and recreation. Alteration methods include dredging, filling, bridging, drainage, and construction of dikes and levees.



U.S. cropland.[35] It is important to recognize that "wetlands" as defined for regulatory purposes[36] does not include many areas classified as having a wetness condition.

The most important crops grown on the drained soils are corn, soybeans, cotton, peanuts, tobacco, feed grains, and wheat. A few specialty crops—mint, cranberries, and wild rice—grow in undrained wetlands, although dikes are used for artificial control of water levels in rice and cranberry farming. Drained or partially drained wetlands are also used for pasture land and for tree farms. The Department of Agriculture has subsidized both wetland drainage and farm pond construction for almost half a century, enabling and encouraging farmers to remove water from cultivated or potential crop areas where nature inconveniently supplied it and to place it on lands used for grazing or other purposes. Many of these over 2 million ponds have borders of wetland vegetation.

Slightly over one-half of the soils classified as wet which are now under cultivation fall into the Agriculture Department's land capability class II—which is generally referred to as "prime farmland"—and the crops grown on these lands and other prime agricultural lands account for a significant part of our agricultural production. Some of our most productive agricultural lands are located in Ohio, Indiana, Iowa, Missouri, and the lower Mississippi River alluvial plain. They were once too wet for any sort of cultivation. But not all wetlands are suitable for agriculture, and the history of drainage projects is studded with disaster. Some land never could be adequately drained; on other land seasonal river floods continued to destroy crops; and often the soils, once drained, proved too acid or too salty or were subject to subsidence and flooding, resulting only in environmental destruction and economic loss.

Today the sciences of soil analysis and hydrology have reached a level of sophistication which makes prediction possible, but much of this knowledge is recent, and the trial-and-error approach to agricultural drainage is not totally a thing of the past. The "cat-clays" of the southeastern coast and the gulf coast and the high-salt soils of the West are frequently cited examples of poor agricultural materials. Although rice has been grown in diked southern Atlantic and gulf marshes for years, many of these marshes were drained for other crops. Only then was it discovered that many of these dried soils along the Atlantic coast developed high concentrations of sulphuric acid and were totally unsuited to agricultural production. Some drained marshes in western states contained such damaging concentrations of salt that they required extensive flushing, creating salinity problems downstream.

The most concerted efforts in draining wetlands for agricultural purposes over recent decades have been in the Mississippi Delta, the prairie pothole region, and the Florida Everglades. The alluvial areas of the Mississippi River Delta region and the pothole region have proven excellent for the cultivation of two of our most valuable commercial crops —soybeans and wheat. In southern Florida, however, where a wide variety of vegetables is grown on former swampland, farmers have discovered that they are cultivating a rapidly disappearing resource.

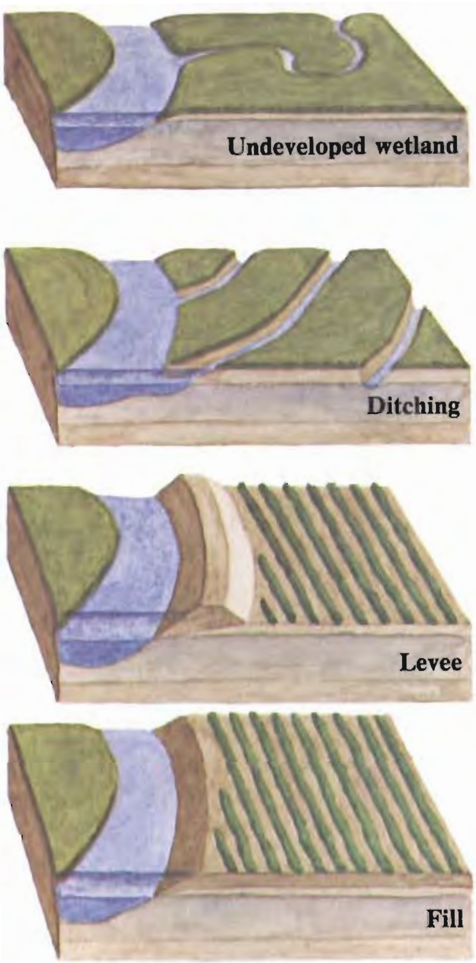
A CASE REPORT:

The Prairie Pothole Region

Fertile prairie potholes can sometimes be converted to excellent agricultural land—but at the sacrifice of an important wildlife resource and of natural retention storage basins. Hunters were among the first people to protest the farmers' turning potholes into cropland as they watched duck populations decline. In the 4 years, 1964–68, an estimated 125,000 acres of potholes—which were prime duck nesting wetlands—were drained in Minnesota and North and South Dakota.[37] In the 1950's, 64,000 potholes covering 188,000 acres of wetlands had been converted to farmland.[38]

Water storage in potholes directly benefits the farmer as well as wildlife because they act as reservoirs during dry periods, when water supplies are critical to the farmer's own grazing cattle. In wet years their storage capacity also helps prevent downstream flooding. But draining the potholes continues because it offers economic returns and because the single-crop farming which developed after World War II uses large, specialized equipment which is difficult to maneuver and which may become stuck

Mint is one of the few commercial crops grown in wetlands.



RECLAMATION OF WETLANDS

Wetlands can be altered for agricultural use in several ways. A series of ditches eliminates standing water and lowers the water table. This method is also used for mosquito control. Other methods include construction of levees and the use of fill. Levees and fill may increase flood heights (page 26).

Opposite: sawgrass and parched soil during the dry season of Florida's Everglades. Diversion of water flowing southward from Lake Okeechobee has worsened the dry periods, reducing wildlife populations and increasing danger of large fires.

in wet areas. Ecologists urge that farmers leave their potholes undrained and plant them with wheat during dry seasons while permitting them to fill with water in wet years. Again because of financial interests and difficulties in moving the heavy farm equipment, this method of "farming *with* nature" is practiced to only a limited extent.

A CASE REPORT:

The Mississippi Delta Region (Alluvial Plain)

In the 24 million-acre Mississippi Delta region drainage and agricultural development have closely paralleled flood control measures in the river. The first Mississippi River levee, completed in 1726, was intended to protect the city of New Orleans. By 1800 many more levees had been constructed, and land clearing and drainage projects were underway up and down the river; flood protection made crop production on riverside farms feasible. Attempts to cultivate undrained acreage were also made, but often the crop was lost to excess water. Until the first farm machines were introduced just before World War I, ditches were dug by hand, first by slaves and later by immigrant labor. In the depression years of the 1930's, subsistence farming, accomplished almost entirely by family hand labor, again took over and supplanted earlier attempts at mechanized farming in the Mississippi Valley.

Although cotton was always the traditional cash crop in the Delta, in the 1960's soybeans suddenly became an internationally important commodity. All along the wet bottomlands of the Mississippi Delta, wet forests were cleared and drained and soybeans planted. Almost 1 million acres of wet soils were drained in this region between 1959 and 1964.[39] Many of the drainage ditches were rudimentary, but farmers made do until they became eligible for improved drainage assistance from the Department of Agriculture after 2 years of crop production. Specialized land clearing machines, which were introduced only after World War II, made clearing the flat bottom lands easy and inexpensive.

Unlike cotton, which must be planted in the spring, soybeans are a short-season crop which can be sown after river levels go down in early summer. To the farmers in the Delta, this meant that soybeans, unlike cotton, could be grown on formerly "useless" riverfront land and on less profitable forested wetlands without extensive drainage. These highly fertile, wet alluvial soils—considered unsuitable for agriculture when "agriculture" meant simply cotton—could now be farmed so profitably that the return on 1 year's crop paid for clearing the land. Soybean farming on former wetlands became an economic bonanza.

In a 1969 study of an extensive densely farmed Mississippi Delta area, it was found that cropland had increased from 41 percent to 57 percent since 1950 while forest land decreased from 48 percent to 31 percent; 200,000 acres of bottom land forest had been cleared annually for agricultural production.[40] Although massive alteration of wet forest and grazing lands in the lower Mississippi Valley has brought about ecological change and concern about declining timber resources in the area, soybean farming has proven so profitable that it is likely to continue. Of the 10 Farm Production Regions* listed by the Department of Agriculture, the Delta states far exceed the others with 50 percent (10 million acres) of their total cropland on wet soils.[41]

A CASE REPORT:

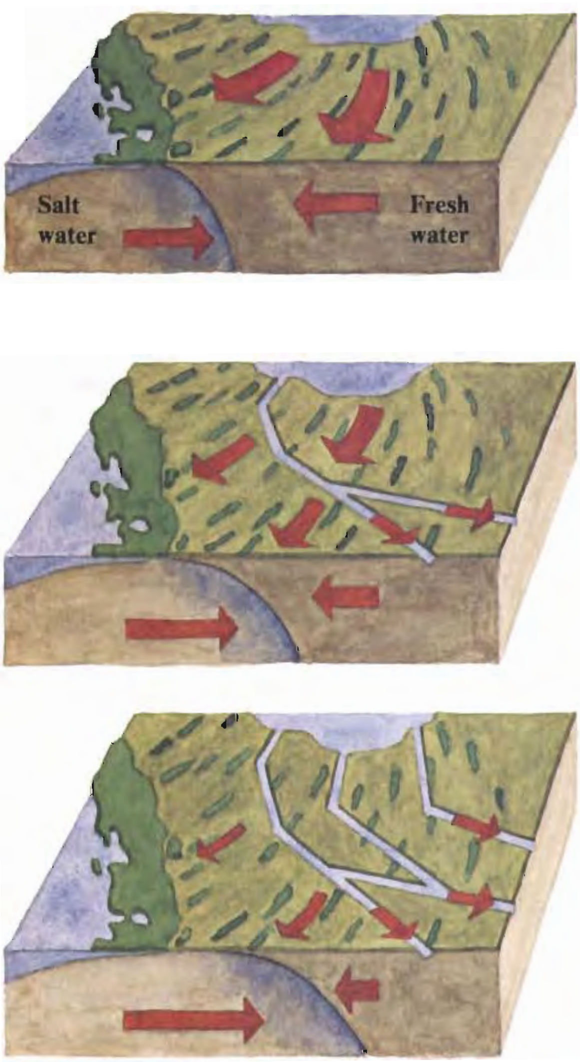
Southern Florida

When Florida joined the Union in 1845, one of the first acts of the new legislature was to commission surveys of the vast Everglades region to determine its potential for conversion to agricultural land. Southern Florida is extraordinarily flat, sloping southward only 2 inches per mile; water travels from north to south at the rate of only one-half mile per day. Rainfall is seasonal, with 75 percent occurring between May and October. In wet years the south bank of vast Lake Okeechobee overflowed, sending thin sheets of water down over the Ever-

* Appalachian, Corn Belt, Delta States, Lake States, Mountain, Northeast, Northern Plains, Pacific, Southeast, Southern Plains.

SALT-WATER INTRUSION

The flow of freshwater through the Everglades created groundwater pressure that held back saltwater. As more and more of the natural flow was diverted, groundwater pressure was reduced, allowing saltwater to seep inland, contaminating drinking water and adversely altering natural systems.



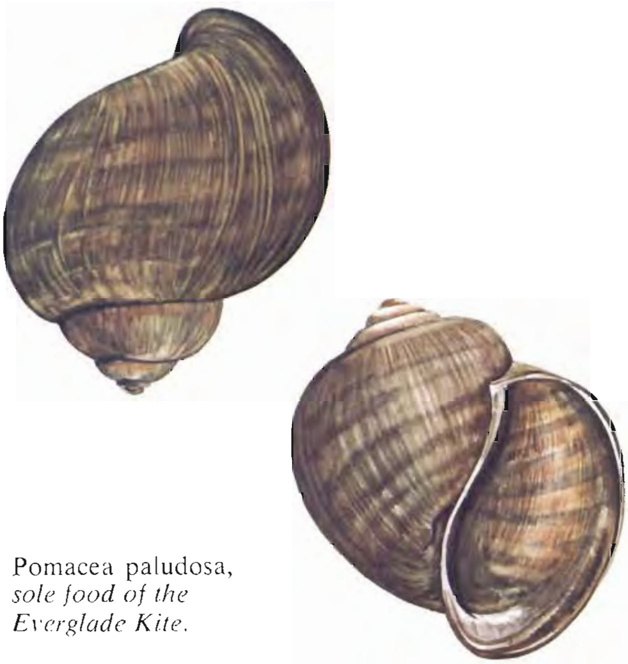
glades, flooding the land, and recharging the shallow aquifers of the southern part of the state. Engineers of the 19th century understood this natural pattern and considered it both regrettable and remediable. In 1881 the first drainage projects began, involving construction of canals to speed water from the lake out to the Atlantic Ocean.

As anticipated, large portions of the Everglades became dry, but as the rich organic peat that had accumulated over the centuries was exposed to the air, it began to subside by compaction, by oxidation, by fire, and by wind. Large areas proved unsuitable for agriculture, for under the muck lay barren rock. In 1929 a well-known botanist wrote of reclamation efforts in the Everglades and titled his work *From Eden to Sahara.*[42] As water levels dropped, saltwater, no longer held back by the pressure of ground water supplies, seeped into the aquifers and into the wells. In the 1940's large areas of the desiccated Everglades burned, leaving rocky landscape where for centuries broad seas of sawgrass had provided habitat for a rich diversity of animal species. Increasing alarm about the loss of so much of the natural beauty that first attracted people to southern Florida led to the establishment of Everglades National Park in 1947, where 460,901 acres of the world's largest sawgrass marsh was rescued from future agricultural development for the enjoyment of the public.

The park has now grown to 1,228,500 acres through additional acquisitions. Agricultural development continues in adjacent areas, however. Currently pollution is feared from huge corporate agribusinesses which have moved into Taylor Slough, the park's major watershed to the east.[43]

Today Florida has more acres of farmland under irrigation outside the Everglades than all the rest of the United States east of the Mississippi River.[44] Estimates place the soil loss in the agricultural areas of the Everglades at as much as 1 inch per year[45] due to oxidation, burning, compaction, and also exploitive farming methods. Because new peat is not being deposited on the drained lands, it is predicted that most soil will be too shallow for agricultural use by 1990–2000.[46]

The Everglade Kite was once abundant in the area for which it is named. Today many of the remaining members of this endangered species live at Lake Okeechobee. Unlike most birds, the Everglade Kite eats one thing only, a freshwater snail known in scientific parlance as *Pomacea paludosa.* Repeated



Pomacea paludosa,
sole food of the Everglade Kite.

agricultural drainage projects in the vast Everglade marshes left the water-loving snail high and dry, and many of the Kites, now on the Endangered Species List, have moved up to the lake where the snail can still be found in the water.

Perhaps it is asking too much to expect the public at large to worry about the disappearance from North America of a creature of such uncompromising habits as the Everglade Kite. And yet the story of this bird is the story of a new awareness. Only recently has it become apparent to research scientists, engineers, government officials, and lay citizens that wetland projects which are bad news for the snail—and bad news for the Everglade Kite—may also be bad news for us.

Timber Production in Wetlands

Few crops will grow in wetlands which are inundated during all seasons or for extended periods of time. The survival of most trees is also endangered by standing water, which leads to poor aeration and soft root anchorage. The bald cypress, a tree which grows well in deep swampy conditions, is the major exception to this rule.

Over 60 tree species can grow in areas subject to overflow and to brief periods of inundation, when the high waters recharge the soils.[47] Much of our commerically valuable timber is harvested in bottom lands which are properly classified as wetland forests.

Extensive areas of commercially important wetland forests are found in the Southeast, the Lake States, Alaska, and the Deep South; smaller wetland forest areas mark the landscape of New England.[48] A few of the better known species which grow in periodically supersaturated environments are swamp tupelo, water tupelo, bald cypress, red maple, sweetgum, willow, water oak, laurel oak, green ash, river birch, slash pine, northern white cedar, eastern larch, and black spruce. In the prairie states of Kansas, Nebraska, and Iowa, where only 1 percent of the land is in natural forest, most of the remaining natural forest is found in wetlands. In North and South Carolina, conifer forests—predominantly pond pines—are rooted in rich organic soils in bog-

Everglade Kite

The Audubon Society's Corkscrew Swamp Sanctuary, Florida, last vestige of a great stand of virgin bald cypress that was logged in the first half of this century.

like areas known as pocosins. An estimated 35 percent of the commercial forest land along the coastal plain is made up of wetland forests.[49]

Although in recent decades fast-growing hardwoods have been widely planted on bottom lands in the Mississippi Delta, most wetland forests exist naturally and are sustained by nature's weeding-out process. Stands of white cedar and bald cypress, for example, grow densely in wetland soils because the competing species which crowd them out on dry land cannot survive the watery conditions. Wet forests also profit by their greatly lessened susceptibility to destructive fires. Although wetland forests may be highly productive, it is commonly accepted among forestry authorities that no species of tree on this continent will grow *only* in wet soils. Cottonwood, for example—an important southern hardwood which will tolerate lengthy flooded conditions—will grow in virtually any type of soil, including the dry and sandy, so long as sunlight and ground water are plentiful and other species do not compete.

A CASE REPORT:

The Mississippi Delta Region

Because cottonwood is one of the fastest-growing hardwoods, seeds abundantly beginning at the age of about 10 years, and is easily propagated from cuttings, both natural stands and cottonwood plantations abound in the Mississippi Delta. Trees are harvested for pulp and more mature saw timber and veneer logs. Dense natural stands of cottonwood along with other tree species cover the *battures*—the areas between the river and the flood control levees—where there is no protection from flooding.

Today the wet bottom lands are rapidly being converted to cropland in Arkansas, Mississippi, and Louisiana, although the lower Mississippi valley is still the region which produces the greatest quantity of hardwood in North America. In the early 1930's, 11.8 million Delta acres were in forest. The most recent studies show that almost 40 percent of this forest land has been converted to other uses, predominantly soybean production.[50] Most of the remaining woodland is owned by farmers—with only one-fourth controlled by the forest industry. Although trees grown from cuttings of superior strains may sometimes be harvested in 5 years, newly established seedlings generally cannot be harvested for 15 to 25 years. Therefore it is likely that farmers will continue to clear forest land for production of soybeans, which bring a more rapid and higher return per acre.

The conversion of wetland forests to cropland is also encouraged by government farm price supports and other economic incentives. In some places, property taxes probably discourage owners from keeping wetlands in a natural wooded state. Property taxes, especially taxes on forest land, vary considerably from one locality to another. However, annual taxes without annual income encourage the conversion of forest land to crop production and may encourage such undesirable practices as premature cutting and shortened intervals in rotation harvesting. In addition, forest owners must wait many years until they are able to realize a return on their investment on newly planted forest lands, and there is considerable risk involved. A 15-year-old stand ready for harvest by a pulp company may be destroyed by fire, insects, disease, hurricanes, or ice storms.

Heavy equipment used in logging can cause considerable environmental damage by compacting soils, destroying vegetation, and increasing runoff in the watersheds. Improper timing and methods of cutting can slow regrowth or end reproduction entirely for a period of time. With sound management practices, commercial growing and harvesting of timber can continue without compromising the wildlife or recreational benefits of natural wetland forest areas.

Drainage projects are becoming more common in wet forests, with the dredged material often used to construct access roads for the logging equipment. Although studies show improved growth rates in some drained wet forests,[51] environmental change is inevitable. Under the permit program now administered by the Corps of Engineers, access roads involving discharge of dredge or fill materials in waters of the United States are regulated to protect the aquatic environment and to satisfy requirements of the Federal Water Pollution Control Act.[52]

Alternatives

The propriety of altering wetlands for agricultural use or for forestry receives less attention today than conversion of wetlands for commercial, residential, and industrial construction. Most of the freshwater wetland areas suitable for farming have already been converted, and, as a result of findings about the importance of wetlands, the Soil Conservation Service no longer provides assistance for drainage of wetlands in order to convert them to other land uses. The U.S. Forest Service promotes the "multiple use" approach to use of wetland forests and is studying sound methods for logging which involve minimal environmental damage. The rate at which wetland forests are giving way to crop land in the South has caused some alarm among forestry authorities.

Although most people approach alternative wetland uses as a conflict between those who would preserve natural resources and those who would exploit and destroy them for commercial purposes, the choices are hardly so clear. Often it is two incompatible financial interests which vie for use of wetlands, such as timber production and crop production. Some agricultural and forestry activities are compatible with retention of important natural wetland functions; others are not. Depending on the kind of alterations made, wetlands may return to their natural state in the absence of cultivation or drainage.

Similar conflicts arise when wetlands are developed for residential, industrial, and recreational purposes. The decision to dredge for construction of a boat docking facility may seem like a decision to permit profitable development at the expense of a natural waterfront environment. Generally it is the commercial fishermen fearing a reduced catch and not the naturalists who effectively protest on environmental grounds. There is little question, however, that a housing development benefits a few individuals directly whereas loss of valuable fisheries adversely affects many indirectly. As the ecologists have taught us, when you begin tampering with the natural environment, there are no isolated incidents.

CHAPTER FIVE

Alteration of Wetlands for Residences, Transportation, Industry, and Recreation

Coastal waterfront development that was once routinely permitted is now the subject of intense national controversy, involving both federal and state government agencies and the highest court in the land. Alteration of inland wetlands by development is also a concern. The U.S. Army Corps of Engineers administers a permit program for various types of construction in many of the nation's wetlands, denying permits if proposed construction is "contrary to the public interest," a concept which formerly had few spokesmen and little thrust but which is now official government policy.

A CASE REPORT:

Big Cypress Jetport

One of the first proposed construction projects in wetlands which attracted national attention was a Florida jetport. In 1968 the proposal for an airport complex five times the size of Long Island's Kennedy International Airport was defeated after the federal government intervened and a Department of the Interior study known as the "Leopold Report" [53] concluded that construction would unfavorably alter the wetland ecosystem.

The issue evolved from the fact that Miami International Airport was overburdened with traffic. To serve and encourage the state's major industry, tourism, a jetport was planned for construction in Big Cypress Swamp, 6 miles north of Everglades National Park. Environmentalists rose to protest development of the swamp site, which supplies water to the western part of the Park. The Leopold Report on the environmental impact of the proposed construction concluded:

> Development of the proposed jetport and its attendant facilities will lead to land drainage and development for agriculture, industry, housing, transportation and services in the Big Cypress Swamp which will inexorably destroy the south Florida ecosystem and thus Everglades National Park.[54]

Pipelines traverse a tidal marsh in San Francisco Bay.

The jetport may yet be built at an alternative site, but all that remains of the original proposal is one training strip—and a remarkable precedent. Citizen concern about further destruction of the Everglades became the impetus for opposition when new skepticism was voiced about the benefits of unconstrained development for the quality of life in the state of Florida.

In addition to the fact that many wetlands development proposals are now being denied on grounds of unacceptable impacts on the environment, attention is being given to methods that minimize environmental damage when the construction is deemed necessary or permissible. We have learned a good deal in the past decade about how wetlands function and about how their functions may be purposely or accidentally damaged or obliterated.

A marsh, we now know, can be attacked directly or indirectly. The time-honored methods of destruction by dredging, filling, and draining are immediately effective. Construction involving dredging *near* marshlands—such as channelization—can also destroy plant and fish populations by creating turbidity, which impedes light penetration necessary for photosynthesis, or by filling marshes with suspended sediments which literally suffocate fish by clogging their gills. More subtle are the effects of construction which alters the quality or quantity of water upstream or of the coastal industry or energy production plant which can cause heat pollution or chemical pollution—methods of wetland alteration which our forefathers never dreamed of.[55]

Marinas and Vacation Homes

Marinas and commercial port facilities are generally considered the most legitimate construction in wetlands simply because docking facilities can be located only on the shorefront, but marina construc-

A single runway, now used as a training strip, is the only portion ever constructed of the Big Cypress Jetport. Original plans called for a facility five times as large as Kennedy International in New York.

tion which minimizes adverse environmental impacts is more and more often discussed.

In resort areas, acres of wetlands often appear to be occupying the most desirable site for a dock. It is precisely *because* the site is sheltered from the waves that the marsh was able to form. Waterfront property is also at a premium for building sites, and traditional arguments hold that when marshes are changed into expensive waterfront real estate, communities benefit through tax revenues. In fact, the cost of services which must be provided to owners of the new properties often cancels such gains. These services include flood and storm water protection, transportation, schools, fire and police services, and water and sewage facilities.

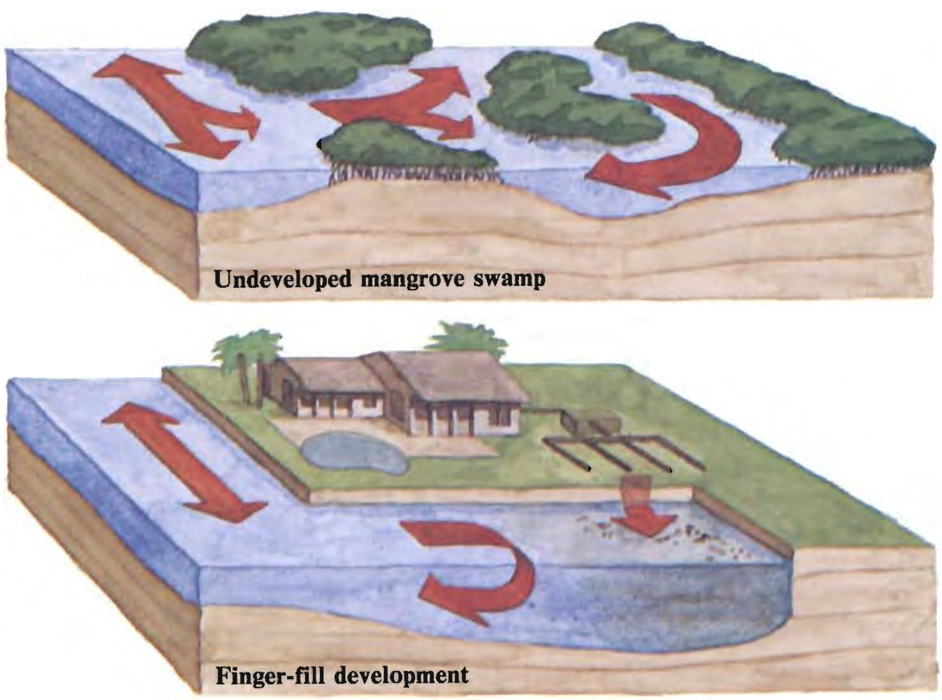
A popular type of construction which turns marshes into both boat docking and building sites is the lagoon or Venetian development. Finger-fill lagoons, which have been constructed in resort areas of the east coast and the Gulf of Mexico, change coastal marshes into alternating strips of fast land and water by dredging parallel channels for boat docking and using the dredged material to create high ground between them for channelside housing. These lagoons, which are typically deeper than the receiving waters into which they open, generally flush inadequately, and without sufficient tidal cleansing, they tend to stagnate. New studies have resulted in recommendations that docking facilities be concentrated in one area of a resort community and in guidelines for engineering these canals in order to minimize damage to coastal water quality and fishing resources.[56]

Inland wetlands, especially those near recreational lakes, are also being lost or adversely affected by development. Because soil types and a high water

table generally create conditions unsuitable for septic tanks adjacent to or in wetlands, sewers become a principal limitation of development. Sewers constructed to improve and protect the recreational lake's water quality from point sources of pollution can allow higher density development to occur as an unanticipated secondary effect. Too often no steps are taken to limit or direct this secondary development away from the wetlands, and development frequently results in filling the wetlands adjacent to a recreational lake. Then the filled or degraded wetlands no longer provide needed water quality maintenance or flood protection. In addition, the nonpoint runoff from developed areas can have as great an adverse effect on the wetlands as the original point sources of pollution. Ironically, the expected benefits of a sewer project may not be realized if the wetlands, which play a major role in water quality maintenance, are destroyed as development occurs.

Parking Lots and Highways

Wetlands have routinely been filled for other construction—highways, airports, parking lots, and playing fields, or they have been used simply as dumping grounds. Most often these facilities, unlike marinas, could be located away from the shoreline because water is not a requirement. In the late 1950's a plan to load 3.5 million cubic yards of gravel dredged from Long Island Sound on Sher-



FINGER-FILL DEVELOPMENT

Finger-fill development destroys natural habitat and interrupts the natural flushing action of the tides. Debris and sewage often accumulate at the dead ends of artificial lagoons, which are beyond the influence of sufficient tidal currents.

wood Island Marsh, located in a state park, aroused immediate, but ultimately unsuccessful, opposition. The stockpiled gravel was slated for use in building the Connecticut Throughway and for a parking lot to accommodate park visitors although other dump and parking lot sites were available and the marsh was regularly visited by naturalists, hikers, bird-watchers, and duck hunters. A group called Connecticut Conservationists, Inc., was hastily formed by representatives of several conservation-minded organizations, and members passionately attempted to defeat the plan legally. The case was dismissed by the court on grounds that the organization could not demonstrate financial damage "not shared by all the citizens of the state." [57]

Today most people agree that replacing a healthy and useful marsh with a parking lot is inadvisable and that using wetlands as dumping grounds is impermissible. Until recent years, the dredge spoils from channel construction or maintenance were commonly dumped on nearby wetlands, smothering vegetation, destroying marshes with the polluted materials, or raising the level of the marsh above tidal reach so that valuable cordgrass changed to ecologically less productive reeds, which take over in less saline conditions. Such changes in vegetation may also occur when roads crossing wetlands are supported on fill causeways instead of on open structures such as pilings.

Industrial development in a former tidal wetland on the shore

Industrial Plants

Marine life may be destroyed as a result of industrial processes—particularly those of powerplants—that take up large quantities of cooling water and discharge heated water. All organisms have limits of tolerance to heat, and although lethal levels are rarely reached due to the movement of water and the ability of larger organisms to swim away, thermal pollution may affect such vital functions as migration, spawning, and basic metabolic rate.[58] Under conditions of heat stress, fish and shellfish are also more vulnerable to predators,[59] more susceptible to disease,[60] and more sensitive to to reductions in salinity.[61]

As water temperatures rise, oxygen levels decrease. One result is changes in fish populations because some species require more oxygen than others. Some are able to adapt, and they are killed not by the elevated water temperatures but by shock when the powerplants are shut down in winter. But for the powerplant effluent (warm waste water), these fish would have migrated south for the winter. In 1972, 100,000–200,000 menhaden were killed by cold shock near a powerplant at Oyster Creek, Barnegat Bay, New Jersey, following a winter shutdown.[62]

Direct fish kills also occur as fish larvae and other tiny aquatic creatures are drawn into plant pumps and condensers despite mesh screens which keep out the larger organisms. In addition, the chlorine and other biocides used to clean out these organism-clogged condenser systems are lethal water pollutants. A number of such incidents have been reported at shoreside and estuarine plants, including a kill of 40,000 blue crabs at Chalk Point in Mary-

of Long Island Sound, New York*

land's Patuxent River.[63]

Industries which extract oil, gas, sand, shell, gravel, or phosphates from coastal waters can damage or kill wetlands and their flora and fauna through turbidity, sedimentation, destruction of productive bottoms, or rupture of pipelines, with resultant contamination. Extraction of shell, which is used for making cement, poultry grit, and a variety of other calcium-based products, is highly damaging environmentally, and some ecologists suggest that the practice be abandoned because other sources of calcium are available.[64] In photographs of the gulf coast taken by astronauts in Gemini XII, clouds of silt from shell dredging were plainly visible 177 miles above the earth.[65]

When building sites are created by using solid wastes as fill material, marshes some distance away may be damaged as acids, alkalis, heavy metals, detergents, and other pollutants leach from the fill into the water. Shellfish from waters polluted in this fashion or by discharge of municipal wastes can be poisonous to humans because shellfish consume both food particles and toxic materials from the water and in fact may concentrate these materials in their tissues.

Although new federal dredge and fill disposal regulations should radically decrease construction in wetlands, some development determined to be in the public interest will continue. A number of recent guides discuss alternative methods of dredging, causeway construction, location of boat docking facilities, and building of bulkheads, jetties, and groins with emphasis on minimizing damage to wetland areas.[66]

CHAPTER SIX

Today and Tomorrow

How much of our wetland acreage has in fact been lost? How much more can be sacrificed? Knowing what we do today, what guidelines should we use in making future decisions about whether specific wetlands will be preserved, modified, or destroyed?

Wetland Surveys

No precise figures are available—or can ever be—on total wetland loss. Wetland definitions are only now being standardized, and our original wetland heritage was never mapped or inventoried. The most commonly accepted estimates of the total national wetland resource lost run from 30 to 40 percent, and they are calculated from surveys designed for different purposes and employing different ground rules. Although none was a complete national inventory, they all revealed many vital facts about soil types and wildlife habitats in addition to providing statistical information on wetland acreage.

Two national surveys were undertaken in this century by the U.S. Department of Agriculture, one in 1906[67] and one in 1922,[68] to determine the number of wetland acres considered suitable for agriculture. The first survey to be undertaken for reasons other than agricultural development was the 1954 U.S. Fish and Wildlife Service inventory, inspired by the realization that reclamation activities were dangerously depleting our heritage of wetlands, viewed at the time primarily in terms of their value as wildlife habitat.[69] On the basis of its own surveys, older local surveys, drainage censuses, and other statistical data, the Soil Conservation Service estimated that the original wetlands in the lower 48 states had totaled 127 million acres.[70] The Fish and Wildlife Service inventory, by far the most comprehensive of the three, concluded that 82 million acres remained. The nationwide survey now being undertaken by the Fish and Wildlife Service will be very much more comprehensive than any previous tally, will include the extensive wetlands of Alaska as well as the other 49 states, and will recognize that wetlands serve a variety of functions to society in addition to their wildlife values.

Scattered data on wetland losses have also been

A wetland oasis in South McKittrick Canyon, Guadalupe Mountains National Park

A dragline devours a New England salt marsh

gathered by state and other surveys. Of California's original 3.5 million wetland acres, in 1954 only 450,000 remained.[71] In 1959 it was estimated that 45 percent of Connecticut's coastal marshes had been lost since a 1914 survey. At current rates of destruction, it was predicted that only 14 percent might remain by the year 2000.[72] Surveys disclosed that the Rainwater Basin of south-central Nebraska had lost over 80 percent of its marshes by the 1960's.[73] Southeastern Wisconsin had lost 61 percent by 1968.[74] An estimated one-half the wetlands in the prairie pothole region of the United States had been drained by 1950.[75] It is estimated that 35,000 acres of prime prairie wetlands are now being sacrificed each year.[76] A survey conducted by the Fish and Wildlife Service in 1974 revealed that over 40 percent of the potholes existing in 1964 in western Minnesota had been destroyed in that 10-year period.[77]

These figures are alarming to a growing body of concerned scientists and informed lay people, who applaud current efforts to halt future wetland loss by legislation and by federal, state, and local regulations when alternative sites for necessary construction or alternative locations for agricultural expansion exist. Other conservation methods include acquisition of valuable wetlands through fee title and easement purchases for permanent preservation by local, state, and federal agencies as well as by such nongovernment groups as The Nature Conservancy, the National Wildlife Federation, the Audubon Society, and other naturalist and conservation societies. In addition, attempts are being made to re-create wetlands. Although no one disputes the fact that only God can make a tree, many people have suspected that man can make a marsh. A current series of large-scale experiments by the U.S. Army Corps of Engineers is demonstrating that it can in fact be done.

Manmade Marshes

As anyone who has ever attempted to keep a hedge clipped knows, nature is a very difficult adversary. Each year the Corps of Engineers removes over 350 million cubic yards of dredged material from navigation channels[78]—much of which finds its way back again.

The Corps has been charged since 1824 with responsibility for construction and maintenance of shipping channels throughout the country. During this 150 years it has created 25,000 miles of channels and has developed 107 commercial ports and harbors as well as 4,000 additional small boat harbors.[79]

Until recent years the heavy housekeeping chore of redredging channels was uncomplicated by concern about where to dump the dredged material, which was simply pushed aside and piled at sites along the coastline or, most often, was heaped on wetlands—which everyone then considered "waste" areas. Because of rising concern about destruction of wetlands and also because of questions about possible contaminants in the dredged material, the Corps has undertaken to find new methods of disposal. Current solutions are upland and diked disposal areas, off-channel dumping, or ocean dumping. All these solutions present potential environmental hazards and involve economic considerations as well.

In 1974 the Corps instituted a 5-year, $30 million research program at its Waterways Experiment Station in Vicksburg, Mississippi, to find ways to recycle dredged materials for such useful projects as renewing eroded beaches, creating recreation areas, and establishing new islands for wildlife use. One particularly fruitful area of research is the Corps' attempt to create new marshes with dredged material.

Although a great deal of research remains to be done, experiments so far have brought encouraging results on the coast of North Carolina,[80] in San Francisco Bay, on the Texas gulf coast, on Buttermilk Sound in Georgia, on the James River in Virginia, on Nott Island in the Connecticut River, on Millers Sands Island in the lower Columbia River,[81] and at other locations on the gulf coast and the Chesapeake Bay.

Critical areas have been selected for the restoration of marshes. In an attempt to combat erosion problems in the Mississippi River Delta, 352 acres of marshes have been established. Two months after planting was begun, herons, egrets, ducks, and nesting muskrats were observed feeding and sheltering among the recently sprigged marsh grasses.[82]

In San Francisco Bay, marshland occupied 300 square miles before 1850. Today, due to diking and filling operations, only 75 square miles remain, a 75 percent loss. Because the Bay is an important resting and feeding area for millions of birds who travel the Pacific flyway from Canada to Mexico, the destruction of such extensive areas of wetland—which once also provided large shellfish harvests—seems particularly regrettable. In 1972 the Corps initiated its San Francisco Bay and Estuary Dredge Disposal Study, experimenting with both transplanting and seeding of marsh grasses.[83]

Although no one views manmade marshes as a solution to the problem of wetland loss, the creation of new marsh from dredged material is one of the more ambitious recycling projects of recent times.

The Role of Government

For almost 200 years the federal government lent encouragement and often strong financial inducement to projects involving wetland destruction. Not everyone has noticed yet, but today the federal government is a leading advocate of wetland preservation.

The Fish and Wildlife Service of the Department of the Interior now manages 12 million wetland acres in its National Wildlife Refuges and Waterfowl Production Areas, which have been acquired under the Migratory Bird Conservation Act and the Land and Water Conservation Fund Act, through other authorizing legislation, and by withdrawal from the public domain. Of these over 3 million are in the lower 48 states and 8.8 million in Alaska.[84] Proposals are before Congress to add 30–70 million more Alaskan acres to the National Wildlife Refuge System, over half of which are wetlands.

A major policy shift in the use of wetlands for agriculture—symbolic of a more widespread reversal of viewpoint—was revealed in a wetland memorandum from the U.S. Department of Agriculture's Soil Conservation Service in 1975. Twenty-two years earlier, in 1953, SCS had announced that 50 million acres of "wet and swamp lands which are subject to overflowing . . . would be physically suitable for crop or pasture use" if proper drainage measures were employed.[85] The 1975 Conservation Planning Memorandum issued by SCS said that in regard to 18 of the 20 types of wetlands described in the 1954 Fish and Wildlife Service Survey (seasonally flooded basins or flats and fresh meadows), "the Soil Conservation Service is not to provide technical and financial assistance for draining or otherwise altering wetlands . . . in order to convert them to other land uses." "Millions of acres of the Nation's original wetlands," the Memorandum read, "have been impaired or converted to other uses. Extraordinary care and effort are required to protect the remaining aquatic ecosystems." [86]

In 1977 it became official policy for all federal agencies to conserve and protect wetlands. President Carter's Executive order on wetlands articulates a strong national policy for preservation of this resource—requiring agency heads not to undertake or assist construction projects in wetlands unless there is no practical alternative (see Appendix D).

Government agencies with regulatory, management, acquisition, or research, planning, and grant programs relating to wetlands include the Environmental Protection Agency; in the Department of the Interior, the Fish and Wildlife Service, Bureau of Outdoor Recreation, National Park Service, Bureau of Land Management, Office of Water Research and Technology, Bureau of Reclamation, and U.S. Geological Survey; in the Department of Commerce, the National Oceanic and Atmospheric Administration, National Marine Fisheries Service; in the Department of Agriculture, the Soil Conservation Service and Forest Service; and the U.S. Army Corps of Engineers (see Appendix B).

Under Section 404 of the Clean Water Act of 1977, the U.S. Army Corps of Engineers is responsible for issuing permits for activities that involve the placement of dredged material or fill material in many of the nation's wetlands. Because of interest aroused by recent highly publicized permit decisions which reflect strong concern for maintenance of environmental values, it may be helpful to review the background of the Corps' regulatory function and policy.

Since passage of the Rivers and Harbors Act of 1899, any construction involving dredging, filling, or obstruction of navigable waters has required permission of the Corps of Engineers. The clear intention of the Act was protection of waters used for commercial navigation. It did little to protect wetlands adjacent to rivers because they were usually outside the high water mark.

In 1968, in conformity with increasing national concern for preservation of the natural environment, the Corps rewrote its permit regulations, inserting a new provision:

> The decision as to whether a permit will be issued must rest on an evaluation of all relevant factors, including the effect of the proposed work on navigation, fish and wildlife, conservation, pollution, aesthetics, ecology, and the general public interest.[87]

Although the regulation announced a radically new concept of Corps' responsibilities, few were listening. In 1970 Zabel and Russell, two Florida developers, applied for a permit to fill 11 acres of wetlands in Boca Ciega Bay in an area of mangrove flats famed for its tarpon, snook, redfish, and sea trout. Zabel and Russell intended to construct a mobile home park, and because Boca Ciega Bay is navigable water, after acquiring the standard local permits, they applied to the Corps. Their application was denied on grounds that such construction would adversely affect the marine life of the Bay although it would *not* impede navigation. The developers sought an injunction to compel the Corps of Engineers to grant a permit and were successful.[88] The decision of the district court was appealed, and the U.S. Court of Appeals for the Fifth Circuit upheld the right of the Secretary of the Army to refuse dredge and fill permits solely on the grounds of environmental damage,[89] establishing Corps' authority to protect ecologically vital areas.

Under the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92–500), the Congress extended Corps' regulatory jurisdiction beyond the traditional "navigable waters" to cover "all waters of the United States"—including wetlands. EPA was made a partner in the program with veto authority and responsibility for establishing guidelines for protection of the aquatic environment (see Appendix C). Although Section 404 does not cover the variety of activities regulated by the 1899 Act, it does require permits for all operations involving the discharge of dredged or fill material into the waters of the United States, including wetlands, and all permits processed now involve assessment of the proposed projects' environmental impacts. Under the 1977 amendments to Section 404, normal agricultural, forestry, and ranching operations do not require permits.

The Corps' wetlands policy is that no alteration of wetlands may take place unless the proposed project can be demonstrated as being in the public interest (see Appendix C).[90] Primary emphasis is on whether the activity is water dependent (e.g., does it have to be placed in the wetland to fulfill its basic purpose?) and whether there are other feasible alternative sites or methods of construction to accomplish the same purpose. In making these decisions, the Corps relies on the views of the Fish and Wildlife Service, the Environmental Protection Agency, and the National Marine Fisheries Service (in the National Oceanic and Atmospheric Administration).[91]

Guided by the criteria then current, the Corps denied the Deltona Corporation two dredge and fill permits involving destruction of 2,152 acres of mangrove swamps and 735 acres of Bay bottom in a vast project to create a community housing 35,000 permanent residents at Marco Island on the southwestern coast of Florida. The Marco Island development—one section of which had already been begun and was allowed to be completed—was to be a "finger-fill" resort complex in which parallel lagoons are dredged, and the land "fingers" filled with dredged material from the canals become waterfront housing sites with private docking facilities. The state of Florida had approved the development, and most of the lots had been sold in advance of dredging operations.

The "Marco Island case" aroused the partisan interests of both environmentalists and developers. The plan was opposed by the Environmental Protection Agency on grounds of water quality, including wetland and Bay bottom destruction, and by the Fish and Wildlife Service, the National Marine Fisheries Service, and the Florida Game and Fresh Water Fish Commission because it would adversely alter productive fish habitat. In denying the permits, the Chief of Engineers noted the important functions of mangrove swamps and stated that the proposed development would "constitute an unacceptable adverse impact upon this aquatic resource" and that destruction of environmentally important wetland areas was "contrary to the public interest." [92]

The Corps of Engineers has officially confirmed its resolution to protect wetlands from destruction "unless the public interest requires otherwise." It lists a number of factors that bear upon the public interest, among them: conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use classifications, navigation, recreation, water supply, and water quality.[93] President Carter's Executive order on wetlands (see Appendix D) supported the Corps of Engineers' program for regulating wetlands as well as establishing a broad national policy for their protection and use.

State and local agencies have, to a varying degree, also acted upon the challenge to preserve wetlands from unnecessary destruction. Model state wetland protection laws and ordinances for adoption by local units of government are currently being drafted by the Environmental Law Institute under contract to the FWS, which recently surveyed local and state efforts nationwide. ELI found that although many states afford some measure of protection for wetland areas through flood plain regulations or through coastal area, shoreland, scenic or wild rivers, or pollution control programs, few states have programs that adequately deal with conservation of wetlands.[94]

Under the 1977 amendments to Section 404, states with approved programs may take over the processing of Section 404 permits for the discharge of dredged or fill material in certain wetlands. Such permits must comply with guidelines issued by EPA.

Massachusetts was the first state to enact a specific wetland regulatory program in 1963, but since then 15 states have adopted legislation specifically regulating development or use of wetlands.[95] Many others are regulating wetland use through dredge and fill and critical area programs. Several offer tax incentives to property owners to encourage protection of wetlands or broader open spaces. Although the scope of efforts varies greatly, many states have acquired wetlands for park and wildlife purposes, usually through federal matching grants. There are three major sources of such funds. The Department of Housing and Urban Development makes monies available for wetland acquisition through revenue sharing programs; the Bureau of Outdoor Recreation, Department of the Interior, makes money available for acquisition of outdoor recreation areas; and the Fish and Wildlife Service makes grants to the states for fish and wildlife restoration projects, including acquisition of wildlife areas.

The Highest Form of National Thrift

When the Marco Island permit was denied, the Deltona Corporation repeatedly pointed out that the 2,000 acres of mangrove swamp to be destroyed accounted for only one-half of 1 percent of those remaining in the state. But today, as we continue to lose 300,000 acres of wetlands per year,[96] those concerned with environmental protection ask about the *next* 2,000 acres . . . and the next. The principle applies equally to the owner of *20* acres who is denied a permit to develop on grounds of public interest.

A decade and a half ago President John F. Kennedy referred to conservation as "the highest form of national thrift."[97] Today conservationists continue to pose the question of value on an economic, ecological, and social level: What is a marsh worth? What is it worth to someone with a financial stake in its destruction? What is it worth to society in its natural state? How much acreage must be preserved in order to maintain the services wetlands now provide?

We have reached a point when uses of wetlands beyond those considered "productive" in the strictest sense of the word must be guarded. We have learned enough to know that we *do not know enough.* We cannot put a figure on how much acreage we can afford to lose because we are only beginning to understand the value of wetlands. It is difficult for most citizens to accept fully the fact that a wetland is something "good," when we all learned in early childhood that a swamp is "bad"—a waste place where mosquitoes breed and snakes lurk, ready to strike. We must now understand that, although financial benefits may accrue to individuals from a project involving wetland destruction, undeveloped wetlands offer benefits to all—and will continue to benefit our children and grandchildren, whose rightful inheritance of a rich natural environment depends on our priorities and on our vigilance.

It was a mere decade ago when children came running home from school on Earth Day to chide the older generation of unmindful wasters and willy-nilly polluters. The children brought glad tidings, assuring all citizens of good will that the situation was correctable, that if we delivered our newspapers to recycling centers and stopped spilling sewage in the waters, we could save the earth and perhaps, next year, go swimming in the river.

Today all of us—who scarcely shuddered as marshes were filled for construction—have lost our naiveté. We recognize that the drive to restore clean waters, to retain the ecological diversity of a wondrous universe, to fashion a national ethic of conservation rather than of profligacy will require individual sacrifice and a grave long-range commitment. We know that enlightened public policies and wise, enforceable legislation will come about only through our dedication.

Researchers can tell us a great deal today about the structure and functions of wetlands. They will offer us new information and new insights in the months and years ahead. But how we use this information is up to us. Ultimately the answer to the query—what is a marsh worth?—will not be resolved by ecologists or economists. Whether we elect to save our wetlands will not be a scientific decision but a social decision made up of an infinite number of small and large choices and actions in which each of us, if we wish, can play a part.

In his Environmental Message to Congress, President Jimmy Carter reminded the nation that "none of us is a stranger to environmental problems." In elevating environmental protection from the purely legislative to the executive realm, he made official a view that many concerned citizens have espoused, that "intelligent stewardship of the environment on behalf of all Americans is a prime responsibility of government." [98]

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APPENDIX A
Glossary

ALGAE—simplest green plant forms having neither roots, stems, nor leaves and ranging from microscopic single-cell organisms to large macroscopic seaweeds several hundred feet long.

ALLUVIAL SOILS—deposits of sediments, clay, silt, sand, and gravel deposited by running water. Ordinarily occurring on floodplains.

BARRIER BEACH—long, narrow sand islands lying parallel to shore and built up by the action of the waves, currents, and winds.

BOG—a wetland usually developing in a depression. Often a lake with poor drainage. Generally characterized by extensive peat deposits, acidic water, floating sedge or sphagnum mats, and health shrubs and often by the presence of coniferous trees such as black spruce and various cedars.

CHANNELIZATION—modifying the course and shape of a stream bed to permit more efficient stream flow.

CONSUMER—any living thing that is unable to manufacture food from nonliving substances but depends on the energy stored in other living things for its food supply.

DETRITUS—minute particles of the decaying remains of dead plants and animals.

ECOLOGY—a branch of science concerned with the interrelationship of organisms to one another and to their environment.

ECOSYSTEM—system of exchanges of materials and energy between living things and their physical environment. The biotic community and the nonliving environment functioning together as a system.

EMERGENT VEGETATION—various aquatic plants usually rooted in shallow water and having most of their vegetative growth above water, such as cattails and bulrushes.

ENVIRONMENT—all the external conditions which surround living things, such as soil, water, and air.

ESTUARY—a semienclosed coastal body of water which has a free connection with the open sea. Estuaries are strongly affected by tidal action and the mixing of seawater with freshwater from land drainage. Examples are river mouths, coastal bays, tidal marshes, and bodies of water behind barrier beaches.

EUTROPHICATION—the process by which a lake becomes rich in dissolved nutrients and deficient in oxygen, occurring either as a natural stage in lake or pond maturation or artificially induced by human activities (principally by the addition of fertilizers and organic wastes).

FOOD WEB—a system of interlocking food chains in which energy and materials are passed through a series of plant-eating and meat-eating consumers.

HABITAT—place where a plant or animal species naturally lives and grows, its immediate surroundings.

HYDROLOGY—a branch of science dealing with properties, distribution, and circulation of water.

INTERFACE—a plane forming a common boundary of two bodies or surfaces.

MARSH—a wetland dominated by herbaceous or nonwoody plants, often developing in shallow ponds or depressions, river margins, tidal areas, and estuaries. Marshes may contain either salt- or freshwater. Vegetation is dominated by grasses and sedges.

NUTRIENT—a chemical element, organic compound, or inorganic compound used to promote growth.

PEAT—partly decayed organic matter formed in boggy areas where lack of oxygen and/or high acidity limits decomposition.

PHOTOSYNTHESIS—synthesis of chemical compounds with the aid of light in chlorophyll-containing cells.

POLLUTANT—a substance, medium, or agent which causes physical impurity.

PREDATOR—an animal that lives by capturing other animals for food.

PRODUCERS—primarily green plants, the basic link in any food web. By means of photosynthesis, plants manufacture the food on which all other living things ultimately depend.

RHIZOMES—elongate underground stems or branches of a plant which send off shoots above and roots below and are often tuber shaped. Contain deposits of reserve food material.

SALINITY—concentration of salt in a solution, usually measured in parts per thousand.

SEDIMENT—the matter that settles to the bottom of a liquid—both organic and inorganic materials.

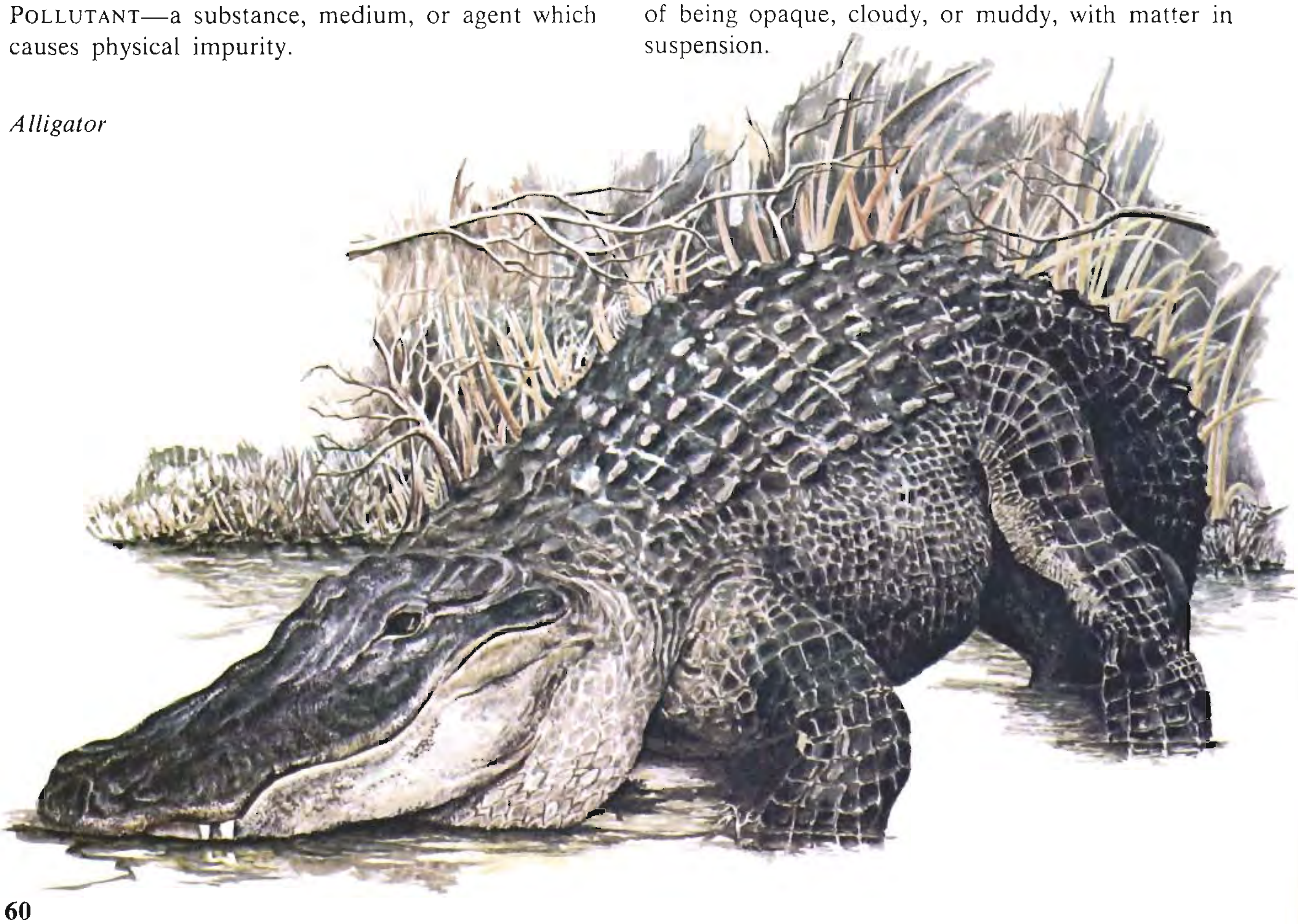
SOIL—upper layer of earth consisting of disintegrated rock with an admixture of organic matter and soluble salts in which living organisms may be found.

SUBSTRATE—nonliving base material which may provide habitat for living organisms.

SWAMP—a wetland dominated by woody plants, shrubs, and trees such as maples, gums, and cypress.

TURBIDITY—a state of having sediment disturbed, of being opaque, cloudy, or muddy, with matter in suspension.

Alligator



APPENDIX B

Federal Agency Functions Relating to Wetlands

Department of Agriculture

FOREST SERVICE

RESEARCH AND MANAGEMENT—The Forest Service is concerned and active with wetland management, maintenance, and improvement in relation to wildlife, timber management, range resources, water yield, and water quality. Programs are ongoing with state and private forestry, National Forest administration, and research. Substantial research on bog hydrology has originated from a project in Laramie, Wyoming, including water yield and water quality aspects. A project in Juneau, Alaska, is involved with coastal wetland research. Studies are being launched on shoreline habitat requirements of harbor seals and the potential of activities associated with logging to influence habitat quality and the ecology of coastal plant communities, with reference to productivity of waterfowl, shorebirds, and other birds or mammals. The Southeastern Forest Experiment Station at Charleston, South Carolina, has done research on the coastal plains.

SOIL CONSERVATION SERVICE

TECHNICAL ASSISTANCE PROGRAMS—The mission of the SCS is to assist in the conservation, development, and productive use of the nation's soil, water, and related resources. SCS offers technical assistance on many aspects of resource conservation to individuals, organizations, local and state agencies, and federal agencies. Resource data and interpretive assistance offered through the National Cooperative Soil Survey, Small Watershed Program, Water Bank Program, and others help local people make workable long-term decisions about wetlands. SCS participation in activities that alter wetlands is limited by technical constraints, mainly soil potential, and by policy constraints as contained in its revised wetlands conservation policy of May 1975.

Department of Commerce

NATIONAL MARINE FISHERIES SERVICE (NATIONAL OCEANIC AND

ATMOSPHERIC ADMINISTRATION)

ADMINISTRATIVE, MANAGEMENT, AND REGULATORY FUNCTIONS—The NMFS has a responsibility to protect and conserve the marine, estuarine, and anadromous fish environment. More than 20 federal laws mandate NMFS involvement in fish habitat protection. The NMFS analyzes and comments on construction proposals and applications for dredge and fill permits issued by the Corps of Engineers, on National Pollutant Discharge Elimination System and ocean dumping permits issued by the Environmental Protection Agency, on bridge and causeway permits issued by the Coast Guard, and on license applications submitted to the Federal Power Commission and Nuclear Regulatory Commission. Any proposed federal construction affecting living marine resources requires analyses and comments from NMFS. Programs are directed toward protection and enhancement of fish habitats and resources. The NMFS is concerned with establishing sanctuaries and reserves to protect critical fish habitats and with disseminating information on fish habitat conservation to other agencies and the public. Activities relating to preservation of wetlands are closely tied to management of fishery resources.

Environmental Protection Agency

GRANT PROGRAMS—EPA has an extensive program of grants to assist state and local governments in developing plans for comprehensive protection of water resources, including wetlands, under Section 208 of the Federal Water Pollution Control Act. Under Title 1 of this Act, EPA is funding research projects specifically designed to advance understanding of freshwater and coastal wetlands and to predict the effects of pollution from industrial and municipal sources and from discharge of dredged or fill material. In cooperation with the Corps of Engineers, EPA has issued 5 grants to develop information that should allow further refinements in describing the upper boundaries of wetlands for regulatory purposes.

REGULATORY FUNCTIONS—EPA controls discharges of pollutants in all waters of the United States, including wetlands. Under Section 402 of the Federal Water Pollution Control Act Amendments, EPA also administers a permit program to regulate discharges from industrial and municipal sources. Although some discharge programs are administered by the states, EPA has authority to rescind state programs. Under Section 311, EPA and the Coast Guard regulate spills of oil and hazardous substances. Guidelines developed by EPA in conjunction with the Corps of Engineers provide the framework for reviewing proposed discharges of dredged or fill materials to evaluate their physical effects and potential for chemical contamination. EPA may deny or restrict such discharges that will have an unacceptable adverse effect on the aquatic environment.

Department of the Interior

U.S. FISH AND WILDLIFE SERVICE

CONSULTATIVE RESPONSIBILITIES—Under the Fish and Wildlife Coordination Act, the FWS assesses the impacts on fish and wildlife of all water and related land resource development projects which are federally funded or are constructed under a federal permit or license and provides reports to federal construction or regulatory agencies and to permit applicants. Many of the projects involved occur in or affect wetland areas. Federal permits for water-related development are reviewed by FWS to encourage avoidance of adverse impacts on fish and wildlife and their habitat, particularly in wetland areas.

ACQUISITION—The U.S. Fish and Wildlife Service uses two funding systems to acquire wetlands. The first is the Migratory Bird Conservation Account, used to acquire significant migratory waterfowl habitat by direct purchase or perpetual easement. Funds come from the sale of "Duck Stamps" required of all waterfowl hunters 16 years and older. The Land and Water Conservation Account is used to acquire habitat for endangered species, recreation and wilderness areas, and other lands designated by legislation. Acquisitions become part of the National Wildlife Refuge System.

RESEARCH—A national inventory of wetlands, limnological studies of prairie wetlands, and research on wetland habitat for fish and wildlife are presently being conducted.

HERITAGE CONSERVATION AND RECREATION SERVICE

ACQUISITION—The Service administers the Land and Water Conservation Fund for wetland and other natural resource acquisition by federal and state agencies.

NATIONAL PARK SERVICE

ACQUISITION AND MANAGEMENT—The Park Service preserves outstanding examples of our natural resources through management of the National Park System and by administration of the Natural Landmarks Program. Significant examples of wetlands are often involved.

RESEARCH: The research program is geared to recognize and inventory wetlands worthy of park or landmark status and to better manage wetlands within the Park System.

BUREAU OF LAND MANAGEMENT

ADMINISTRATIVE AND MANAGEMENT FUNCTIONS—BLM prepares management plans to suggest optimum use of wetland areas within its jurisdiction.

OFFICE OF WATER RESEARCH AND TECHNOLOGY

RESEARCH—Allotment and matching grants are made available to state and local institutions and universities. Examples of present wetland studies include: prediction of pesticide effects in salt marshes, evaluation of marsh ecosystem response to nutrients contained in agricultural runoff, and effects of sewage effluents on freshwater tidal marsh ecosystems.

BUREAU OF RECLAMATION

ADMINISTRATIVE AND MANAGEMENT FUNCTION—Wetlands important to waterfowl in the western states which lie on or adjacent to reclamation projects come under this authority.

U.S. GEOLOGICAL SURVEY

RESEARCH—USGS is involved in topographic, geologic, and hydrologic mapping, with recent emphasis on coastal and flood-prone areas. Projects include studies of the hydrology of wetlands and classification mapping of wetlands using high altitude and satellite remote sensing.

Canvasback drake

Department of the Army

U.S. ARMY CORPS OF ENGINEERS

CIVIL WORKS PROGRAM—The Corps of Engineers has responsibility for the development and maintenance of the nation's water and related land resources, including construction and operation of projects for navigation, flood control, shore and beach restoration and protection, hurricane and flood protection, hydroelectric power production, water supply, water quality control, fish and wildlife conservation and enhancement, and outdoor recreation.

RESEARCH—In its Dredged Material Program, the Corps conducts research on methods of reducing the adverse environmental impacts associated with dredging and on beneficial uses for dredged material.

REGULATORY FUNCTIONS—Corps' permission is required for any construction activities in navigable waters, including coastal waters up to their mean high tide line (about 40 percent of U.S. coastal wetlands). The Corps also has permit authority to regulate activities involving discharges of dredged or fill material in all "waters of the United States," including all adjacent wetlands.

APPENDIX C

• U.S. Army Corps of Engineers' Public Interest Review and Wetlands Policy
• Wetlands Considerations in the Environmental Protection Agency 404 Guidelines

Corps of Engineers

42 *Fed. Reg.* 37136-37 (1977)

§ 320.4 General policies for evaluating permit applications.

The following policies shall be applicable to the review of all applications for Department of the Army permits. Additional policies specifically applicable to certain types of activities are identified in Parts 321–324 of this chapter.

(a) *Public interest review.* (1) The decision whether to issue a permit will be based on an evaluation of the probable impact of the proposed activity and its intended use on the public interest. Evaluation of the probable impact which the proposed activity may have on the public interest requires a careful weighing of all those factors which become relevant in each particular case. The benefit which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. The decision whether to authorize a proposal, and if so, the conditions under which it will be allowed to occur, are therefore determined by the outcome of the general balancing process (e.g., see 33 CFR 209.400, Guidelines for Assessment of Economic, Social and Environmental Effects of Civil Works Projects). That decision should reflect the national concern for both protection and utilization of important resources. All factors which may be relevant to the proposal must be considered; among those are conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage prevention, land use, navigation, recreation, water supply, water quality, energy needs, safety, food production, and, in general, the needs and welfare of the people. No permit will be granted unless its issuance is found to be in the public interest.

(2) The following general criteria will be considered in the evaluation of every application:

(i) the relative extent of the public and private need for the proposed structure of work;

(ii) the desirability of using appropriate alternative locations and methods to accomplish the objective of the proposed structure or work;

(iii) the extent and permanence of the beneficial and/or detrimental effects which the proposed structure or work may have on the public and private

American beaver

uses to which the area is suited; and

(iv) the probable impact of each proposal in relation to the cumulative effect created by other existing and anticipated structures or work in the general area.

(b) *Effect on wetlands.* (1) Wetlands are vital areas that constitute a productive and valuable public resource, the unnecessary alteration or destruction of which should be discouraged as contrary to the public interest.

(2) Wetlands considered to perform functions important to the public interest include:

(i) Wetlands which serve important natural biological functions, including food chain production, general habitat, and nesting, spawning, rearing and resting sites for aquatic or land species;

(ii) Wetlands set aside for study of the aquatic environment or as sanctuaries or refuges;

(iii) Wetlands the destruction or alteration of which would affect detrimentally natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics;

(iv) Wetlands which are significant in shielding other areas from wave action, erosion, or storm damage. Such wetlands are often associated with barrier beaches, islands, reefs and bars;

(v) Wetlands which serve as valuable storage areas for storm and flood waters;

(vi) Wetlands which are prime natural recharge areas. Prime recharge areas are locations where surface and ground water are directly interconnected; and

(vii) Wetlands which through natural water filtration processes serve to purify water.

(3) Although a particular alteration of wetlands may constitute a minor change, the cumulative effect of numerous such piecemeal changes often results in a major impairment of the wetland resources. Thus, the particular wetland site for which an application is made will be evaluated with the recognition that it is part of a complete and interrelated wetland area. In addition, the District Engineer may undertake reviews of particular wetland areas in consultation with the appropriate Regional Director of the Fish and Wildlife Service, the Regional Director of the National Marine Fisheries Service of the National Oceanic and Atmospheric Administration, the Regional Administrator of the Environmental Protection Agency, the local representative of the Soil Conservation Service of the Department of Agriculture, and the head of the appropriate State

agency to assess the cumulative effect of activities in such areas.

(4) No permit will be granted to work in wetlands identified as important by subparagraph (2), above, unless the District Engineer concludes, on the basis of the analysis required in paragraph (a), above, that the benefits of the proposed alteration outweigh the damage to the wetlands resource and the proposed alteration is necessary to realize those benefits. In evaluating whether a particular alteration is necessary, the District Engineer shall consider whether the proposed activity is primarily dependent on being located in, or in close proximity to the aquatic environment and whether feasible alternative sites are available. The applicant must provide sufficient information on the need to locate the proposed activity in the wetland and must provide data on the basis of which the availability of feasible alternative sites can be evaluated.

Wild iris

Environmental Protection Agency

40 *Fed. Reg.* 41296 (1975)

(8) *Wetlands.* (i) Discharge of dredged material in wetlands may be permitted only when it can be demonstrated that the site selected is the least environmentally damaging alternative; provided, however, that the wetlands disposal site may be permitted if the applicant is able to demonstrate that other alternatives are not practicable and that the wetlands disposal will not have an unacceptable adverse impact on the aquatic resources. Where the discharge is part of an approved Federal program which will protect or enhance the value of the wetlands to the ecosystem, the site may be permitted.

(ii) Discharge of fill material in wetlands shall not be permitted unless the applicant clearly demonstrates the following:

(a) the activity associated with the fill must have direct access or proximity to, or be located in, the water resources in order to fulfill its basic purpose, or that other site or construction alternatives are not practicable; and

(b) that the proposed fill and the activity associated with it will not cause a permanent unacceptable disruption to the beneficial water quality uses of the affected aquatic ecosystem, or that the discharge is part of an approved Federal program which will protect or enhance the value of the wetlands to the ecosystem.

APPENDIX D

Protection of Wetlands: Executive Order 11990

42 *Fed. Reg.* 26961 (1977)

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative, it is hereby ordered as follows:

SECTION 1. (a) Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

(b) This Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property.

SEC. 2. (a) In furtherance of Section 101(b)(3) of the National Environmental Policy Act of 1969 (42 U.S.C. 4331(b)(3)) to improve and coordinate Federal plans, functions, programs and resources to the end that the Nation may attain the widest range of beneficial uses of the environment without degradation and risk to health or safety, each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use. In making this finding the head of the agency may take into account economic, environmental and other pertinent factors.

(b) Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require

The peregrin falcon, an endangered species

the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

SEC. 3. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in wetlands, whether the proposed action is in accord with this Order.

SEC. 4. When Federally-owned wetlands or portions of wetlands are proposed for lease, easement, right-of-way or disposal to non-Federal public or private parties, the Federal agency shall (a) reference in the conveyance those uses that are restricted under identified Federal, State or local wetlands regulations; and (b) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successor, except where prohibited by law; or (c) withhold such properties from disposal.

SEC. 5. In carrying out the activities described in Section 1 of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are:

(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion;

(b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

(c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses.

SEC. 6. As allowed by law, agencies shall issue or amend their existing procedures in order to comply with this Order. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order.

SEC. 7. As used in this Order:

(a)The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section 1 which are located in or affecting wetlands.

(b) The term "new construction" shall include draining, dredging, channelizing, filling, diking, impounding, and related activities and any structures or facilities begun or authorized after the effective date of this Order.

(c) The term "wetlands" means those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

SEC. 8. This Order does not apply to projects presently under construction, or to projects for which all of the funds have been appropriated through Fiscal Year 1977, or to projects and programs for which a draft or final environmental impact statement will be filed prior to October 1, 1977. The provisions of Section 2 of this Order shall be implemented by each agency not later than October 1, 1977.

SEC. 9. Nothing in this Order shall apply to assistance provided for emergency work, essential to save lives and protect property and public health and safety, performed pursuant to Section 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

SEC. 10. To the extent the provisions of Sections 2 and 5 of this Order are applicable to projects covered by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decision-making, and action pursuant to the National Environmental Policy Act of 1969, as amended.

JIMMY CARTER

The White House,
May 24, 1977.

Statement by the President Accompanying Executive Order 11990

The Nation's coastal and inland wetlands are vital natural resources of critical importance to the people of this country. Wetlands are areas of great natural productivity, hydrological utility, and environmental diversity, providing natural flood control, improved water quality, recharge of aquifers, flow stabilization of streams and rivers, and habitat for fish and wildlife resources. Wetlands contribute to the production of agricultural products and timber, and provide recreational, scientific, and aesthetic resources of national interest.

The unwise use and development of wetlands will destroy many of their special qualities and important natural functions. Recent estimates indicate that the United States has already lost over 40 percent of our 120 million acres of wetlands inventoried in the 1950's. This piecemeal alteration and destruction of wetlands through draining, dredging, filling, and other means has had an adverse cumulative impact on our natural resources and on the quality of human life.

The problem of loss of wetlands arises mainly from unwise land use practices. The Federal Government can be responsible for or can influence these practices in the construction of projects, in the management of its own properties, and in the provisions of financial or technical assistance.

In order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative, I have issued an Executive order on the protection of wetlands.

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Moose

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