

Great Lakes Ecosystems and People: Mutual Influence and Dependence

The unique waters and landforms of the Great Lakes region are a striking legacy of climates past. For two and a half million years, massive ice sheets advanced and retreated across the land, scouring the bedrock, gouging out spectacular lake basins, and depositing the geological forerunners of the soils that now nurture forests, farms, and gardens. The ecosystems and human economies of the region, like the landscape itself, have been profoundly shaped by this climatic legacy. Now the world is entering another period of climate change, this time unusually rapid and driven largely by human activities that release heat-trapping greenhouse gases into the atmosphere. The impacts of this climate change, in concert with other human pressures on our lands and waters, promise to alter the character, economy, and environment of the Great Lakes region during the twenty-first century. Examining the potential impacts of future climate on the region is the purpose of this report.

The vast majority of scientists are now certain that the world's climate is changing. Average global temperatures are warming, and the current rate exceeds the normal range of temperature swings experienced for at least the last thousand years. Temperatures in the northern hemisphere have

increased by more than 1°F (0.5°C), growing seasons have lengthened, and precipitation has increased by 5 to 10 percent since 1900. Other indicators that the climate is warming include documented losses in the extent of alpine glaciers, sea ice, and seasonal snow cover.

Evidence strongly suggests that current climate change is being driven by increasing atmospheric concentrations of greenhouse gases, mainly carbon dioxide (CO₂) but also methane (CH₄) and nitrous oxide (N₂O). The main reason for the buildup of these gases is the burning of fossil fuels, the clearing of forests, and other activities of a burgeoning human population. Without major shifts in global policies or energy technologies, these changes in the atmosphere will continue. Even if human emissions were to be reduced drastically, CO₂ already in the atmo-

sphere would take decades to decay, ensuring continuing impacts on the climate for several generations. Life on earth has rarely experienced shifts in climate as rapid as those now in progress, and it is unclear whether the plants, animals, and ecosystems on which humans depend can adapt quickly enough. These factors lend added urgency to the need to address both the causes and the impacts of climate change.

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Regional Landscapes

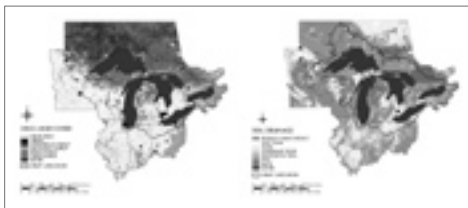
The Great Lakes basin encompasses more than 308,000 square miles of the North American heartland and contains the largest single concentration of liquid fresh water on the planet. The

FIGURE 1
The Great Lakes Region



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FIGURE 2
Satellite-Derived Maps Showing
Land Cover and Soil Drainage



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for full-size color image of this figure

five Great Lakes themselves cover more than 95,000 square miles and hold about 20 percent of the world's supply of fresh water. The region hosts not only the largest lake in the world (Lake Superior) and the four other Great Lakes (Erie, Huron, Michigan, and Ontario), but also hundreds of thousands of smaller lakes, streams, and wetlands — the greatest concentration of small water bodies in the world in an area of this size (Figure 1).

This report focuses on the six Great Lakes states (Illinois, Indiana, Michigan, Minnesota,

Ohio, and Wisconsin), the southern half of the province of Ontario, and portions of New York and Pennsylvania within the boundaries of the Great Lakes Basin (Figure 1). Because of the way economic and social statistics are collected, this report will sometimes talk about the six Great Lakes states plus Ontario.

The glacial history of the region constrains and influences most aspects of the environment. The repeated glaciations that began 2.4 million years ago ended with the last ice age, which covered the entire region as far south as the Ohio River from 18,000 to 21,000 years ago. The ice finally receded completely about 9,000 years ago, leaving the mark of its passing on the current landscape. Current patterns of land cover and land use in the region (Figure 2) mirror the distribution of soils and sediments left by the glaciers. In the northern upland region located on the Canadian Shield, thin coarse-textured soils support extensive spruce and fir forests. The cold climate and relatively poor soils have discouraged development of large population centers, and the economy depends largely on tourism, timber, and mining. In the lowland areas to the south and east, deep and fertile soils, combined with a warmer climate, support a large proportion of the agricultural production for both Canada and the United States, along with remnant oak and hickory forests and prairie habitat.

Human Geography and Economy

More than 60 million people live in the Great Lakes states and Ontario, half of them within the Great Lakes drainage basin itself, and the population continues to grow. Population grew by 8.7 percent in the Great Lakes states over the past decade¹ (Figure 3) and 12.2 percent over the same period in Ontario.² Many major cities are situated on the shores of the Great Lakes, including Buffalo, Chicago, Cleveland, Detroit, Hamilton, Milwaukee, Toronto, and Windsor.

The economy of the region is large and diversified

and includes strong manufacturing, services (including tourism and recreation), agriculture, forestry, and government sectors (Figure 4). Regional production in 2000 totaled nearly \$2 trillion (US), an amount that exceeds the gross domestic production of any nation except the United States and Japan.

The Great Lakes region forms the industrial heartland of North America. In 2000, over 50 percent of the value of manufacturing shipments in Canada came from Ontario,³ and the six Great Lakes states contribute more than 25 percent of total value added*

*The term generally means the enhanced value of a commodity when processed into a secondary, more valuable product or service.

in US manufacturing.⁴ Early industry relied upon raw materials mined or harvested in the region and low-cost shipping on the lakes. Iron ore from northern Minnesota, for instance, was shipped down the lakes to feed the giant steel mills of Gary and Pittsburgh. In recent years, the economy has become more diversified and no longer relies to such a large degree on steel, automobile manufacturing, and other heavy industry. The region remains a major shipping center, however, and freighters ply the lakes and sea-way corridors to the Atlantic Ocean carrying grain, soybeans, coal, iron ore, and other goods and commodities worth billions of dollars from the Midwest and Canada to markets worldwide. This traffic generates \$3 billion (US) in yearly business revenue and 60,000 jobs.⁵

The region also forms part of the agricultural heartland of the continent, and more than 25 percent of the total value of US agricultural products is grown in the Great Lakes states.⁶ That includes more than 50 percent of the nation's corn and 40 percent of its soybeans. Agricultural harvests on the Canadian side of the basin represent nearly 25 percent of that nation's output, and total farm cash receipts in Ontario exceed those from all other provinces in Canada except Alberta.⁷

Although forestry contributes less to the regional economy than industry or agriculture, locally important forestry sectors remain. For example, the forest products industry in Ontario employed more than 90,000 people and generated receipts of more than \$15 billion (Cdn) in the late 1990s.⁸ In Wisconsin in 2000, pulp, paper, wood products manufacturing, and other forest products industries employed 74,000 workers and generated more than \$18 billion (US) in shipments.⁹

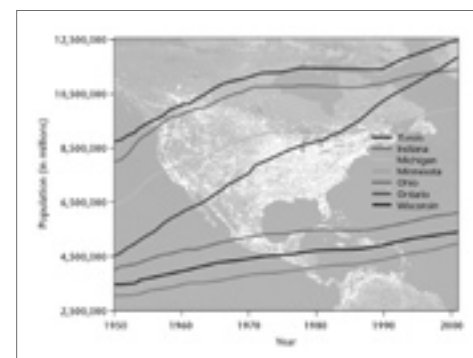
The services sector, which includes many tourism,

recreation, and environment-related enterprises, has grown increasingly important and is now one of the largest economic sectors in the region. The Great Lakes themselves represent the major recreation and tourism attraction in middle America.¹⁰ Indiana Dunes National Lakeshore and Sleeping Bear Dunes National Lakeshore in Michigan

each hosted more than one million visitors in 1999.¹¹ In 2001, Ontario parks from Point Pelee to Lake Superior drew more than 11 million visitors altogether.¹² In addition, crowds of summer vacationers flock to the many small inland lakes of Northern Michigan, Minnesota, Ontario, and Wisconsin. In winter, too, large numbers of visitors arrive to take

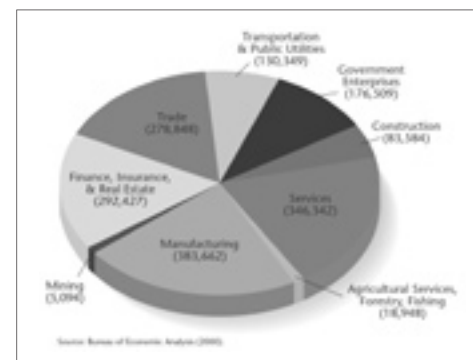
advantage of opportunities for downhill and cross-country skiing and snowmobiling. More than 15 million people in the Great Lakes states participate in fishing, hunting, or wildlife watching (Figure 5), activities that bring \$18.5 billion (US) in sales annually.¹³ In Ontario, travel and tourism brought in more than \$20 billion (Cdn) in 2000.¹⁴

FIGURE 3
Population Change in the Great Lakes Region (1950–2001)



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for full-size color image of this figure

FIGURE 4
The World's Third-Largest Economy (in Millions of US Dollars)



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Human Pressures on Ecosystem Health and Services

The well-being of people in the Great Lakes region depends on the healthy functioning of ecosystems and the services they provide. Some of these services are easily valued because they are bought, sold, or traded. Clearly, agriculture, forestry, tourism, and outdoor recreation rely directly

on the vitality of both natural and managed ecosystems and the plant and animal communities they harbor. Other ecological processes have not been assigned any direct economic value, yet they supply vital support services such as air and water purification, flood protection, pest control, soil renewal,

habitat, aesthetic values, and support of cultural traditions, especially for Native Americans and First Nations groups. Forest birds and amphibians, for example, serve humans by devouring insects that would otherwise

FIGURE 5
The Changing Character of the Region



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harm people, forests, and crops. Amphibians may be especially important as consumers of mosquitoes in small, ephemeral wetlands that lack fish.

These and other ecological services and the ecosystems and species that supply them face increasing pressure, not only from human-induced climate changes

but from many direct human disturbances as well. These include land development and land-use change, discharges of pollutants into the air and water, timber harvesting, mining, intensive agriculture, tourism, and even shipping, an activity responsible for introducing the zebra mussel and other damaging non-native invasive species into the Great Lakes. As the population of the region grows, these direct stresses will increase; so too will the region's contribution to changes in the atmosphere and, indirectly, climate.

The six Great Lakes states use an estimated 16.5 quadrillion BTUs (17,000 PJ) of energy each year. Of this total, more than 90 percent comes from burning fossil fuels: 36 percent from petroleum, 32 percent from coal, and 25 percent from natural gas. Electricity production in this part of the United States depends heavily on burning coal, which emits the most carbon per BTU. More than 60 percent of electricity in the six states is generated by coal-fired power plants.¹⁵ In contrast to the US states in the region, Ontario electricity production is highly diversified, with 27 percent from coal and natural gas. For its total energy needs, Ontario currently uses 3,000 PJ (2.8 quadrillion BTUs) per year, including 40 percent from petroleum products, 32

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percent from natural gas and 3.5 percent from coal.¹⁶

The pace of land-use change is likely to continue to outstrip population growth in the region thanks to urban sprawl and vacation home development. From 1970 to 1990, the population of northeastern Illinois grew by only 4.1 percent while residential land consumption increased by nearly 46 percent. In Michigan, the population is projected to grow 12 percent between 1990 and 2020, but urbanized land may increase 63 to 87 percent during that period. In Ontario, the greater Toronto area is expected to expand its urbanized area by 60 percent by the year 2021.¹⁷ Much of the land not taken up by urban sprawl is given to agriculture, and almost half of the land in the Great Lakes states has been converted to crop fields, pastures, and dairy farms.

Converting land from forest or grassland to farms, houses, shopping malls, or factories not only results in outright loss of habitat for plant and animal species, but also fragments the landscape, leaving islands of natural habitat isolated in a sea of human development. These habitat remnants may be too small and degraded to sustain healthy plant and animal populations, especially when roads, fences, and other human structures create barriers to migration between them.¹⁸ Landscape fragmentation also makes it more difficult for species to migrate to suitable new habitats as the climate shifts.

Urban development greatly modifies local hydrology as well by increasing the extent of impervious surfaces such as roofs and pavement and destroying natural wetlands and floodplains that would otherwise absorb storm runoff and recharge ground waters.¹⁹ Increasing impervious surfaces in a watershed by 10 to 20 percent causes a 35 to 50 percent increase in surface runoff.²⁰ Paved sur-

faces also behave as heat sinks, raising air and stream water temperatures. Removing streambank trees exacerbates this heating.²¹ Overall, the impacts of climate change on the environment and on human well-being in the Great Lakes region will be strongly modified by changes in population, urbanization, land use, and policy and management decisions.²²