Climate Change in the Great Lakes Region

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Algal Blooms

- Warmer water surface temperatures increase stratification of the lakes and decrease vertical mixing.
- Stronger storms and the use of impervious surfaces increase runoff and nutrient loading to the Great Lakes.
- Combined sewer overflows and agricultural fertilizers are major contributors to high nutrient loads.
- Stronger storms, warmer temperatures, and nutrient loading are conspiring to produce more hypoxic dead zones and toxic algal blooms.

Fish and Wildlife

- The rate of warming may outpace the rate at which ecosystems are able to migrate and adapt.
- Wildlife populations better adapted to cold temperatures will continue to decline as competing species migrate into the region from the south with rising temperatures.
- Lake stratification and more hypoxic conditions will further stress biomass productivity in lakes and wetlands.
- Increased evaporation rates may decrease wetland area in the region.

Energy and Industry

- Reduced summer water availability may interfere with some industrial operations.
- Warmer temperatures and more frequent heat waves will likely increase electricity demands, particularly in urban areas and during the summer months.

Forests

- As temperatures rise, the distribution and composition of tree species will change and shift northward.
- With warmer temperatures and increasing CO_2, forest productivity will likely increase until other impacts of climate change, such as increased drought, fire, and invasive species present additional stressors to forests.

Water Availability

- Despite increasing precipitation, land surfaces in the Great Lakes region are expected to become drier overall due to increasing temperatures and evaporation rates.
- More frequent summer droughts could affect soil moisture, surface waters, and groundwater supply.
- The seasonal distribution of water availability will likely change. Warmer temperatures may lead to more winter rain and earlier peak streamflows.

Agriculture

- The frost-free season lengthened by 9 days in the Midwestern U.S. and 10 days in the Northeast from 1958-2012, and may be up to 1-2 months longer by 2100.
- Through mid-century, a longer growing season and higher CO_2 concentrations will likely have a positive effect on many crop yields.
- By 2100, the negative effects of increasing storm activity, flooding, extreme heat, summer drought risk, and pests may outweigh the benefits of other climate changes.

Transportation

- More extreme heat may increase the risk of heat damage to pavement and rails.
- More extreme precipitation may compromise transportation routes and damage infrastructure.
- Shipping lanes will likely be open earlier and longer due to reduced ice cover on the Great Lakes.
- Lower lake levels lead to decreased depth of navigation channels and a reduction in the maximum loads carried by vessels. For each inch of lost draft, the average 1,000-foot freighter loses $30,000 per transit.

Public Health

- Increased risk of heat waves and increased humidity may increase the number of heat-related deaths and illnesses.
- More storm activity and flooding will increase the risk of watershed contamination while warmer surface waters amplify the risk of toxic algal blooms and fish contamination.
- Diseases such as West Nile virus and Lyme disease may become more widespread since carrier insects will be more likely to survive milder winters.

Tourism and Recreation

- Winter recreation and tourism are likely to suffer due to reduced snow cover and shorter winters.
- Increased lake contamination and decreasing lake levels may lead to less desirable shorelines, but increasing summer temperatures and a longer summer season, may increase demand for beaches.
- Overall, summer tourism may grow before temperatures rise become unfavorable for many recreational activities.
- Many coldwater species of fish important to recreation are likely to decline while populations of warmwater species grow.

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GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

Average Temperature	Total Precipitation	Heavy Storm Precipitation	Great Lakes Ice Coverage	Frost-free Season
2.0°F	11%	37%	71%	9 Days
1900-2012	1900-2012	1958-2012	1973-2010	1958-2012

Temperature

- Since 1900, annual average temperatures have increased by 2.0°F (1.1°C) in the U.S. Great Lakes region.
- By 2050, average air temperatures are projected to increase by 1.8 to 5.4°F (1 to 3°C).
- By 2100, average air temperatures are projected to increase by 3.6 to 11.2°F (2 to 6.2°C).

Precipitation

- Since 1900, total annual precipitation has increased by 10.8% in the U.S. Great Lakes Region, and is expected to continue to increase, though projections of future precipitation vary.
- Precipitation will increase during wet seasons but may remain nearly stable or decrease during the summer.
- Reduced lake ice coverage will result in more exposed water and more opportunity for lake-effect precipitation.

Snow, Ice Cover and Lake Temperature

- Lake temperatures have been increasing faster than surrounding air temperatures.
- From 1973 to 2010, annual average ice coverage on the Great Lakes declined by 71%.
- From 1975 to 2004, the annual number of days with land snow cover decreased by 15 and the average snow depth decreased by 2 inches (5.1 cm).
- Snow and ice levels on the Great Lakes and on land will likely continue to decrease, with little significant ice cover on Lake Superior by mid-century in a typical year.

Extreme Weather

- The frequency and intensity of severe storms has increased. This trend will likely continue as the effects of climate change become more pronounced.
- The amount of precipitation falling in the heaviest 1% of storms increased by 37% in the Midwest and 71% in the Northeast from 1958 through 2012.
- More severe storms may have a negative economic impact due to resulting damages and increased costs of preparation, clean up, and business disruption.

Water Quality and Stormwater Management

- Increased risk of droughts, severe storms, and flooding events may increase the risk of erosion, sewage overflow, lead to more interference with transportation, and more flood damage.
- Future changes in land use could have a far greater impact on water quality than climate change. The coupling of climate change and land use change could therefore result in even stronger effects in some areas.

Lake Levels

- Long-term water levels in the Great Lakes have fallen since reaching record highs in the 1980s.
- While most models project continued, long-term declines in lake levels, shorter-term variations will remain large, and periods of high lake levels are probable.
- Other factors, such as lake regulations, also affect lake levels, though no major management changes have occurred since 2000.

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