EPA
United States
Environmental Protection
Agency

Economic Benefits of Wetlands

A wetland is a natural area that is often wet but may not be wet all year round. Wetlands are characterized by their distinctive hydrology, soils and plants. Once regarded as wastelands, wetlands are now recognized as important features of the landscape that provide numerous beneficial services for people and wildlife. The economic value of a wetland is an estimate of the importance, or worth, of one or more of its services to society. Some of these services, or functions, include protecting and improving water quality, supporting the fishing industry, storing floodwaters and providing opportunities for education and recreation. If wetlands are destroyed or damaged, it can be difficult or impossible to replace all of these functions.

Wetlands contribute to the national and local economies by producing resources, enabling recreational activities and providing other benefits, such as pollution control and flood protection. While it can be difficult to calculate the economic value provided by a single wetland, it is possible to evaluate the range of services provided by all wetlands and assign a dollar value. These amounts can be impressive. According to one assessment of natural ecosystems, the dollar value of wetlands worldwide was estimated to be $14.9 trillion. (Source: Costanza et al. 1997) This fact sheet summarizes some of the important ways in which wetlands contribute to the economy.

Drinking Water Quality

Wetlands improve water quality in rivers and streams. they are valuable filters for water that may eventually become drinking water.

Wetlands improve water quality in nearby rivers and streams, and thus have considerable value as filters for future drinking water. When water enters a wetland, it slows down and moves around wetland plants. Much of the suspended sediment drops out and settles to the wetland floor. Plant roots and microorganisms on plant stems and in the soil absorb excess nutrients in the water from fertilizers, manure, leaking septic tanks and municipal sewage. While a certain level of nutrients is necessary in water ecosystems, excess nutrients can cause algae growth that's harmful to fish and other aquatic life. A wetland's natural filtration process can remove excess nutrients before water leaves a wetland, making it healthier for drinking, swimming and supporting plants and animals. For example, the Congaree Bottomland Hardwood Swamp in South Carolina removes a quantity of pollutants from the watershed equivalent to that which would be removed by a $5 million treatment plant. (Source: EPA832-R-93-005)

Flood Control

Flood damages in the U.S. average $2 billion each year, causing significant loss of life and property. (Source: National Oceanic and Atmospheric Administration). Wetlands can play a role in reducing the frequency and intensity of floods by acting as natural buffers, soaking up and storing a significant amount of floodwater. A wetland can typically store about three-acre feet of water, or one million gallons. An acre-foot is one acre of land, about three-quarters the size of a football field, covered one foot deep in water. Three acre-feet describes the same area of land covered by three feet of water. Coastal wetlands serve as storm surge protectors when hurricanes or tropical storms come ashore. In the Gulf coast area, barrier islands, shoals, marshes, forested wetlands and other features of the coastal landscape can provide a significant and potentially sustainable buffer from wind wave action and storm surge generated by tropical storms and hurricanes. (Source: Working Group for Post-Hurricane Planning for the Louisiana Coast) After peak flood flows have passed, wetlands slowly release the stored waters, reducing property damage downstream or inland. One reason floods have become more costly is that over half of the wetlands in the United States have been drained or filled. The loss of more than 64 million acres of wetlands in the Upper Mississippi Basin since the 1780's contributed to high floodwaters during the Great Flood of 1993 that caused billions of dollars in damage. (Source: "Flood Damage Reduction in the Upper Mississippi River Basin—An Ecological

One of the most valuable benefits of wetlands is their ability to store flood waters. Maintaining only 15% of the land area of a watershed in wetlands can reduce flooding peaks by as much as 60%. (Source: The Wetlands Initiative, EPA) (See EPA843-F-06-001, "Wetlands and Flooding.")

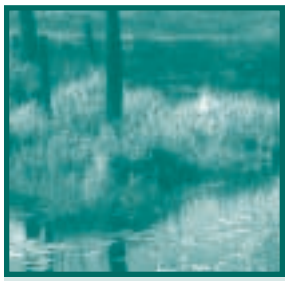
Valuation of Wetlands

Although wetlands provide important services to society, these services are typically not sold nor do they have market value. Wetland benefits can be estimated by several standard market and non-market valuation techniques. The three most common are cost-benefit analysis, cost-effectiveness analysis and benefits valuation for compensation for environmental damages. The techniques can be applied whether the change in the environment is an improvement or degradation. (Source: "Economic Valuation of Environmental Benefits")

Alternative", 2004) The damage sustained by the Gulf Coast during Hurricane Katrina could have been less severe if more wetlands along the coast and Mississippi delta had been in place.

Cleaning the Water

Because natural wetlands are so effective at removing pollutants from water that flows through them, engineers and scientists construct systems that replicate some of the functions of natural wetlands.



Anneke Davis

Natural wetlands are effective at cleaning the water passing through them. Wetland plants and soils absorb much of the excess nutrients in the water. Wetlands perform this function so well that similar systems are being constructed to treat wastewater.

These constructed treatment wetlands use natural processes involving wetland vegetation, soils and their associated microbial life to improve water quality. They are often less expensive to build than traditional wastewater and stormwater treatment options, have low operating and maintenance expenses and can handle fluctuating water levels. For example, in 1990 city managers in Phoenix, Arizona, needed to improve the performance of a wastewater treatment plant to meet new state water quality standards. After learning that upgrading the plant might cost as much as $635 million, the managers started to look for a more cost-effective way to provide final treatment to the plant's wastewater discharge into the Salt River. A preliminary study suggested that a constructed wetland system would sufficiently clean the discharge water while supporting high-quality wetland habitat for birds, including endangered species, and protecting downstream residents from flooding. All these benefits would be achieved at a lower cost than retrofitting the existing treatment plant. As a result, the 12-acre Tres Rios Demonstration Project began in 1993 with assistance from the Corps of Engineers, the Bureau of Reclamation and EPA's Environmental Technology Initiative and now receives about two million gallons of wastewater per day. This project is still flourishing, serving as a home for thousands of birds and other wildlife. (Source: City of Phoenix) There are hundreds of wastewater treatment wetlands operating in the United States today. (Source: EPA832-R-93-005)

Fisheries

The Nation's wetlands are vital to fish health and thus to the Nation's multi-billion dollar fishing industry. Wetlands provide an essential link in the life cycle of 75 percent of the fish and shellfish commercially harvested in the U.S., and up to 90 percent of the recreational fish catch. Wetlands provide a consistent food supply, shelter and nursery grounds for both marine and freshwater species. Landings of crab, shrimp and salmon were valued at $1,167 billion in 2004. These species are dependent on wetlands for at least part of their life cycles. In 2004 the dockside value of fin fish and shellfish landed in the United States was $3.7 billion and was the basis for the $7.2 billion fishery processing business. U.S. consumers spent an estimated $54.4 billion for fishery products in 2000. (Source: U. S. Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS))

Wetlands are essential to our multi-billion dollar National commercial fishing industry. Wetlands have an important place in the life cycle of 75 percent of the fish and shellfish commercially landed in U.S. waters.

Recreation

Wetlands are often inviting places for popular recreational activities including hiking, fishing, bird watching, photography and hunting. More than 82 million Americans took part in these activities in 2001, spending more than $108 billion on these pursuits. (Source: USFWS, Ducks Unlimited). For example, over 34 million people went fishing in 2001, spending an average of $1,046 and 16 days each on the water. Anglers spent $14.7 billion in 2001 for fishing trips, $17 billion on equipment and $4 billion for licenses, stamps, tags, land leasing and ownership, membership dues, contributions and magazines. The overall economic impact of recreational fishing is estimated at $116 billion (American Sportfishing Association), and wetlands play a crucial role in the life cycle of up to 90 percent of the fish caught recreationally. In 2001, approximately 3 million people hunted migratory birds, and 6.5 million small mammals that are often

Wetlands are pleasant places for recreational activities like fishing. They may provide a place of natural beauty and solitude that can be enjoyed by persons of all ages who may seldom be exposed to nature.

found in wetlands. They spent more than $2.2 billion, including $111million paid by migratory bird and large game hunters to lease hunting areas and blinds, often located on private property with wetlands. (Source: U. S. Fish and Wildlife Service) Each year nearly $200 million in hunters' federal excise taxes are distributed to state agencies to support wildlife management programs, the purchase of lands open to hunters and hunter education and safety classes. Proceeds from the federal Duck Stamp, a required purchase of migratory water fowl hunters, have purchased more than five million acres of habitat for the refuge system. (Source: Ducks Unlimited) Just watching the wildlife, many of which depend on wetlands, has become a popular pastime. More than 66 million people 16 years old and older--31% of all Americans-- fed, photographed and observed wildlife in 2001 and spent $40 billion on their activities. (Source: U. S. Fish and Wildlife Service)

Wildlife Habitat

Patricia Deege

Many species of wildlife rely on wetlands for their very existence. Wetlands provide mammals, plants, amphibians, reptiles, birds and fish with food, habitat, breeding grounds and shelter. While the diversity of wetland wildlife contributes to many businesses, they are also inherently wonderful to observe.

Diverse species of mammals, plants, insects, amphibians, reptiles, birds and fish rely on wetlands for food, habitat or shelter. Wetlands are some of the most biologically productive natural ecosystems in the world, comparable to tropical rain forests or coral reefs in the number and variety of species they support. Although wetlands make up only about 5 percent of the land area of the lower 48 states, more than one-third of threatened and endangered species live only in wetlands. An additional 20% of the country's threatened and endangered species use or inhabit wetlands at some time in their life. Some species must have a wetland in order to reproduce. Migrating waterfowl rely on wetlands for resting, eating and breeding areas, leading to increased populations. As noted, the appeal of wetlands and the diversity of plant and animal life they attract contribute to or support many businesses. (Source: U.S. Fish and Wildlife Service)

Other Commercial Benefits

Many industries, in addition to the fishing industry, derive benefits or produce products dependent on wetlands. Part of this economic value lies in the variety of commercial products they provide, such as food and energy sources. Rice can be grown in a wetland during part of the year, and the same area can serve as a wildlife habitat for the rest of the year. Some wetland plant species, such as wild rice and various reeds, can be harvested for or used to produce specialty foods, medicines, cosmetics and decorative items. In many coastal and river delta wetlands, haying of wetland vegetation is important to livestock producers. In Europe, reed-growing for building materials is undergoing a revival in some countries as people realize the full potential of reeds as a roofing material. Aesthetically pleasing, thatched roofs are superior insulators to conventional tile roofs, and they have a life span of 25-40 years. (Source: Ramsar) Fur-bearing animals, such as mink, muskrat and beaver, use wetlands during some part of their life cycle. Income can be derived from trapping these furbearers, either by direct sale of their pelts or by leasing wetlands for the fur harvest. The nation's harvest of muskrat pelts alone was worth $124 million in 2004. (Source: U.S. Fish and Wildlife Service) Wetlands also provide employment opportunities, including such positions as surveyor or park ranger. The production of raw materials from wetlands provides jobs to those employed in the commercial fishing, specialty food and cosmetic industries. These are billion dollar industries that depend in part on wetlands to flourish.

In addition to the many ways wetlands provide economic benefits, they offer numerous less tangible benefits as well. These include providing aesthetic value to residential communities, reducing streambank erosion and providing educational opportunities as an ideal "outdoor classroom." By nearly any measure used, it pays to save wetlands.

Did You Know?

- Although wetlands cover only about 5 percent of the land surface in the lower 48 states, they are home to 31 percent of plant species. (U.S. Fish and Wildlife Service)
- In 2002 Louisiana commercial fish landings exceeded 1 billion pounds with a dockside value of $343 million – approximately 30% of the total catch by weight in the lower 49 states. (Source: America's Wetland)
- Rivaling the likes of tropical rainforests and coral reefs, wetlands are among the most fertile, productive ecosystems in the world. (Source: Ramsar)
- Two thirds of all fish consumed worldwide are dependent on coastal wetlands at some stage in their life cycle. (Source: Ramsar)
- Annual fish and seafood production in swamps and marshes worldwide has been estimated at an average of nine tons per square kilometer, 259 hectares or 640 acres. (Source: Ramsar)
- As many as one-half of all North American bird species nest or feed in wetlands.
- Five to seven million migratory waterfowl, including the endangered whooping crane, use wetlands, i.e. prairie potholes, as resting and feeding areas and as an abundant food source. (Source: U.S. Fish and Wildlife Service)

EPA843-F-06-004
Office of Water
May 2006

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For additional information, visit the U.S. EPA's website (www.epa.gov/owow/wetlands), or call the toll-free Wetlands Helpline at 1-800-832-7828.

United States
Environmental
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Hypoxia & Wetland Restoration

What Is Hypoxia?

Hypoxia is the condition in which dissolved oxygen is below the level necessary to sustain most animal life. For many members of an aquatic community, hypoxia is like drowning, because life-giving dissolved oxygen levels in a body of water drop much lower than normal. Hypoxia often occurs when high concentrations of nutrients enter water as a result of human actions.

Just as on land, nutrients like nitrogen and phosphorus, which are found in fertilizer, stimulate plant growth in water. In water, algae is the predominant plant. Although algae is integral to a healthy aquatic ecosystem, addition of nitrogen and phosphorous beyond natural levels can lead to the formation of large, unattractive algal mats on the surface of lakes and algal blooms in lakes and coastal waters. The decomposition of algal blooms consumes oxygen, and the resulting low oxygen condition, or hypoxia, is inhospitable to many aquatic organisms that then must flee or die.

Where Does Hypoxia Occur?

Hypoxia occurs throughout the world. In the United States, the largest known area is off the Louisiana Coast (see sidebar). Other known areas in the United States are the Long Island Sound and the Chesapeake Bay. Hypoxia can occur naturally; however, there is no doubt that human activites have increased the frequency, areal extent, and severity of hypoxia around the world. Although nutrient enrichment is the primary contributor to hypoxia, landscape changes such as the loss of coastal and freshwater wetlands that naturally remove nutrients from the water also contribute to the problem. Many of the original freshwater wetlands and riparian zones that were connected to streams and rivers are now gone.

The Gulf Dead Zone

The Gulf of Mexico is the largest area of hypoxia in the United States. In the summer of 2002, the hypoxic zone measured larger than ever before. In fact, it covered an area greater than the size of Massachusetts. Hypoxia in the Gulf of Mexico has raised considerable concern throughout the United States because many people in coastal states make their livelihood fishing in the Gulf and many Americans vacation on the Gulf. It is also an indication of the quality of the waters that feed the Gulf, including the Mississippi River Basin. The nitrogen concentration in Mississippi River Basin water has doubled since the 1950s.

The six major sub-basins of the Mississippi River Basin and the Gulf of Mexico. Nutrients transported from these areas contribute to Gulf of Mexico hypoxia.

Mitigating Hypoxia Through Wetland Restoration

There is growing interest and expertise in the field of wetland restoration. Federal, state, tribal, and local agencies, as well as private and nonprofit groups, are working not just to slow wetland loss, but to actually increase wetland acres. This trend is good news for hypoxia-affected waters since some wetlands can significantly reduce the amount of nutrients reaching our inland and coastal waters. Restoring these wetlands can help reduce nutrient loading to our nation's streams and rivers. The following two examples highlight such efforts.

Effects of Hypoxia

- **More expensive water treatment**
- **Threat to commercial fisheries**
- **Harmful algal blooms and shellfish toxicity**
- **Unattractive or smelly water**
- **Fish kills**
- **Damage to ecosystems and wildlife, including "dead zones"**
- **Decreased diversity of aquatic plant and animal life**

Ducks Unlimited

Winter ricefield management protects the Gulf of Mexico from sediments and nutrients.

Hunters Increase Wetland Acres

The conservation group Ducks Unlimited is working with rice farmers to provide habitat for migrating birds at a critical time of year. Farmers flood their fields between crops creating temporary wetlands that are needed by the birds and that also reduce the concentration of nutrients in runoff water. Much of this same runoff water will finally make its way to the Gulf less laden with harmful concentrations of nutrients. Ducks Unlimited hopes to enroll 150,000 acres of such wetlands in Arkansas alone. This win-win situation benefits farmers, waterfowl, and downstream water users.

Iowa and the US Department of Agriculture (USDA)

Iowa farmers, in coordination with USDA, are presently hard at work creating and restoring 9,000 acres of wetlands that are strategically located and designed to be especially effective at removing nutrients and herbicides from agricultural fields. Their project targets the Raccoon River which produces one of the highest nitrogen loads in the Mississippi River Basin. Not only will this project improve conditions in the Gulf of Mexico, but it will also protect drinking water in Iowa.

Lynn Betts, USDA NRCS

Restored Wetland in Northeastern Iowa

What Can You Do?

To protect your local waters and those downstream, you can take some precautions:

1. *Use fertilizers on your farm prudently, and on your yard and garden sparingly or not at all. When you do use fertilizers, be sure to follow application time and amount recommendations closely. One useful tool to avoid over-applying (which can also be bad for plants) is a soil test. A test kit can be obtained from your local USDA extension office. Find yours at: www.reeusda.gov/1700/statepartners/usa.htm*
2. *Protect the wetlands and stream-side vegetation on your own property and in your community. Visit a wetland near your home and learn about its contributions to your local watershed.*
3. *Help restore a wetland or a stream bank. Visit EPA's restoration website at www.epa.gov/owow/wetlands/restore*
4. *Properly maintain septic systems.*
5. *Support local efforts to reduce contamination of the water in your community. The first step is to determine the condition of water supplies and local streams in order to identify and then mitigate or eliminate sources of pollutants.*

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Office of Water

For more information, call EPA's Wetlands Helpline at 1-800-832-7828, or visit www.epa.gov/owow/wetlands

Wetland Resources

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Wetland Regulatory Authority

Regulatory Requirements

Section 404 of the Clean Water Act (CWA) establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g. certain farming and forestry activities).

Wetlands subject to Clean Water Act Section 404 are defined 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 basic premise of the program is that no discharge of dredged or fill material may be permitted if: (1) a practicable alternative exists that is less damaging to the aquatic environment or (2) the nation's waters would be significantly degraded. In other words, when you apply for a permit, you must show that you have, to the extent practicable:

- Taken steps to avoid wetland impacts;
- Minimized potential impacts on wetlands; and
- Provided compensation for any remaining unavoidable impacts.

Proposed activities are regulated through a permit review process. An *individual permit* is required for potentially significant impacts. Individual permits are reviewed by the U.S. Army Corps of Engineers, which evaluates applications under a public interest review, as well as the environmental criteria set forth in the CWA Section 404(b)(1) Guidelines. However, for most discharges that will have only minimal adverse effects, a *general permit* may be suitable. General permits are issued on a nationwide, regional, or State basis for particular categories of activities. The general permit process eliminates individual review and allows certain activities to proceed with little or no delay, provided that the general or specific conditions for the general permit are met. For example, minor road activities, utility line backfill, and bedding are activities that can be considered for a general permit. States also have a role in Section 404 decisions, through State program general permits, water quality certification, or program assumption.

Striped bass

Agency Roles and Responsibilities

The roles and responsibilities of the Federal resource agencies differ in scope.

U.S. Army Corps of Engineers:

- Administers day-to-day program, including individual and general permit decisions;
- Conducts or verifies jurisdictional determinations;
- Develops policy and guidance; and
- Enforces Section 404 provisions.

U.S. Environmental Protection Agency:

- Develops and interprets policy, guidance and environmental criteria used in evaluating permit applications;
- Determines scope of geographic jurisdiction and applicability of exemptions;
- Approves and oversees State and Tribal assumption;
- Reviews and comments on individual permit applications;
- Has authority to prohibit, deny, or restrict the use of any defined area as a disposal site (Section 404(c));
- Can elevate specific cases (Section 404(q));
- Enforces Section 404 provisions.

U.S. Fish and Wildlife Service and National Marine Fisheries Service:

- Evaluates impacts on fish and wildlife of all new Federal projects and Federally permitted projects, including projects subject to the requirements of Section 404 (pursuant to the Fish and Wildlife Coordination Act); and
- Elevates specific cases or policy issues pursuant to Section 404(q).

Manual for Identifying Wetlands

The U.S. EPA and U.S. Army Corps of Engineers use the 1987 *Corps of Engineers Wetlands Delineation Manual* to identify wetlands for the CWA Section 404 permit program. The 1987 manual organizes the environmental characteristics of a potential wetland into three categories: soils, vegetation, and hydrology. The manual contains criteria for each category. Using this approach, an area that meets all three criteria is considered a wetland.

Wetlands on Agricultural Lands

Farmers who own or manage wetlands are directly affected by two important Federal programs—Section 404 of the CWA and the Swampbuster provision of the Food Security Act. The Swampbuster provision withholds certain Federal farm program benefits from farmers who convert or modify wetlands. The U.S. EPA, U.S. Army Corps of Engineers, U.S. Department of Agriculture, and U.S. Fish and Wildlife Service have established procedures to ensure consistency between the programs. Many normal farming practices are exempt from Section 404.

Water lilies

The Wetland Fact Sheet Series

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Office of Water

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For more information, call EPA's Wetlands Helpline at 1-800-832-7828

Wetland Resources

On the Internet

EPA's Wetlands Website ..... www.epa.gov/owow/wetlands/regs/

Section 404 of the Clean Water Act ..... www.epa.gov/owow/wetlands/laws/

Wetland Delineation Manual ..... www.wes.army.mil/el/wetlands/wlpubs.html

U.S. Army Corps of Engineers Regulatory Program..... www.usace.army.mil/inet/functions/cw/cecwo/reg/

U.S. Army Corps of Engineers' Waterways Experiment Station Environmental Laboratory ..... www.wes.army.mil/el/wetlands/wetlands.html

Environmental Law Institute ..... www.eli.org

In Print

America's Wetlands: Our Vital Link Between Land and Water. For a copy, order from EPA's publications web site at http://yosemite.epa.gov/water/owrccatalog.nsf or call the EPA Wetlands Helpline at 1-800-832-7828.

Wetlands Deskbook, 2nd Edition, Margaret N. Strand. Available from the Environmental Law Institute. Call 1-800-433-5120; fax your request to (202) 939-3868; or e-mail to orders@eli.org.

Our National Wetland Heritage: A Protection Guide, 2nd Edition, Jon A. Kusler, Ph.D., Executive Director, Association of State Wetland Managers. Available from the Environmental Law Institute. Call 1-800-433-5120; fax your request to (202) 939-3868; or e-mail to orders@eli.org.

United States
Environmental Protection
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Office of Water
Office of Wetlands,
Oceans and Watersheds (4502T)

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Functions and Values of Wetlands

Dave Davis

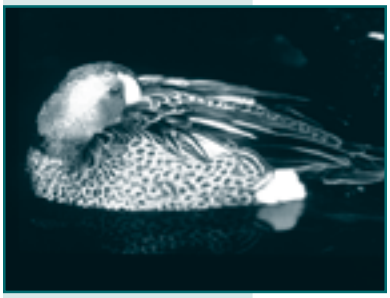
Long regarded as wastelands, wetlands are now recognized as important features in the landscape that provide numerous beneficial services for people and for fish and wildlife. Some of these services, or functions, include protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods. These beneficial services, considered valuable to societies worldwide, are the result of the inherent and unique natural characteristics of wetlands.

Wetlands are considered valuable because they clean the water, recharge water supplies, reduce flood risks, and provide fish and wildlife habitat. In addition, wetlands provide recreational opportunities, aesthetic benefits, sites for research and education, and commercial fishery benefits.

Functions Versus Values

Wetland functions include water quality improvement, floodwater storage, fish and wildlife habitat, aesthetics, and biological productivity. The value of a wetland is an estimate of the importance or worth of one or more of its functions to society. For example, a value can be determined by the revenue generated from the sale of fish that depend on the wetland, by the tourist dollars associated with the wetland, or by public support for protecting fish and wildlife.

Although large-scale benefits of functions can be valued, determining the value of individual wetlands is difficult because they differ widely and do not all perform the same functions or perform functions equally well. Decision-makers must understand that impacts on wetland functions can eliminate or diminish the values of wetlands.



Water storage. Wetlands function like natural tubs or sponges, storing water and slowly releasing it. This process slows the water's momentum and erosive potential, reduces flood heights, and allows for ground water recharge, which contributes to base flow to surface water systems during dry periods. Although a small wetland might not store much water, a network of many small wetlands can store an enormous amount of water. The ability of wetlands to store floodwaters reduces the risk of costly property damage and loss of life—benefits that have economic value to us. For example, the U.S. Army Corps of Engineers found that protecting wetlands along the Charles River in Boston, Massachusetts, saved $17 million in potential flood damage.

Water filtration. After being slowed by a wetland, water moves around plants, allowing the suspended sediment to drop out and settle to the wetland floor. Nutrients from fertilizer application, manure, leaking septic tanks, and municipal sewage that are dissolved in the water are often absorbed by plant roots and microorganisms in the soil. Other pollutants stick to soil particles. In many cases, this filtration process removes much of the water's nutrient and pollutant load by the time it leaves a wetland. Some types of wetlands are so good at this filtration function that environmental managers construct similar artificial wetlands to treat storm water and wastewater.

Red-osier dogwood

Biological productivity. Wetlands are some of the most biologically productive natural ecosystems in the world, comparable to tropical rain forests and coral reefs in their productivity and the diversity of species they support. Abundant vegetation and shallow water provide diverse habitats for fish and wildlife. Aquatic plant life flourishes in the nutrient-rich environment, and energy converted by the plants is passed up the food chain to fish, waterfowl, and other wildlife and to us as well. This function supports valuable commercial fish and shellfish industries.

The Great Flood of 1993 in the upper Mississippi River Basin caused billions of dollars in property damage and resulted in 38 deaths. Historically, 20 million acres of wetlands in this area had been drained or filled, mostly for agricultural purposes. If the wetlands had been preserved rather than drained, much property damage and crop loss could have been avoided.

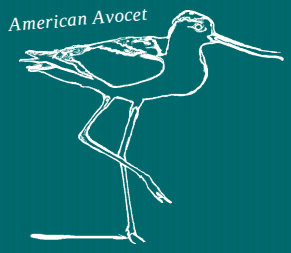
DID YOU KNOW?

- In 1991 wetland-related ecotourism activities such as hunting, fishing, bird-watching, and photography added approximately $59 billion to the national economy.
- According to the Pacific Coast Federation of Fishermen's Associations, almost $79 billion per year is generated from wetland-dependent species, or about 71 percent of the nation's entire $111 billion commercial and recreational fishing industry in 1997.
- An acre of wetland can store 1–1.5 million gallons of floodwater.
- Up to one-half of North American bird species nest or feed in wetlands.
- Although wetlands keep only about 5 percent of the land surface in the conterminous United States, they are home to 31 percent of our plant species.

Steve Delaney

Seventy-five percent of commercially harvested fish are wetland-dependent. Add shellfish species and that number jumps to 95 percent.

The Wetland Fact Sheet Series



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Wetland Monitoring & Assessment
Sustainable Communities
Volunteering for Wetlands
Teaching about Wetlands

For more information, visit www.epa.gov/owow/wetlands.

Wetland Resources

On the Internet

Ecosystem Valuation ..... www.ecosystemvaluation.org

Economic Valuation of Wetlands ..... www.ramsar.org/lib_val_e_index.htm

In Print

Restoration, Creation, and Recovery of Wetlands: Wetland Functions, Values, and Assessment, R.P. Novitzki, R.D. Smith, and J.D. Fretwell. United States Geological Survey Water Supply Paper 2425. Available on-line at http://water.usgs.gov/nwsum/WSP2425/functions.html.

Technical Aspects of Wetlands: Wetland Hydrology, Water Quality, and Associated Functions, Virginia Carter. United States Geological Survey Water Supply Paper 2425. Available on-line at http://water.usgs.gov/nwsum/WSP2425/hydrology.html.

Wetlands Functions and Values. Visit the North Carolina State University Water Quality Group's on-line informational database, WATERSHEDSS, at http://h2osparc.wq.ncsu.edu/info/wetlands/funval.html.

United States
Environmental Protection
Agency

Office of Water
Office of Wetlands,
Oceans and Watersheds (4502T)

EPA 843-F-01-002d
September 2001

Threats to Wetlands

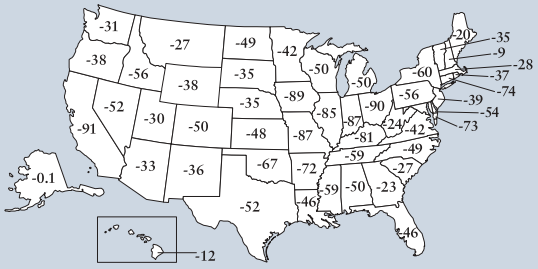
Destroying or degrading wetlands can lead to serious consequences, such as increased flooding, extinction of species, and decline in water quality. We can avoid these consequences by maintaining the valuable wetlands we still have and restoring lost or impaired wetlands where possible.

What Is the Status of Our Nation's Wetlands?

More than 220 million acres of wetlands are thought to have existed in the lower 48 states in the 1600s. Since then extensive losses have occurred, and more than half of our original wetlands have been drained and converted to other uses. The mid-1950s to the mid-1970s were a time of major national wetland loss. Since then the rate of loss has slowed.

The National Audubon Society notes that bird populations continue to decrease as wetlands are destroyed. In the past 15 years alone, the continental duck breeding population fell from 45 million to 31 million birds, a decline of 31 percent. The number of birds migrating over the Gulf of Mexico, which rely on coastal wetlands as staging areas (especially in Louisiana and Mississippi), has decreased by one-half since the mid-1960s. Approximately 100 million wetland acres remain in the 48 contiguous states, but they continue to be lost at a rate of about 60,000 acres annually. Draining wetlands for agricultural purposes is significant, but declining, while development pressure is emerging as the largest cause of wetland loss. Unfortunately, many remaining wetlands are in poor condition and many created wetlands fail to replace the diverse plant and animal communities of those destroyed.

Percentage of Wetlands Acreage Lost, 1780s–1980s



Twenty-two states have lost at least 50 percent of their original wetlands. Since the 1970s, the most extensive losses have been in Louisiana, Mississippi, Arkansas, Florida, South Carolina, and North Carolina.

Source: ***Wetlands***, 2nd edition, Van Nostrand and Reinholdt, 1993.

When a wetland functions properly, it provides water quality protection, fish and wildlife habitat, natural floodwater storage, and reduction in the erosive potential of surface water. A degraded wetland is less able to effectively perform these functions. For this reason, wetland degradation is as big a problem as outright wetland loss, though often more difficult to identify and quantify.

What Is Adversely Affecting Our Wetlands?

Human activities cause wetland degradation and loss by changing water quality, quantity, and flow rates; increasing pollutant inputs; and changing species composition as a result of disturbance and the introduction of nonnative species. Common human activities that cause degradation include the following:

Hydrologic Alterations. A wetland's characteristics evolve when hydrologic conditions cause the water table to saturate or inundate the soil for a certain amount of time each year. Any change in hydrology can significantly alter the soil chemistry and plant and animal communities. Common hydrologic alterations in wetland areas include:

- Deposition of fill material for development.
- Drainage for development, farming, and mosquito control.
- Dredging and stream channelization for navigation, development, and flood control.
- Diking and damming to form ponds and lakes.
- Diversion of flow to or from wetlands.
- Addition of impervious surfaces in the watershed, thereby increasing water and pollutant runoff into wetlands.

Pollution Inputs. Although wetlands are capable of absorbing pollutants from the surface water, there is a limit to their capacity to do so. The primary pollutants causing wet-land degradation are sediment, fertilizer, human sewage, animal waste, road salts, pesticides, heavy metals, and

selenium. Pollutants can originate from many sources, including:

- Runoff from urban, agricultural, silvicultural, and mining areas.
- Air pollution from cars, factories, and power plants.
- Old landfills and dumps that leak toxic substances.
- Marinas, where boats increase turbidity and release pollutants.

Vegetation Damage. Wetland plants are susceptible to degradation if subjected to hydrological changes and pollution inputs. Other activities that can impair wetland vegetation include:

- Grazing by domestic animals.
- Introduction of nonnative plants that compete with natives.
- Removal of vegetation for peat mining.

What Can You Do?

Nearly 75 percent of all wetlands are privately owned, making it imperative that the public participate in wetland management and protection. Here are some things you can do:

- Conserve and restore wetlands on your property.
- Support local wetlands and watershed protection initiatives by donating materials, time, or money.

Pollutants such as sediment, nutrients, pesticides, and heavy metals degrade wetlands and water quality across the country.

- Work with your local municipalities and state to develop laws and ordinances that protect and restore wetlands.
- Purchase federal duck stamps from your local post office to support wetland acquisition.
- Participate in the Clean Water Act Section 404 program and state regulatory programs by reviewing public notices and commenting on applications.
- Encourage neighbors and developers to protect the function and value of wetlands in your watershed.
- Avoid wetland alteration or degradation during project construction.
- Maintain wetlands and adjacent buffer strips as open space.
- Reduce the amount of fertilizers, herbicides, and pesticides applied to lawns and gardens.

Swamp tupelo

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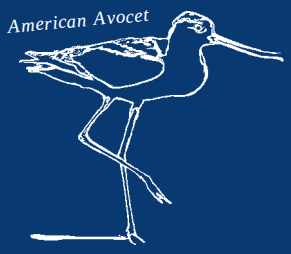

American Avocet

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Wetland Resources

A Global Overview of Wetland Loss and Degradation. Available on The Ramsar Convention on Wetlands' web site at www.ramsar.org/about_wetland_loss.htm.

Wetland Issues. Available on-line at www.ncseonline.org/NLE/CRSreports/Wetlands/wet-5.cfm.

Wetlands Loss and Degradation. Visit the North Carolina State University Water Quality Group's on-line informational database, WATERSHEDSS, at h2osparc.wq.ncsu.edu/info/wetlands/wetloss.html.

Wetlands and Agriculture: Private Interests and Public Benefits, Ralph E. Heimlich et al. USDA–ERS Report No. 765. Available on-line at www.ers.usda.gov/publications/aer765.

United States
Environmental Protection
Agency

Office of Water
Office of Wetlands,
Oceans and Watersheds (4502T)

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September 2001

Types of Wetlands

Do you think all wetlands are the same? Think again. Each wetland differs due to variations in soils, landscape, climate, water regime and chemistry, vegetation, and human disturbance. Below are brief descriptions of the major types of wetlands found in the United States organized into four general categories: marshes, swamps, bogs, and fens.

MARSHES are periodically saturated, flooded, or ponded with water and characterized by herbaceous (non-woody) vegetation adapted to wet soil conditions. Marshes are further characterized as tidal marshes and non-tidal marshes.

The Vernal Pool Association

Many vernal pools fill with water in fall or spring.

Tidal (coastal) marshes occur along coastlines and are influenced by tides and often by freshwater from runoff, rivers, or ground water. Salt marshes are the most prevalent types of tidal marshes and are characterized by salt-tolerant plants such as smooth cordgrass, saltgrass, and glasswort. Salt marshes have one of the highest rates of primary productivity associated with wetland ecosystems because of the inflow of nutrients and organics from surface and/or tidal water. Tidal freshwater marshes are located upstream of estuaries. Tides influence water levels but the water is fresh. The lack of salt stress allows a greater diversity of plants to thrive. Cattail, wild rice, pickerelweed, and arrowhead are common and help support a large and diverse range of bird and fish species, among other wildlife.

Leigh Dunkelberger

Freshwater marshes, like this one in Sequoia National Park, are dependent on rainfall, runoff, and seasonal flooding for their water supplies.

Dave Davis

Farmland surrounds these prairie potholes in Nebraska.

Nontidal (inland) marshes are dominated by herbaceous plants and frequently occur in poorly drained depressions, floodplains, and shallow water areas along the edges of lakes and rivers. Major regions of the United States that support inland marshes include the Great Lakes coastal marshes, the prairie pothole region, and the Florida Everglades.

- ***Freshwater marshes*** are characterized by periodic or permanent shallow water, little or no peat deposition, and mineral soils. They typically derive most of their water from surface waters, including floodwater and runoff, but do receive ground water inputs.
- ***Wet meadows*** commonly occur in poorly drained areas such as shallow lake basins, low-lying depressions, and the land between shallow marshes and upland areas. Precipitation serves as their primary water supply, so they are often dry in the summer.
- ***Wet prairies*** are similar to wet meadows but remain saturated longer. Wet prairies may receive water from intermittent streams as well as ground water and precipitation.
- ***Prairie potholes*** develop when snowmelt and rain fill the pockmarks left on the landscape by glaciers. Ground water input is also important.
- ***Playas*** are small basins that collect rainfall and runoff from the surrounding land. These low-lying areas are found in the Southern High Plains of the United States.
- ***Vernal pools*** have either bedrock or a hard clay layer in the soil that helps keep water in the pool. They are covered by shallow water for variable periods from winter to spring, but may be completely dry for most of the summer and fall.

U.S. Army Corps of Engineers

Trees found in swamps are sometimes buttressed at the base, which helps anchor them in the saturated soils.

SWAMPS are fed primarily by surface water inputs and are dominated by trees and shrubs. Swamps occur in either freshwater or saltwater floodplains. They are characterized by very wet soils during the growing season and standing water during certain times of the year. Well-known swamps include Georgia's Okefenokee Swamp and Virginia's Great Dismal Swamp. Swamps are classified as forested, shrub, or mangrove.

Forested swamps are found in broad floodplains of the northeast, southeast, and south-central United States and receive floodwater from nearby rivers and streams. Common deciduous trees found in these areas include bald cypress, water tupelo, swamp white oak, and red maple.

Forested swamps serve a critical role in the watershed by reducing the risk and severity of flooding to downstream areas.

Shrub swamps are similar to forested swamps except that shrubby species like buttonbush and swamp rose dominate.

Mangrove swamps are coastal wetlands characterized by salt-tolerant trees, shrubs, and other plants growing in brackish to saline tidal waters. These tropical and subtropical systems have a North American range that extends from the southern tip of Florida along the Gulf Coast to Texas.

BOGS are freshwater wetlands characterized by spongy peat deposits, a growth of evergreen trees and shrubs, and a floor covered by a thick carpet of sphagnum moss. These systems, whose only water source is rainwater, are usually found in glaciated areas of the northern United States. One type of bog, called a pocosin, is found only in the Southeastern Coastal Plain.

FENS are ground water-fed peat-forming wetlands covered by grasses, sedges, reeds, and wildflowers. Willow and birch are also common. Fens, like bogs, tend to occur in glaciated areas of the northern United States.

Dave Davis

Bog ecosystems support cranberries, blueberries, and carnivorous plants like the pitcher plant.

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Wetland Resources

On the Internet

EPA's Wetland Home Page contains information and pictures on several types of wetlands ..... www.epa.gov/owow/wetlands/types

Types of Wetlands and Their Roles in the Watershed, part of North Carolina State University's WATERSHEDSS h2osparc.wq.ncsu.edu/info/wetlands/types3.html

Wetlands of the United States from the USGS Northern Prairie Wildlife Research Center www.npwrc.usgs.gov/resource/1998/uswetlan/types.htm

Prairie Potholes www.greatplains.org/resource/1999/ppjv/ppjv.htm

In Print

Wetlands. 3rd Edition. W.J. Mitsch, and J.G. Gosselink. 2000. John Wiley & Sons, Inc. New York, NY.

In Search of Swampland: A Wetland Sourcebook and Field Guide. R.W. Tiner, 1998. Rutgers University Press, Piscataway, NJ.

Adopting a Wetland—A Northwest Guide. S. Yates. 1989.

United States Environmental Protection Agency

Protecting Wetlands for Amphibian and Reptile Conservation

Wetlands are important elements of a watershed because they serve as the vital link between land and water resources. Wetlands play an integral role in the ecology of a watershed. Their shallow waters, nutrients, and primary productivity are ideal for organisms that form the base of the food web upon which many species of wildlife depend. Wetland habitat provides the necessary food, water and shelter for mammals and migrating birds. Other animals, such as amphibians and reptiles, collectively known as herpetofauna, or "herps," depend on wetlands for all or part of their life cycle, meaning that their survival is directly linked to the presence and condition of wetlands.

Amphibians and Reptiles Depend on Wetlands

Wetlands serve as critical habitat for many species of amphibians and reptiles. Most amphibians lay gelatinous eggs under water, while others, like certain salamanders, lay their eggs on moist land. After the eggs hatch, the baby amphibians enter an aquatic larval stage, which can last from several days to many months. Once the aquatic stage is completed, the amphibians leave the water and enter the terrestrial adult stage of life. Wetlands serve as breeding sites, as a habitat for larval development and as a primary food source for adults. Insects, spiders, snails, worms and small fish are all prey for certain amphibians.

Amphibians and reptiles depend upon a variety of wetland types. These may include marshes, swamps, bogs and fens (and their associated subclasses). Some wetlands are only wet a portion of the year and are considered "ephemeral" wetlands. These wetlands provide important habitat and breeding grounds (see side bar).

There are often strong ecological connections among wetlands in a landscape. Although some may be permanent and others ephemeral, amphibian populations can depend on multiple wetlands within a given area. To protect these species over the long term, the variety and density of suitable habitat sites within the landscape must be preserved, along with terrestrial corridors that connect the wetlands.

For many reptiles, wetlands also serve as primary habitat, supplying them with an ample source of food and habitat for breeding and nursing. Specially adapted reptiles that are able swimmers are likely to be found in wetlands. Some of these include the common snapping turtle, spotted turtle, northern water snake, cottonmouth snake, diamondback water snake and garter snakes.

Photo courtesy of PARC

Garter Snake *(Thamnophis elegans)* - When disturbed, garter snakes will release an unpleasant smelling musk from glands located at the base of their tail.

Why are ephemeral wetlands important?

Vernal pools, one type of ephemeral wetland, are of critical importance to amphibian populations. As small, often isolated wetlands, vernal pools are only wet for a portion of the year. Periodic drying creates a fish-free environment for amphibians, many of which have adapted rapid egg and larval stages as a race against the dry season. The absence of fish predators in vernal pools benefits amphibian populations.

Threats to Herps and Wetlands

Photo by Jay Osenkowski

The American toad *(Bufo americanus)* is one of the most commonly heard frog or toad species in the United States. The male toad's call is a long, uninterrupted 15-20 second trill that can be heard over a long distance.

In order to maintain healthy amphibian and reptile populations, wetland habitat must be protected. A watershed contains multiple habitats, all of which are affected by changes in hydrology, land use and water quality. Since no habitat is isolated from its surroundings, protection of herps must take place at both the large-scale watershed level and at the smaller scale of individual wetlands.

Population declines and disappearances of amphibians and reptiles leading to widespread scientific and public concern have been well documented. The causes for their decline, while not fully understood, appear to be complex and numerous.

Wetland Habitat Loss

Over 220 million acres of wetlands are thought to have existed in the lower 48 states prior to 1700. Since then, extensive losses have occurred, and over half of our original wetlands have been drained and converted to other uses. Though the rate of loss has decreased in recent decades, wetlands and other aquatic resources are still threatened by activities such as ditching, draining, dredging and stream channelization; deposition of fill material for commercial and residential development, dikes, levees and dams; crop production, logging and mining. Since many amphibian species need both aquatic and terrestrial habitat, it is very important to preserve wetlands and a buffer strip of adequate upland habitat.

47 of the 60 reptile species found in Illinois rely upon wetlands

Why are amphibians so vulnerable?

Some amphibians breathe through their porous skin, which makes them extremely vulnerable to pollution in the soil, air, and water. You can think of amphibians as sponges that soak up their surrounding environment. This is why you shouldn't try to catch frogs if you have insect repellent on- the toxic repellent will seep into their skin and harm them.

Chemical Pollution

Due to their amphibious lifestyles, herpetofauna are very sensitive to changes in the water and surrounding land. Many synthetic organic compounds and metals adversely affect amphibians and reptiles. Sublethal effects of chemical pollutants can impair a herp's ability to swim, catch food and reproduce successfully. Amphibians are particularly sensitive to chemical contaminants owing to their permeable eggs and skin. A recent study by the U.S. Geological Survey (USGS) showed that "organophosphorus pesticides from agricultural areas, which are transported to the Sierra Nevada on prevailing summer winds, may be affecting populations of amphibians that breed in mountain ponds and streams." The scientists estimate that damage could be even worse for those species more closely associated with water.

Endocrine disrupting chemicals (EDC) have been of great concern in the amphibian and reptile community. Studies have shown that chemicals like polychlorinated biphenyls (PCBs) build up in turtle eggs, reduce eggshell thickness and cause reproductive failure. Other studies have shown reduced male organ size among reptiles, which results in difficult sex recognition and the subsequent lack of reproduction. Both amphibians and reptiles are very susceptible to the dangers of EDCs.

Photo by Alan Savitsky

Marbled Salamander (*Abystoma opacum*) - Courtship begins when the male nudges the female with his snout.

Nutrient Loading

The indirect effects of excess nutrients can be very detrimental to amphibians. Nutrients such as nitrogen and phosphorous can cause dominance of algae, which is not conducive to laying eggs. Excess nutrients can also reduce the amount of oxygen available in the water for amphibian tadpoles and alter the composition and numbers of the invertebrate communities that are food for the juveniles. In Texas, playa wetlands receiving nutrient-laden feedlot effluent were devoid of amphibians found in natural wetlands. In this case, experiments indicated that the nutrient concentrated effluent had to be reduced to less than 3% of its original strength in order to minimize adverse effects.

Some turtles, such as the diamondback terrapin, are endangered owing to commercial harvesting, stemming primarily from the food industry.

The pet trade also endangers many reptiles, such as the box turtle.

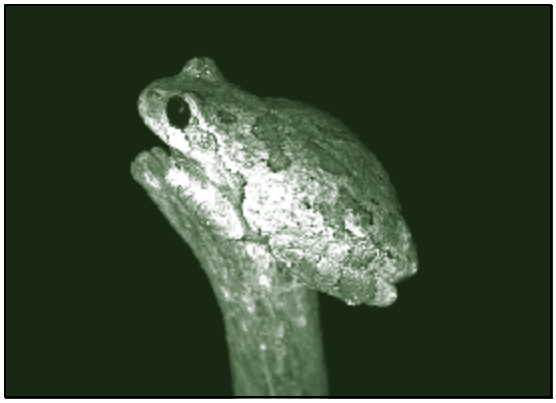


Photo by Melinda Knutson

Eastern Gray Treefrog (*Hyla versicolor*) - Its call is a resonant, flutelike trill similiar to the call of the red-bellied woodpecker. Depending upon its environment, this treefrog can range in color from bright green to gray. They breed in permanent to semi-permanent wetlands.

On the whole, it is difficult to document reptile population trends. Many species have secretive natures, which, when combined with large home ranges, low population densities and a rarity of congregational behavior, may result in a severe population decline without being noticed by people.

Photo by Mark Bright

American Crocodile *(Crocodylus acutus)* - Once hunted intensively for their hides, today poaching and the loss of habitat to human development are the greatest threats faced by American crocodiles.

Additional Threats

Global climate change *may threaten aquatic and semiaquatic life by reducing wetland acreage due to frequency and severity of storms and sea level rise. Latitudinal shifts in temperature and precipitation patterns also threaten herps.*

Ozone depletion *causes an increase in the amount of Ultraviolet radiation that reaches the earth's surface and waters. Research has shown that UV-B radiation has adverse effects on some amphibians. The Montreal Protocol has reduced emissions of ozone-depleting chemicals.*

Invasive species *pose a constant threat to native herps. Invasive plants and animals can alter the ecological community that is relied upon by native reptiles and amphibians. Invasive herpetofauna can also directly damage native populations. In many parts of the U.S., invading bullfrogs are preying on and often eliminating other amphibians, as well as impacting some reptiles and fish.*

Disease and Parasites ***s****ignificantly contribute to declining amphibian and reptile populations. To help prevent the spread of disease and parasites, follow careful washing procedures when traveling between wetlands.*

Conservation Efforts for Amphibians and Reptiles

Conservation efforts for amphibians and reptiles come in many different forms. Like other wildlife conservation efforts, the first step is to identify and monitor existing populations. The USGS has a volunteer monitoring program where participants learn to identify local frog calls and submit observational data at different times of the year.

Fortunately, laws are being passed in some States to protect herpetofauna. New Jersey adopted special protections for vernal pools to ensure sufficient regulatory review. California enforces laws to prevent people from taking native reptiles and amphibians without a license, except common herp species. The laws also forbid the sale of herpetofauna for human consumption. Various bird and wetland initiatives have positive impacts on herps as well.

The North American Wetlands Conservation Act (NAWCA), a habitat-oriented program led by the U.S. Fish and Wildlfe Service, has been particularly helpful to amphibians and reptiles, as waterfowl and herpeto-fauna often share the same habitat. The conservation programs within the U.S. Department of Agriculture's Farm Bill program also help to preserve or restore habitat for herpetofauna.

Photo courtesy of PARC

The chicken turtle (*Deirochelys reticularia*) is found in the southeastern United States from southeast Virginia to east Texas. Their preferred habitat includes quiet bodies of water such as ponds, swamps, and marshes. Although an aquatic species, it readily wanders and is often found out of water. They are mainly carnivorous, and their diet includes tadpoles and crayfish.

How Can You Help?

You can help to save amphibian and reptile diversity in many different ways. On a larger scale, working to protect your watershed is the first step to ensuring clean water and healthy habitat for herps. You should:

- Prevent soil erosion by seeding for grass or planting shrubs;
- Avoid dumping chemicals down drains;
- Maintain vegetative buffer strips between your land and any surface waterbody; and
- Avoid releasing or transporting exotic plant or animal species into the environment.

Protecting surface water and wetlands is important to promoting herp diversity. Identfying, monitoring and restoring local wetlands are great ways to educate yourself and your community about the important functions and values of wetlands. Supporting public and private organizations involved in habitat protection is another way to help. Further information can be found at http://www.epa.gov/owow/wetlands/vital/protection.

PARC - Partners in Amphibian and Reptile Conservation

Partners in Amphibian and Reptile Conservation (PARC) is the largest herpetological conservation partnership in the nation. They are a habitat-focused partnership involving State agencies, Federal agencies, the private sector, conservation organizations, and the academic community. The partnership is dedicated to protecting endangered reptile and amphibian species and keeping common native species common. Their website (www.parcplace.org) contains educational materials on the conservation of amphibians and reptiles along with an extensive list of weblinks.

EPA 843-F-03-015
Office of Water

Additional Resources

On the Internet

Partners for Amphibian and Reptile Conservation ..... www.parcplace.org

U.S. Environmental Protection Agency ..... www.epa.gov/owow/wetlands

U.S. Geological Society ..... www.usgs.gov/amphibians

U.S. Fish and Wildlife Service ..... www.wetlands.fws.gov

USDA Natural Resources Conservation Service ..... www.nrcs.usda.gov/programs/wrp

United States
Environmental
Protection Agency

Wetlands Overview

Dave Davis

Is there a wetland in your neighborhood?

The best way to find out if there's a wetland in your watershed or neighborhood is to contact your Natural Resources Conservation Service office or local public works or planning department. Most have specialists trained in identifying and delineating wetlands. The U.S. Fish and Wildlife Service's National Wetland Inventory maps can also help. The maps indicate open water and likely wetland areas. For copies, call 1-888-ASK-USGS or visit the National Wetlands Inventory web site at www.nwi.fws.gov.

What Is a Wetland?

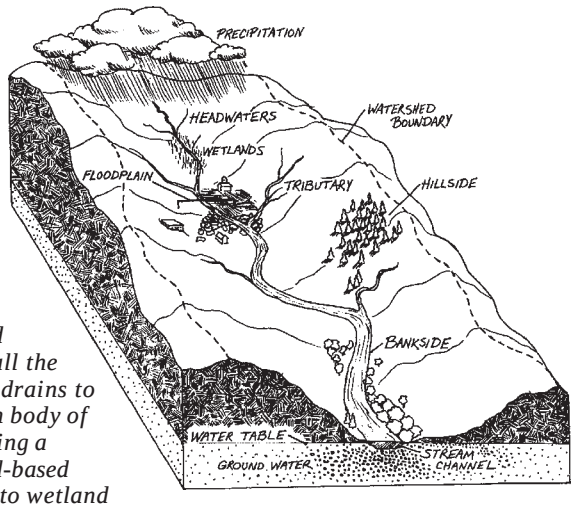
Although wetlands are often wet, a wetland might not be wet year-round. In fact, some of the most important wetlands are only seasonally wet. Wetlands are the link between the land and the water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils, and vegetation—making these areas very important features of a watershed. Using a watershed-based approach to wetland protection ensures that the whole system, including land, air, and water resources, is protected.

Wetlands found in the United States fall into four general categories—marshes, swamps, bogs, and fens. Marshes are wetlands dominated by soft-stemmed vegetation, while swamps have mostly woody plants. Bogs are freshwater wetlands, often formed in old glacial lakes, characterized by spongy peat deposits, evergreen trees and shrubs, and a floor covered by a thick carpet of sphagnum moss. Fens are freshwater peat-forming wetlands covered mostly by grasses, sedges, reeds, and wildflowers.

Good News

Often called "nurseries of life," wetlands provide habitat for thousands of species of aquatic and terrestrial plants and animals.

Although wetlands are best known for being home to water lilies, turtles, frogs, snakes, alligators, and crocodiles, they also provide important habitat for waterfowl, fish, and mammals. Migrating birds use wetlands to rest and feed during their cross-continental journeys and as nesting sites when they are at home. As a result, wetland loss has a serious impact on these species. Habitat degradation since the 1970s has been a leading cause of species extinction.



A watershed includes all the land that drains to a common body of water. Using a watershed-based approach to wetland protection ensures that the whole ecosystem is protected.

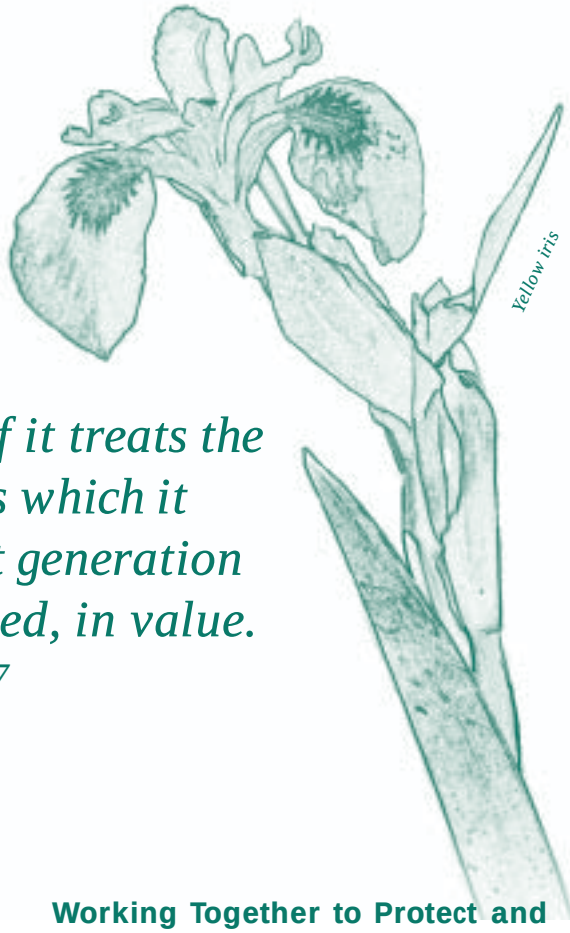
Two-thirds of the 10 million to 12 million waterfowl of the continental United States reproduce in the prairie pothole wetlands of the Midwest. In the winter millions of ducks like these can be found in the wetlands of the south-central United States.

Dave Davis

This forested wetland on the Chincoteague National Wildlife Refuge on Virginia's Eastern Shore is part of the Atlantic flyway, where shorebirds and waterfowl rest before they migrate south for the winter.

Dave Davis

A freshwater pool at Assateague National Seashore in Virginia.



Yellow iris

The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired, in value.

—Theodore Roosevelt, 1907

Living systems cleanse water and make it fit, among other things, for human consumption.

Elliot A. Norse, in R.J. Hoage, ed., *Animal Extinctions,* 1985, Smithsonian Press.

Wetlands do more than provide habitat for plants and animals in the watershed. When rivers overflow, wetlands help to absorb and slow floodwaters. This ability to control floods can alleviate property damage and loss and can even save lives. Wetlands also absorb excess nutrients, sediment, and other pollutants before they reach rivers, lakes, and other waterbodies. They are great spots for fishing, canoeing, hiking, and bird-watching, and they make wonderful outdoor classrooms for people of all ages.

Bad News

Despite all the benefits provided by wetlands, the United States loses about 60,000 acres of wetlands each year. The very runoff that wetlands help to clean can overload and contaminate these fragile ecosystems. In addition, nonnative species of plants and animals and global climate change contribute to wetland loss and degradation.

What Is EPA Doing to Protect Wetlands?

EPA has a number of programs for wetland conservation, restoration, and monitoring. EPA, along with the U.S. Army Corps of Engineers (Corps), establishes environmental standards for reviewing permits for discharges that affect wetlands, such as residential development, roads, and levees. Under Section 404 of the Clean Water Act, the Corps issues permits that meet environmental standards (after allowing the public to comment).

Working Together to Protect and Restore Wetlands

In addition to providing regulatory protection for wetlands, EPA works in partnership with states, tribes, and local governments, the private sector, and citizen organizations to monitor, protect, and restore these valuable habitats. EPA is helping states and tribes incorporate wetland monitoring, protection, and restoration into their watershed plans. EPA is also developing national guidance on wetland restoration, as well as constructed wetlands used to treat storm water and sewage. Nationally, EPA's Five-Star Restoration Program provides grants and promotes information exchange through community-based education and restoration projects.

EPA works with a variety of other federal agencies to protect and restore wetlands, including the U.S. Fish and Wildlife Service, the U.S. Department of Agriculture, and the National Marine Fisheries Service. EPA is working with these agencies and others to achieve an overall increase of wetlands over the next five years. EPA also partners with private interests and public organizations like the Association of State Wetland Managers, the National Association of Counties, local watershed associations, schools, and universities to advance conservation and restoration programs.

How Can I Help?

First, identify your watershed and find the wetlands in your neighborhood. Learn more about them and share what you learn with someone you know! Encourage neighbors, developers, and state and local governments to protect the functions and values of wetlands in your watershed.

To prevent wetland loss or degradation, follow these simple guidelines:

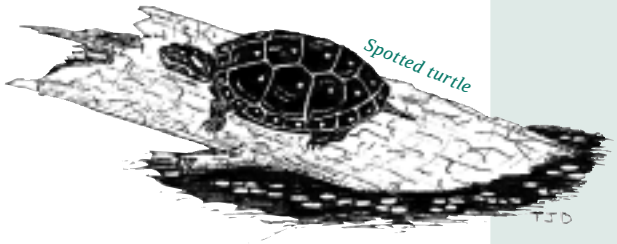
- Invest in wetlands by buying duck stamps. Proceeds from these $15 migratory bird hunting stamps support wetland acquisition and restoration. The stamps are available on-line at the U.S. Fish and Wildlife Service's web site (www.fws.gov) or at your local post office.
- Instead of draining or filling wetlands, find more compatible uses, such as waterfowl and wildlife habitat.
- When developing your landscaping plan, keep wetlands in mind. Plant native grasses or forested buffer strips along wetlands on your property to protect water quality.
- Participate in a volunteer wetland monitoring program.
- Plan to avoid wetlands when developing or improving a site. Get technical assistance from your state environmental agency before you alter a wetland.
- Maintain wetlands and adjacent buffer strips as open space.
- Support your local watershed association.
- Plan a wetland program or invite a wetland expert to speak at your school, club, youth group, or professional organization.
- Build a wetland in your backyard. Learn how by visiting the U.S. Department of Agriculture's web site at www.nrcs.usda.gov/feature/backyard/

Dave Davis

Wetland habitat along this Idaho riparian corridor provides food and shelter for diverse wildlife species.

Dave Davis

If bottomland hardwood swamps are protected, Bald Cypress trees like these can grow for more than 2000 years.



Wetlands can be found in every county and climatic zone in the United States.

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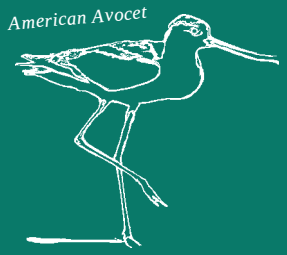
Office of Water
December 2004



Wetland Resources

On the Internet

EPA's Wetland Home Page ..... www.epa.gov/owow/wetlands

USDA's Wetland Reserve Program ..... www.nrcs.usda.gov/programs/wrp

The Association of State Wetland Managers ..... www.aswm.org

National Marine Fisheries Service Restoration Center ..... www.nmfs.noaa.gov/habitat/restoration

USDA NRCS's Wetland Science Institute ..... www.pwrc.usgs.gov/WLI

National Wetlands Inventory Center ..... www.nwi.fws.gov

Izaak Walton League ..... www.iwla.org

U.S. Fish and Wildlife Service ..... www.fws.gov

Army Corps of Engineers ..... www.usace.army.mil

USGS National Weltands Resources Center ..... www.nwrc.usgs.gov

U.S. Forest Service ..... www.usda.fs.gov

In Print

America's Wetlands: Our vital link between land and water. Available on the Internet at www.epa.gov/owow/wetlands/vital/toc.html.

Our National Wetland Heritage: A Protection Guide, Jon Kusler and Teresa Opheim. Available from the Association of State Wetland Managers. Call (518) 872-1804 or visit www.aswm.org.

Wetlands, 3rd edition, William J. Mitsch and James G. Gosselink. Available from the Association of State Wetland Managers. Call (518) 872-1804 or visit www.aswm.org.

History of Wetlands in the Conterminous United States: National Water Summary on Wetland Resources, U.S. Geological Survey Water Supply Paper 2425. Available from the U.S. Fish and Wildlife Service at wetlands.fws.gov/bha or from the U.S. Geological Survey at water.usgs.gov/nwsum/WSP2425/history.html.

National Wetlands Status and Trends Study and Report for the Year 2000. Available from the U.S. Fish and Wildlife Service at wetlands.fws.gov/bha.

Recognizing Wetlands. Available from the U.S. Army Corps of Engineers at www.wes.army.mil/el/wetlands.

United States Environmental Protection Agency
Office of Water
Office of Wetlands, Oceans and Watersheds (4502T)
EPA 843-F-01-002e
March 2002

Wetland Restoration

Wetlands are one of the most valuable and fragile components of a watershed, but for many years they were filled and drained for agriculture and development. Now we are learning that wetlands are crucial to the health of our waters and wildlife. Wetland restoration, the renewal of natural and historical wetlands that have been lost or degraded, is a growing activity. It can improve water quality and wildlife habitat across the nation.

Wetland restoration involves renewing natural and historical wetlands that have been lost or degraded.

What Is Restoration?

Restoration is the return of a degraded wetland or former wetland to its preexisting naturally functioning condition, or a condition as close to that as possible. It is a complex process that requires expertise, resources, and commitment from many different stakeholders. Ideally, a successfully restored wetland will mimic the functions of a healthy natural wetland.

All restoration projects require planning, implementation, monitoring, and management. Many projects require a team with expertise in ecology, hydrology, engineering, and environmental planning. Getting local experts and the community involved gives the project local ownership, which is important for restoration success.

Why Restore Wetlands?

Restoring our lost and degraded wetlands to their natural state is essential to ensure the health of America's watersheds. Unless we reverse the tide of wetland loss, the quality of our waters will continue to be threatened and a part of our natural heritage will be lost. The quality of America's waters is closely linked to the integrity of America's wetlands. Over the past 200 years, wetlands have vanished at an alarming rate. More than half of our nation's original natural wetlands in the contiguous states have been lost to agriculture and development. Many of the wetlands that remain today continue to be degraded. Such losses and damage hamper wetland functions, such as water quality protection, habitat for fish and other wildlife, and flood prevention. Read more about wetland and watershed restoration at EPA's web site at www.epa.gov/owow/wetlands/restore.

Through its Five-Star Restoration Program, EPA is working with multiple partners to reach a goal of 500 community-based wetland restoration projects across the nation.

Community-based Wetland Restoration

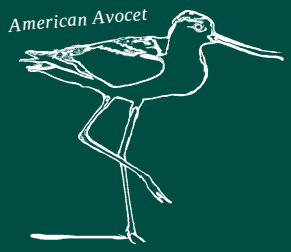
EPA is working with its partners on community-based wetland restoration projects in 500 watersheds across the nation. EPA's Five-Star Restoration Program (www.epa.gov/owow/wetlands/restore/5star), provides wetlands challenge grants, facilitates technology/information transfer and partnership collaboration, and supports peer-to-peer communication programs.

If you want to restore a wetland on your property or in your community, many different organizations and agencies can help. Many land-owners are eligible to enroll in federal programs that provide restoration expertise and funding, such as the USDA's Conservation Reserve Program or the Fish and Wildlife Service's Partners for Fish and Wildlife Program. If your project doesn't qualify for such a program or it is a community project involving many different stakeholders, you might want to hire a professional to draft a plan and put together a team to do the work. You can obtain more information through the web sites and resources listed on the reverse.

LOCAL YOUTH RESTORE NEW YORK MARSH

Youth organizations are working hard to restore and protect an urban wetland in Utica, New York. The marsh is home to more than 190 bird species and 250 plant species. The Sustainable Utica Project, headed by Utica Community Action, Inc. (UCAI), recently became one of eight youth corps organizations nationwide to receive a $20,000 grant from EPA's Five-Star Restoration Grant Program. Over the next few months, project organizers will improve existing nature trails to make the entire trail network accessible to the public. They'll also develop a nature interpretation trail system for marsh visitors that will enhance public understanding of the wetland's value. UCAI will also remove invasive plants, trash, and other debris from the marsh to enhance its wildlife habitat value. So far, they have removed 6 tons of garbage from the marsh. In addition to promoting conservation education and tourism, the project will generate economic development opportunities for the local community. For more information, contact John Furman, Program Planner, Utica Community Action, Inc., 253 Genesee Street, Utica, NY 13501. Phone: (315) 797-7364; fax: (315) 792-1983; e-mail: JFurman835@aol.com.

The Wetland Fact Sheet Series



Wetlands Overview
Types of Wetlands
Functions & Values of Wetlands
Threats to Wetlands
Wetland Restoration
Funding Wetland Projects
Wetland Monitoring & Assessment
Sustainable Communities
Volunteering for Wetlands
Teaching about Wetlands

For more information, visit www.epa.gov/owow/wetlands.

Wetland Resources

On the Internet

EPA's River Corridor and Wetland Restoration home page ..... www.epa.gov/owow/wetlands/restore
USDA's Conservation Reserve Program ..... www.fsa.usda.gov/dafp/cepd/crpinfo.htm
USDA's Wetland Reserve Program ..... http://wl.fb-net.org
Partners for Fish and Wildlife Program ..... http://partners.fws.gov
The Association of State Wetland Managers ..... www.aswm.org
Society for Ecological Restoration ..... www.ser.org
National Wetlands Conservation Alliance ..... http://users.erols.com/wetlandg
National Marine Fisheries Service Restoration Center ..... www.nmfs.noaa.gov/habitat/restoration
Chesapeake Bay Program. ..... www.chesapeakebay.net
Society of Wetland Scientists ..... www.sws.org
Izaak Walton League of America ..... www.iwla.org/siteindx.htm

In Print and On Video

A Citizen's Guide to Wetland Restoration (EPA910-R-94-006). Available from EPA Region 10. Call (206) 553-1200.

Wetland Creation and Restoration: The Status of the Science, Jon Kusler and Mary Kentula, 1990. Available from Island Press. Call 1-800-828-1302.

Wetlands: An Approach to Improving Decision-Making in Wetland Restoration and Creation, Mary Kentula et al., 1992. Available from Island Press. Call 1-800-828-1302.

Wetland Restoration: Steps to Success. This 21-minute video from The Wetlands Conservancy discusses techniques for wetland restoration, including using native plants and when and where to plant. For copies, call The Wetland Conservancy at (503) 691-1394.

Restoration, Creation, and Recovery of Wetlands: National Water Summary on Wetland Resources, Mary Kentula, 1999. United States Geological Survey Water Supply Paper 2425. Available on-line at http://water.usgs.gov/nwsum/WSP2425/restoration.html.

EPA United States Environmental Protection Agency

Wetlands: Protecting Life and Property from Flooding

Wetland Hydrology and Flood Control

Wetlands are transition zones between uplands and deeper water, unique ecosystems characterized by their hydrology, soils and vegetation. They function like natural tubs, storing flood waters that overflow riverbanks and surface water that collects in depressional areas. In this way, wetlands can help protect adjacent and downstream property from flood damage.

The Federal Emergency Management Agency (FEMA) states that floods are the most common and widespread of all natural disasters—except fire. Most communities in the United States have experienced some kind of flooding. FEMA encourages the use of wetlands for stormwater detention in lieu of, or in conjunction with, traditional structural flood control measures. (Source: FEMA)

How Do Wetlands Help Reduce Flooding?

The effectiveness of wetlands for flood abatement may vary, depending on the size of the area, type and condition of vegetation, slope, location of the wetland in the flood path and the saturation of wetland soils before flooding. A one-acre wetland can typically store about three-acre feet of water, or one million gallons. An acre-foot is one acre of land, about three-quarters the size of a football field, covered one foot deep in water. Three acre-feet describes the same area of land covered by three feet of water. Trees and other wetland vegetation help slow the speed of flood waters. This action, combined with water storage, can actually lower flood heights and reduce the water's destructive potential. (Source: EPA)

The Wetlands Initiative completed an 18-month study, "Flood Damage Reduction in the Upper Mississippi River Basin: An Ecological Means." The study revealed that restoring the 100-year flood zone of the Upper Mississippi five-state watershed could store 39 million acre-feet of floodwater, the volume that caused the Great Flood of 1993, and save over $16 billion in projected flood damage costs.

In Minnesota, an additional study by The Wetlands Initiative noted that flood peaks and damage costs would be decreased by restoring the natural hydrology of the floodplain. The cost of replacing the flood control function of the 5,000 acres of wetlands drained each year in Minnesota alone would be $1.5 million, compared to the potentially millions of dollars lost to flooding. Preserving wetlands in the first place and restoring some of those that have been drained could help reduce future flood losses. (Source: The Wetlands Initiative)

Preserving and protecting coastal wetlands can help reduce storm damage. St. Stanislaus was a boy's Catholic Boarding School over a hundred years old in Bay St. Louis, MS. Located on the beach overlooking the Gulf, it was destroyed by Hurricane Katrina. This picture was taken before the building disintegrated.

Where Wetland

Where Wetlands are Helping

These studies and others indicate that wetlands may play a part in flood abatement. The following examples illustrate how communities across the country are restoring wetlands in order to reduce the threat and costs of flood damage.

Charles River, Massachusetts

Along the Charles River in Massachusetts, the U.S. Army Corps of Engineers (the Corps) has acted to utilize wetlands in preventing flood damage. It was calculated that loss of all wetlands in the Charles River watershed would have caused an average annual flood damage cost of $17 million. The Corps concluded that conserving wetlands was a natural, less expensive solution to controlling flooding than the construction of dikes and dams alone, and they proceeded to acquire 8,103 acres of wetlands in the Charles River basin for flood protection. (Source: U.S. Army Corps of Engineers – Charles River Natural Valley Storage Area)

Horseshoe Park, Colorado

In 1982, an earthen dam on Lawn Lake in Rocky Mountain National Park collapsed, suddenly releasing almost 700 acre-feet of water into the Roaring River. A wall of water 25 to 30 feet high moving at 9 miles per hour rushed downstream and entered Fall River at Horseshoe Park. The Park contained wetlands adjacent to the river, with meadow grasses, reed and dense willow stands. Here the flood wave spread across the broad, flat valley and was slowed by wetland vegetation. The height of the wall of water was reduced to about 10 feet, and the water spread out over the meadow to a width of 1,300 feet. The flood was finally contained by Olympus Dam on Lake Estes, but it had claimed 4 lives and caused $31 million in damage. If not for the wetlands and meadows at Horseshoe Park, the damage would have been much worse. The height and speed of flood waters were reduced by the wetland vegetation, and the damaging flood peak was greatly reduced. (Source: Jarrett and Costa 1984)

Paul McIver

In 1982 these meadows and wetlands at Horseshoe Park in Colorado were hit by a 25 to 30 foot wall of water. The height and speed of the flood waters were reduced by the wetland vegetation, and the damaging flood peak was greatly reduced.

Grand Kankakee Marsh, Indiana

In 1900, the Kankakee Marsh was one of the largest, most ecologically diverse wetlands in the United States. During the 20th century much of the marsh was drained and converted to agricultural use. Channelization of the Kankakee River, which fed the marsh, reduced its length from 250 to 90 miles. As a result, water quality was degraded and flooding increased. An ambitious project was undertaken to address these concerns. The project, featuring diverse partners from all levels of government, private conservation groups and business, was designed to restore over 25,000 acres of wetlands. With a grant from the North America Wetlands Conservation Act and donations of cash and land, 3,000 acres of wetlands have already been restored. Waterfowl populations have increased, water quality is improving and flooding has decreased. (Source: National Park Service, "Floods, Floodplains and Folks", 1996, U.S. Fish and Wildlife Service, Private Lands Office)

Mayview Wetland Project, Pennsylvania

The Pennsylvania Department of Transportation (DOT) completed a wetland restoration project to offset impacts to 32 acres of wetlands that were filled during the construction of Interstate 279 through Southwestern Pennsylvania and the Southern Expressway. The site of the wetland restoration is Mayview, a 65-acre piece of land, flanking Chartiers Creek, a major stream. The creek was subject to frequent, high velocity flooding and constructing wetlands there is helping control these floods. The new wetlands provide flood storage capacity for 63 million gallons of water and serve as an outdoor classroom for nearby schools. The Department of Transportation is seeking funding to restore additional acreage. (Source: National Park Service, "Floods, Floodplains and Folks", 1996)

Prairie Wolf Slough, Illinois

The Middle Fork of the North Branch of the Chicago River flows through an abandoned farm field in the suburbs. The area was identified as the future location for a trail, part of the North

Branch of the Chicago River Open Space Plan designed by the Friends of the Chicago River and Lake County Stormwater Management Commission, a regional open space advocacy organization. By restoring wetlands hydrology, clearing non-native vegetation and planting wetland, prairie and savanna vegetation, the functions and values of the wetlands have been restored. Structures used to drain the area for farming were removed, and a new water control structure was constructed to decrease sedimentation of the river. The result was moderation of stormwater flows which provided the area with flood protection, as well as permanent open space and new environmental education opportunities. (Source: National Park Service, "Floods, Floodplains and Folks", 1996, Friends of the Chicago River)

Vermillion River, South Dakota

The Vermillion River has always flooded. It has a narrow channel and flows slowly, making it "flood prone." Thousands of years ago, this part of South Dakota was scoured by glaciers that carved out shallow depressions which remain today and seasonally fill with water. These "prairie potholes" are intermittent, seasonal wetlands which dot the landscape. They quickly thaw in spring and provide habitat for a multitude of migratory birds and other water fowl.

For hundreds of years, the rain and snow melt in the watershed were held in these wetlands, and runoff across the prairie was slowed. As South Dakota became populated, many prairie potholes were filled to facilitate farming. While these wetlands are small, they are numerous and can hold a significant amount of flood water. As more wetlands were filled, flooding increased.

The Great Flood of 1993 was devastating to the area. To combat future flooding, structural flood controls were put in place, but they were not sufficient. In response to this problem, the National Park Service and the Federal Emergency Management Agency formed a partnership with the South Dakota Division of Emergency Management and Turner-Lincoln-Clay Counties Water Project District. Working together, this coalition assessed the area and condition of the remaining network of potholes. They developed a plan to protect the remaining wetlands and restored some of those that had been filled.
(Source: National Park Service, "Floods, Floodplains and Folks", 1996, The Vermillion River: Managing the Watershed to Reduce Flooding, Federal Emergency Management Agency)

The Special Case of Coastal Wetlands

Wetlands in many locations play an important role in flood protection. Nowhere is this function more important than along coastal areas. Coastal areas are vulnerable to hurricanes and other powerful storms, and the flat coastal terrain means that land and property can be exposed to the full power of these storms. Preserving and reconstructing coastal marshes can help reduce storm damage. Coastal wetlands serve as storm surge protectors when hurricanes or tropical storms come ashore. in the Gulf coast area, barrier islands, shoals, marshes, forested wetlands and other features of the coastal landscape can provide a significant and potentially sustainable buffer from wind wave action and storm surge generated by tropical storms and hurricanes. (Source: Working Group for Post-Hurricane Planning for the Louisiana Coast)

This diagram indicates that wetlands reduce peak stormwater flows. (Source: Kusler 1983)

More Wetlands Mean Less Flooding

These examples illustrate how protecting and restoring wetlands can reduce the destructive potential of flooding. Wetland restoration and preservation is an important component of a comprehensive flood protection strategy. EPA, working with other federal agency partners, is a resource for state and local decision-makers, providing tools and limited funding for development of state wetland programs. Preserving wetlands, along with other flood control measures, can offer a degree of protection against flooding that is often more effective and costs less than a system of traditional dikes and levees. If more communities protect existing wetlands and increase the quantity of wetlands through restoration projects, we will be better protected against the consequences of floods.

EPA843-F-06-001
Office of Water
May 2006

Wetland Resources

On the Internet:

Charles River Natural Valley Storage Area . . . . . www.nae.usace.army.mil/recreati/crn/crnhome.htm
Federal Emergency Management Agency . . . . . www.fema.gov
Friends of the Chicago River . . . . . www.chicagoriver.org
National Park Service . . . . . www.nps.gov
The Wetlands Initiative . . . . . www.wetlands-initiative.org
U.S. Army Corps of Engineers . . . . . www.usace.army.mil

In Print:

Floods, Floodplains and Folks. 1996. National Park Service. Rivers, Trails and Conservation Assistance Program.

Flood Damage Reduction in the Upper Mississippi River Basin—An Ecological Alternative. 2004. Donald L. Hey, et al. The Wetlands Initiative, Chicago, IL. Available at www.wetlands-initiative.org

Jarrett, R.D., and J.E.Costa. 1984. *Hydrology, geomorphology, and dam break modeling of the July 15, 1982 Lawn Lake Dam and Cascade Lake Dam Failures, Larimer County, Colorado: U.S. Geological Survey Professional Paper 1369.*

Johnson, Rex R. 1997. *The Vermillion River: Managing the Watershed to Reduce Flooding.* Clay County Conservation District, Vermillion, SD.

Additional Wetland Resources

For additional information, visit the U.S. EPA's website (www.epa.gov/owow/wetlands/), call the toll-free Wetlands Helpline at 1-800-832-7828 or refer to the sources below.

On the Internet:

"A New Framework for Planning the Future of Coastal Louisiana after the Hurricanes of 2005." January 26, 2006. Working Group for Post-Hurricane Planning for the Louisiana Coast . . . . . www.umces.edu/la-restore

Association of State Floodplain Managers . . . . . www.floods.org

Association of State Wetland Managers . . . . . www.aswm.org

"Reinventing a Flood Control Strategy." 1994. Donald L. Hey and Nancy S. Philippi. The Wetlands Initiative, Chicago, IL. . . . . www.wetlands-initiative.org

Society of Wetland Scientists . . . . . www.sws.org

U.S. National Weather Service . . . . . www.nws.noaa.gov

Wetlands Status and Trends . . . . . http://wetlandsfws.er.usgs.gov

In Print:

Bradley, A.A., K.W. Potter, T. Price, P. J. Cooper, J. Steffen and D. Francz. 1994. Dahl, T.E. 1990. "Wetland losses in the United States: 1780's to 1980's." Washington, DC. U.S. Department of Interior.

"Flood analysis in DuPage County using HSPF," *Proceedings of the Transportation Research Board (TRB) Annual Meeting*, Washington, DC.

Protecting Floodplain Resources, a Guidebook for Communities. June 1996. The Federal Interagency Floodplain Management Task Force.

Shabman, L. 1994. "Responding to the 1993 Flood: The Restoration Option," *Water Resources Update*, University Council on Water Resources, 95, 26-30.

U.S. National Weather Service, 1993, "Update on Midwestern floods, heat and drought in the East: Special Climate Summary," 93/2, Climate Analysis Center.