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Wetlands

These havens of biodiversity are often endangered because they can be hard to identify. Understanding their variable characteristics can lead to more successful conservation efforts

by Jon A. Kusler, William J. Mitsch and Joseph S. Larson

Variously dry, wet or anywhere between, wetlands are by their nature protean. Such constant change makes wetlands ecologically rich; they are often as diverse as rain forests. These shallow water-fed systems are central to the life cycle of many plants and animals, some of them endangered. They provide a habitat as well as spawning grounds for an extraordinary variety of creatures and nesting areas for migratory birds. Some wetlands even perform a global function. The northern peat lands of Canada, Alaska and Eurasia, in particular, may help moderate climatic change by serving as a sink for the greenhouse gas carbon dioxide.

Wetlands also have commercial and utilitarian functions. They are sources of lucrative harvests of wild rice, furbearing animals, fish and shellfish. Wetlands limit the damaging effects of waves, convey and store floodwaters, trap sediment and reduce pollution—the last attribute has earned them the sobriquet "nature's kidneys."

Despite their value, wetlands are rapidly disappearing. In the U.S., more than half of these regions in every state except Alaska and Hawaii have been destroyed. Between the 1950s and the 1970s more than nine million acres—an area equivalent to the combined size of Massachusetts, Connecticut and Rhode Island—were wiped out. Some states have almost entirely lost their wetlands: California and Ohio, for example, retain only 10 percent of their original expanse. Destruction continues today, albeit at a slightly reduced rate, in part, because there are fewer wetlands to eliminate. No such numbers are available internationally, but we estimate that 6 percent of all land is currently wetlands.

The extensive losses can generally be attributed to the same feature that makes wetlands so valuable: their ever changing nature. The complex dynamics of wetlands complicate efforts to create policies for preserving them. Their management and protection must incorporate a realistic definition, one that encompasses all these intricate

JON A. KUSLER, WILLIAM J. MITSCH and JOSEPH S. LARSON work on aspects of wetland management and ecology. Kusler, who has advised many state and federal agencies on water resource policy, is executive director of the Association of Wetland Managers. Professor of natural resources and environmental science at Ohio State University, Mitsch has conducted extensive research on wetlands restoration and ecosystem modeling. Larson is professor at and director of the Environmental Institute at the University of Massachusetts at Amherst. He has studied, among other topics, the behavior of beavers and the assessment of freshwater wetlands.

FLOODING IN THE MIDWEST left thousands of houses submerged—including these along the Missouri River—and powerfully demonstrated the dangers of destroying wetlands. When undisturbed, wetlands can absorb excess floodwater. Development, however, can reduce or eliminate this capability.

ecosystems—from marshes, bogs and swamps to vernal pools, playa lakes and prairie potholes. If scientists can better clarify and communicate to the public and to policymakers the special characteristics of wetlands as well as their economic and ecological importance, perhaps those that do remain will not disappear.

Over the years, researchers and government agencies have developed many definitions of wetlands. All share the recognition that wetlands are shallow-water systems, or areas where water is at or near the surface for some time. Most descriptions also note the presence of plants adapted to flooding, called hydrophytes, and hydric soils, which, when flooded, develop colors and odors that distinguish them from upland soils.

Wetlands can be found in diverse topographical settings. They arise in flat, tidally inundated but protected areas, such as salt marshes and mangrove swamps. Wetlands exist next to freshwater rivers, streams and lakes and their floodplains (such areas are often called riparian). In addition, they form in surface depressions almost anywhere. Such wetlands comprise freshwater marshes, potholes, meadows, playas and vernal pools where vegetation is not woody, as well as swamps where it is. Wetlands can also flourish on slopes and at the base of slopes, supplied by springs, and as bogs and fens fed by precipitation and groundwater. Finally, they can occur in cold climates where permafrost retains water and low evaporation rates prevail.

Although the kinds and locations of wetlands vary greatly, fluctuating water levels are central to all of them. Water rises or falls in accordance with tides, precipitation or runoff; the activities of humans and other animals can also determine water levels. The extent of the fluctuation is often very different from site to site. In the salt marshes of the northeastern U.S. and eastern Canada, daily tides may bring about shifts of 10 feet or more in water level. Other regions undergo even more extreme changes. For example, rainfall can cause the Amazon River to rise 25 feet during a season and invade neighboring wetlands [see "Flooded Forests of the Amazon," by Michael Goulding; SCIENTIFIC AMERICAN, March 1993]. In the prairie potholes of the Midwest, groundwater or melting snow may alter water levels by four or five feet over several years.

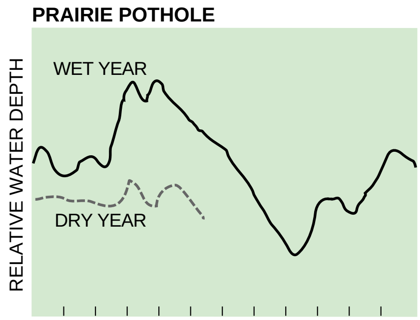
Even when levels fluctuate dramatically, these systems can adjust so that they sustain little permanent damage. Indeed, the very existence of some wetlands is related to the ravages of hurri-

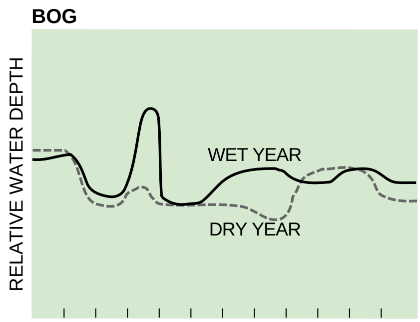
canes, floods and droughts. Most wetlands along rivers and coastlines as well as those that formed in depressions in the landscape are long-lived precisely because of events that people consider economically devastating. Raging fires burn excess deposited organic matter and recycle nutrients. Hurricanes and high-velocity floods scour sediments and organic matter, removing them from wetlands or creating wetlands nearby. Droughts temporarily destroy hydrophytic vegetation and allow oxidation and compaction of organic soils.

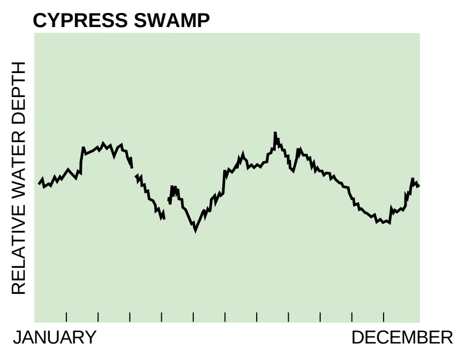
This anomalous feature of wetlands—the way that short-term destruction ensures long-term gain—is poorly understood by the general public. Much of the press coverage of Hurricane Andrew and its impact on the Florida Everglades illustrates this fact. Although

The Fluctuating Water Levels of Wetlands

Wetlands are often as different in their appearance and in the species they host as they are in the range of saturation they experience in the course of a year or a season. Their topographical variety and the complexity of their hydrology have made some wetlands difficult to identify and, hence, difficult to preserve.



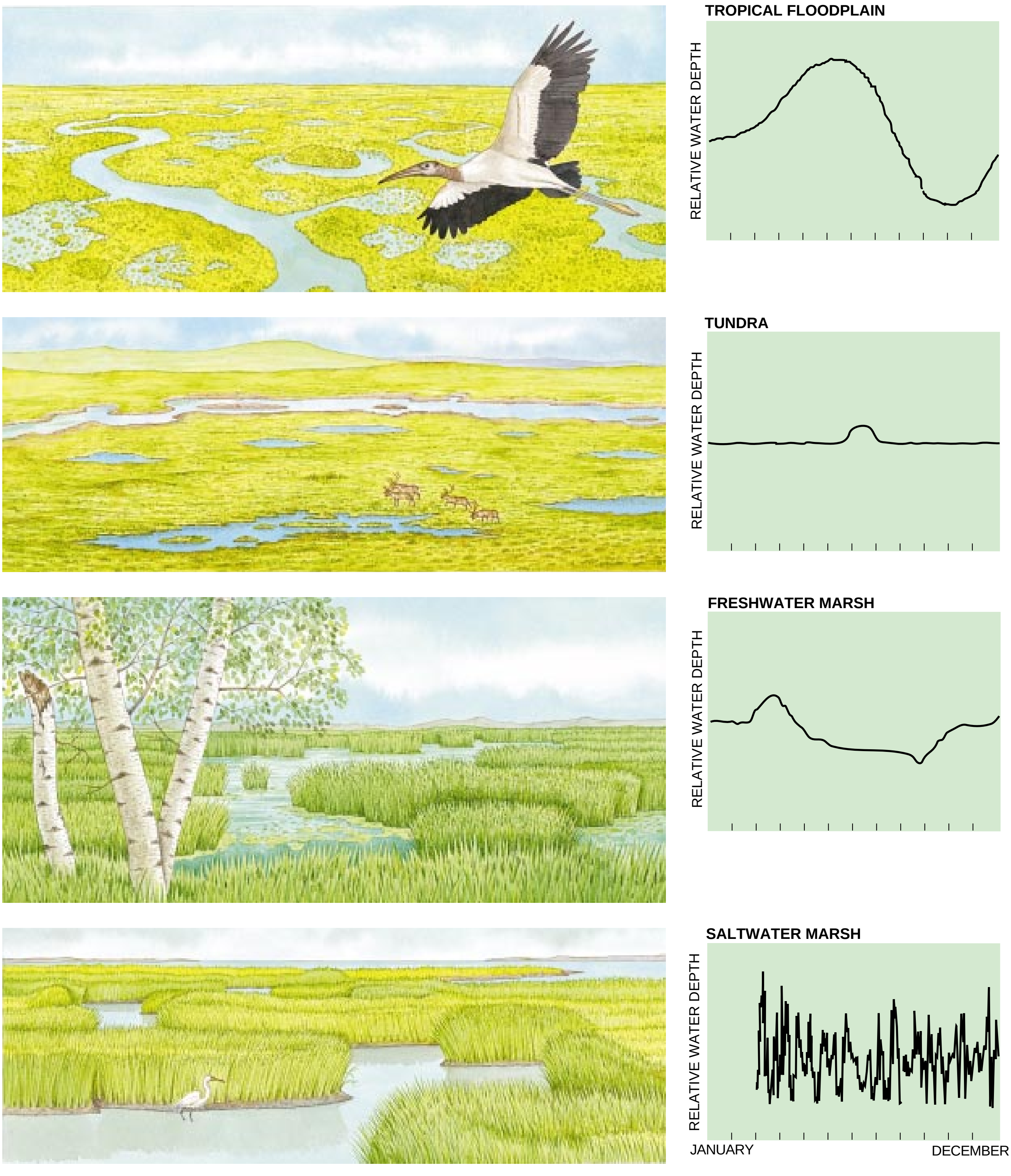


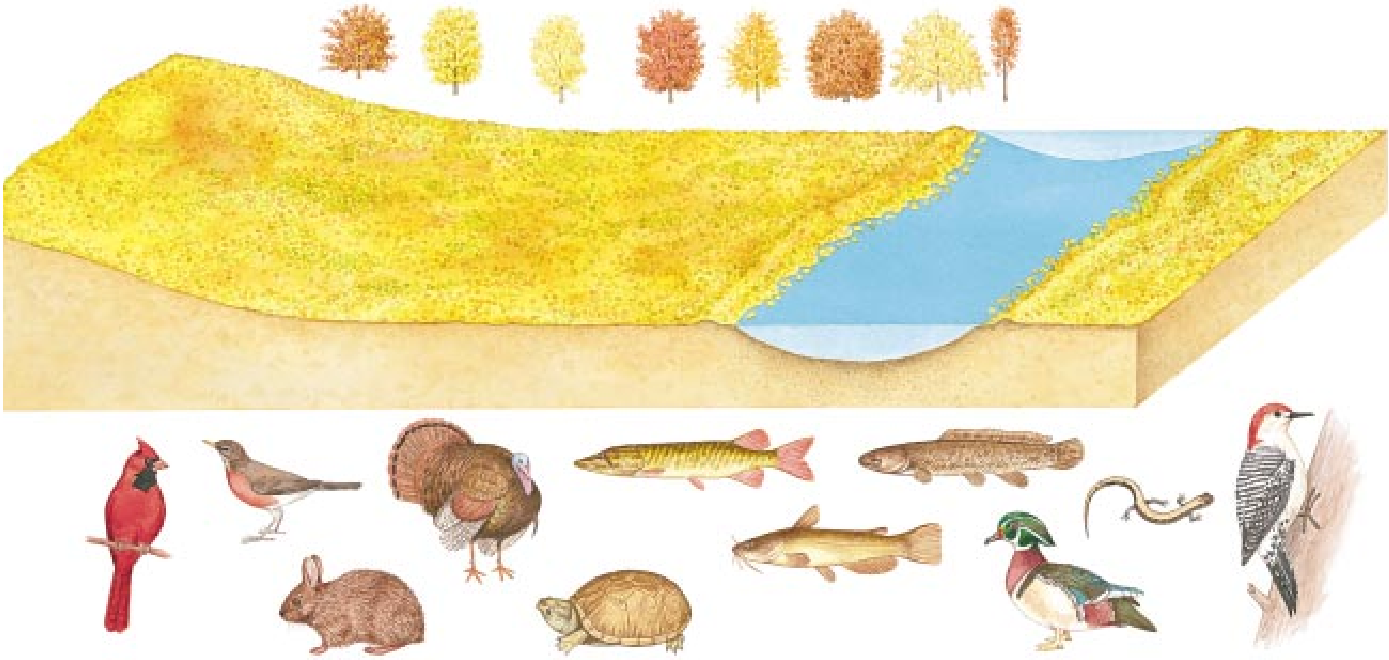


the damage was serious, the ecosystem and others like it have survived thousands of such cataclysms. Some researchers have suggested that trees in the coastal mangrove swamps reach maturity at about 30 years of age, a periodicity that coincides almost perfectly with the frequency of hurricanes in the tropics.

Misunderstanding has also led to many well-intentioned proposals to stabilize water levels in wetlands. The flooding along the Mississippi, Missouri and other rivers last summer was especially severe because wetlands had been destroyed as people built on them. These ecosystems could no longer serve to absorb floodwaters.

Of course, the levels of many bodies of water rise and fall. Lakes and streams are occupied by plants and animals





BOTTOMLAND HARDWOOD WETLANDS that occur in the major river basins of the southeastern U.S. have two very distinct hydroperiods, or periods of inundation. During the dry season (*left*), fish species such as the yellow bullhead stay in the channel, whereas animals and birds move throughout all zones of the region. But during the flooded period

that are adapted to a permanently watery environment—even temporary dry spells could kill them. In contrast, a wetland encompasses an array of shallow-water and saturated soil environments that possess some elements of a terrestrial system and some of an aquatic system. Because water levels rise and fall continuously, portions of wetlands—and, in some cases, entire wetlands—at times resemble true aquatic systems, at times terrestrial systems and at times intermediate systems. Plants, animals and microbes are constantly adapting and changing.

Wetlands also differ from deep-water aquatic systems in their sensitivity to the effects of water-level changes. A one-foot change in the level of a lake or a river brings about little difference in a system's boundaries or functions. But an equivalent change in a wetland can significantly affect both. Certain wetland vegetation—sedges, grasses or floating plants—often grows in one location during a wet year, another location during an intermediate year and not at all during a dry year. Thus, cycles of plant growth can change over time. As a result, the kinds of animals that frequent a wetland will also vary.

Such shifts explain the immense biodiversity of wetlands. Alterations in their water levels give rise to a series of ecological niches that can support terrestrial, partially aquatic and fully aquatic plants and animals. In addition, vertical gradients caused by differing depths of water and saturation create further environmental variation. Wetlands essentially borrow species from both aquatic and terrestrial realms.

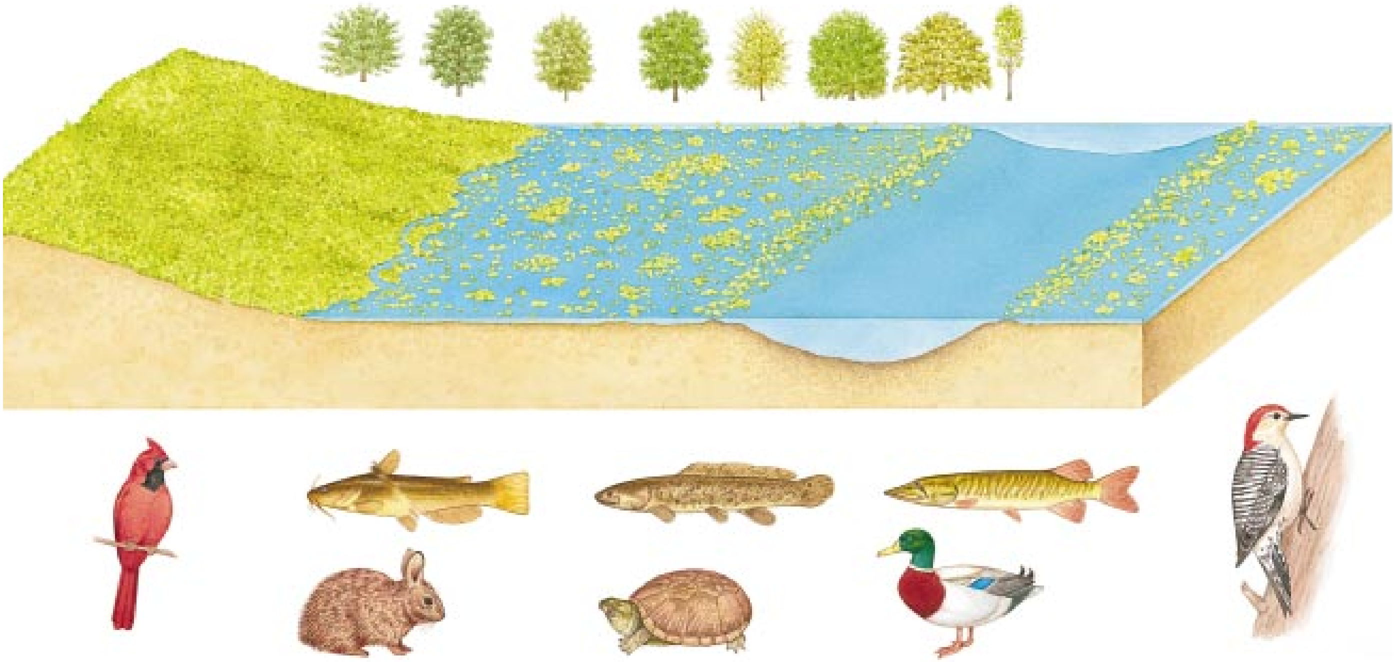
Even a temporary niche can be crucial to the nesting, spawning, breeding or feeding patterns of a particular species. Short-legged birds such as green-backed herons and limpkins feed along shallow-water shorelines. Longer-legged species, including egrets and great blue herons, feed in deeper water. Swimming waterfowl such as mallards, coots and purple gallinules feed in the deepest open water. Shifts in water levels serve to trigger nesting by wood storks in Florida and breeding by ducks in prairie potholes.

Rising and falling water levels not only influence the internal character of a wetland, but they also link wetlands to one another and to other aquatic systems. Because of their sensitivity to water levels, wetlands are highly dependent on the quantity and quality of water in their immediate area. This fact is particularly true for isolated or small wetlands. In such terrain, rain, local runoff and the aquifer are the only sources of water. Wetlands bordering major lakes and streams may be less sensitive to such natural changes. They rely on the levels in adjacent water bodies that, in turn, depend on precipitation in larger watersheds. Coastal wetlands are also somewhat more resilient since levels depend on the tides.

Such associations with the neighboring environment are critical to wetland functions. Wetlands can serve as reproductive or feeding sites for some species only if they are connected with other waterways. Moreover, the incoming water brings nutrients and sediments that can make the system more productive. The wetlands then cleanse these waters by retaining sediments as well as phosphorus and other chemicals. Pollutants such as nitrogen can be turned into harmless gases by the aerobic and anaerobic bacteria found there.

Clearly, the dependence of many wetlands on contiguous water systems makes them especially vulnerable to even minor human activity. Development in watershed areas and the pumping of groundwater can disrupt or destroy them. Landfills, dikes or other measures that isolate wetlands from nearby wetlands or waters can reduce their ability to provide flood storage, water purification and habitats.

Barriers also can prevent wetland plants and animals with highly sensitive aquatic tolerances from migrating up and down gentle slopes. Without sufficient room to move, wetlands themselves may temporarily or permanently disappear. Some—including headwater riparian wetlands, depressional wetlands and slope wetlands—are particularly prone to such interference. A seawall or a dike at the landward boundary of a salt marsh can prevent the inland migration of the marsh when the sea



(*right*), the crucial role of the wetland as spawning ground and nursery becomes evident. The fish move into the inundated forest, where they spawn and feed; wood ducks fly into the area to nest. Many other creatures move upland to dry ground. The bottomland hardwood plants and animals are thus adapted to both the dry and the wet periods.

level rises. Indeed, such diking currently threatens, rather than helps, many coastal areas.

Increased amounts of sediment, nutrients and pesticides from watersheds undergoing development can drastically alter the biological makeup of a wetland and overload its ability to purge pollutants if they are added beyond the wetland's ability to assimilate them. Such additions can even destroy a wetland in a short time. Isolated wetlands arising in topological depressions are quite vulnerable because they are not periodically purged of sediment by storms or high-velocity river flows.

Many pothole and kettle-hole wetlands in the northern American states and the southern parts of Canadian provinces are at just such risk. Most wetlands in these regions were created 8,000 to 12,000 years ago by the retreat of the glaciers. As blocks of ice in glacial outwash and till (the assemblage of rocks, boulders and clay that rides along with the glacier) melted, pothole depressions were formed. The deeper ones became lakes; the shallow ones, wetlands. In presettlement times, heavily vegetated surroundings contributed small amounts of sediment and nutrients to these wetlands. But the clearing of land increased this influx of sediment, which continues to build up because the ecosystems lack effective flushing mechanisms.

Ironically, decreased sediment from dams and reservoirs along rivers and streams threatens other wetlands. In the Mississippi Delta, levees have prevented loads of sediment from being deposited—to the point that marshes can no longer build up at a rate equal to sea-level rise and land subsidence. The result is a massive loss, an estimated 25,000 acres of marsh every year. Watershed development and diversions that decrease the freshwater flow of rivers similarly threaten many estuarine wetlands by reducing the quantity of freshwater and increasing salinity.

It is not difficult to see how fluctuating water levels and the intricate relations between wetlands and human development pose serious challenges to any simple wetland policy. Highly generalized rules are often insensitive to the physical characteristics and dynamics of wetlands.

To some extent, the battle over wetlands has been a conflict between conservation and development. There is hardly a farmer, developer or shopping-mall builder in the U.S. who is not familiar with wetlands. The debate has pivoted around the problem of devising management strategies that provide certainty for developers while protecting the ecological features of wetlands. Fluctuating water levels and the sensitivity of wetlands to these changes as well as the dependence of wetlands on the surrounding landscape must consistently be taken into account.

Landowners understandably want to know the exact effect of wetland regulations when they construct a house or road. They want to know what activities will be allowed in which areas under what conditions. They want to be able to compensate for wetland losses at one site by restoring wetlands at other locations. And they want hard and fast rules, without surprises.

This need has led to proposals to take wetland policy out of the hands of the scientists and to establish simplistic rules through legislative fiat. Such attempts include congressional bill HR 1330, co-sponsored by 170 members of the House in 1992 and 100 members in 1993, which provides an example of science and legislation in conflict. The bill would require that hydric vegetation be present in every wetland. It also stipulates that wetlands be classified according to a once-and-for-all determination of a wetland's value or function.

In essence, HR 1330 treats wetlands like static water systems. (A similar problem of failing to recognize wetlands as a dynamic system was seen in the fall of 1991, when the U.S. administration tried and failed to redefine wetlands.) Moreover, the proposal would allow a landowner to select the time of year during which to decide whether or not a particular area constitutes a wetland. Because such hydric plants are missing at one time or another from most wetland sites, provisions of this kind could be used to define most wetlands out of existence.

FLORIDA EVERGLADES appeared to be severely damaged by Hurricane Andrew, which ripped through the region in 1992. Yet contrary to public perception, the wetlands that make up the Everglades rely on such storms for their survival. Gale-force winds remove excess organic matter and sediment that are suffocating the ecosystem.

The bill would require that federal agencies document 21 days of inundation or saturation for all wetlands. This artificial standard would be impossible to meet because water-level records are rarely available, and fluctuations are extremely difficult to predict. The expense of using modeling to foresee water levels is prohibitive: one study to determine the probability of a 100-year, or extremely rare, flood on about half the nation's floodplains cost more than $870 million.

Finally, the bill, which would allow for compensating the loss of one wetland by preserving another—called mitigation banking—ignores the tight associations between certain wetland functions and their watershed. A wetland's ability to control floodwater or maintain water quality can be seen immediately downstream. But, under the bill, downstream landowners are not compensated for the fact that their wetlands can no longer fulfill these functions. Further, because of their surroundings, two wetlands of similar size in different locations may have distinctly different attributes, functions and therefore value.

Scientifically sound management of wetlands that satisfies everyone is not easy to achieve, but there are signs of hope. In the past decade, investigators have learned much about defining and managing wetlands as dynamic features in the landscape. This knowledge could form the basis of a workable policy.

Recognizing the role of fluctuating water levels and the interrelation of the landscape is a first step. Water levels vary within relatively well defined ranges in most wetlands and can therefore provide a foundation for definition and regulation. Soil and geologic information can be gathered to identify long-term shifts. Other criteria can help indicate altered or managed wetlands as well as those that are infrequently flooded. It is also important to consider the immediate landscape when the wetland is being evaluated.

In the future, natural processes should be preserved as much as possible. In general, people have attempted to control the rise and fall of rivers by building dams. When such fluctuations cannot be maintained, remedial management should be undertaken to simulate natural hydrologic pulses.

Regional watershed analyses that address not only present but future situations can help delineate wetlands. These analyses can form the foundation for planning and regulation. At the same time, protection of these systems can be integrated into broader land-use policies—including the management of water supplies and of floodplains, storm water and pollution.

Such scientifically sound policies have been implemented in many countries. In 1971 the Ramsar Convention called for the protection of wetlands and for the formulation of national plans to use them wisely. Today 37 million hectares at 582 sites have been designated as Ramsar sites—including 1.1 million hectares in the U.S. Nevertheless, only 74 nations have joined the convention.

Because of their special characteristics, wetlands pose difficult but not insurmountable challenges in terms of protection and restoration. If we recognize these features and incorporate them into policies at all levels of government, we can save the remaining wetlands, from the tropics to the tundra.

FURTHER READING

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