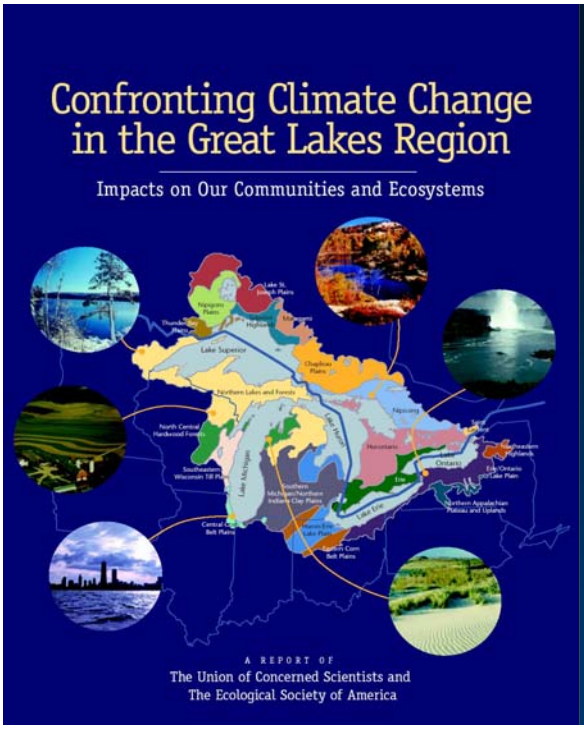
http://www.ucsusa.org/greatlakes

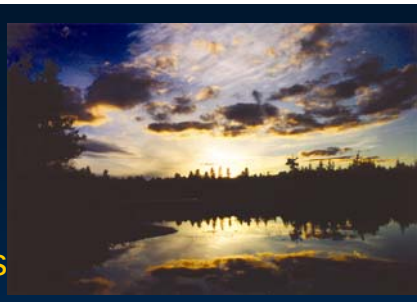


George Kling (U Mich, lead)
Katharine Hayhoe (U IL)
Lucinda Johnson (U MN)
John Magnuson (U WI)
Steve Polasky (U MN)
Scott Robinson (U IL)
Brian Shuter (U of Toronto)
Michelle Wander (U IL)
Donald Wuebbles (U IL)
Donald Zak (U Mich)
Richard Lindroth (U WI)
Susanne Moser (UCS)
Mark Wilson (U MI)

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

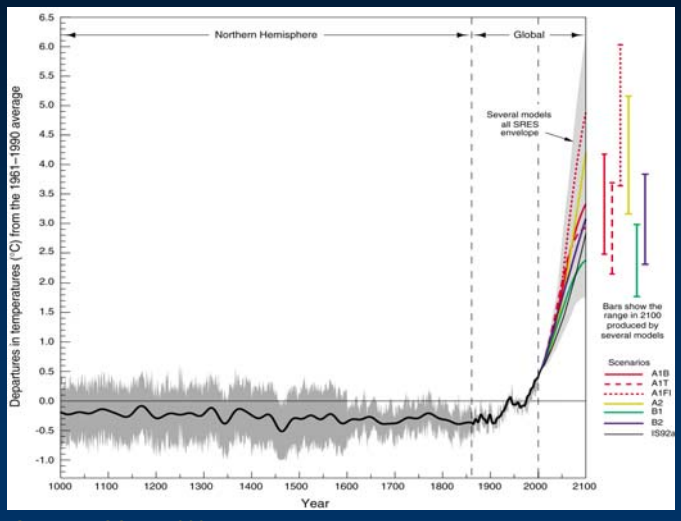
esa
The Ecological Society of America

Take Home Messages:



- Human activities produce heat-trapping gas emissions that cause climate change
- Climate change is changing the character of the Great Lakes region
- Climate change magnifies existing health and environmental problems
- Common sense solutions are available now

Climate Change is Already Underway

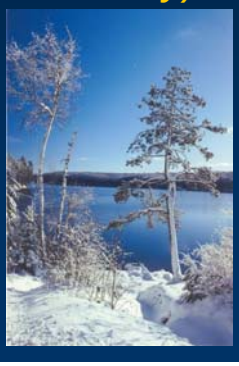


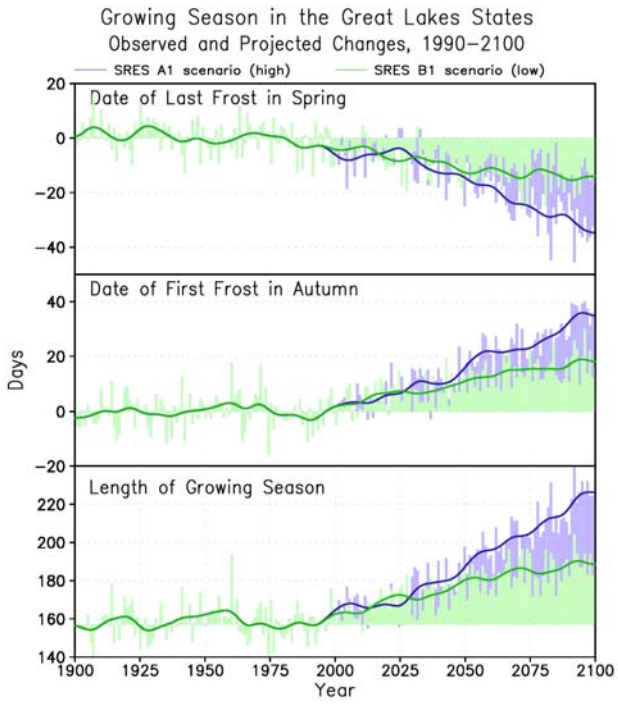
- 1000 to 1861, N. Hemisphere, proxy data
- 1861 to 2000, Global, instrumental
- 2000 to 2100, SRES projections

Source: IPCC TAR 2001

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

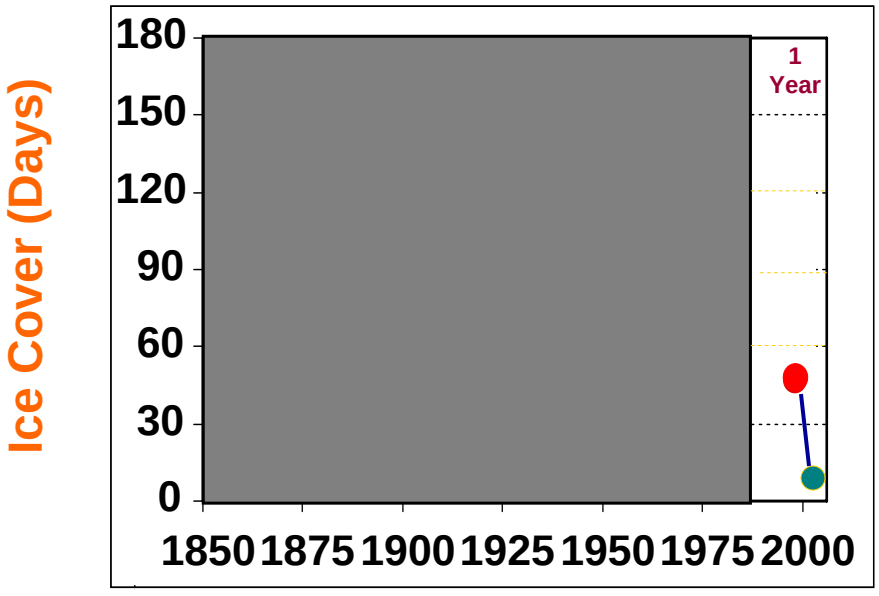




Reproduced with permission from Kunkel at al. (1999) Journal of Climate

Extreme rainfall events (24-hr and 7-day) are becoming more frequent

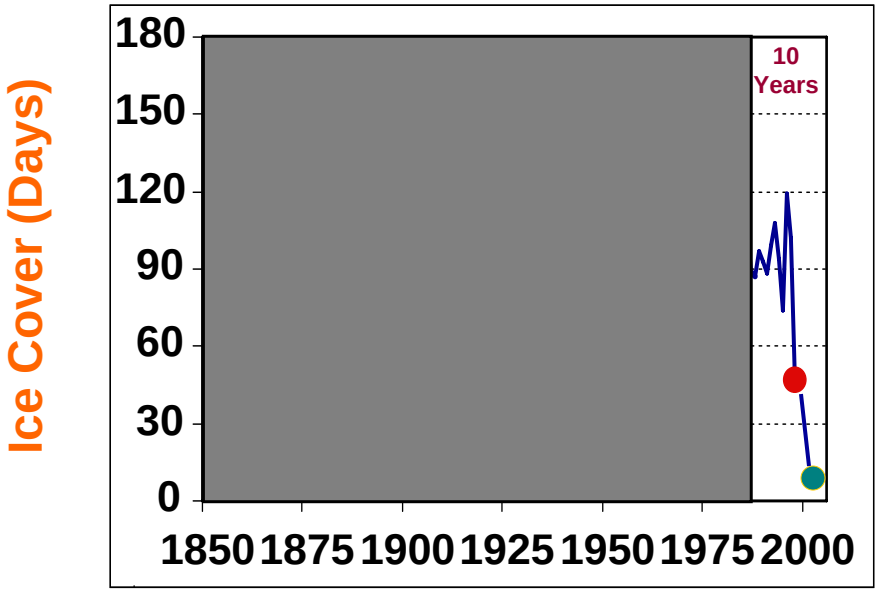
Lake Mendota, Wisconsin



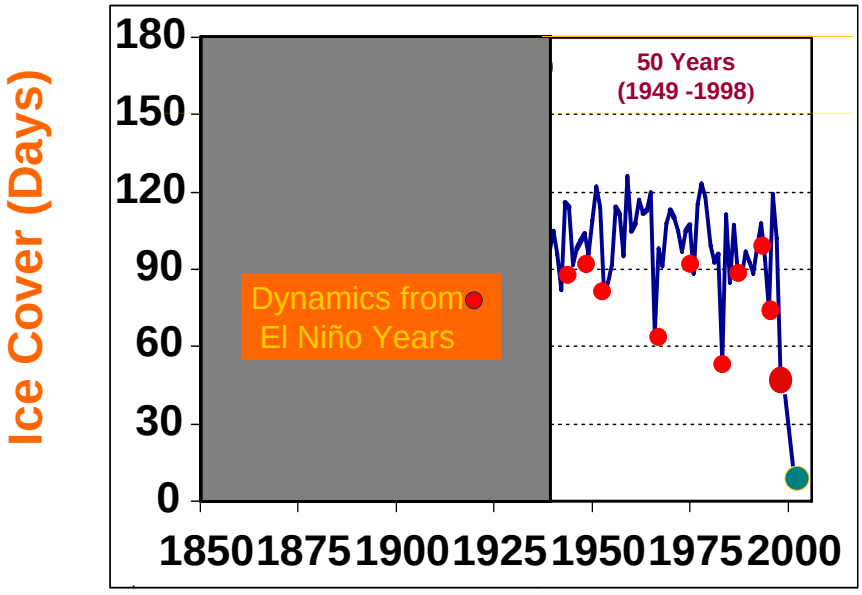
Magnuson April 2001

Unusual Events on Lake Mendota

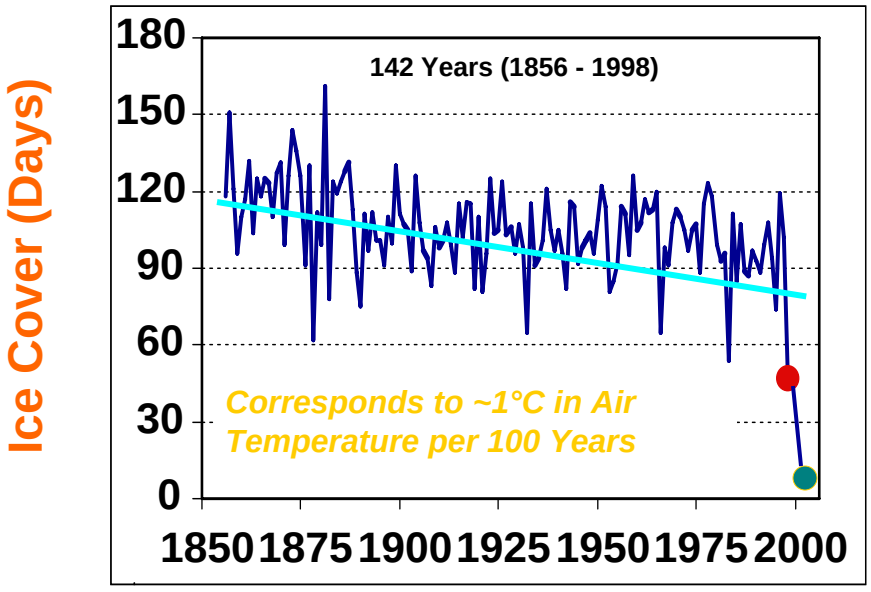
Lake Mendota, Wisconsin



Lake Mendota, Wisconsin



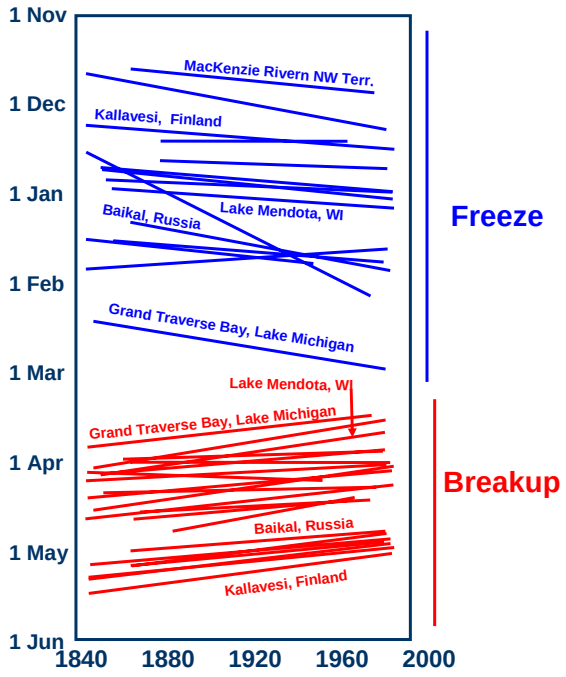
Trend from Global Change



Historical Trends in Lake and River Freeze and Breakup Dates in the Northern Hemisphere.

(37 of the 39 time series are in the direction of warming)

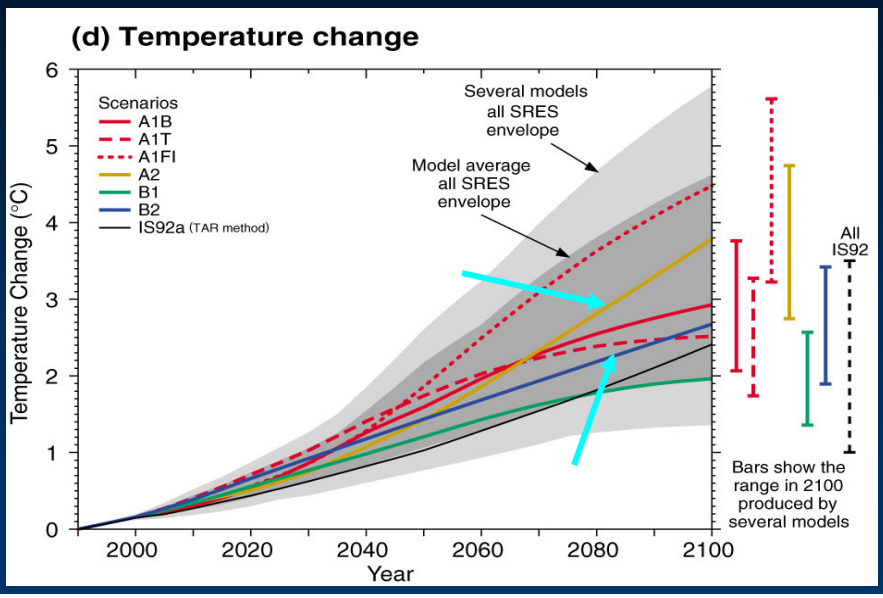
Modified from Magnuson et al. 2000 for IPCC 3rd Assessment 2001



Modeling Future Climate Change

2000 to 2100, SRES projections

Source: IPCC TAR 2001

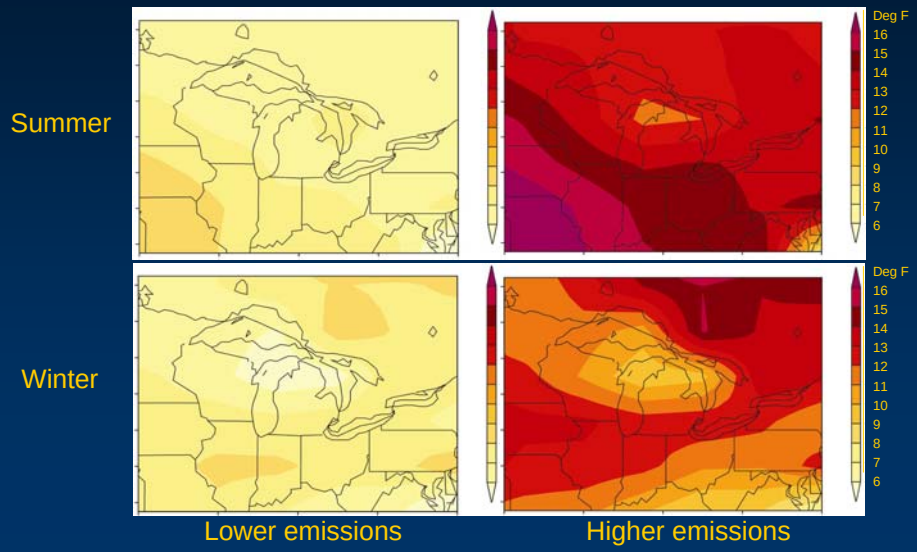


Projected Climate Changes in the Great Lakes Region by 2100

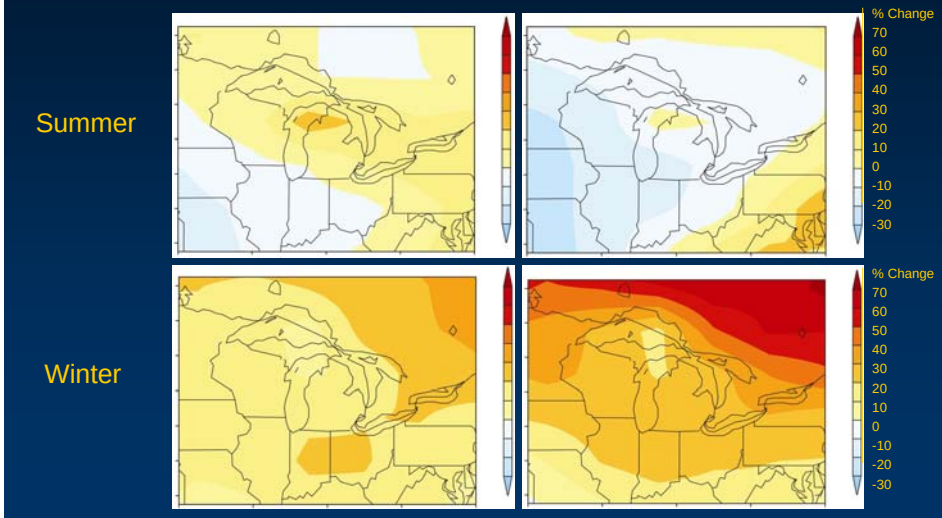
- **Temperature**
  - Winter 5-12 °F (3-7 °C)
  - Summer 5-20 °F (3-11 °C)
  - Extreme heat more common
  - Growing season several weeks longer
- **Precipitation**
  - Winter, spring increasing
  - Summer, fall decreasing
  - Drier soils, more droughts

- **More extreme events** – storms, floods
  - Could be 50-100% more frequent than now
- **Ice cover decline will continue**

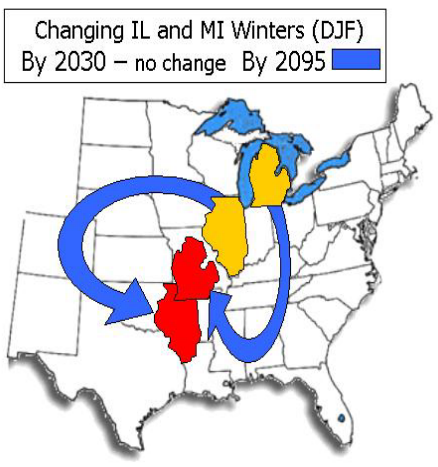
Projected Temperature Increase in the Great Lakes Region (by 2070-99)

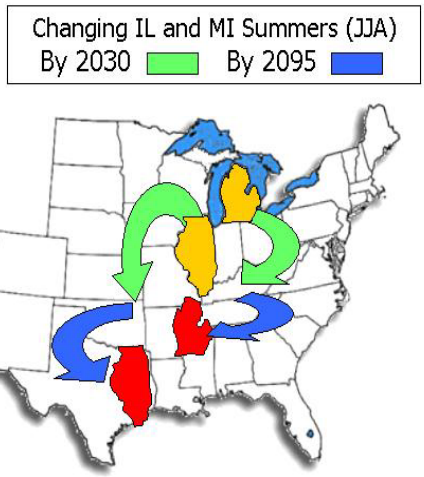


Projected Precipitation Changes in the Great Lakes Region (by 2070-99)



Climate Warming will Impact the Future Weather we "Feel" in Michigan and Illinois





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

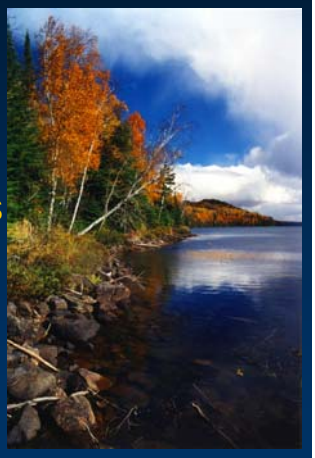
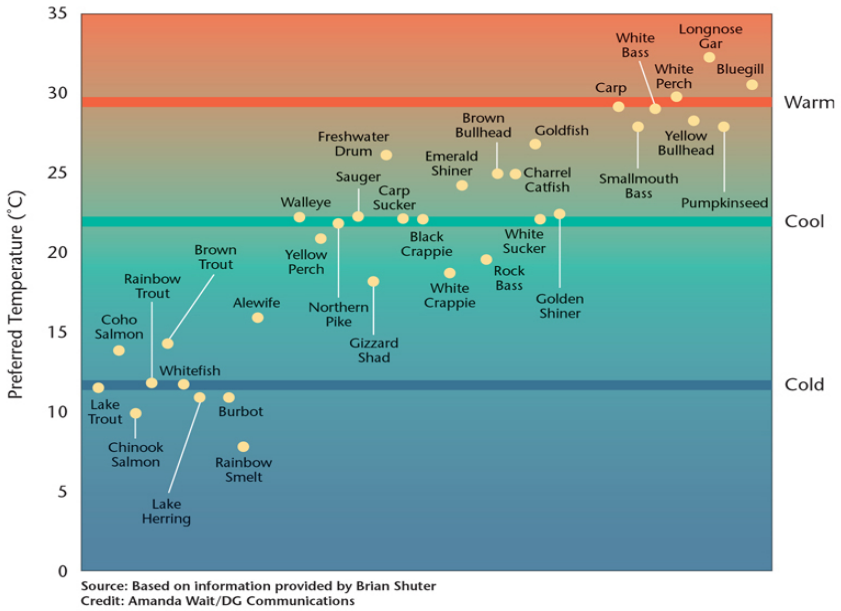


FIGURE 23

Temperature Groupings of Common Great Lakes Fish

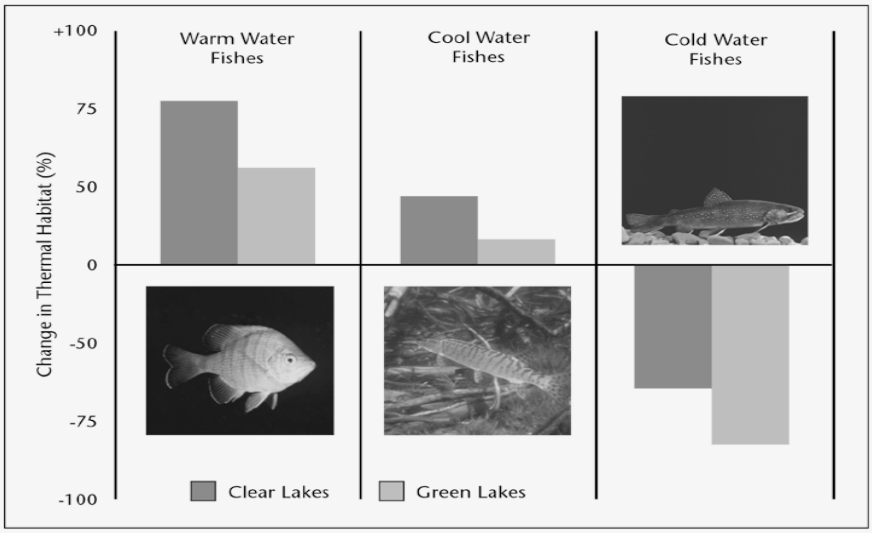
from page 53



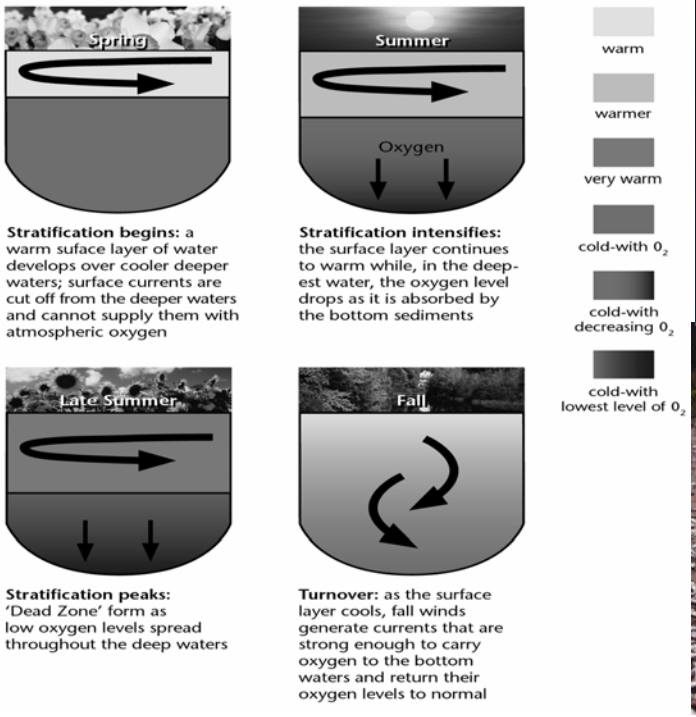
Source: Based on information provided by Brian Shuter
Credit: Amanda Wait/DG Communications

FIGURE 24
Water Temperature and Fish Distribution Changes

from page xx



Source: Data from Stefan et al. (1995)
Photo Credits: Blue Gill (warm water), Doug Stamm; Musky (cool water), John Magnuson; Brook Trout (cold water), Gerald C. Bucher



Stratification begins: a warm suface layer of water develops over cooler deeper waters; surface currents are cut off from the deeper waters and cannot supply them with atmospheric oxygen

Stratification intensifies: the surface layer continues to warm while, in the deepest water, the oxygen level drops as it is absorbed by the bottom sediments

Stratification peaks: 'Dead Zone' form as low oxygen levels spread throughout the deep waters

Turnover: as the surface layer cools, fall winds generate currents that are strong enough to carry oxygen to the bottom waters and return their oxygen levels to normal

"Dead Zones" & Fish Kills will increase

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

The Changing Character of Great Lakes Forests & Wildlife

- Boreal forests likely to disappear
- Higher CO_2 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
- Raccoons, skunks, and white-tailed deer may benefit, moose likely to suffer

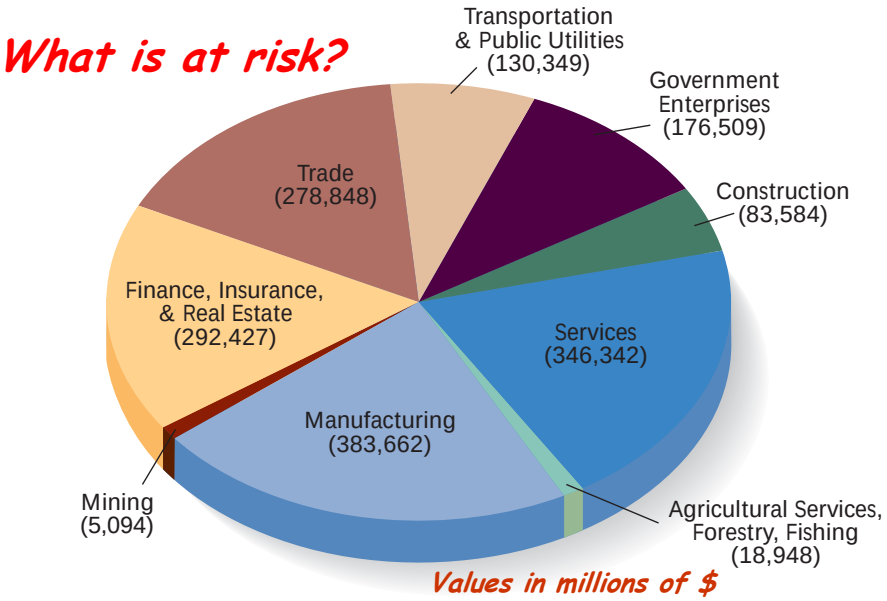
The Changing Character of Great Lakes Recreation & Tourism

- Significant impacts on multi-billion/year industry
- Millions of anglers affected by fish impacts
- Bird-watchers and hunters affected

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

Great Lakes Regional Production ~$2 Trillion

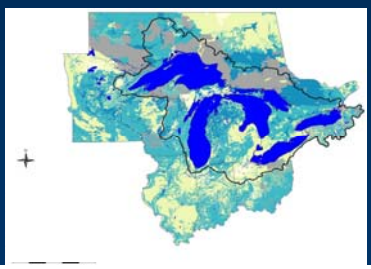
What is at risk?



Source: Bureau of Economic Analysis (2000).

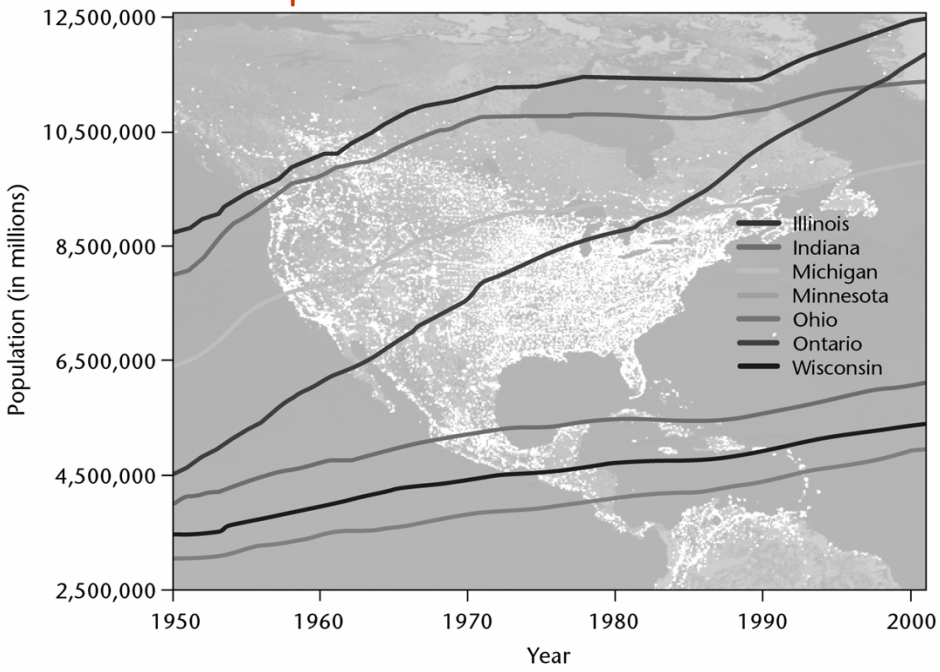
Climate Change Impacts Will Not Occur in a Vacuum

- Population is growing
- Increasing urbanization and sprawl
- Fragmentation of the landscape



- Industrial pollution of air and water
- Social challenges
- Geographic variability and limits

Population Growth will Continue



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

Exacerbation of Existing Problems
Agriculture

- Benefits:
  - warmer temperatures, longer growing season, CO_2 fertilization

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

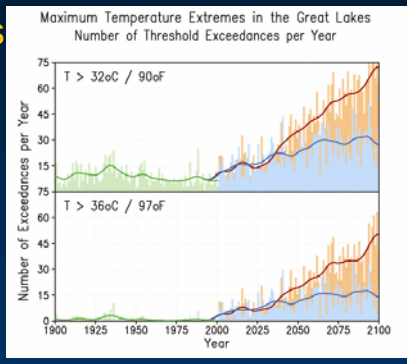
Exacerbation of Existing Problems
Property & Infrastructure

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

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

Worst Impacts Are Not Inevitable

No-regrets solutions available now

A three-pronged approach to deal with climate change:

1. Reducing our emissions
2. Minimizing pressure on the environment
3. Planning and preparing to manage the impacts of a changing climate

Reducing Our Emissions

- Energy Solutions
- Transportation Solutions
- Agricultural Solutions
- Forestry Solutions
- Integrated Strategies

Minimizing Pressure on Our Environment

- Air Quality Improvements
- Water Resource Protection

- Habitat Protection
- Urban and Land Use Planning

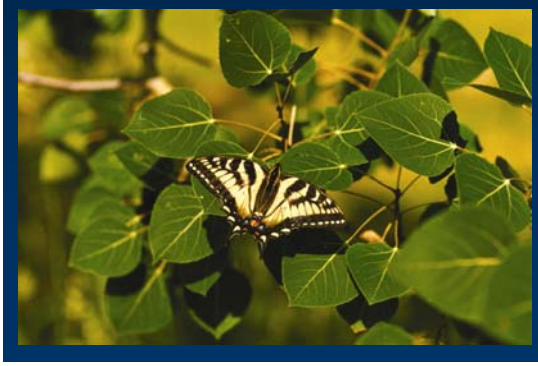
Managing Climate Impacts

- Emergency Preparedness
- Agricultural and Forestry Adaptations
- Public Health Improvements
- Infrastructure Adjustments
- Education

" An Armageddon is approaching at the beginning of the third millennium. … It is the wreckage of the planet by an exuberantly plentiful and ingenious humanity. … The race is now on between the technoscientific forces that are destroying the living environment and those that can be harnessed to save it. … The situation is desperate but there are encouraging signs. … Surely our stewardship is [the] only hope. We will be wise to listen carefully to the heart, then act with rational intention and all the tools we can gather and bring to bear."

E.O. Wilson in a fictitious letter to Henry David Thoreau
The Future of Life (2001)

" I hope I have justified the conviction, shared by many thoughtful people from all walks of life, that the problem can be solved. Adequate resources exist. Those who control them have many reasons to achieve that goal, not least their own security. In the end, however, success or failure will come down to an ethical decision, one on which those now living will be defined and judged for all generations to come."



E.O. Wilson (2001)
The Future of Life

Acknowledgments

This presentation was compiled by the Union of Concerned Scientists (UCS) and is based on *Confronting Climate Change in the Great Lakes Region: Impacts on our Communities and Ecosystems* (Kling et al., 2003).

http://www.ucsusa.org/greatlakes

The project was jointly sponsored by UCS and the Ecological Society of America (ESA).