Climate Change and the Great Lakes:
Predicted Long Term Climate Changes
and
Severe Weather Effects.

“Climate is what you’re supposed to get;
Weather is what you get”

Climatologist George Taylor
This chain of 5 large freshwater lakes form the largest lake group in the world, covering an area of 95,000 sq mi.
## Water Withdrawals

* Cubic feet per second  
** Millions of cubic metres per year  

**Source:** Bulletins E-1866-70, Sea Grant College Program, Cooperative Extension Service, Michigan State University, E. Lansing, Michigan, 1985.

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The world's longest deep-draft inland waterway.

In 2002 - 162 million net tons of dry bulk cargo was moved on the Lakes.

In order of volume:
Iron ore
Coal
Stone
Grain
Salt
Cement
Potash.

The system extends from Duluth, Minn., on Lake Superior, to the Gulf of St. Lawrence on the Atlantic Ocean, a distance of more than 2,340 miles.
Confronting Climate Change in the Great Lakes Region
Impacts on Our Communities and Ecosystems

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Scott Robinson (U IL)
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Susanne Moser (UCS)
Mark Wilson (U MI)

A REPORT OF
The Union of Concerned Scientists and
The Ecological Society of America

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

The Ecological Society of America
Climate Change is Already Underway

- 1000 to 1861, N. Hemisphere, proxy data
- 1861 to 2000, Global, instrumental
- 2000 to 2100, SRES projections

**The IPCC Special Report on Emissions Scenarios (SRES)**

Source: IPCC TAR 2001

A1: Very rapid global economic growth
A2: Growth slower and more fragmented
B2: Intermediate growth
B1: Introduction of clean technologies and emphasis on environmental sustainability
Evidence of Climate Change in the Great Lakes Region

• Temperatures are rising, especially in winter
• Extreme rainfall events (24-hr and 7-day) are becoming more frequent
• Winters have become shorter
• Spring coming earlier
• Shorter duration of ice cover, especially on smaller lakes
Great Lakes water levels are currently at their lowest in 35 Years with no relief in sight.

Low water levels on the Great Lakes last year forced the New York Power Authority to repeatedly reduce hydroelectric allocations to businesses and other power customers. The Boston Globe
Increased Lake Effect Snow; 
Warmer surface waters 
Less ice cover 
Greater Lake evaporation

Adam W. Burnett: Colgate University
“For every inch of water Lake Michigan loses, a cargo ship must reduce its load by 90 to 115 metric tons. Per barge, that means a loss of between $22K-$28K—Costs that are typically passed on to the consumer”

_Helen Brohl, US Great Lakes Shipping Assoc._
Great Lakes Region - Canada

Weather-related disasters in Canada, 1900 – 1999

Source: Emergency Preparedness Canada.
Severe Weather in Illinois

1988: Severe Drought
1993: Flooding
1995: Heat Wave
1996: Severe Rainstorm, Heat Wave
1999: Windstorm
2004: Utica Tornados
Drought and Agriculture

Table 1. Rainfall and Maximum Temperature Date, Urbana, Illinois and Ohio.

<table>
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<tr>
<th>Year</th>
<th>County Yield</th>
<th>Total Precipitation in:</th>
<th>Average Daily Max. Temp.</th>
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<td></td>
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<td>July</td>
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<tr>
<td>Average</td>
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</table>

Figure 1. County Corn Yields in Champaign County Illinois and Ohio, 1972-2002.
1993

Considered the most costly and devastating flood to ravage the U.S. in modern history. The number of record river levels, its aerial extent, the number of persons displaced, amount of crop and property damage and its duration surpassed all earlier U.S. floods in modern times.
- Nearly fifty people died as a result of the flooding.

- 26,000 were evacuated and over 56,000 homes were damaged.

- Economic losses directly attributable to the flooding totaled $10-12 billion. Indirect losses in the form of lost wages and production can not be accurately calculated.

- The flooding submerged eight million acres of farmland. Production of corn and soybeans were down 5-9% as a result and corn prices rose by $0.15 per bushel.

- Barge traffic was halted for two months, carriers lost an estimated $1 million per day. (Mississippi River Barges: carry 20% of the nation’s coal, 1/3 of its petroleum, and 50% of its exported grain.)

- Some power plants along the river saw their coal stocks dwindle from a two-month supply to enough to last just 20 days.

- Hundreds of miles of roads built on the flat, wide floodplain were closed. Flooding is estimated to have cost $500 million in road damage.
A total of 19 Illinois levees failed, covering the landscape with water and killing wildlife that were unable to vacate to higher ground in time.

After the waters receded, tons of sand from sandbagging efforts left many areas looking like a desert.

Plant and animal populations increased in areas where the nutrient-rich water rose at a steady rate. Zebra mussels thrived in the flood environment, widely expanding their original area.

Within the Sanganois Wildlife Management Area near Beardstown, Illinois, four stands were identified in which virtually all trees had been killed. These stands were underwater continuously for six to eight months, including one entire growing season.
Heat Waves are by far the greatest weather-related killer in the US

In 1995, hot weather claimed over 500 lives and was a contributing cause in more than 200 additional deaths.

The heat storm that affected Chicago from July 12 to 16, 1995, was a particularly acute episode containing all the danger signals—high temperatures and humidity and low wind speeds over a five-day period.

The heat index reached 118°F (48°C) on the hottest day.
The storm produced a maximum of 43.0 cm of rainfall within 24 hours at Aurora, which was the greatest point rainfall recorded in this century in Illinois and most surrounding states.

The 27.9 cm storm rainfall recorded in the southwestern part of the Chicago metropolitan area was the heaviest 24-hr amount ever recorded in the city.
Windstorm 1999
The “Mother Ship” lands at Argonne

The major storm on Aug. 12, destroyed thousands of acres of corn across the area, causing more than $53 million in crop damage in eight counties.

A second series of storms six days later caused an additional $4 million in hail damage to corn and soybeans.
Utica 2004

A cluster of nineteen tornadoes struck Illinois April 20.

National Weather Service officials said they received reports of 51 tornadoes, most clustered in Illinois and Indiana, but some as far as Nebraska, Iowa and
Twister devastated town's historic center

The tornado that touched down Tuesday damaged most of Utica's downtown buildings and destroyed several, including a tavern where eight people died.

**AMOUNT OF DAMAGE TO MILL STREET BUILDINGS**

- **Destroyed**
- **Severely damaged**
- **Moderately damaged**
- **No visible damage**

**Utica Police Department and Village Hall**
(Built before 1888)

**Holland's Utica Garage** (1920)

**Milestone Tap** (1887)
8 fatalities

**Ambulance station** (NA)

**Towpath collectibles**
(1890)

**Skoog's Bar and Grill** (1892)

**Second Look Antiques** (1890)

**Vacant** (1890)

**Joy and Ed's Supper Club**
(1895)

**Utica Hair Company**
(1888-91)

**Duffy's Tavern**
(1892)

Note: Damage accounts based on Tribune survey of buildings' exteriors.

Source: Utica Police Department.
Projected Climate Changes in the Great Lakes Region

Average temperatures rise **5-20°F (3-11°C)** in summer, **5-12°F (3-7°C)** in winter.

**Little change** in annual average precipitation but higher temperatures leads to **more evaporation**, which leads to drier conditions, especially in the summer and fall.

More **extreme downpours**, dramatic increases in **extreme-heat days**, more **droughts**.

More evaporation and declining ice cover likely to **lower lake levels**.

**Lengthening** by several weeks, but varying across region.
Projected Temperature Increase in the Great Lakes Region (by 2070-99)

Summer

Winter

Lower emissions

Higher emissions
Projected Precipitation Changes in the Great Lakes Region (by 2070-99)

Summer

Winter

Lower emissions

Higher emissions
Projected Climate Changes in the Great Lakes Region by 2100

- Temperature
  - Winter: 5-12°F (3-7°C)
  - Summer: 5-20°F (3-11°C)
  - Extreme heat more common
  - Growing season several weeks longer

- Precipitation
  - Winter, spring increasing
  - Summer, fall decreasing
  - Drier soils, more droughts

- More extreme events
  - Storms, floods
  - Could be 50-100% more frequent than now

- Ice cover decline
  - Will continue

Source: Bob Allan, NREL
GCCM1 predicts a drop of 1.5 to 3 feet across the lakes within the next 30 years.
Nutrient Contamination of Lakes

Lower O\(_2\) and warmer T promote microbial decomposition
And release of nutrients and sediment contaminants.

Higher rates of evaporation and lower lake levels require more frequent dredging of channels and harbors, releasing toxic contaminants.
## Air Pollution

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Number of days with synoptic patterns that are conducive to high ozone will increase by the end of this century across much of the Great Lakes region.
Agriculture:

Models suggest that future crop yields (ton/acre) may be greater than historical yields through 2050, and then may decrease with time from 2051-2100.

Simple adaptations to a changing climate such as a switch to a longer-season variety or earlier planting date were found to result in significant increases in potential crop yield along with a northward shift of some current crop production areas.
The Changing Character of Great Lakes

Lakes, Streams, & Fish

• Cold-water fish may decline dramatically, while cool- & warm-water species move north

• Aquatic ecosystem disruptions will be compounded by invasions of non-native species

• Summer lake stratification will increase and cause higher risk of dead-zones and fish kills

• Mobilization of mercury and other contaminants, uptake in aquatic food chain
The Changing Character of Great Lakes Wetlands & Shorebirds

- Earlier spring runoff, more intense flooding, and lower summer water levels increase the challenges for wetlands and species

- Lower flood-absorbing capacity

- Fewer safe breeding sites for amphibians, shorebirds and waterfowl

- Shrinking wetland habitat, drying of prairie potholes

Source: Tim Daniel, Ohio DNR
The Changing Character of Great Lakes Forests & Wildlife

- Boreal forests likely to disappear
- Higher CO₂ and N could increase short-term forest productivity
- Higher ozone, more frequent droughts, forest fires, and greater risk from insect pests could damage long-term forest health
- Resident bird species breed more and earlier, migratory birds decline
- Raccoons, skunks, and white-tailed deer may suffer

Photo: USDA Forest Service

Source: J.G. Graham
The Changing Character of Great Lakes Recreation & Tourism

- Significant impacts on multi-billion/year industry
- Millions of anglers affected by fish impacts
- Bird-watchers and hunters affected by impacts on birds, waterfowl
- Communities dependent on winter recreation revenues especially hard hit
- Summer season expanding, but more extreme heat, heavy downpours, higher ozone, and risk of infectious diseases

Source: John Magnuson
Exacerbation of Existing Problems

Property & Infrastructure

• More frequent extreme storms and floods
  - greater property damage
  - heavier burden on emergency management
  - increase clean-up and rebuilding costs
  - financial toll on businesses and homeowners

Source: Dave Saville, courtesy of FEMA

• Damage of water-related infrastructure
• Lake level drops will require more dredging and other shipping- and boating-related infrastructure adjustments
Exacerbation of Existing Problems

Agriculture

- warmer temperatures, longer growing season, CO$_2$ fertilization

- declining soil moisture, thin soils, higher ozone, more pests, storms & floods during planting and harvesting, extreme heat

Source: USDA and Forestry Images

Source: University of Minnesota
Exacerbation of Existing Problems

Water Resources

• Reduced groundwater recharge, small streams likely to dry up

• Average lake levels expected to decline

• Pressure to increase water extraction from the Great Lakes

• Degradation of flood-absorbing capacity of wetlands, increased flooding and erosion

Source: Dave Hansen, MN Extension Service
Exacerbation of Existing Problems

Human Health

- Cold-related health problems will decline while heat-related morbidity and mortality will increase
- Extreme heat more likely:
  - 40+ days by 2100 $>$ 90°F (32 °C)
  - 25+ days by 2100 $>$ 97°F (36 °C)
- Higher ground-level ozone concentrations
- Waterborne and other infectious diseases may become more frequent and widespread

Source: USDA
2002: Everglades – Water Resources Development Act

2003: Kalmath Falls – Farmers vs Fish

2004: Climate Change and the Great Lakes