

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.

			Superior	Michigan	Huron	Erie	Ontario	Totals
Municipal	Canada	*	40		120	190	660	1,010
		**	36		107	170	589	902
	U.S.	*	70	2,940	310	2,820	380	6,520
		**	62	2,262	277	2,515	339	5,455
	Total	*	110	2,940	430	3,010	1,040	7,530
		**	98	2,622	384	2,685	927	6,716
Manufacturing	Canada	*	860		1,360	1,900	2,760	6,880
		**	767		1,213	1,694	2,462	6,136
	U.S.	*	410	9,650	1,060	9,110	530	20,760
		**	366	8,608	945	8,126	473	18,518
	Total	*	1,270	9,650	2,420	11,010	3,290	27,640
		**	1,133	8,608	2,158	9,820	2,935	24,652
Power Production	Canada	*	70		2,870	1,160	8,370	12,470
		**	62		2,560	1,035	7,466	11,123
	U.S.	*	760	13,600	2,570	13,180	6,520	36,360
		**	678	12,131	2,292	11,757	5,816	32,674
	Total	*	830	13,600	5,440	14,340	14,890	49,100
		**	740	12,131	4,852	12,791	13,282	43,796
Grand Totals	*		2,210	26,190	8,290	28,360	19,220	84,270
	**		1,971	23,361	7,394	25,296	17,144	75,166

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

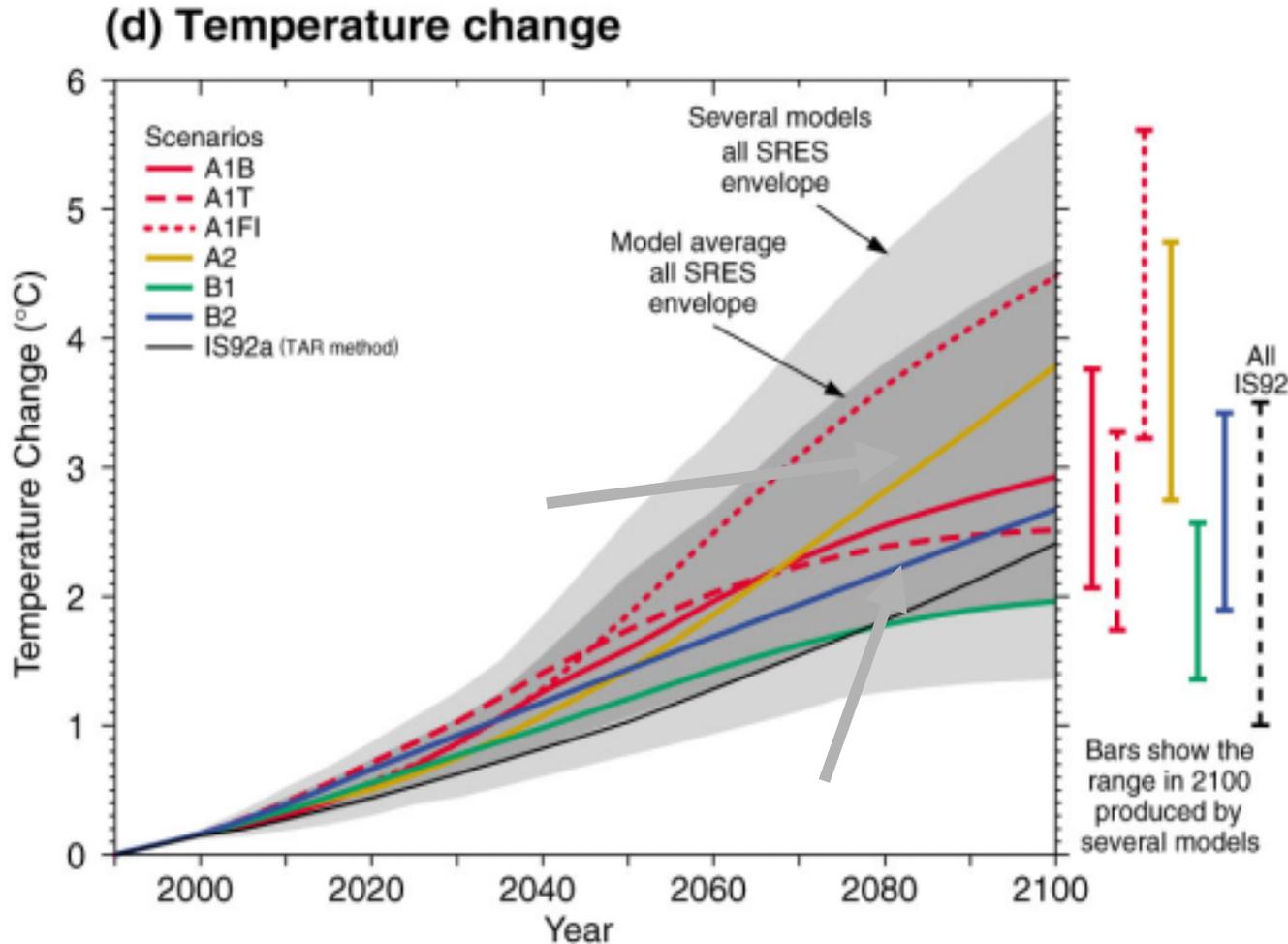


A REPORT OF
The Union of Concerned Scientists and
The Ecological Society of America

George Kling (U Mich, lead)
Katharine Hayhoe (U IL)
Lucinda Johnson (U MN)
John Magnuson (U WI)
Steve Polasky (U MN)
Scott Robinson (U IL)
Brian Shuter (U of Toronto)
Michelle Wander (U IL)
Donald Wuebbles (U IL)
Donald Zak (U Mich)
Richard Lindroth (U WI)
Susanne Moser (UCS)
Mark Wilson (U MI)



Climate Change is Already Underway



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

Source: IPCC TAR 2001

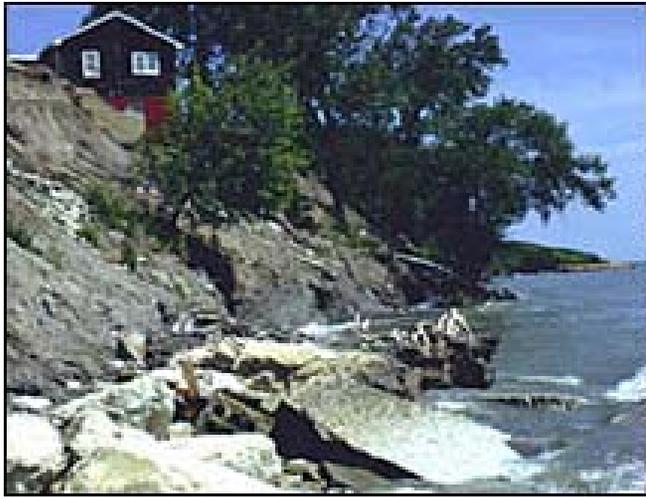
The IPCC Special Report on Emissions Scenarios (SRES)

- 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





(WISCONSIN SEA GRANT)



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](#)



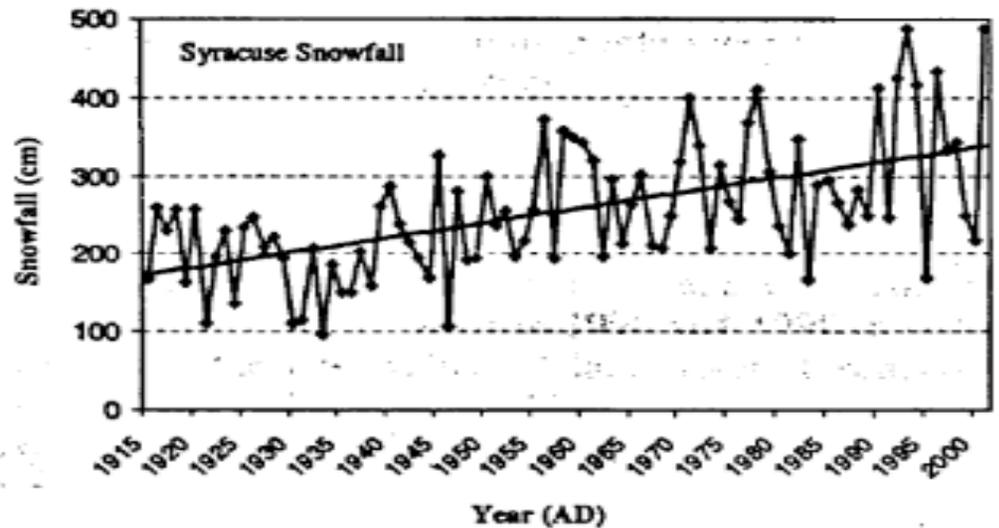


FIG. 1. Total Oct–Apr snowfall for Syracuse, NY, with statistically significant linear trend line. Note overall increase in snowfall since 1915 at an average rate of 1.9 cm yr^{-1} .

Increased Lake Effect Snow;
 Warmer surface waters
 Less ice cover
 Greater Lake evaporation

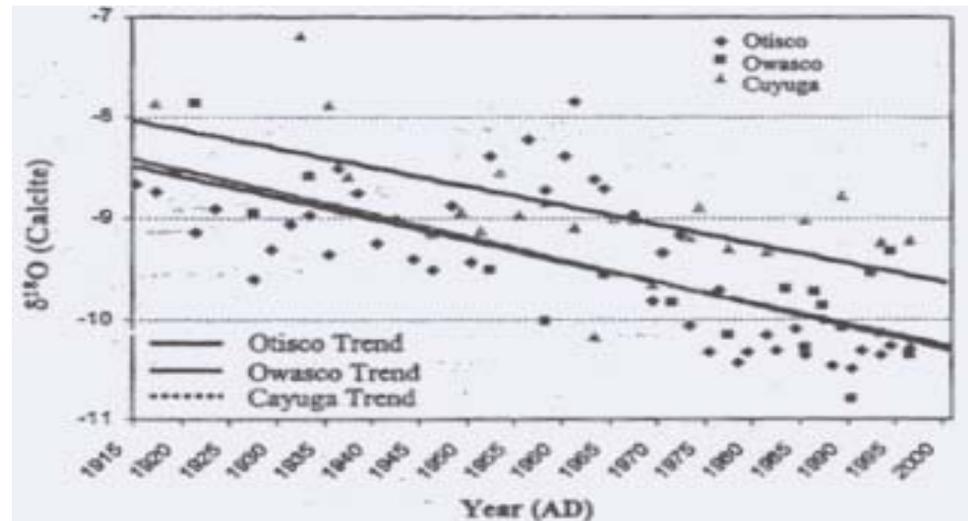


FIG. 5. Historic $\delta^{18}\text{O}$ calcite trends from Cayuga, Owasco, and Otisco Lake sediments between 1915 and 1998. Note decreasing $\delta^{18}\text{O}$ values for all three lakes as a result of increased lake-effect snowfall in the eastern Finger Lakes during the twentieth century.

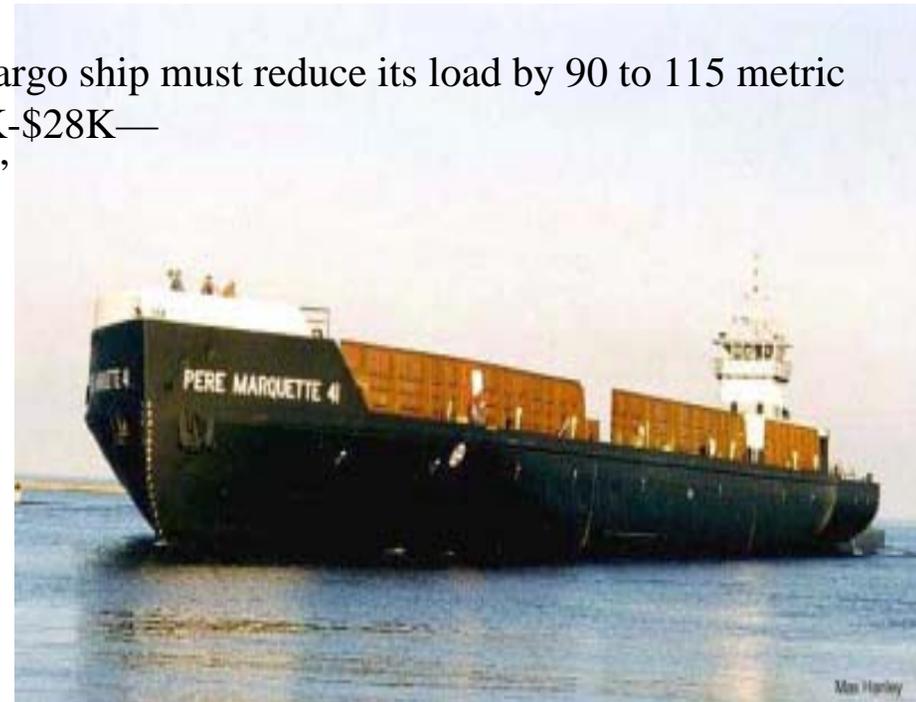


Indiana's International Port at Burns Harbor.
Photo credit Indiana Port Commission

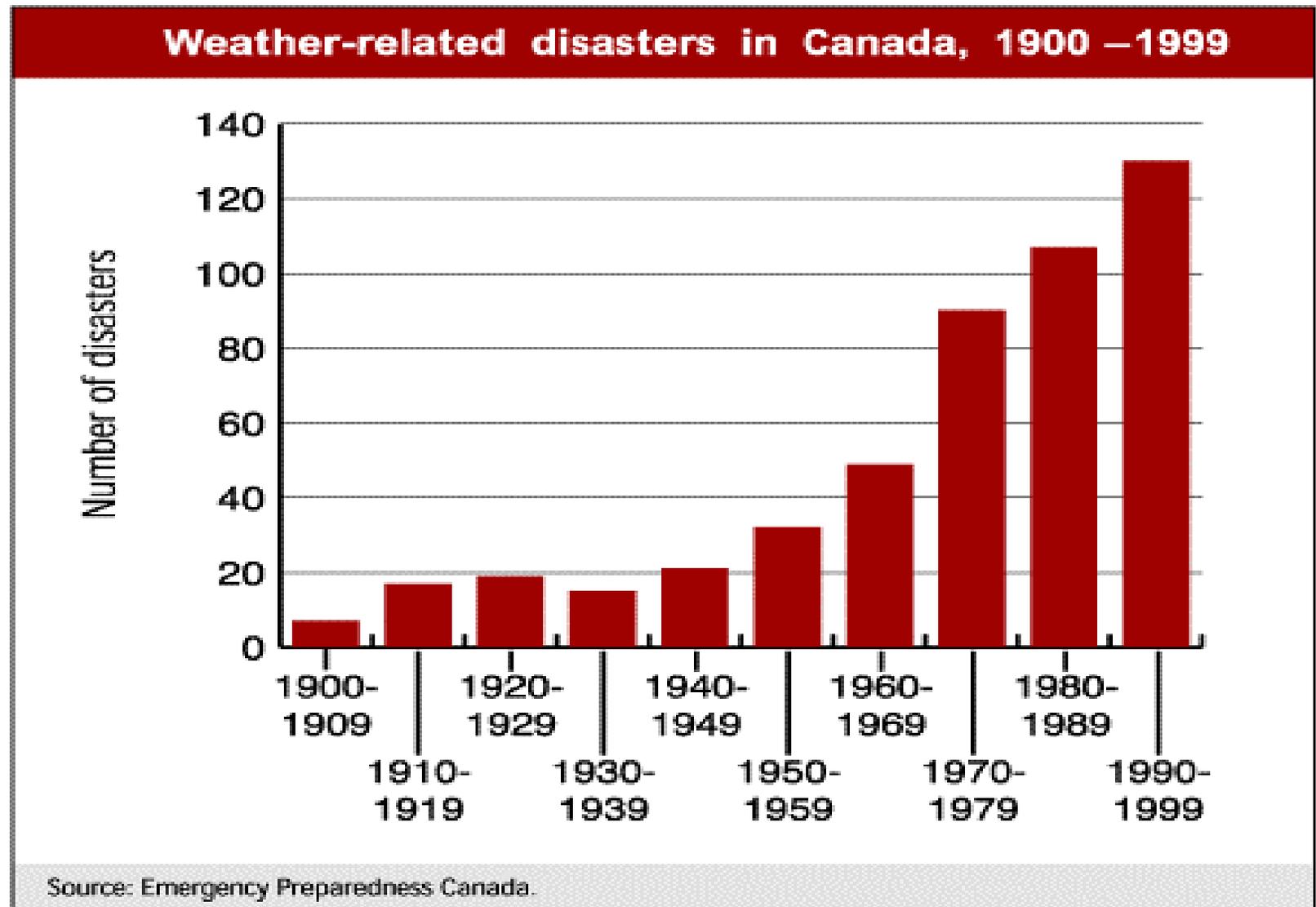


“For every inch of water Lake Michigan loses, a cargo ship must reduce its load by 90 to 115 metric tons. Per barge, that means a loss of between \$22K-\$28K—
Costs that are typically passed on to the consumer”

Helen Brohl, US Great Lakes Shipping Assoc.



Great Lakes Region - Canada



Severe Weather in Illinois

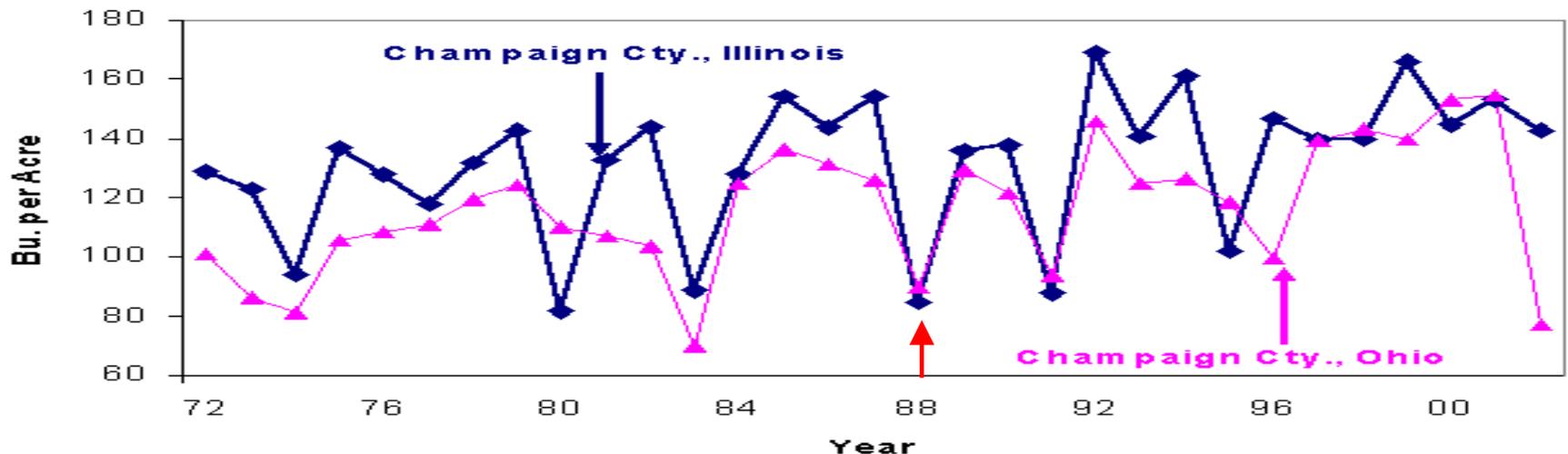
- 1988: Severe Drought
- 1993: Flooding
- 1995: Heat Wave
- 1996: Severe Rainstorm, Heat Wave
- 1999: Windstorm
- 2004: Utica Tornados

Drought and Agriculture

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

Year ¹	County Yield	Total Precipitation in:				Average Daily Max. Temp.		
		June	July	Aug	Summer ²	June	July	Aug
Panel A. Urbana, Illinois		----- Inches -----				----- Degrees F -----		
Average ³	134	4.2	4.2	4.3	12.6	83	86	84
1980	82	4.6	1.4	4.2	10.2	81	90	87
1983	89	9.2	1.4	4.6	15.2	83	90	89
1988	85	→ 0.3	3.6	1.3	5.2	88	91	90
1991	88	0.7	2.6	2.3	5.6	87	88	87
1995	102	1.9	2	5.4	9.3	84	88	88
1996	147	5.7	3.4	1.4	10.5	82	83	84
2002	143	2.8	2.7	7.7	13.2	84	90	85
Average		4.0	4.0	3.4	11.4			

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.

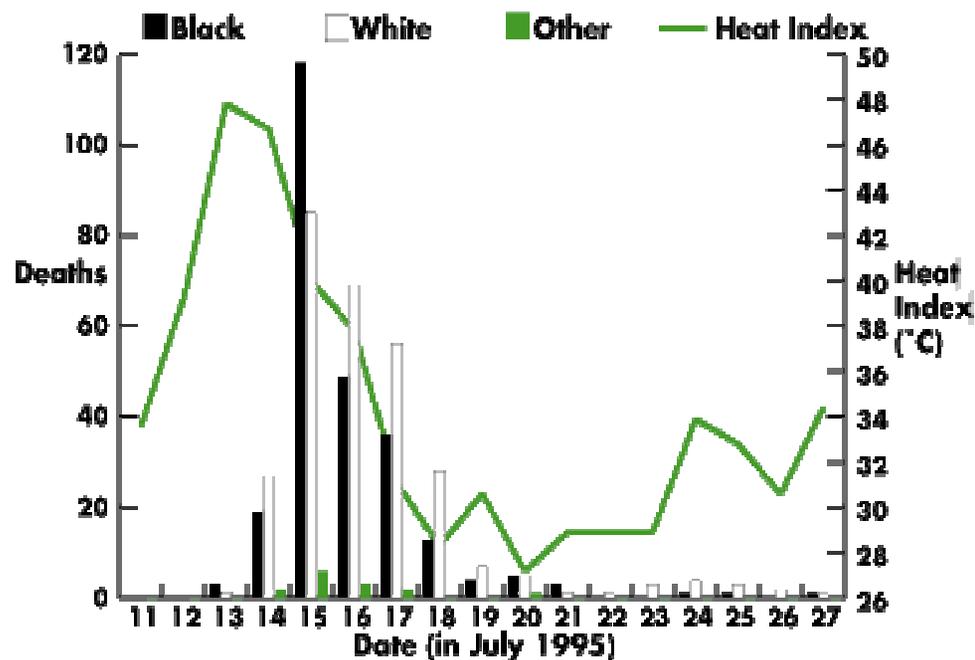
- A total of 19 Illinois levees failed, covering the landscape with water and killing wildlife that were unable to vacate to higher ground in time.
- After the waters receded, tons of sand from sandbagging efforts left many areas looking like a desert.
- Plant and animal populations increased in areas 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

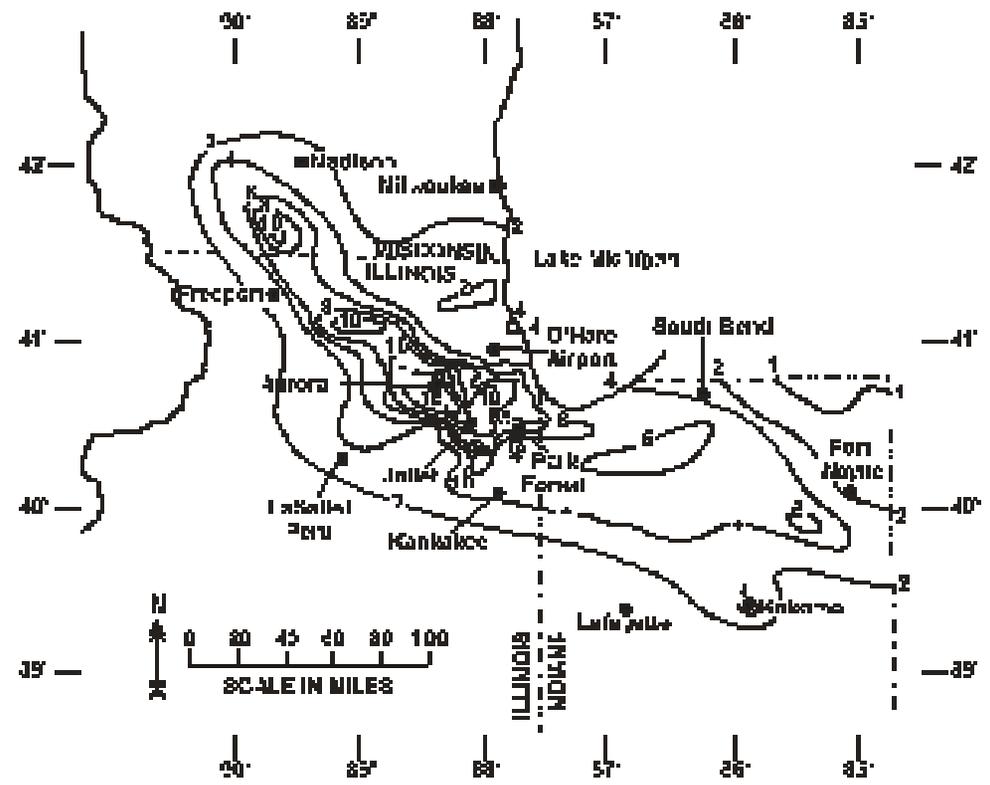
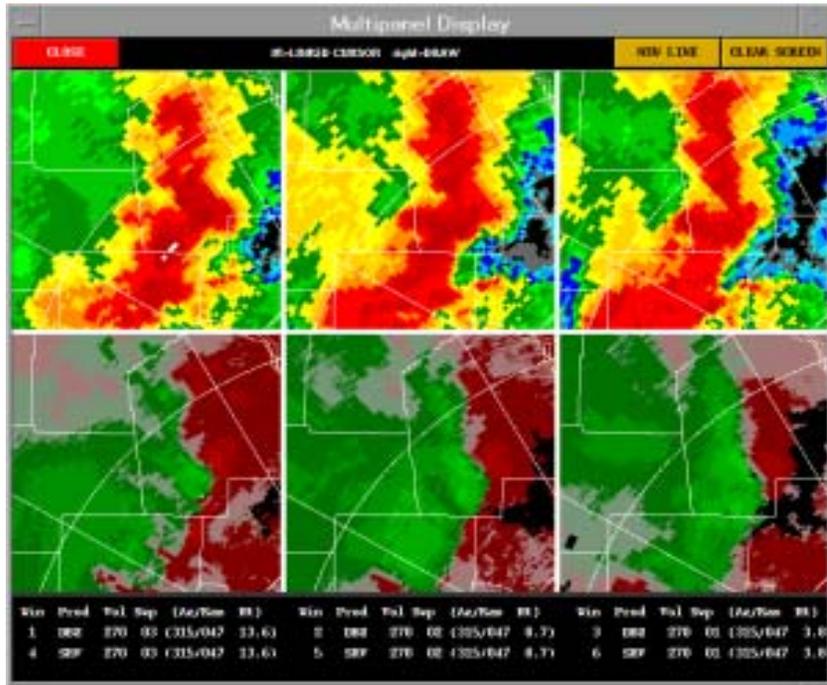
In 1995, hot weather claimed over 500 lives and was a contributing cause in more than 200 additional deaths.



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 Northeastern Illinois Storm of 17-18 July 1996



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)

GROVE ST.

Utica Public Library (1972)

Fire Department (1951)

Community Center (1905)

CHURCH ST.

Country Village Studio (1874)

Mary's Beauty Shop (1900)

Craft House (1890)

Canal Port (1915)

Vacant (1975)

Mill Street Market (1974)

Vacant (1890)

Vacant (1891)

Four Feathers (1890)

Village Oak Haus (1895)

La Salle State Bank (1900)

MILL ST.

CLANK ST.

CANAL ST.



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

Chicago Tribune/MapInfo/PA

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**.

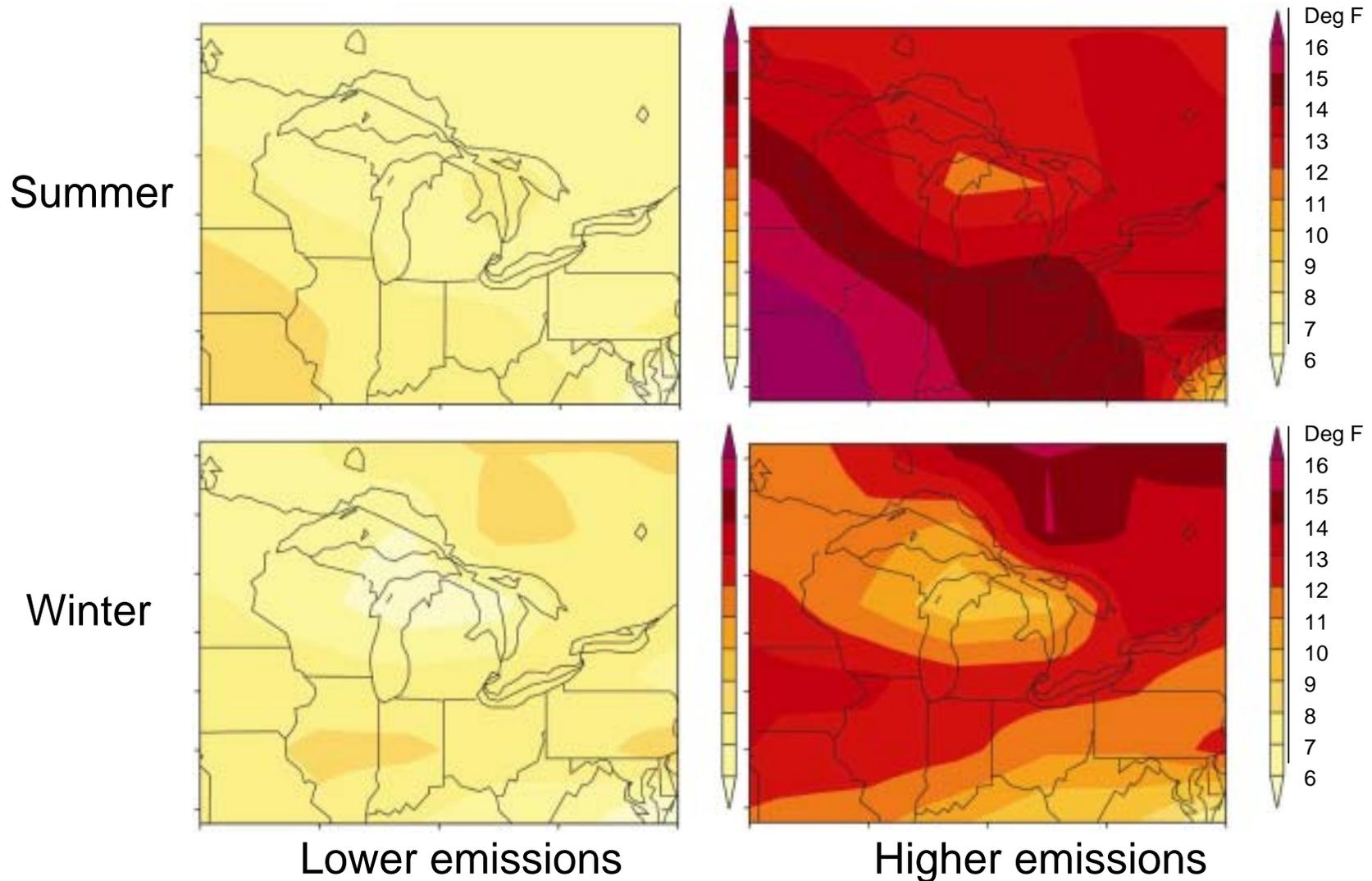


More evaporation and declining ice cover likely to **lower lake levels**.



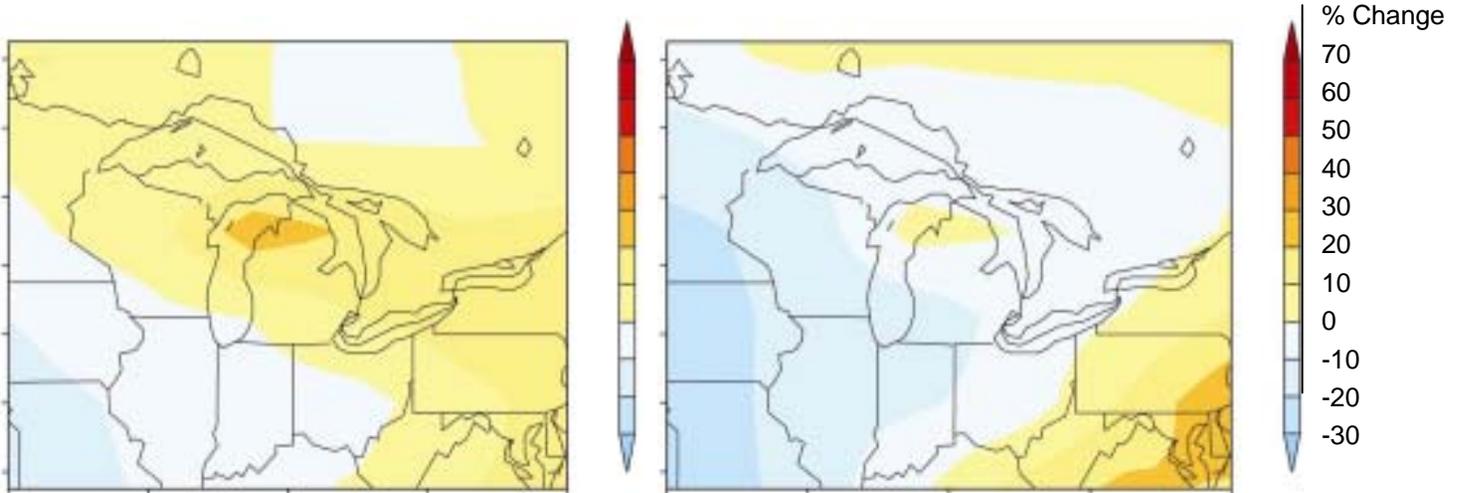
Lengthening by several weeks, but varying across region.

Projected Temperature Increase in the Great Lakes Region (by 2070-99)

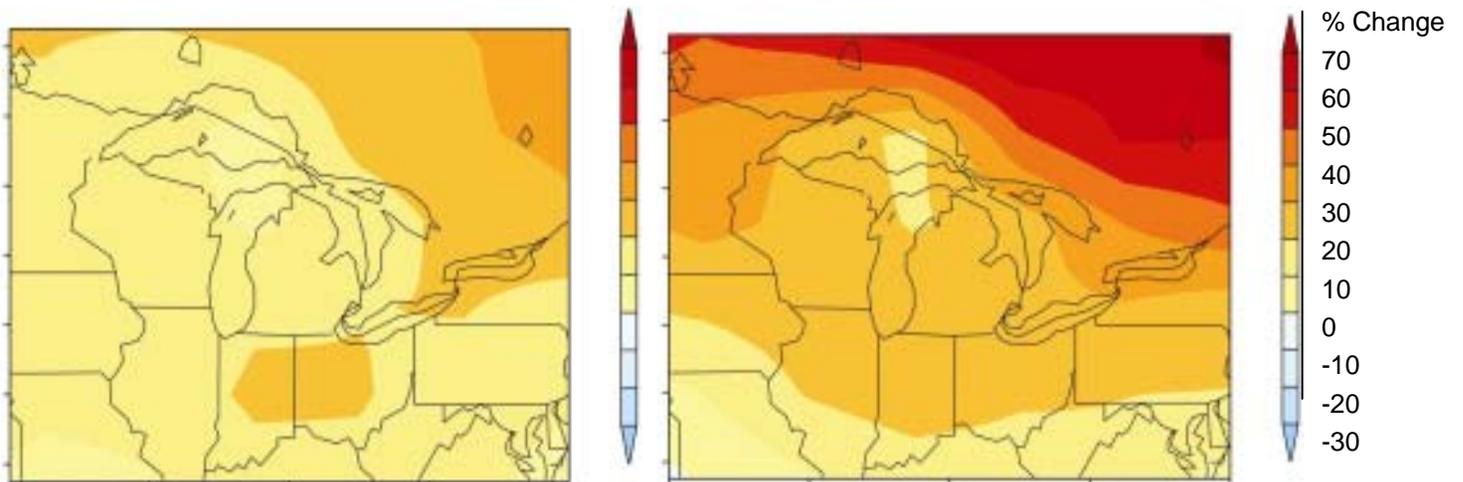


Projected Precipitation Changes in the Great Lakes Region (by 2070-99)

Summer



Winter

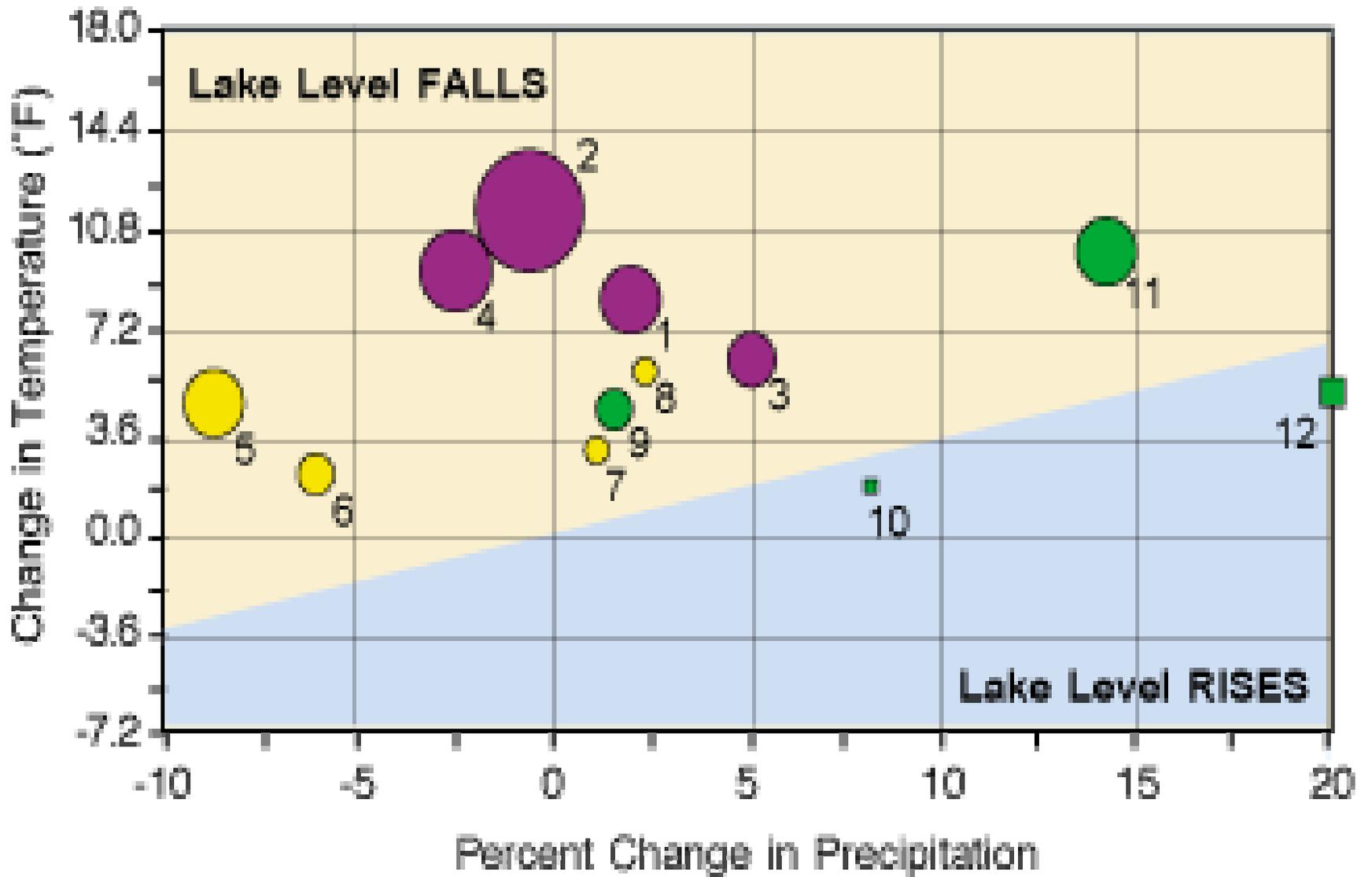


Lower emissions

Higher emissions



ce: 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

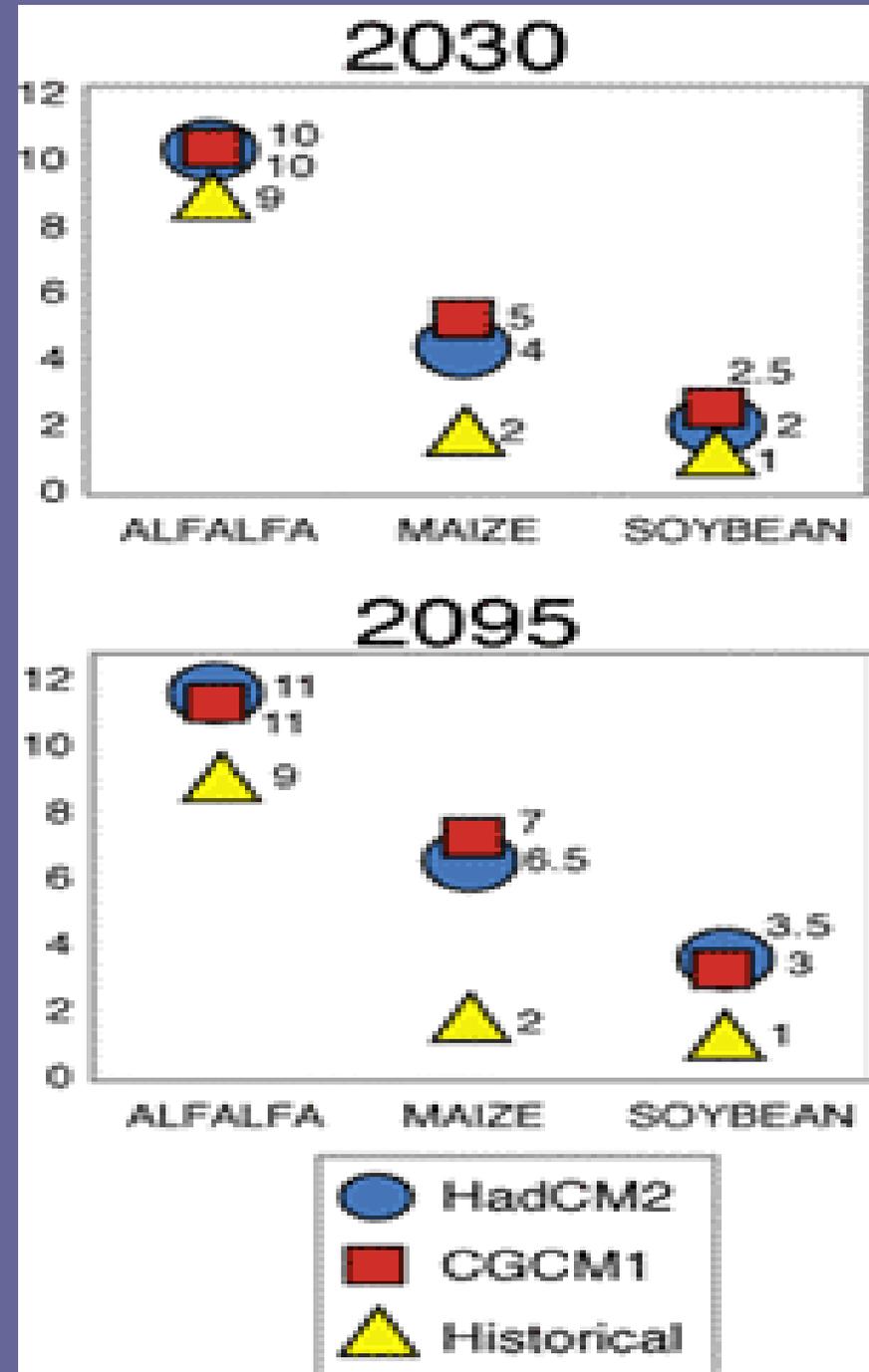
<u>Model</u>	<u>Years</u>	<u>Southwest Flow</u>	<u>High P</u>	<u>High T</u>	<u>High O₃</u>
GCCM1	1975- 1994	1570	2205	10	3
HadCM2	1970- 1989	1295	2162	140	22
GCCM1	2080- 2099	1603	2171	987	377
HadCM2	2078- 2097	1254	2167	582	157

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



Source: LHR Images

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



Photo: USDA Forest Service

- Resident bird species breed more and earlier, migratory birds decline
- Racoons, skunks, and white-tailed deer may

likely to

suffer



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



Source: John Magnuson



Source: Don Brenneman

diseases

- Communities dependent on winter recreation revenues especially hard hit
- Summer season expanding, but more extreme heat, heavy downpours, higher ozone, and risk of infectious

Exacerbation of Existing Problems

Property & Infrastructure

- More frequent extreme storms and floods



Source:: Dave Saville, courtesy of FEMA

- greater property damage
- heavier burden on emergency management
- increase clean-up and rebuilding costs
- financial toll on businesses and homeowners

- 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, CO₂ fertilization



Source: USDA and Forestry Images

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

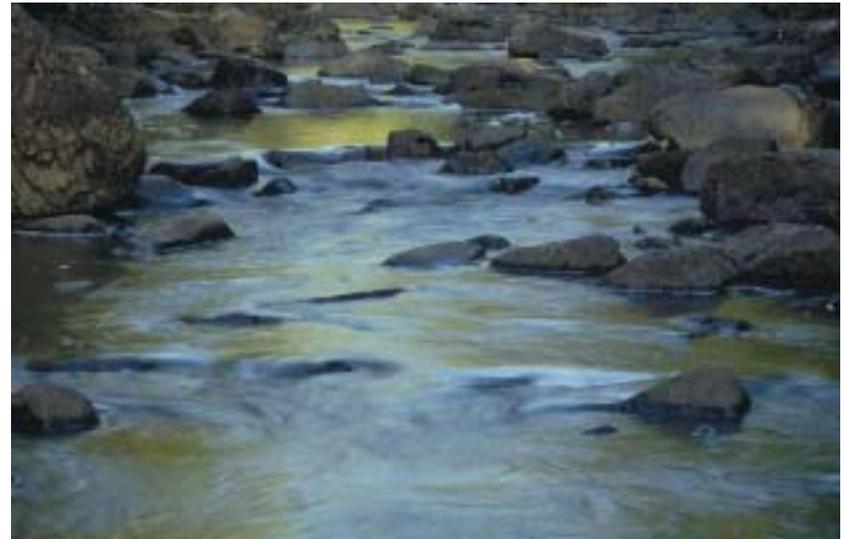


Source: University of Minnesota

Exacerbation of Existing Problems

Water Resources

- Reduced groundwater recharge, small streams 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

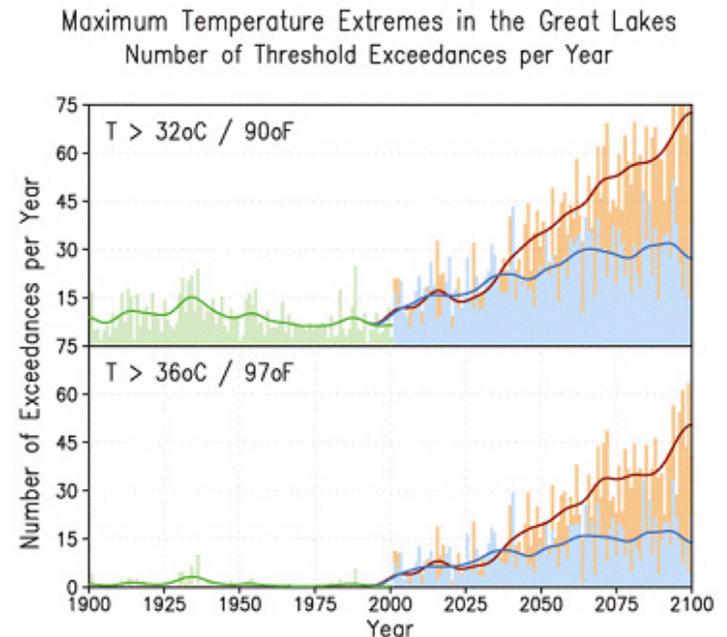


Source: Dave Hansen, MN Extension Service

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

2002: Everglades – Water Resources Development Act

2003: Kalmath Falls – Farmers vs Fish

2004: Climate Change and the Great Lakes