Pintail duck photo by Peter LaTourette

Climate Change, Wildlife, and Wildlands

Case Study

Western Mountains and Plains

Impacts at a Glance

- Continued warming could melt all the glaciers in Glacier National Park by 2030.
- Mountain glaciers in many other parts of the world, including the Pacific Northwest, also may disappear.
- Snow cover may be reduced, leading to drier conditions downstream.
- Warmer mountain streams may harm trout and other cold-water species, adding to existing stresses such as whirling disease.
- Yellowstone National Park may experience more frequent fires if the climate becomes drier.
- Plant species distributions may change as the climate changes.
- Rare alpine plants may become increasingly rare under warmer conditions.
- Some plants and animals in alpine lakes above treeline may disappear locally as treelines move higher and lakes warm.
- Global warming could reduce populations of ducks and other waterfowl that breed in the prairie pothole region of the north-central United States and south-central Canada.

Climate Change, Wildlife, and Wildlands

Case Study — Western Mountains and Plains

Melting Glaciers, Changing Ecosystems

The glaciers in Glacier National Park are shrinking. Today, the park's largest glaciers are only about a third of the size they were in 1850, and many small mountain glaciers have disappeared completely during the past 150 years. The area of the park covered by glaciers declined by 73 percent from 1850-1993. The cause? A regional warming trend that some scientists believe may be related to global climate change. Since 1900, Glacier National Park's average summer temperatures have increased by about 1.8 degrees Fahrenheit.

Park visitors can experience the scale of glacial retreat by hiking the trail to Upper Grinnell Lake, where a series of signs mark the former end points of Grinnell Glacier. The glacier once covered 576 acres on the eastern slope of the Continental Divide. To reach its terminus today, one must climb steadily upward through an area that was covered with ice in the 1850s. Still farther uphill is the sign marking the terminus in the 1930s, still higher the 1960s, and finally the 1980s. Today the remnants of Grinnell Glacier—one of more than 50 mountain glaciers in the park—are reached just below the summit of Mt. Gould. The glacier has shrunk by more than 62 percent since 1850 and now covers barely 200 acres.

If scientists' predictions are accurate, Grinnell and all of the park's other glaciers will disappear entirely within the next 30 years.

Melting glaciers are only part of the story. Experts believe that climate change will have wide-ranging impacts on fish, wildlife, trees, and plants throughout the western mountains and plains.

In some areas, a warmer climate could cause streams to become too warm to support trout, salmon, and other cold-water fish. If mountain snowpacks decline, summer soils and vegetation may become drier, increasing the risk of fire. Changes in stream flow and water temperature also could affect insects and other invertebrates that live in streams and rivers, with repercussions up the food web on fish, amphibians, and waterfowl.

Climate change may affect agriculture in the plains states, the heart of the nation's breadbasket. It also may affect ducks and other waterfowl by increasing the severity and frequency of drought in the continent's major duck breeding area—the prairie potholes and parklands of the north-central United States and south-central Canada.

Another hazard—forest fire—may occur more frequently in Yellowstone National Park if the climate becomes drier. Fire frequency depends on local weather, sources of fuel and ignition, and the effectiveness of fire suppression. Climate change also could reduce the abundance of whitebark pines and army cutworm moths, two favored foods of grizzly bears. Whitebark pines already are in decline, primarily due to a fungus known as white pine blister rust.

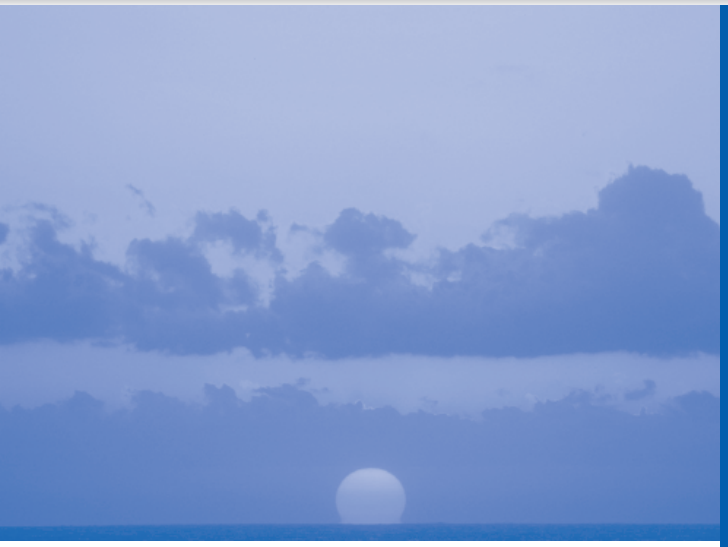
If the region's climate continues to warm in the future, forests of lodgepole pine and western cedar in Glacier National Park may gradually be replaced with forests dominated by spruce and western hemlock. Treelines are expected to move upslope at a rate of roughly 350 feet for every degree Fahrenheit of warming. Alpine meadows may be invaded by fir trees, and rare alpine plants may disappear locally as conditions change.

"It's increasingly hard to understand why it's called Glacier National Park, because the glaciers are getting hard to find."

— Bruce Babbitt, Secretary of the Interior
October 7, 1998

Climate Change, Wildlife, and Wildlands

Case Study — Western Mountains and Plains



A History of Change

The western mountains and plains always have been subject to major natural disturbances such as fires, avalanches, landslides, windstorms, floods, droughts, and pest invasions. It would seem like the region's plants and wildlife would be able to handle a gradual change like global warming.

But fires and floods are short-term events. Long-term changes in average conditions, such as those caused by global warming, exert very different forces on ecosystems. For example, an overall warming may allow low-elevation plants and animals to move upslope and invade habitats currently occupied by high-elevation species. Changing conditions may benefit some species more than others, causing

What is Global Warming?

The Earth's climate has changed in the past, and will continue to change naturally in the future. Ice ages, long warm periods, and short-term fluctuations in temperature and precipitation are all elements of the global climate's natural variability.

Today, the average global temperature is rising. Is that natural? Some of the temperature increase can be explained by natural factors. But many scientists believe that a portion of the warming trend may be caused by humans. Human activities are creating a buildup of greenhouse gases—primarily carbon dioxide, methane, and nitrous oxide—in the atmosphere. The heat-trapping property of these gases is undisputed. Although scientists do not know exactly how the Earth's climate responds to increases in greenhouse gases, they do know that the current warming trend is consistent with changes that would be expected from the increase in greenhouse gases.

Scientists generally believe that the burning of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide in the atmosphere. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for almost 99 percent of U.S. anthropogenic carbon dioxide emissions and about 20 percent of our nitrous oxide emissions. Of the carbon dioxide emissions, industrial activity accounted for 33 percent in 1997. Personal and commercial transportation accounted for 30 percent, and residential and commercial energy use accounted for 19 and 16 percent, respectively. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of carbon dioxide, methane, and other greenhouse gas emissions.

Average global temperatures at the Earth's surface have increased 0.6–1.2°F since the late 19th century. The 10 warmest years in the 20th century all occurred in the last 15 years. Snow cover in the northern hemisphere, floating ice in the Arctic Ocean, and the areas covered by mountain glaciers have all decreased. Globally, sea level has risen 4–10 inches during the past century. Worldwide precipitation over land has increased by about 1 percent, and the frequency of extreme rainfall events has increased throughout much of the United States.

Although it is impossible to predict future changes in climate with certainty, many scientists believe that the continued addition of greenhouse gases to the atmosphere is likely to raise the Earth's average temperature by several degrees in the next 100 years. Rising global temperatures are expected to raise sea level and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies. It also could threaten human health and harm birds, fish, and many types of ecosystems.

the composition of natural communities to change. A single fire may make no noticeable long-term change in an ecosystem. But if conflagrations become more frequent, fire-adapted trees such as lodgepole pine, Douglas fir, and western larch may become more common and expand their range in areas such as Yellowstone National Park.

Although dramatic changes in climate have occurred in the Earth's past, and some of the current global warming trend may be natural in origin, many scientists believe that the world will warm more rapidly during the next 100 years than it has at any time in the past 10,000 years. That rate of change may have significant effects on natural ecosystems and individual plant and animal populations.

What Can Be Done?

To address the threat of climate change, first we have to understand the risks. The potential impacts of climate change also should be considered within the context of other stresses that affect natural areas today, such as invasive species, pollution, and habitat loss.

Scientists currently are analyzing how climate change might affect natural ecosystems in many national parks and preserves, including Glacier, Yellowstone, Olympic, and North Cascades National Parks.

Prevention of human-induced climate change also is an important strategy. Some global warming probably will occur no matter what we do, because some of it is natural. But also, humans have become dependent on fossil fuels. The burning of fossil fuels emits greenhouse gases, which may remain in the atmosphere for years, decades, or even centuries, exacerbating the natural warming. But we as individuals can take action now to reduce our own consumption of fossil fuels by improving energy efficiency and using alternative energy sources. (See "Searching for Solutions" on page 7 and "What People Can Do" on page 8.)

Glacier National Park

Today's climate may be too warm to sustain the park's mountain glaciers long-term. Researchers estimate that even if average temperatures were to remain at their current level, all the glaciers would disappear within the next 100 years. If warming in the region proceeds as expected, the glaciers will be gone much sooner, probably by the year 2030.

The size of the park's glaciers already is affected by changes in climate. For example, the glaciers retreated dramatically from 1920-1940, when the region experienced above-average summer temperatures and below-average annual precipitation. From 1960-1979, temperatures dropped, precipitation increased, and some of the larger glaciers actually grew slightly. Since that time the glaciers have receded farther.

Glacier National Park is not the only area where glaciers are melting. Mountain glaciers in the Alps, south-central Alaska, and the Pacific Northwest also have retreated over the past century.

"Glacier's ecosystem has already altered in response to climate change."

— Daniel Fagre, Research Ecologist
U.S. Geological Survey, Glacier Field Station

In addition to the melting glaciers, a warmer climate could cause declines in snow cover, reductions in trout populations, the loss of rare alpine plants, and changes in forest composition in Glacier National Park.

The park has a wide range of habitats and climatic conditions that are responsible for the area's rich biological diversity. Mountains rise abruptly from the prairies, and the east and west sides of the Continental Divide exhibit a sharp contrast in climate. The park includes soils that are rich in calcium as well as soils that are calcium-poor, each supporting a very different community of plants and animals. Various parts of the park contain plants that are typical of the northern Rocky Mountains, the Great Plains, the Pacific Northwest, boreal regions, and Arctic-alpine regions. Each of the three major river systems in the park (Missouri, Columbia, and Saskatchewan) also has its own distinct aquatic community.

Global warming could lead to many complex changes in the park's plant and animal communities, including shifts in the treeline and changes in stream and lake communities. Such changes have occurred naturally during past climatic changes and will occur naturally in the future. The difference is that now humans may be increasing the pace and magnitude of climate change.

Yellowstone National Park

Global warming may result in a warmer and drier climate in the Yellowstone region, increasing the risk of forest fires. Some computer models project a warmer and wetter climate, but the trend over the 20th century was toward warm and dry.

Since the massive fires of 1988, when nearly half of Yellowstone National Park burned, scientists who study the area have paid close attention to climate change. The number of fires and their severity depends on many factors other than climate, such as fuel management practices (e.g., prescribed burns and the thinning of forests) and the effectiveness of fire suppression efforts. But climate and weather clearly play a role. Experts agree that the fires of 1988 came about as result of a winter drought, a hot dry summer, and unusually strong winds.

Also important were the large areas of highly flammable, old-growth lodgepole pine forest. Under normal conditions, large fires like those of 1988 occur only once in every few generations. But with approximately 40 percent of Yellowstone still vulnerable to large-scale burns, any

Fish in the Future

Imagine casting a line into the Flathead River at Glacier National Park and not finding any trout. Or picture a fly fisherman revisiting the Madison River in Wyoming in the future and catching only half the cutthroat trout of today. This kind of scenario could become reality sometime in the next 100 years.

A recent EPA study found that a moderate warming of 4.5°F over the next 70 years could cut the habitat of brook, rainbow, and cutthroat trout by one-fourth to one-third nationwide, with similar habitat losses for chum, chinook, pink, and coho salmon. Habitat losses are not evenly distributed around the country. For example, rainbow trout habitat is projected to decline by only 9 percent in Washington, whereas Pennsylvania, New York, Ohio, Indiana, and Illinois collectively lose 86 percent of their baseline habitat for rainbow trout. When added to existing threats such as whirling disease and other exotic diseases, climate change could be stressful for many cold-water fish.

Cutthroat trout, rainbow trout, and other fish in the trout and salmon family require cold water. These fish, and the cold-water invertebrates they feed on, could lose habitat as the climate becomes warmer. The loss of mountain glaciers, warmer air temperatures, reductions in winter snowpack, and changes in the timing and rate of spring snowmelt could make many streams too warm for cold-water fish.

Streamflows altered by changes in rainfall and snowfall could affect fish populations. The young of some species of native trout hatch in summer when snowmelt is declining, while others hatch in spring before runoff occurs. Warmer winters could increase the occurrence of rain falling on snow, which may harm incubating eggs of trout that spawn in the autumn.

Changes in streamflow and temperature may affect insects and other invertebrates that live in streams and are important food sources for fish. In the McDonald Basin of Glacier National Park, for example, the distribution of six species of caddisfly larvae in streams is closely related to water temperature. If water temperatures change, the variety and abundance of invertebrates living in stream water are likely to change as well.

Ducks in Peril

From 50 to 80 percent of North America's ducks and other waterfowl nest in the prairie pothole region of the north-central United States and south-central Canada. The shallow prairie wetlands are vulnerable to drought, and computer models indicate that global warming is likely to bring stronger and more frequent droughts to the prairie pothole region.

According to one study, global warming could cause the number of prairie ponds in the north-central United States that hold water in the spring to drop from today's average of 1.3 million to just 0.6–0.8 million by the year 2060. The loss of habitat could reduce the average number of ducks settling to breed in the north-central United States from 5 million birds today to between 2.1 and 2.7 million by the year 2060.

Duck populations reached historical lows in the 1980s due to a combination of prolonged drought, the loss and degradation of habitat, and land use changes that favored predators. In recent years, better water conditions and intensive wetland conservation and management programs have helped duck populations rebound.

When the prairie potholes dry up during drought years, waterfowl normally move north to nest in the parkland potholes of Alberta and Manitoba—pothole wetlands that are surrounded by aspens and willows. But researchers have found that many parkland potholes also may dry up in the future as the climate changes, leaving ducks with fewer potential nesting sites.

What can be done to protect the pothole region from the potential effects of global warming? Scientists recommend that we start by conserving the least drought-sensitive areas so they are available to birds in the future as the climate warms.

increased fire risk due to climate change could pose a significant problem.

Fire plays an important role in several ecosystems in the region, including sagebrush steppe, western juniper woodlands, and ponderosa pine forests. In the past, frequent low-intensity surface fires perpetuated ponderosa pine stands with grassy undergrowth. Today, after 60 years of policies to prevent and suppress forest fires, many ponderosa and lodgepole pine forests have high densities of trees, are plagued by epidemics of insects and diseases, and are subject to severe fires that can destroy entire stands of trees. The trees' high density could lead to more frequent and more damaging outbreaks of defoliating attacks by western spruce budworms. Insect outbreaks have occurred many times in the past, but fire suppression policies and climate change may exacerbate them in the future. The replacement of old-growth forest stands by younger stands could affect some of the park's plant and bird species, such as the northern twinflower, fairy slipper, pine martin, and goshawk.

Even a modest warming and drying could reduce the habitat of whitebark pine by up to 90 percent within 50 years. Whitebark pine populations already are declining because of the white pine blister rust fungus and other invasive exotic pests. Whitebark pine nuts and army cutworm moth caterpillars, which are found in these forests, provide vital food for the region's grizzly bear population. Whitebark pine forest may be replaced with Douglas fir, and on the lower slopes, forest would give way to treeless landscapes dominated by big sagebrush, Idaho fescue, and bluebunch wheatgrass.

Climate change also could cause high alpine ecosystems to shrink in many areas. Local extinctions of alpine species such as arctic gentian, alpine chaenactis, rosy finch, and water pipit could be expected as a result of habitat loss and fragmentation.

Parks in the Pacific Northwest

The impacts of climate change in North Cascades, Mt. Rainier, and Olympic National Parks may be similar to those affecting Glacier National Park. If the regional climate follows the global trend toward warming, scientists expect receding glaciers, warmer stream waters, changes in plant and animal communities, and increased risk of fire.

North Cascades National Park

North Cascades National Park contains more than 300 glaciers, accounting for approximately a third of all the glaciers in the lower 48 states. Since the end of the Little Ice Age in the late 1800s, glaciers have retreated throughout the park area. Although historical data on the glaciers' size are scant, scientists believe that several dozen glaciers may have disappeared during that time.

Warmer temperatures and disappearing glaciers could harm the five species of salmon—sockeye, pink, coho, chum, and chinook—that rely on rivers in the park. Some streams in the North Cascades can support salmon only because the streams are fed by glacial meltwater. Salmon in the region already face immediate stresses from human activities outside the park.

Olympic National Park

Above the old-growth temperate rainforest, the high alpine and subalpine meadows of Olympic National Park come alive with wildflowers every spring. Future hikers may experience only a fraction of today's colorful displays, as some meadows may give way to forests moving upslope in response to changing climate.

Fire, the length of the growing season, and soil moisture are among the factors that determine the growth and distribution of alpine and subalpine plants. All of these natural processes are sensitive to climate change, and changes in any of them could produce conditions favorable for trees to invade the meadows.

In fact, changes already are occurring at the treeline: Forest species are beginning to crowd the edge of the meadows and fill the gaps of open grassland. Furthermore, computer simulations suggest that in the future, a warmer climate will allow trees to become established in all current meadows.

Mt. Rainier National Park

The size of glaciers on Mount Rainier has fluctuated significantly over time. For example, during the last ice age, from about 25,000 to about 15,000 years ago, glaciers covered most of the area now within the boundaries of Mount Rainier National Park and extended to the perimeter of the present Puget Sound Basin. The glaciers retreated after the last ice age, but advanced again between the 14th century and 1850.

From 1850 to 1920, the mountain's glaciers gradually retreated, with the melting accelerating after 1920. Many of the major glaciers advanced again from the 1950s through the early 1980s in response to relatively cooler temperatures and high snowfalls in the region. Since the early 1980s, many glaciers in the park have been thinning and retreating again. How they will fare in the future depends on regional changes in climate, which may be affected by global warming.

Searching for Solutions

To address the threat of global warming, governments and organizations in the states that contain the national parks of the western mountains and plains could improve the health and resiliency of natural ecosystems, prepare for a changing climate, and work to limit future global warming by reducing greenhouse gas emissions.

Conservation biologists note that, in most cases, park boundaries cannot be expanded to continue protecting species that leave the area as the climate changes. They recommend that governments and nonprofit agencies establish wildlife habitat corridors to connect parks with other protected habitats for plants and wildlife. Corridors could be designed to

allow protected species to shift their range if their habitat changes.

If personnel in parks and other protected areas worked with scientists to come up with long-term management plans and strategies, then together they could mitigate the future impacts of global warming in protected areas. Efforts to control invasive non-native plants and animals, prescribed burning programs that help prevent devastating conflagrations in times of drought, and programs to monitor species and habitats at risk are examples of methods parks could employ to continue to protect their resources as the climate changes. The additional stresses posed by climate change must be considered and managed in the context of existing environmental impacts and changes.

What People Can Do

We all add greenhouse gases to the atmosphere whenever we use energy from fossil fuels. Residential energy use accounted for 19 percent of overall CO_2 emissions from the combustion of fossil fuels in 1997, and motor vehicle use accounted for approximately 20 percent. Here are a few actions that people can take to reduce their emissions.

- **Use mass transit, carpool with friends, or ride a bike whenever possible.**
- **When it's time to replace the family vehicle, consider one that gets more miles per gallon than your present vehicle.**
- **When it's time to replace an appliance, look for the ENERGY STAR® label identifying energy-efficient models.**
- **When buying or building a new house, an ENERGY STAR model gives greater quality and comfort as well as lower monthly costs. For more information, go to the ENERGY STAR Homes web site, www.epa.gov/homes.**
- **Buy products that feature reusable, recyclable, or reduced packaging to save the energy required to manufacture new containers and reduce greenhouse gas emissions from landfills.**
- **Encourage your company to join EPA programs such as ENERGY STAR Buildings℠ and Waste Wi$e recycling programs, and to buy office equipment with the ENERGY STAR label.**
- **Plant trees, which absorb carbon dioxide from the air.**
- **Educate others. Let friends and family know about these practical, energy-saving steps they can take to save money while protecting the environment.**
- **Encourage scientific research and public discussion on global warming and solutions such as energy efficiency and alternative energy.**

Slowing Climate Change

Today, action is occurring at every level to reduce, avoid, and better understand the risks associated with global warming. Many cities and states across the country have prepared greenhouse gas inventories, and many are pursuing programs and

policies that will result in reductions of greenhouse gas emissions.

At the national level, the federal government is working in partnership with businesses, states, and localities to address global warming while also strengthening the economy. In addition, the U.S. Global Change Research Program coordinates the world's most extensive research effort on climate change.

For More Information

- The U.S. Environmental Protection Agency's global warming site includes detailed information on climate change, impacts, and actions.

  www.epa.gov/globalwarming/

- Diagrams showing how Glacier National Park's Sperry, Grinnell, and Swiftcurrent glaciers have receded over time are available on the web.

  www.mesc.usgs.gov/glac/glacier_retreat.htm

- EPA's state-specific climate change fact sheets include information on potential impacts in the western mountains and plains states.

  www.epa.gov/globalwarming/impacts/stateimp/

- The latest U.S. *National Assessment of Climate Variability and Change* gives a detailed report on the potential effects of global warming in the United States.

  www.nacc.usgcrp.gov/

- Animation illustrating the predicted impact of climate change in Glacier National Park to the year 2100.

  http://nrmsc.usgs.gov/research/glacier_model.htm

"We should be thinking in terms of what will be here for the 22nd century and the 23rd. We will have dishonored our legacy if we are not prepared to protect it, preserve it, and pass it on to succeeding generations."

— Robert G. Stanton, Director, National Park Service, August 12, 1999