

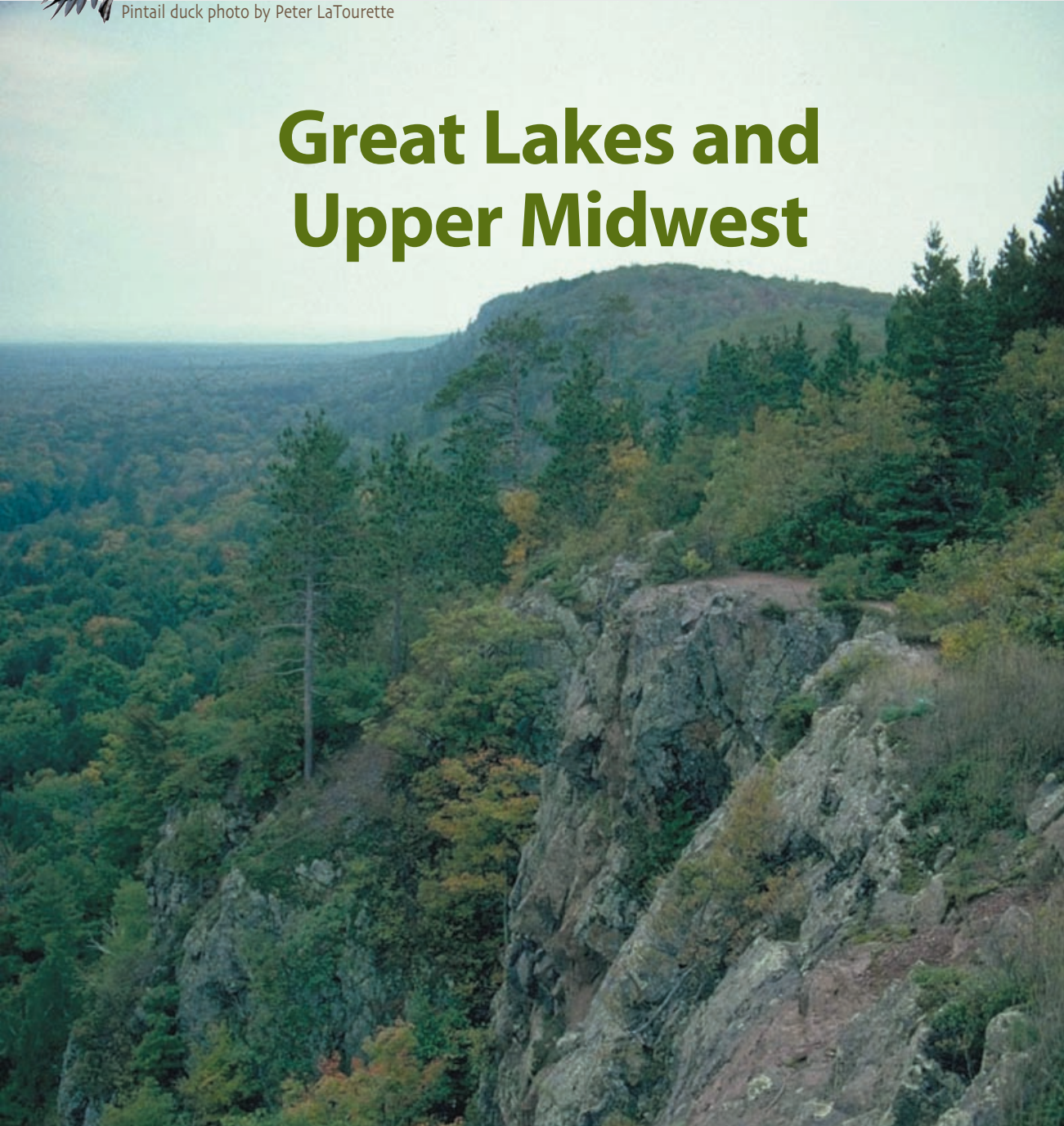


Pintail duck photo by Peter LaTourette

Climate Change, Wildlife, and Wildlands

Case Study

Great Lakes and Upper Midwest



Impacts at a Glance

- Global warming could reduce the habitat available for cold water fish such as trout and salmon in lakes and streams.
- Lake levels in the Great Lakes could drop significantly, affecting wetlands, water quality, recreational facilities, and shipping.
- Forests may change, with some species shifting their range northward or dying out, and other trees moving in to take their place.
- Endangered species such as the Kirtland's warbler could lose habitat.
- Ducks and other waterfowl could lose breeding habitat.
- Changes in the timing of migration and nesting could put some birds out of sync with the life cycles of their prey species.



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Global Warming and the Great Lakes Region

In the opening scene of Holling Clancy Holling's classic children's book, *Paddle-to-the-Sea*, a young boy stands at his cabin door in the Nipigon country north of Lake Superior. It is late winter, and the season's first flock of Canada geese is flying overhead. "Geese!" he cries. "They come back too soon!"

Those words, written by Holling nearly 60 years ago, have a familiar ring today. For the geese—and many other birds—now come back "too soon" to the Great Lakes region on a regular basis. In Holling's home state of Michigan, at least 15 bird species have advanced their spring arrival dates in the upper peninsula by one to eight weeks since 1965.

photo: National Park Service, Indiana Dunes National Lakeshore



Why? Some researchers believe the birds are responding to long-term changes in climate that may be due to global warming. In fact, scientists have noted similar changes in other parts of the world. A study in England, for example, found that many birds there laid their eggs an average of 19 days earlier in 1995 than in 1971.

Wildlife researchers are concerned that such behavioral shifts could be harmful for some birds. Insect-eating migratory birds that return too early in the spring might have trouble finding food, especially during late-season snowfalls and cold snaps. Similarly, birds that lay their eggs earlier might have poor nesting success if their young hatch before favored prey species become available.

Birds are not the only organisms responding to changes in the climate. Scientists reported in 1997 that plant growth in northern latitudes has increased by more than 10 percent since 1981 due to longer growing seasons. The growing season in latitudes where the effect is strongest—

including the northern Great Lakes region—may have lengthened by 8–16 days. This sounds like a change for the better, but it will take time to see the effects.

Ecosystems respond to environmental trends in complex ways. Scientists have not yet determined how the longer growing seasons and warmer temperatures might affect competition among tree species in a forest, or what the changing climate might mean for northern plants that are near the southern end of their geographic range.

The Great Lakes-St. Lawrence basin, which includes the five Great Lakes, the St. Lawrence River, and their surrounding watersheds, contains 20 percent of the world's freshwater. The basin covers 295,000 square miles and includes huge forests and wilderness areas, rich agricultural land, lakes, streams, rivers, mineral deposits, and a world-class fishery. It also is home to a diverse range of plants and wildlife, including endangered and threatened species such as the Canada

"It appears that global warming could have negative impacts on many of our region's strengths, assets, and resources."

— The Honorable Anthony Masiello, Mayor of Buffalo, NY
June 1998

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lynx, gray wolf, peregrine falcon, Kirtland's warbler, and Karner Blue butterfly.

Encompassing portions of Minnesota, Wisconsin, Illinois, Indiana, Michigan, Ohio, Pennsylvania, and New York, plus the Canadian provinces of Ontario and Quebec, the basin is home to more than one-tenth of the population of the United States and one-quarter of the population of Canada.

The region supports a multibillion-dollar outdoor recreation and tourism industry, with a number of popular national parks and recreation areas such as Isle Royale National Park; Voyageurs National Park; Superior National Forest; Indiana Dunes National Seashore; the Boundary Waters Canoe Area Wilderness; and Quetico, Algonquin, and Killarney Provincial Parks in Canada.

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.

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If scientists' projections are accurate, global warming could bring substantial changes—both positive and negative—to the region and its inhabitants in the years ahead.

Birds, plants, and other forms of life in the Great Lakes region have always been exposed to changes in climate and weather. But the changes underway now, and those projected for the future, are different. Climate scientists believe the Earth will experience an average rate of warming during the next 100 years that will be faster than any seen in the last 10,000 years. For the Great Lakes region, that means the next century could bring one of the greatest environmental transformations since the end of the last ice age, perhaps rivaling the dramatic changes wrought by humans after Europeans settled the region nearly 400 years ago.

If a Nipigon boy in the year 2050 were to place a small carved wooden canoe into the headwaters of Lake Superior, his *Paddle-to-the-Sea* might eventually reach the ocean just as the one in Holling's book did. But the sights and sounds along the way—the fish in the brooks, the trees lining the marshes, even the shape of the shorelines—might be very different from what Holling painted and described in 1941.

What Can We Expect?

Global warming could cause lake levels in all the region's lakes, including the Great Lakes, to drop substantially. Climate change probably will reduce the habitat available for cold water fish, such as trout and salmon, in lakes and streams. Wetlands also may be vulnerable to changes in climate. Forests and other ecosystems in the Great Lakes region may be transformed as the climate warms. Depending on the magnitude of changes in temperature and precipitation, northern tree species such as balsam fir may migrate northward or die out, with other tree species such as maple moving in to take their place. Habitat for endangered species such as the Kirtland's warbler could be lost as forests change.

Changes in the Lakes

The Great Lakes, their connecting channels, and the St. Lawrence River form the largest fresh surface water system on the planet. The lakes cover more than 94,000 square miles and hold an estimated 6 quadrillion gallons of water, 95 percent of the U.S. freshwater supply. The Great Lakes and other lakes and streams in the region are famous for their recreational fishing and boating opportunities.



photo: Minnesota Department of Natural Resources, Steve Geving

With global warming, the water temperatures of the Great Lakes and smaller lakes in the region could increase because of the warmer summer air temperatures and longer ice-free season. Warmer temperatures could degrade water quality by decreasing dissolved oxygen in the water and increasing the growth of algae.

Warmer waters in the region's lakes and streams would reduce the size of favorable habitat for trout, whitefish, and other cold water fish species. A recent EPA study found that a warming of 4.5°F over the next 70 years could cut the habitat of brook, rainbow, cutthroat, and brown trout by one-fourth to one-third nationwide. A 4.5°F warming is slightly below the midpoint of the 2–8°F range predicted by climate models for the year 2100; the actual temperature change that

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occurs could be smaller or greater. Chum, chinook, pink, and coho salmon would experience similar habitat losses. According to the study, Pennsylvania, New York, Ohio, Indiana, and Illinois would collectively lose 86 percent of their habitat for rainbow trout. These changes are expected to occur gradually over the decades ahead as the climate shifts.

Would the Great Lakes basin be as popular a fishing destination if classic northern cold water species like pike, muskellunge, trout, and salmon became less common? Recreational fishing certainly would continue, but the experience might change.

Warmer waters also could affect the timing and frequency of “overturning,” in which oxygen-rich surface waters sink and mix with other water layers in the lake. The lakes currently turn over in the spring and fall of every year. In a warmer climate, the overturning may not occur every year in all lakes. Turnover is the main way for deeper lake waters to become replenished with oxygen. Without enough dissolved oxygen, cold water lake fish and other species will be unable to survive in their deepwater habitats.

If the climate warms, ice cover on lakes and streams would not last as long as it does today. Streamflows could peak sooner in the spring because of earlier snowmelt

and ice breakup. There already is evidence that the annual rising and falling of some of the Great Lakes occurs nearly a month earlier than it did 140 years ago. Changes in the timing and volume of peak streamflow also may affect fish and other creatures that live in the streams.

A warmer climate would lead to increased evapotranspiration. (Evapotranspiration is the water lost to the atmosphere by evaporation and transpiration combined. Evaporation is the loss from open bodies of water; transpiration is the loss from living plants.) Summer streamflows probably would decrease, reducing the water quality. Freshwater flow into the Great Lakes could decrease by 20 percent with a 4°F warming (slightly below the current mid-range estimate projected by climate models), potentially reducing lake levels by a foot or more. Because lake levels respond to hydrologic changes in their drainage basins, the Great Lakes would respond to global warming very differently than the oceans would. Global warming will cause the oceans to rise as warm water expands and freshwater from melting glaciers and ice sheets enters the sea. Water levels in the Great Lakes, on the other hand, are likely to fall.

Lower lake levels would reduce inputs to hydroelectric power facilities, increase the concentration of water pollutants, and

require more dredging to maintain ship channels.

Lake levels in the Great Lakes have varied dramatically in the past due to natural variations in the region’s climate. For example, very low levels occurred in the late 1920s, mid-1930s, and mid-1960s, while very high levels occurred in the 1830s, 1880s, early 1950s, early 1970s, mid-1980s, and mid-1990s. The low water levels in the 1960s caused significant losses in hydroelectric power output, economic hardships for marina operators and other lakeside recreational facilities, loss of wetlands, and reductions in municipal water quality. Global warming could increase the frequency and severity of droughts in the Midwest, causing low lake levels to occur more frequently.

photo: Michigan Travel Bureau



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In the region's smaller lakes, prolonged drought from climate change could decrease the number of lakes with suitable habitat for organisms such as crayfish and snails. Drought also could decrease groundwater supplies of silica, an essential nutrient for freshwater sponges and diatoms.

On the positive side, flood damages could be reduced by lower lake levels. Global warming also would lengthen the ice-free season for the Great Lakes and St. Lawrence Seaway, with benefits for ship navigation. Warm-water fish, both native and introduced, could experience longer growing seasons and flourish in a warmer climate.

photo: Minnesota Sea Grant



Forests Transformed

Despite nearly 400 years of forest clearing, agricultural and industrial development, and other human impacts, the Great Lakes basin still contains vast tracts of forest. Boreal and northern mixed forestlands such as those in the Boundary Waters Canoe Area Wilderness, a million-acre wilderness in the Superior National Forest, provide habitat for spectacular wildlife species such as moose, black bears, and wolves. The region's forests are a popular destination for backpackers, naturalists, hunters, anglers, and wildlife photographers.

Trees and forests are adapted to specific climatic conditions. As these conditions are altered, forests will change. Global warming could cause forests to undergo changes in species, geographic extent, health, and productivity. If conditions become drier, the current range and density of forests could be reduced and replaced by grasslands and pasture. Even a warmer and wetter climate would lead to changes; trees that are better adapted to these conditions, such as oaks, would thrive. Under wetter conditions, forests could become more dense. These changes could occur during the lifetimes of today's children, particularly if the changes are accelerated by other stresses, such as fire, pests, and diseases, that could

themselves be worsened by a warmer and drier climate.

In Michigan, for example, changes in climate could cause the extent of forested areas to change little—or decline by as much as 50–70 percent. The uncertainties depend on many factors, including whether soil becomes drier and, if so, by how much. Hotter, drier weather could increase the frequency and intensity of naturally caused wildfires. The mixed aspen, birch, beech, maple, and pine forests found in the northern part of the state could be replaced over time by a combination of grasslands, savanna, and hardwood forests of oak, elm, and ash. The predominant hardwood forests in southern Michigan could give way to pine and oak forests. These changes could affect the character of Michigan forests and the activities that depend on them.

In northern Minnesota, the boreal forests in Voyageurs National Park and in the Boundary Waters Canoe Area Wilderness could be replaced by mixed forests better adapted to warmer conditions. Boreal forests are what most people think of when they envision Minnesota's remote north woods: small northern conifers such as tamarack, black spruce, and balsam fir, in a landscape that typically includes wetlands, bogs, and carpets of lichens and mosses. According to one climate study, changes in

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the Great Lakes' boreal forests could be apparent in the relatively near future, between 2010 and 2040.

The world's boreal forests cover a vast area 29 times the size of Texas, but they are rare in the lower 48 states. The Great Lakes region contains mostly transitional forests that include species typical of both the Canadian boreal forests to the north and the broadleaf deciduous woodlands to the south. But a few regions of boreal or boreal-like forests occur near the Canadian border. If climate change causes boreal species to shift their range northward out of the United States, some of the romance and evocative character of the northern borderlands will be lost.

Whether we consider these changes to the forests "good" or "bad" depends on our individual perspectives. Some plants and

animals may benefit from climate change while others may be harmed. An increase in wildfires might create new habitats for some populations while eliminating habitats for others. A decline in one species may make way for another species to expand its range.

What Can Be Done?

To address the threat of climate change, first we have to understand the risks. U.S. and Canadian scientists have been studying potential impacts on the Great Lakes region through programs such as the bi-national Great Lakes–St. Lawrence Basin Project, the Canada Country Study, and the U.S. National Assessment of the Potential Consequences of Climate Variability and Climate Change.

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" and "What People Can Do" on pages 9 and 10.)

Isle Royale National Park

As Holling noted in *Paddle-to-the-Sea*, Lake Superior is shaped like the head of a wolf. The wolf's eye is Isle Royale, the largest island in the world's largest lake. This roadless 45-mile long island is part of an archipelago off Lake Superior's northwestern shore. Isle Royale is an International Biosphere Reserve and is known worldwide as a living laboratory, the site of the longest continuous ecological study of wolves and moose. The Royal

photo: U.S. Fish and Wildlife Service, Mark E. Hodgkins



"Small changes in climate, which we may not even notice, may make the difference as to where certain trees can grow."

— John Pastor, Minnesota Natural Resources Research Institute, University of Minnesota, March 1997

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National Park has 400 islands, 165 miles of hiking trails and 36 campgrounds, and is used by backpackers, boaters, scuba divers, and anglers. Park waters contain the most productive native fishery and the most genetically diverse lake trout populations in Lake Superior.

In the park staff's own summation, Isle Royale "offers visitors a chance to experience wildness, seclusion, solitude, and recreation. It restores the human spirit. It is a wilderness to be entered on its own terms. It is an adventure."

Visitors who climb to Lookout Louise on Isle Royale have a spectacular view of the island's heavily wooded north shore and the Ontario mainland 20 miles away. In 50 or 100 years from now, the view might be quite different. There still would be plenty of trees, but the conifers that dominate the north shore today might be largely replaced by deciduous species such as the maples that today are more common on the island's southwestern shore and interior.

The moose on Isle Royale browse heavily on balsam fir, one of the tree species that researchers believe may be strongly affected by global warming. Balsam fir prefers colder climates and may shift its range northward as the temperature warms.

A study published in 1999 found that changes in winter snowfall affect the hunting behavior of wolves on Isle Royale, which in turn affects the population density of moose and ultimately the growth of balsam fir trees on the island. In years of high snowfall, wolves hunt in larger packs and kill more moose. With fewer moose, the growth of understory balsam firs increases. This study concludes that changes in climate can cause what ecologists call a "trophic cascade," an impact that trickles down through the food web with repercussions for the larger ecosystem.

Voyageurs National Park and the Boundary Waters

"Here as all know is the last great wilderness area of its kind on the continent," proclaimed the noted Minnesota nature writer and conservationist Sigurd F. Olson in a speech to the Izaak Walton League in 1929. "Nowhere else can such beautiful lakes be found. Nowhere else can you find them close together enough to make what is known as a canoe country, and nowhere else is there so much beauty concentrated in one spot as here. It is the last area of its kind in the country."



photo: National Park Service, Indiana Dunes National Lakeshore

Olson was referring to Superior National Forest in Minnesota's north woods, an area that includes popular recreational areas such as Voyageurs National Park and the Boundary Waters Canoe Area Wilderness.

Voyageurs National Park lies on the southern fringe of the Canadian Shield. The park contains a classic boreal ecosystem, with bogs, beaver ponds, swamps, lakes, and islands. The nearby Boundary Waters Canoe Area Wilderness and Quetico Provincial Park are famous canoeing and camping destinations. Established in 1978, the Boundary Waters Canoe Area Wilderness has changed little since the glaciers melted. With 1,500 miles of canoe routes, nearly 2,200 designated campsites, and 1,000 lakes and streams, the Boundary Waters draws more than 200,000 visitors each year.

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These wilderness areas provide visitors with exciting opportunities to observe wildlife, catch fish, hear wolves, and spend time in a landscape rich in the lore of the north woods.

One study suggests that global warming could cause forests in the southern portion of the Boundary Waters Canoe Area Wilderness and the adjacent Superior National Forest to shift from boreal evergreens such as spruce and fir to northern hardwoods such as sugar maple. Under one computer model scenario, a 400-year-old stand of balsam fir on fertile, moist soil in the Boundary Waters would lose two-thirds of its area by 2010, with sugar maples moving in to take the place of the fir.

Waterfowl in Peril

The plentiful lakes and ponds in the Great Lakes region support large numbers of ducks, geese, and other waterfowl. Will they be affected by global warming? Unfortunately, the answer appears to be yes. Waterfowl may be vulnerable to changes in water quality, the availability of food resources, and impacts on wetlands and other nesting habitats.

Global warming is expected to affect the prairie pothole region of the north-central

United States and south-central Canada, where 50-80 percent of North America's ducks and other waterfowl nest. 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. This loss of habitat could reduce the average number of ducks settling to breed in this area from 5 million birds today to between 2.1 and 2.7 million. The Great Lakes also serve as important staging areas for migratory waterfowl and other birds. Changes in water levels and food availability may affect migrants as they pass through the region.

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

Searching for Solutions

To address the threat of global warming, the Great Lakes and Upper Midwest states 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.

Programs to improve the health of the Great Lakes environment, such as the Great Lakes Basin Compact and the remedial action plans for the 43 Great Lakes Areas of Concern, will help make the region's ecosystems more robust. A healthy environment will be better able to withstand some of the potential impacts of global warming.

The U.S. Environmental Protection Agency's Great Lakes National Program Office, located in Chicago, brings together federal, state, tribal, local, and industry partners in an integrated ecosystem approach to protect, maintain, and restore the chemical, biological, and physical integrity of the Great Lakes.

The Great Lakes 5-Year Strategy, developed jointly by EPA and its multistate, multiagency partners, provides a promising agenda for management of the Great Lakes ecosystem: reducing toxic substances, protecting and restoring

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important habitats, and protecting human and ecosystem health.

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

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 CO₂ 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.
- If you have a small boat for fishing and recreation, run it with "human power" when possible.
- 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 BuildingsSM 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.

Change Research Program coordinates the world's most extensive research effort on

climate change.

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photo: Minnesota Extension Service, Dave Hansen



photo: Michigan Travel Bureau

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/
- The Great Lakes Information Network, created by the Great Lakes Commission, offers a wide range of information.
www.great-lakes.net/
- The joint U.S.-Canadian Great Lakes Atlas is another excellent source of environmental and economic information on the Great Lakes region.
www.epa.gov/glnpo/atlas/intro.html

- EPA's Great Lakes Program coordinates many environmental protection efforts in the basin.
www.epa.gov/glnpo/index.html
- EPA's state-specific climate change fact sheets include information on potential impacts in the Great Lakes and Upper Midwest 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/