Union of Concerned Scientists

Citizens and Scientists for Environmental Solutions

Executive Summary, Updated 2005

Confronting Climate Change in the Great Lakes Region:

Impacts on Our Communities and Ecosystems

Foreword

In November 2005, nearly three years after research was completed for *Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems,* Dr. George Kling and Dr. Donald Wuebbles undertook the task of updating their comprehensive report. Consulting with several other experts on the author team, they identified and reviewed more than two dozen scientific papers of regional significance.

This literature review yielded several directly relevant studies published in the intervening three years. Most of the recent evidence corroborates the findings and flavor of the 2003 report, and the original conclusions are well supported by recent publications.

The executive summary of the 2003 report is reprinted on the following pages. Black text represents original summary findings, all of which remain robust today, while **blue text** represents new information that either changed the original findings or supplemented them.

Executive Summary

The Great Lakes region of the United States and Canada is a land of striking glacial legacies: spectacular lakes, vast wetlands, fertile southern soils, and rugged northern terrain forested in spruce and fir. It is also home to 60 million people whose actions can profoundly affect the region's ecological bounty and the life-sustaining benefits it provides. Now that the world is entering a period of unusually rapid climate change, driven largely by human activities that release heat-trapping greenhouse gases into the atmosphere, the responsibility for safeguarding our natural heritage is becoming urgent.

Growing evidence suggests that the climate of the Great Lakes region is already changing:

- Winters are getting shorter.
- Annual average temperatures are growing warmer.
- **Extreme heat events are occurring more frequently (Chagnon et al. 2003).**

- The duration of lake ice cover is decreasing as air and water temperatures rise.
- **Heavy precipitation events, both rain and snow, are becoming more common (Chagnon et al. 2003).**

This report examines these trends in detail and discusses the likelihood that they will continue into the future. The consequences of these climatic changes will magnify the impacts of ongoing human disturbances that fragment or transform landscapes, pollute air and water, and disrupt natural ecosystems and the vital goods and services they provide. *Confronting Climate Change in the Great Lakes Region* explores the potential consequences of climate change, good and bad, for the character, economy, and environment of the Great Lakes region during the coming century. It also examines actions that can be taken now to help forestall many of the most severe consequences of climate change for North America's heartland.

What is the likely climate future for the Great Lakes region?

In general, the climate of the Great Lakes region will grow warmer and probably drier during the twenty-first century. When this report was prepared in 2003, the climate models used at that time predicted that by the end of the century, temperature in the region will warm by 5 to 12°F (3 to 7°C) in winter, and by 5 to 20°F (3 to 11°C) in summer. **Newly emerging analyses that use a larger number of models and more emissions scenarios may imply a wider temperature range (Hayhoe 2005; Wuebbles 2005).** Nighttime temperatures are likely to warm more than daytime temperatures, and extreme heat will be more common. While annual average precipitation levels are unlikely to change, the seasonal distribution *is* likely to, increasing in winter and decreasing in summer. Overall, the region may grow drier because any increases in rain or snow are unlikely to compensate for the drying effects of increased evaporation and transpiration in a warmer climate. This drying will affect surface and groundwater levels, and soil moisture is projected to decrease by 30 percent in summer. In addition, the frequency of 24-hour and multi-day downpours, and thus flooding, may continue to increase.

These changes in temperature, precipitation, and humidity will strongly alter how the climate feels to us. Within three decades, for example, a summer in Illinois may feel like a summer in Oklahoma does today. By the end of the century, an Illinois summer may well feel like one in east Texas today, while a Michigan summer will probably feel like an Arkansas summer does today. Residents in Toronto could experience a shift from a southern Ontario summer to one that by 2030 may feel more like one in upstate New York, and by the end of the century more like one in northern Virginia today.

What might these changes mean for Great Lakes ecosystems and the goods and services they provide?

Lakes:

- **Lake levels were highly variable in the 1900s and quite low in recent years. Future declines in both inland lakes and the Great Lakes are expected as winter ice coverage decreases, although levels of the Great Lakes are uncertain once they are ice-free (Lofgren 2006a; Lofgren 2006b).**
- Declines in the duration of winter ice are expected to continue.
- Loss of winter ice may be a mixed blessing for fish, reducing winterkill in shallow lakes but also reducing the stream miles suitable for trout and jeopardizing reproduction of whitefish in the Great Lakes, where ice cover protects the eggs from winter storm disturbance.
- The distributions of many fish and other organisms in lakes and streams will change. Coldwater species such as lake trout, brook trout, and whitefish and cool-water species such as northern pike and walleye are likely to decline in the southern parts of the region, while warm-water species such as smallmouth bass and bluegill are likely to expand northward.
- Invasions by native species currently found just to the south of the region and invasions of warm-water nonnative species such as common carp will be more likely, increasing the stress on native plant and animal populations in the region.
- In all lakes, the duration of summer stratification will increase, adding to the risk of oxygen depletion and formation of deep-water “dead zones” for fish and other organisms.
- Lower water levels coupled with warmer water temperatures may accelerate the accumulation of mercury and other contaminants in the aquatic food chain and ultimately in fish.
- Many fish species should grow faster in warmer waters, but to do so they must increase their feeding rates. It remains uncertain whether prey species and the food web resources on which they depend will increase to meet these new demands.

Streams and Wetlands:

- Earlier ice breakup and earlier peaks in spring runoff will change the timing of stream flows, and increases in heavy rainstorms may cause more frequent flooding.
- Changes in the timing and severity of flood pulses are likely to reduce safe breeding sites, especially for amphibians, migratory shorebirds, and waterfowl, and may cause many northern migratory species such as Canada geese to winter further north.
- Reduced summer water levels are likely to diminish the recharge of groundwater supplies, cause small streams to dry up, and reduce the area of wetlands, resulting in poorer water quality and less habitat for wildlife.

- Drought and lower water levels may ultimately increase ultraviolet radiation damage to frogs and other aquatic organisms, especially in clear, shallow water bodies.
- River flooding may become more common and extreme because of the interaction of more frequent rainstorms with urbanization and other land management practices that increase pavement and other impervious surfaces and degrade the natural flood-absorbing capacities of wetlands and floodplains. The result could be increased erosion, additional water pollution from nutrients, pesticides, and other contaminants, and potential delays in recovery from acid rain.
- Land use change and habitat fragmentation combined with climate change–induced shrinking of streams and wetlands will also decrease the number and type of refugia available to aquatic organisms, especially those with limited dispersal capabilities such as amphibians and mollusks, as streams and wetlands shrink.

Forests:

- The distribution of forests is likely to change as warmer temperatures cause the extent of boreal forests to shrink and many forest species to move northward. The new forest composition will depend on the ability of individual species to colonize new sites and the presence of both geographic and human barriers to migration.
- **A hotter and drier climate will create ideal conditions for the start and spread of wildfires. Fire disturbance can bring about changes in the distribution of tree species and can reduce their genetic diversity (Liu 2005; Radeloff et al. 2004).**
- **An increased number of forest fires can exacerbate drought episodes by reducing rainfall. Smoke particles absorb solar heat, robbing convective currents of the energy they need to transport water vapor upward, and thus interfering with the cycle that generates rainfall in the region (Liu 2005).**
- Increasing atmospheric CO_2 concentration is likely to spur forest growth in the short term, but the long-term response is not clear at present. Increasing ground-level ozone concentrations, for example, will probably damage forest trees, potentially offsetting the positive effect of CO_2.
- Continued deposition of nitrogen from the atmosphere may spur growth in forests, but the long-term consequences include increased nitrate pollution of waterways, groundwater, and drinking water supplies.
- Long-distance migratory birds such as scarlet tanagers, warblers, thrushes, and flycatchers depend on trees and caterpillars for food. Especially for those migratory birds that time their migration by day length rather than by weather, food sources may be severely reduced when they arrive in the Great Lakes region.

- Resident birds such as northern cardinals, chickadees, and titmice might be able to begin breeding earlier and raise more broods each season. However, increasing populations of resident species could further reduce the food available for migratory songbirds that breed in the Great Lakes, ultimately reducing forest bird diversity in the region.
- The geographic range of forest pest species such as the gypsy moth is likely to expand as temperatures warm and the distribution of food plants changes.
- Changes in leaf chemistry due to CO_2 fertilization are possible, reducing food quality for some organisms. This could cause some leaf-eating pests to eat more and could ultimately alter aquatic and terrestrial food webs.

Agriculture:

- Earlier studies predicted that climate change would benefit or only marginally disrupt Great Lakes agricultural productivity over the next 100 years, with warming and increased CO_2 fertilization boosting yields in the northern parts of the region. Newer climate projections used in this report, however, suggest a less favorable impact on agriculture, largely because of changes in the distribution of rain: Wetter periods are expected during times that could delay harvest or planting, and dry spells are projected during times when crops need water. As optimal agricultural climates move northward and eastward, crop yields may be limited by soil quality and be more vulnerable to weather extremes such as floods and droughts.
- The length of the growing season will continue to increase so that by the end of the century it may be four to nine weeks longer than over the period 1961–1990.
- **Increased incidences of extreme events such as severe storms and floods during the planting season are likely to depress crop yields. The combination of flooding and high heat is especially lethal to both corn and soybeans, and soybeans seem to be particularly vulnerable to climate variability. Perennial crops such as fruit trees and vineyards are also vulnerable because adjustments cannot be made as flexibly, putting long-term investments at risk (Wander and Clemmer 2005).**
- Crop losses may increase as new pests and diseases become established in the region and as warmer, longer growing seasons facilitate the buildup of larger pest populations. Already the range of the bean leaf beetle, a pest of soybeans, appears to be shifting northward. **On the other hand, extremes in temperatures and precipitation at important insect growth stages may reduce the threat of some pests such as western corn rootworm or European corn borer (Wander and Clemmer 2005).**
- **Elevated CO_2 levels are also likely to exacerbate pest problems because CO_2 changes the quality of crop tissues, making plants themselves more susceptible to pest damage (Long et al. 2005; DeLucia et al. 2005).**

- Ozone concentrations already reach levels that damage soybeans and horticultural crops. **The greatest damage to crops occurs in midsummer, when peak accumulated ozone levels coincide with peak crop productivity (Felzer et al. 2004).** Increasing ozone concentrations may counteract the increased production expected from CO_2 fertilization.
- **Warmer summer temperatures will likely suppress appetite and decrease weight gain in livestock, and extreme heat decreases milk productivity. Extreme weather events such as heat waves, droughts, floods, and blizzards could have severe consequences for livestock (Wander and Clemmer 2005).**
- **Increasing temperatures will potentially increase temperate grassland production but reduce warm-season grasslands. Warmer winters and less snow cover are likely to reduce the quantity and quality of spring forage and, thus, milk quality (Wander and Clemmer 2005).**
- Overall, the influence of climate change on both crop and livestock sectors will be greatly moderated by technological advances and trends in markets. However, increasing variability in the climate is likely to increase economic risks for smaller farms.

Economic, Social, and Health Impacts:

- As lake levels drop, costs to shipping in the Great Lakes are likely to increase, along with costs of dredging harbors and channels and of adjusting docks, water intake pipes, and other infrastructure. On the other hand, a longer ice-free season will increase the shipping season.
- **In those parts of the region where lake-effect snow is a fact of winter life, these snow events could increase as a result of warmer lake surface waters and decreased ice cover. Heavy lake-effect snow is a potential natural hazard and burdens municipal budgets with large snow removal expenses, but has benefits for winter recreational activities, agriculture, and regional hydrology (Burnett et al. 2003).**
- Nevertheless, shorter, warmer winters will result in losses in winter recreation such as skiing, ice fishing, and snowmobiling over much of the region, but may lengthen the season for warm-weather recreation. Changes in recreational fishing, hunting, and wildlife viewing may occur as the distribution of species shifts across the region.
- Climate warming may lower heating costs in winter, but that may be offset by higher costs for air conditioning in summer.
- Water withdrawals from the Great Lakes are already the subject of contentious debate, and pressures for more water for irrigation, drinking, and other human uses may intensify the conflicts as water shortages develop.
- Decreased water levels could reduce hydropower generation in the region.

- **Increases in droughts and floods, and corresponding changes in moisture surpluses and deficiencies, will increase agricultural production costs. For example, wet fall weather increases the need for crop drying, and mid-summer drought would increase the number of acres requiring irrigation. Such shifts will impose additional costs on farmers and increase tensions over limited resources (Wander and Clemmer 2005; Wander and Hollinger 2005).**
- **Livestock production may become more expensive as higher temperatures may necessitate reduced stocking rates or investments in improved ventilation or cooling equipment (Wander and Clemmer 2005).**
- More days with high heat will exacerbate the formation of dangerous levels of ozone. Ozone and other air pollutants generated by coal-fired power plants in the region are likely to exacerbate asthma and other respiratory diseases.
- **A warming climate will increase the severity, and potentially the number, of summertime pollution episodes in the region, due in part to decreased air movement in more stagnant air masses and a reduction in pollution-ventilating storms that sweep across the Great Lakes states (Mickley et al. 2004).**
- **Air quality might deteriorate due to harmful gases discharged during more frequent and widespread forest fires. Such fires can also reduce the capacity of the region's forests to store carbon, thus releasing even greater amounts of CO_2 into the atmosphere (Radeloff et al. 2004).**
- Health risks associated with extreme heat are likely to increase, while cold-related illnesses are likely to decrease.

How can residents of the Great Lakes region address the challenge of a changing climate?

There are prudent and responsible actions that citizens and policymakers can take now to reduce the vulnerability of ecosystems and safeguard the economy of the region in the face of a changing climate. These actions represent three complementary approaches:

- Reducing the region's contribution to the global problem of heat-trapping greenhouse gas emissions: Although some warming is inevitable as a result of historical emissions of CO_2, many of the most damaging impacts can be avoided if the pace and eventual severity of climate change are moderated. Strategies for reducing emissions include increasing energy efficiency and conservation in industries and homes, boosting the use of renewable energy sources such as wind power, improving vehicle fuel efficiency, reducing the number of miles driven, avoiding waste, and recycling.

- Minimizing human pressures on the global and local environment to reduce the vulnerability of ecosystems and vital ecological services to climate change: Prudent actions include reducing air pollution, protecting the quality of water supplies as well as aquatic habitats, reducing urban sprawl and attendant habitat destruction and fragmentation, restoring critical habitats, and preventing the spread of invasive nonnative species.
- Anticipating and planning for the impacts of change to reduce future damage: This may include a wide range of adaptations, from shifts in fisheries management and farming activities to changes in building codes and public health management plans to prepare for extreme weather events.

Climate change is already making an impact on the environment of the Great Lakes region. Waiting to begin reducing emissions or to plan for managing the effects of climate change only increases the eventual expense and the potential for irreversible losses. Fortunately, many of the actions that can be taken now to prevent the most damaging impacts of climate change can also provide immediate collateral benefits such as cost savings, cleaner air and water, improved habitat and recreational opportunities, and enhanced quality of life in communities throughout the region.

This executive summary updates the findings of *Confronting Climate Change in the Great Lakes Region*, a report published in April 2003 by the Union of Concerned Scientists and the Ecological Society of America. Oversight for this update was provided by George Kling (University of Michigan) and Donald Wuebbles (University of Illinois at Urbana-Champaign). Literature review was conducted by Yue (Michael) Li (University of Illinois at Urbana-Champaign). Original report authors Katharine Hayhoe (ATMOS Research), Richard L. Lindroth (University of Wisconsin), John J. Magnuson (University of Wisconsin), Michelle Wander (University of Illinois at Urbana-Champaign), Mark Wilson (University of Michigan), and Donald Zak (University of Michigan) also contributed to this update.

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