

## Ecosystem Services for Society: Terrestrial, Marine, and Freshwater Environments



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Healthy ecosystems enhance our environmental, economic, and social ways of life. Civilization depends on the life-support services that natural ecosystems provide, including regulating climate, helping offset or limit the effects of floods and drought, protecting shorelines from erosion, purifying air and water, detoxifying and decomposing wastes, and pollinating crops and natural vegetation. Healthy ecosystems also provide healthy habitat for diverse fish and wildlife communities. USGS Terrestrial, Freshwater, and Marine Environments scientists produce solid information to identify and predict ecological and societal consequences of short- and long-term environmental changes under various management and policy actions. We develop techniques for restoration and rehabilitation and provide tools that can be used to rehabilitate impaired ecosystems into self-sustaining landscapes and freshwater systems, sustain plants and animals, and find means to adapt management to global change.

### Wetlands

Wetlands give us food and clean water; shelter us from storms, floods, and coastal erosion; provide habitat for birds, fish, and other wildlife; and clean and store water before returning it to us again. USGS conducts research on wetlands from Alaska to Florida.

**Sound Science for Puget Sound:** Puget Sound is the second-largest U.S. estuary, and supports a diverse and economically productive ecosystem with immense cultural, commercial, and recreational value. Yet the Puget Sound is experiencing troubling changes: nearly three-fourths of its salt marshes have been lost, more than a third of its shoreline has been altered, and biologists have reported significant declines for more than 40 species of concern including killer whales, bald eagles, and salmon that depend on the nearshore for food, shelter, or spawning. As population growth continues (more than 1.4 million new

residents are expected by 2025), ongoing USGS and partner research will continue to assist resource managers in identifying how urban development interacts with habitat processes and the nearshore environment, giving them the information they need to manage and plan for change in ecologically and economically sound ways. Examples of our Puget Sound research include investigating how shoreline armoring affects beach-spawning forage fish, and monitoring changes in food web dynamics near urban areas. The USGS collaborates with state, tribal, and federal agencies.



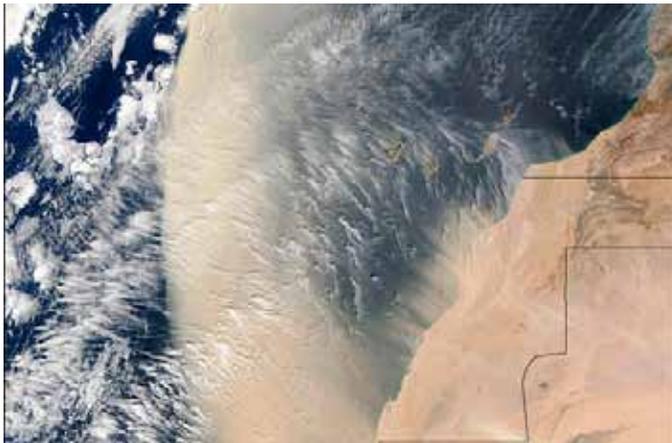
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**Sea-Level Rise, Subsidence, and Wetland Loss in the Mississippi River Delta:** Rising sea levels are threatening coastlines worldwide, but areas where the land is sinking due to natural and human-related activities are particularly vulnerable. The Mississippi River Delta contains vast areas of marshes, swamps, and barrier islands—important habitat for wildlife, as nursery grounds for marine life and rich fisheries, and as protective buffers against storms and hurricanes. However, rapid land

subsidence due to sediment compaction and dewatering, construction of levees, and periodic hurricanes has contributed to increases the rate of submergence in this deltaic system. USGS is studying how these factors combined with global processes such as sea-level rise are causing wetland loss in the region -- these studies are vital to land managers making important decisions that affect not only ecosystems, but also tourism, human safety, and fisheries.

## Coral Reefs and Tropical Ecosystems

Coral reef ecosystems are declining worldwide, and in some places their survival is doubtful. This is both ecologically and economically troubling since coral reefs are the source of essential tourism revenue and local fisheries. In the Caribbean are in decline due to human activities, high water temperatures, and coral diseases. There, we are investigating the causes of decline, as well as African dust, which bring hundreds of millions of tons of mineral dust (including pesticides) to the region each year and may be one cause of coral reef disease, as well as high rates of respiratory illness.



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**Mountain Ridge to Coral Reefs:** As one example our USGS response to coral reef decline, our scientists are working with local communities and agencies in Hawaii and other U.S. islands in the Pacific Ocean to understand major reasons for these declines so managers can take actions for coral reef conservation. Many of these spectacular coral reefs are being degraded by sediment from runoff, and soil loss is made worse by wildfire, agriculture, and grazing by non-native pigs and goats. USGS studies are helping resource managers understand the link between increased sediment loads to reefs and grazing in watersheds, and the speed of recovery of ecosystem services following watershed restoration. For example, after biologists excluded pigs and goats from an experimental site in Hawaii, the result was rapid revegetation and dramatic reductions in erosion within 3 years. Managers are using these and other study results to design mitigation and management policies that make the best use of limited funds.

## Ecosystem Restoration

Interconnected wetlands and uplands are critical elements of most of the North American landscape and profoundly support our quality of life. Consequently, USGS ecosystem restoration projects across the country are restoring or will help restore essential ecosystem services for people and wildlife, such as clean water, buffers against storms, and increased recreational and economic opportunities, such as increased fisheries and tourism.

**Fish and Water Issues in the Sacramento-San Joaquin River Delta:** The Sacramento-San Joaquin River Delta is a highly altered and populated region, with substantial demands on its water resources for about 22 million people, as well as agriculture and important fish species, such as the federally listed Chinook salmon and the Delta smelt. Our multi-discipline ecosystem, fisheries, and water research, done in collaboration with state and federal agencies, is helping Cal-Fed resource managers identify key management actions they can take to both protect these fish species and to have water needed for other agricultural and human uses as well.



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**The Great Lakes: New Approaches to Wetland Restoration:** More than 95 percent of the original wetland habitat along the U.S. shoreline of western Lake Erie has been lost since the 1860s. Most of the remaining coastal wetlands have been isolated by earthen dikes and no longer provide many of the functions and ecosystem services of wetlands. Consequently, more than 40 species of fishes have been negatively affected. USGS researchers and partners installed a novel water-control structure to maintain a more continuous connection between these formerly isolated wetlands, better mimicking historical patterns of water-level fluctuations. We are monitoring subsequent changes to better inform future management decisions and help restore fisheries and other ecosystem services.

**Shoreline Changes and Impacts to Natural Resources in Chesapeake Bay:** Climate change and sea-level rise are expected to affect many miles of shoreline in the Chesapeake Bay and elsewhere along the Atlantic Coast in the coming years. Consequently, federal and state agencies need to have assessments now to plan for the future. The USGS, along with the Smithsonian Institution and a number of universities and other organizations, is conducting studies on many estuaries along the entire Chesapeake Bay and on the ocean coast from Delaware to Virginia. This five-year project will assess watershed condition and shoreline types ranging from bulkhead and riprap to natural marsh. We are also investigating water quality, and vegetation, fish, and waterbird abundance. The resulting information will allow us to assist managers in prescribing shoreline and island management actions that will have the best outcomes for limiting the effects of sea-level rise and climate change on the natural and economic resources impact of the region.

## Fire

USGS fire provides essential information to land and resource managers and fire fighters from Alaska to Florida. And with wildlife impacts becoming worse each successive decade – from 200 to 2008, about 6 ½ million acres burned each year in this country -- this work is increasingly important. USGS, the U.S. Forest Service and The Nature Conservancy, for example, have developed comprehensive geospatial data products characterizing fuels for all U.S. lands. These products, updated every 2 years, are used strategically to allocate firefighting resources, prepare for upcoming fire seasons, and plan large hazardous fuel reduction projects ([www.landfire.gov](http://www.landfire.gov)).

**Managing Wildfire Risks in Southern California:** Our fire work in southern California is an example of fire research going on around the country. Southern California is a world-famous center of industrial, cultural and natural landmarks, but since the mid-20th century, it has seen one or more massive wildfires each decade, with about 500 homes destroyed per year – and fire impacts are becoming worse. In 2001-2010 alone, Southern California saw nearly 10,000 residential structures damaged or destroyed; the ecological damage to



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remaining coastal habitats and endangered species populations is more difficult to account. USGS research not only addresses wildfire risks at the urban-wildland interface to inform community planners, but we also address the ecosystem impacts of these wildfires for federal, state and local land managers. The landscape ecology and wildlife ecology strengths of USGS help Southern California manage its natural and urban landscapes as it continues to face the ever-present threat of wildfires.

## Arid Lands and Grasslands

### **Climate Change and Wetlands in the Great Basin:**

Climate change is already altering aquatic ecosystems worldwide, particularly in arid and semi-arid regions such as the Great Basin, where water is scarce, and life is disproportionately concentrated in the wetlands. USGS is producing a scientifically sound model that predicts how wetland habitat quality and species connectivity in the Great Basin will change in the coming decades under future climate scenarios. This approach can be used around the world to help researchers, resource managers, and policy makers understand population- and community-level climate impacts for timely conservation planning and adaptive management. The animals that depend on Great Basin wetlands are likely to experience significant shifts in range, phenology (timing of life-cycle events such as hatching, migration, and mating), and population structure, including loss of landscape-level connections among the necessary fresh (nesting) and brackish (feeding) water habitats required for different life stages.



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**North America's Prairie Potholes Vulnerable to Warming Climates:** A warmer and drier climate poses unprecedented challenges to wetland and bird conservation, as well as the ecosystem services associated with carbon sequestration, water quality improvement and the recharge of groundwater systems that supply water to farmlands across North American prairie landscapes. Changes to the climate of north-central North America will also negatively affect millions of waterfowl that depend



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on the region for food, shelter and raising young, according to research by the USGS and its colleagues. USGS research shows the region is likely much more sensitive to climate warming and drying than previously thought. Our work projects major reductions in water volume, shortening of the time water remains in wetlands, and changes to wetland vegetation dynamics in this 800,000-square kilometer region in the U.S. and Canada. Advance knowledge of such changes will enable water, agricultural, and resource managers to formulate strategies for preserving key ecosystem services associated with these wetlands.

## **Mountains and the Arctic**

Mountain and arctic ecosystems are highly sensitive to climate change, and USGS is conducting montane research across the West and in the Arctic to help resource managers plan now for the future. Coordination with scientists around the world has led to mountain research networks to expand our understanding of how mountain ecosystems respond to climate change.

### **Disappearing Glaciers in Glacier National Park:**

The higher elevations of the Northern Rockies have experienced three times the global average temperature increase over the



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past century. These same ecosystems provide up to 85 percent – that is, more than three-fourths -- of the water people depend on. They also are the source of ecosystem services such as snow-based recreation, fishing, timber, unique plants and animals, and critical habitat for rare and endangered species such as bull trout and grizzly bear. In Glacier National Park, our research (since 1991) has shown that glacier recession is already under way, and many glaciers have already disappeared. There were about 150 glaciers there in 1850; most of them were still present in 1910. But by 2010, only 25 glaciers larger than 25 acres remained in GNP, and our research predicts some of the park's largest glaciers will vanish by 2030. If true, the park's glaciers could disappear in the next several decades. However, glacier disappearance may occur even earlier, as many of the glaciers are retreating faster than their predicted rates.

**Using Fish Ear Bones to Reconstruct Climate and Productivity of Freshwater and Marine Ecosystems:** USGS is using otoliths (ear bones of fish) to reconstruct the growth and productivity of arctic and sub-arctic lakes and nearshore coastal habitats of the Pacific Coast. Like trees, otoliths grow in concentric yearly rings and can be used to determine the age and reconstruct the growth patterns of fish using techniques commonly used in tree ring studies. USGS researchers take advantage of otoliths collected over the last 35 years to develop growth histories for a variety of fish species, providing long-term and cost effective data sets. Long-lived fishes, such as lake trout and black rockfish, can be used to reconstruct temperature histories of lakes or as indicators of marine productivity. These long-term data sets provide important information to resource managers concerning trends in environmental conditions to better understand how environmental change impacts important habitats and populations of fish.



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## **For more information,**

visit or contact <http://ecosystems.usgs.gov/wter/> or contact

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