Climate Change in the Great Lakes Region

MICHIGAN STATE UNIVERSITY

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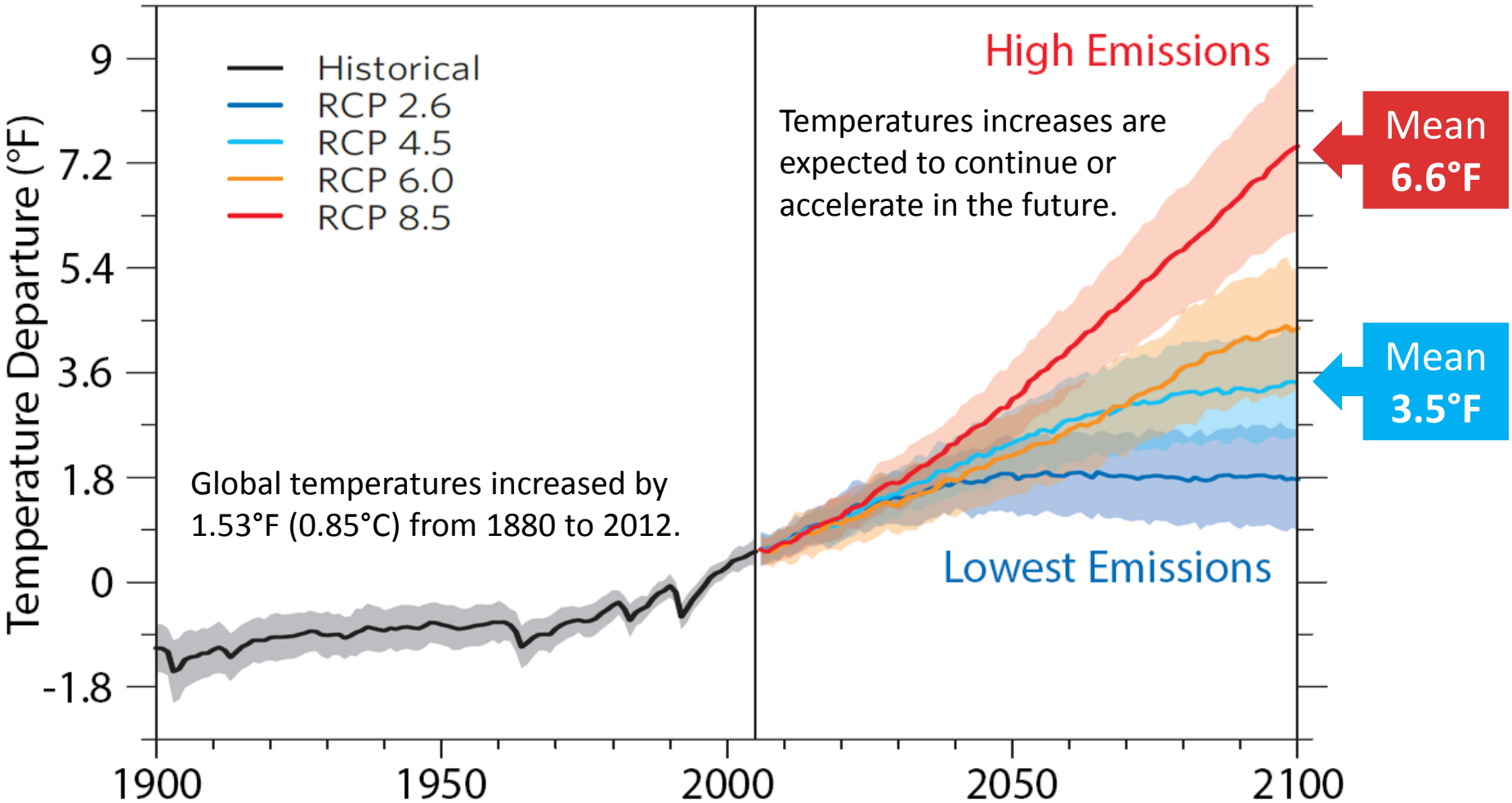
GREAT LAKES INTEGRATED SCIENCES + ASSESSMENTS

UNIVERSITY OF MICHIGAN

Global Temperature



From Knutti and Sedlacek, 2012

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Scale Matters: Global, Regional, Local



Global trends are more certain than regional trends.

Natural variability plays a larger role at the regional scale.

Local changes in land use can alter the severity of climate change impacts.

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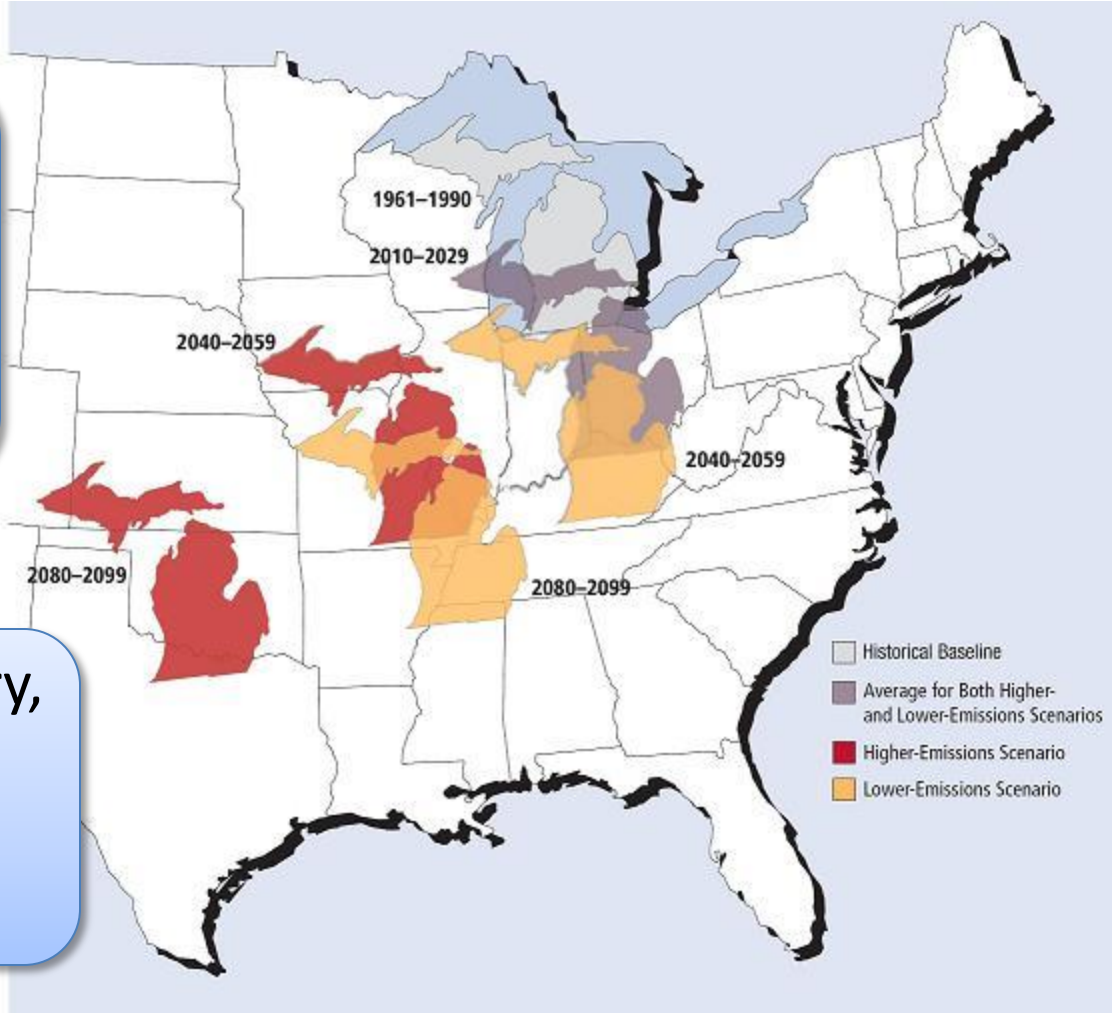
A Migrating Climate

The climate future generations experience will be fundamentally different than the climate today.

By the end of this century, Michigan summers will *feel* more like current summers in Arkansas.



Courtesy UCS 2009, original work by Hayhoe et al.

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What has Changed?

- Temperature
  - Averages
  - Extremes
  - Seasonality
- Precipitation
  - Averages
  - Extremes
  - Seasonality

Scientists often discuss changes in terms of averages, but *our environments are managed in terms of timing and extremes.*

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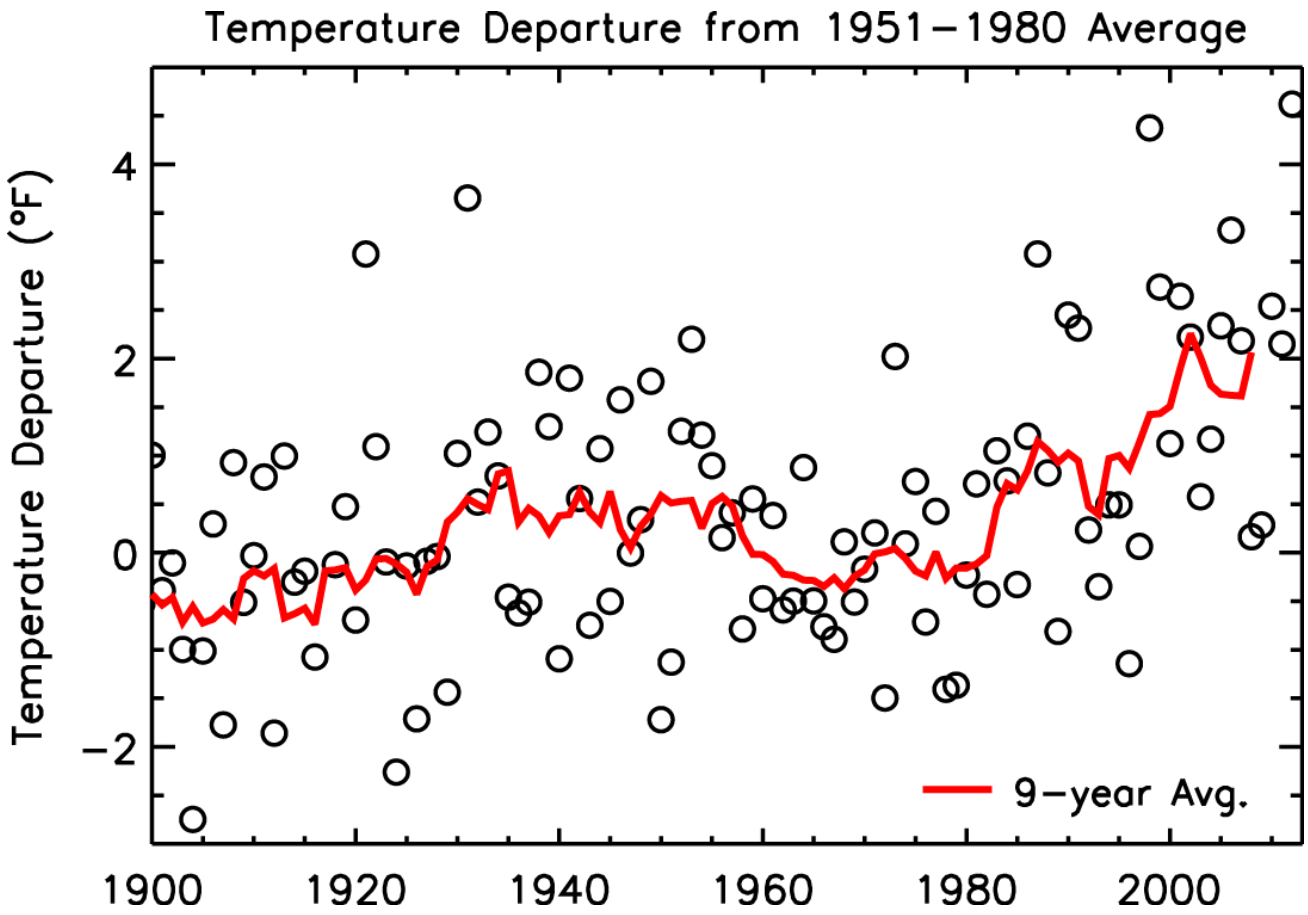
Observed Regional Temperature



2.0°F
1.1°C
1900-2012

Winter temperatures and overnight low temperatures have increased faster than annual averages.

Weighted averages of nClimDiv divisional data from 8 U.S. Great Lakes States.

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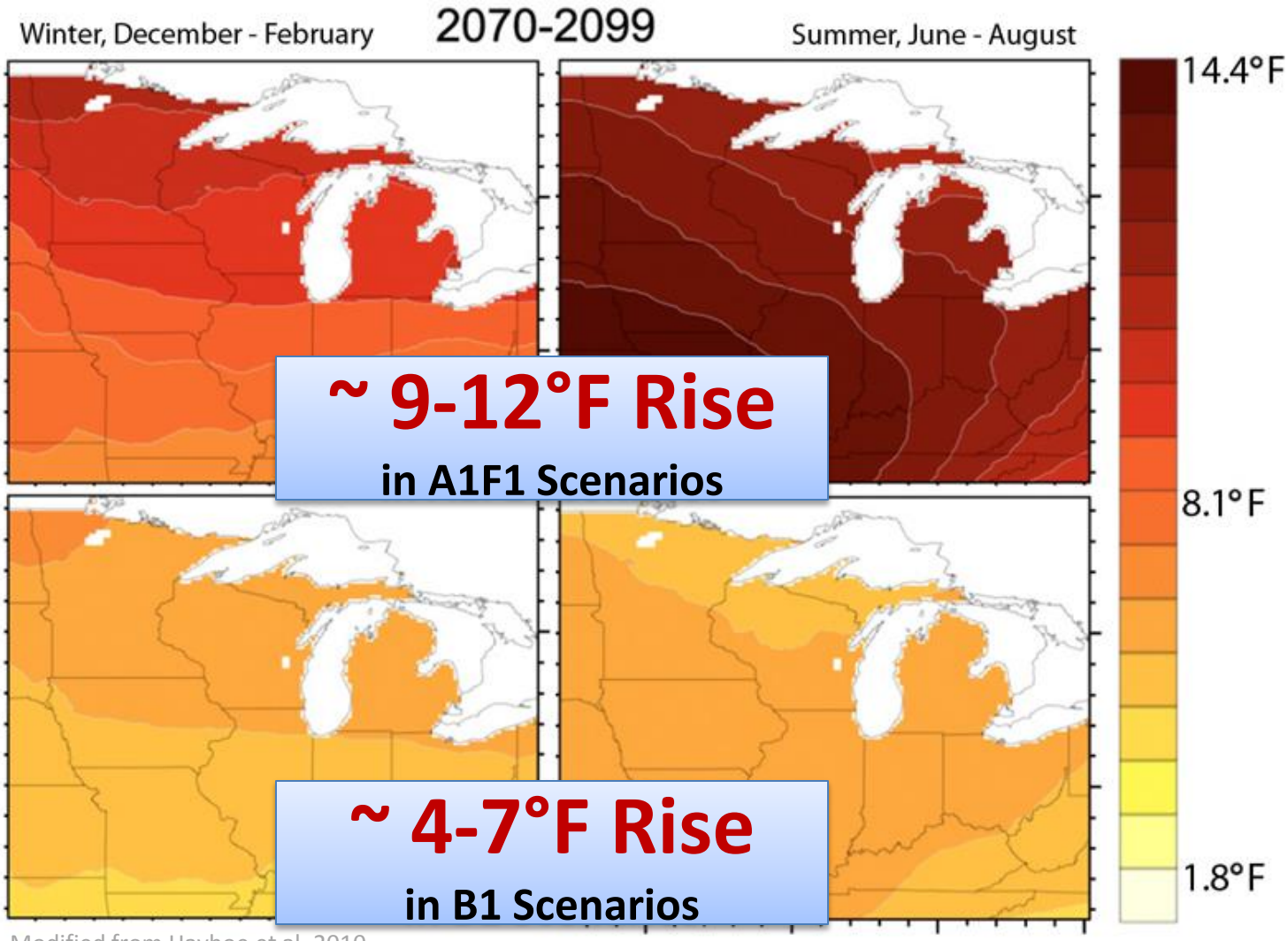
Projected Midwest Temperature

Very High Emissions Scenario

Low Emissions Scenario



~ 9-12°F Rise

in A1F1 Scenarios

~ 4-7°F Rise

in B1 Scenarios

Modified from Hayhoe et al, 2010

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Observed Heat Waves

The number of heat waves that pose risks to human health have increased in most major Midwestern cities.

Increasing overnight, minimum temperatures have increased at a faster rate, limiting relief during hot periods.

Observed Change in Number of Harmful Heat Waves

Chicago, IL
1948–2011
(63 years)

Increased 1 per year

Detroit, MI
1959–2011
(52 years)

Increased 2 per year

UCS Heat in the Heartland, 2012

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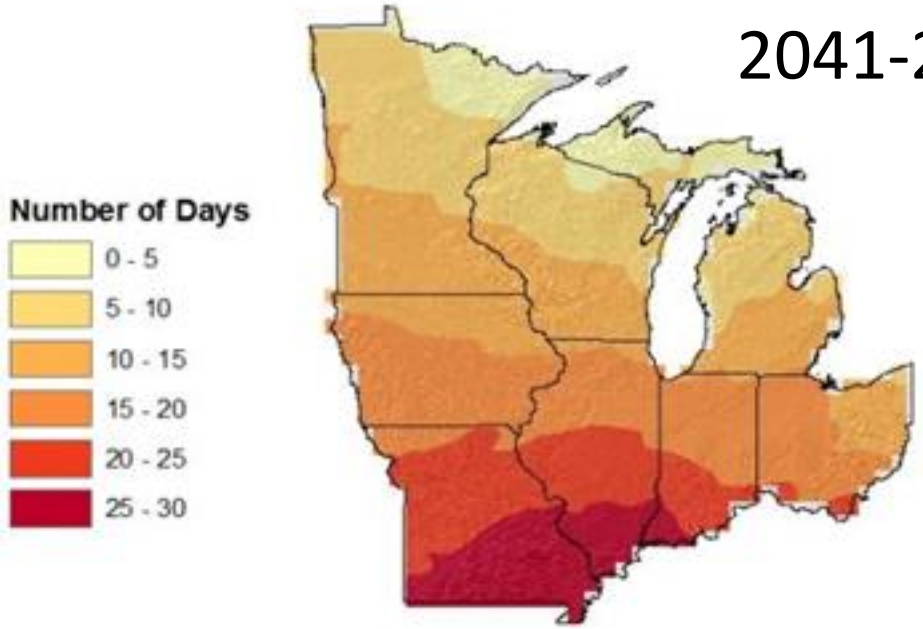
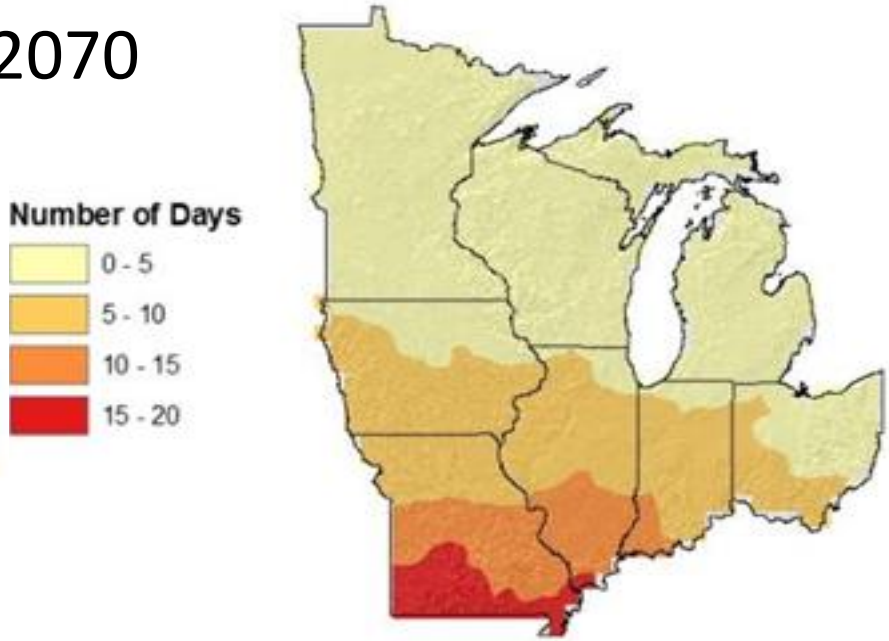
More Hot Days Anticipated

2041-2070



Increase in Days > 95°F (35°C)



Increase in Consecutive Days > 95°F (35°C)

Kunkel (2011)

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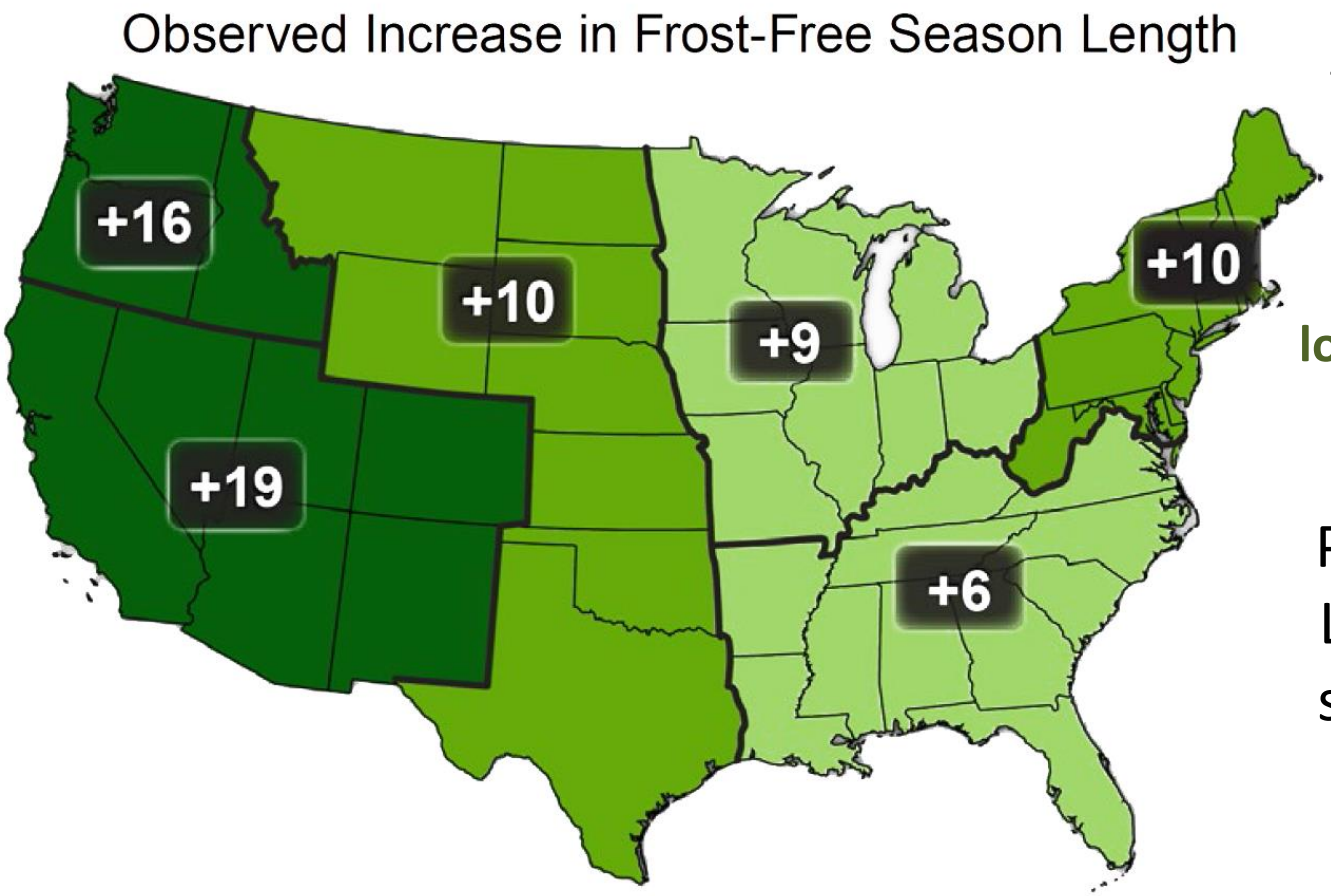
Longer Frost-free Season



The **frost-free season** has become **9 days longer in the Midwest** and **10 days longer in the Northeast.**

Projected Great Lakes frost-free season in 2100: **~1-2 months longer**

From the 3rd National Climate Assessment, 2014

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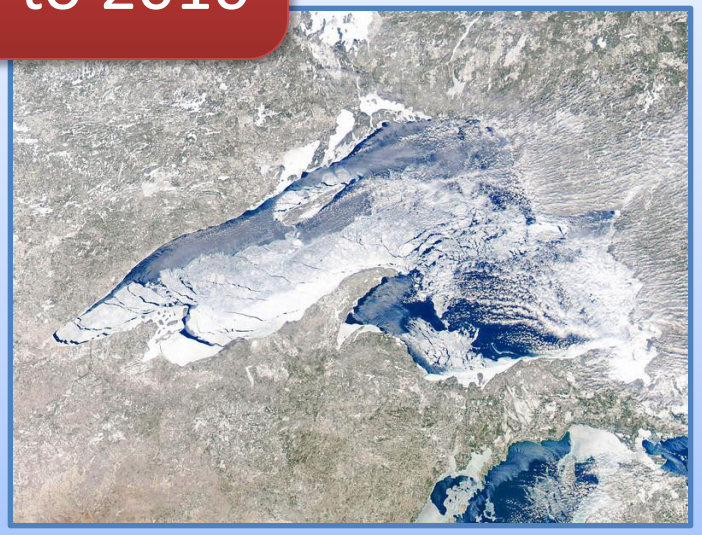
The Great Lakes are Warming

Average Great Lakes ice coverage ***declined 71% percent*** from 1973 to 2010

Wang et al., 2012



NASA

- Lake Superior is warming twice as fast as nearby air.
- Winter ice cover is decreasing.
- Lake Superior could have little to no open-lake ice cover during a typical winter within the next 30 years.

Austin and Colman, 2007

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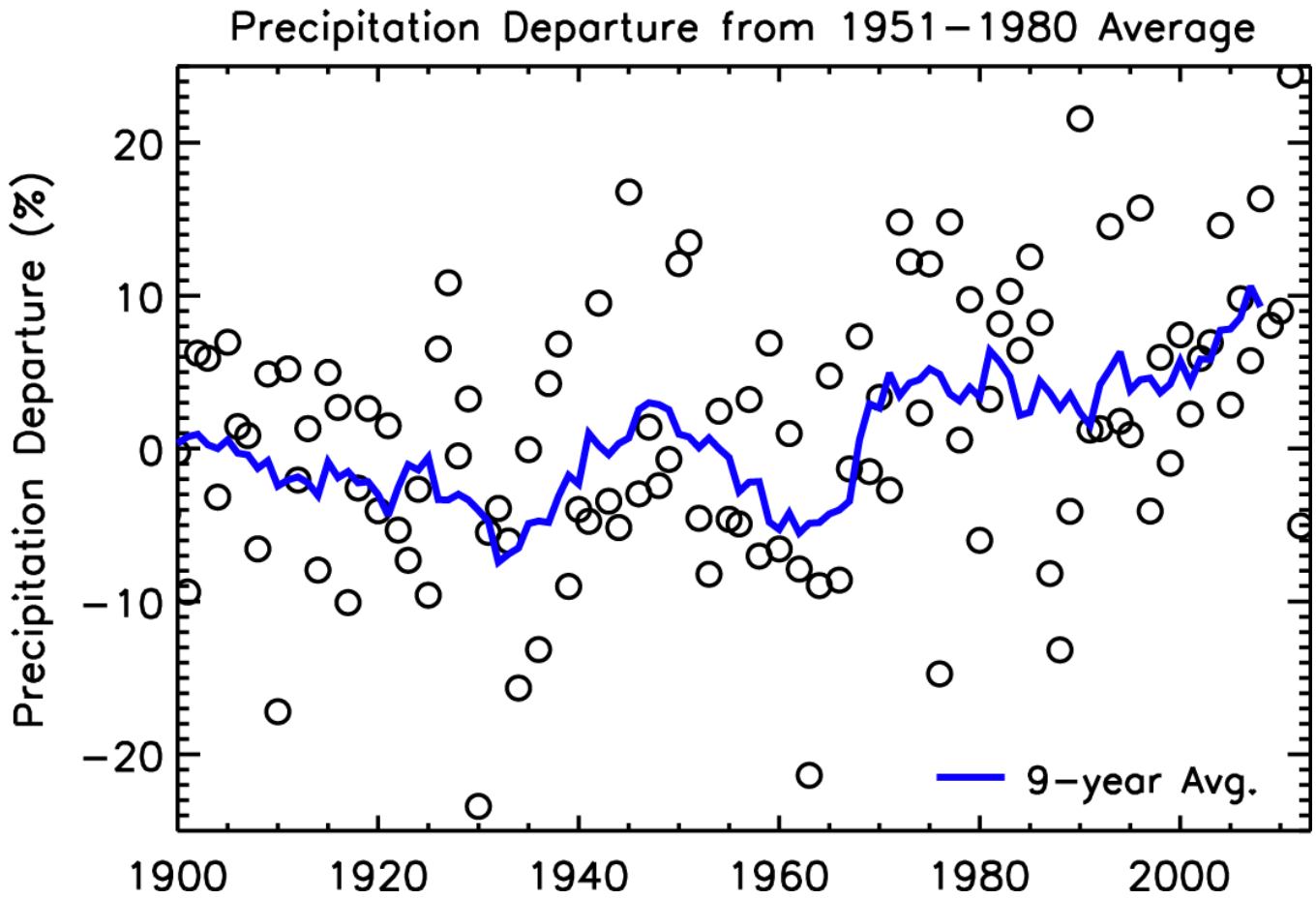
Observed Regional Precipitation



11%

1900-2012

Precipitation is variable. Some areas have seen declines while the region overall has seen an increase.

Weighted averages of nClimDiv divisional data from 8 U.S. Great Lakes States.

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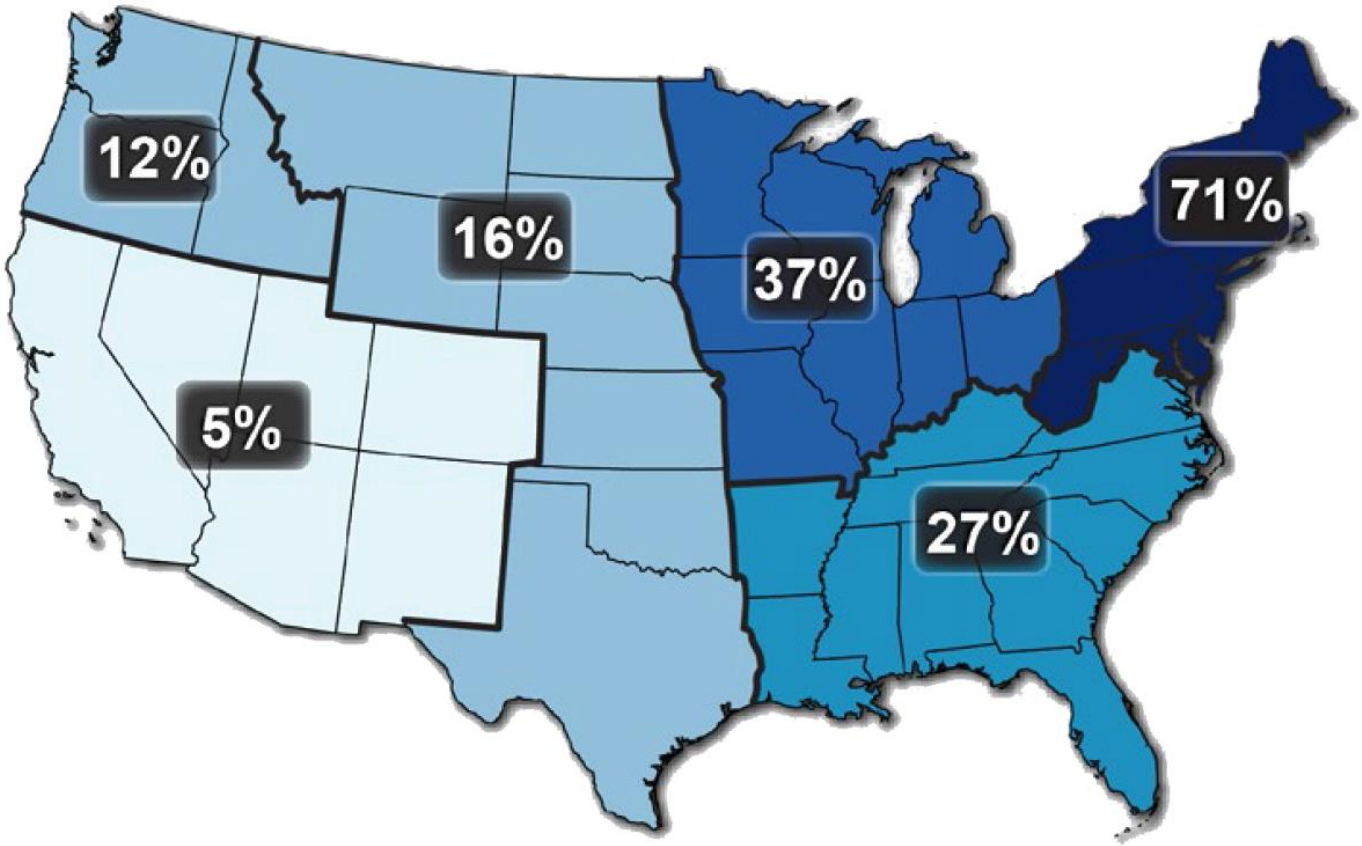
Observed Extreme Precipitation



The amount falling in the heaviest 1% of precipitation events increased by 37% in the Midwest and by 71% in the Northeast from 1958 to 2012.

Following methodology from Groisman et al, 2005, updated.

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Changing Precipitation Seasonality

- Shorter winters have lead to more precipitation falling as rain instead of snow.
- Warmer surface temperatures have reduced snow accumulation.
- More lake effect precipitation events have increased snowfall in some areas.

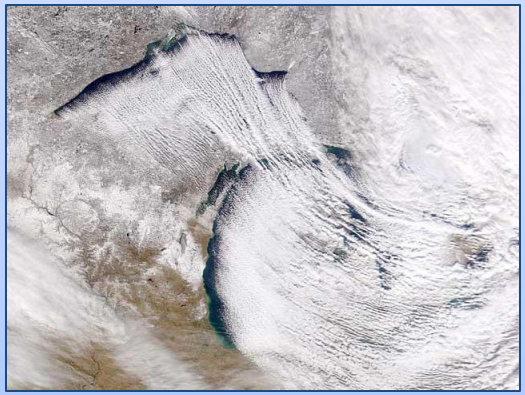

Photo credits: Umich.edu, NASA, weather.com

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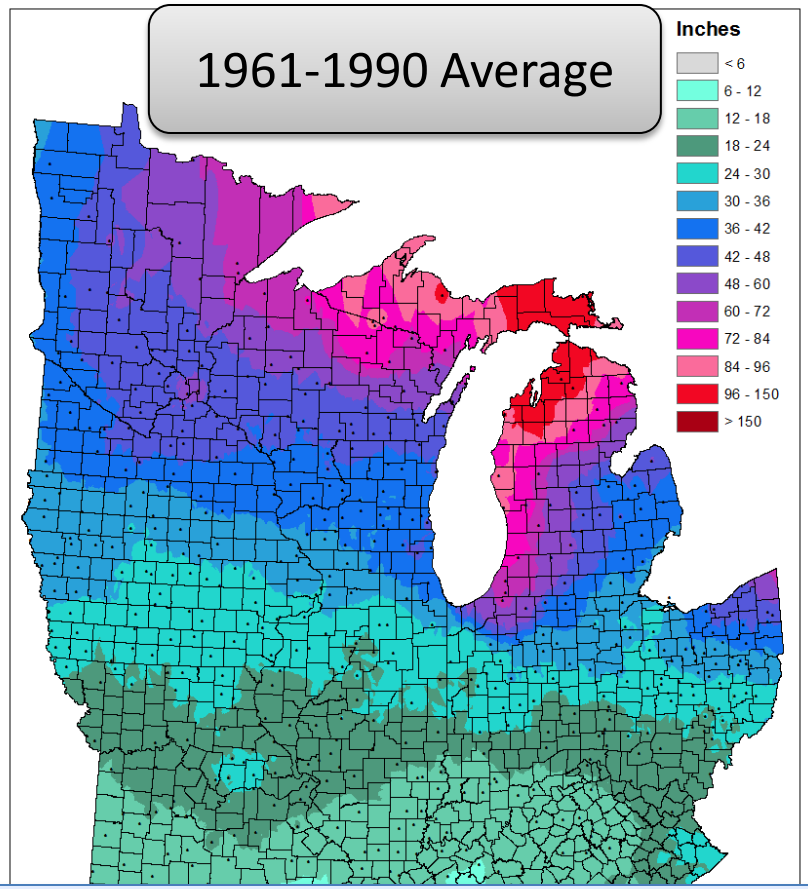
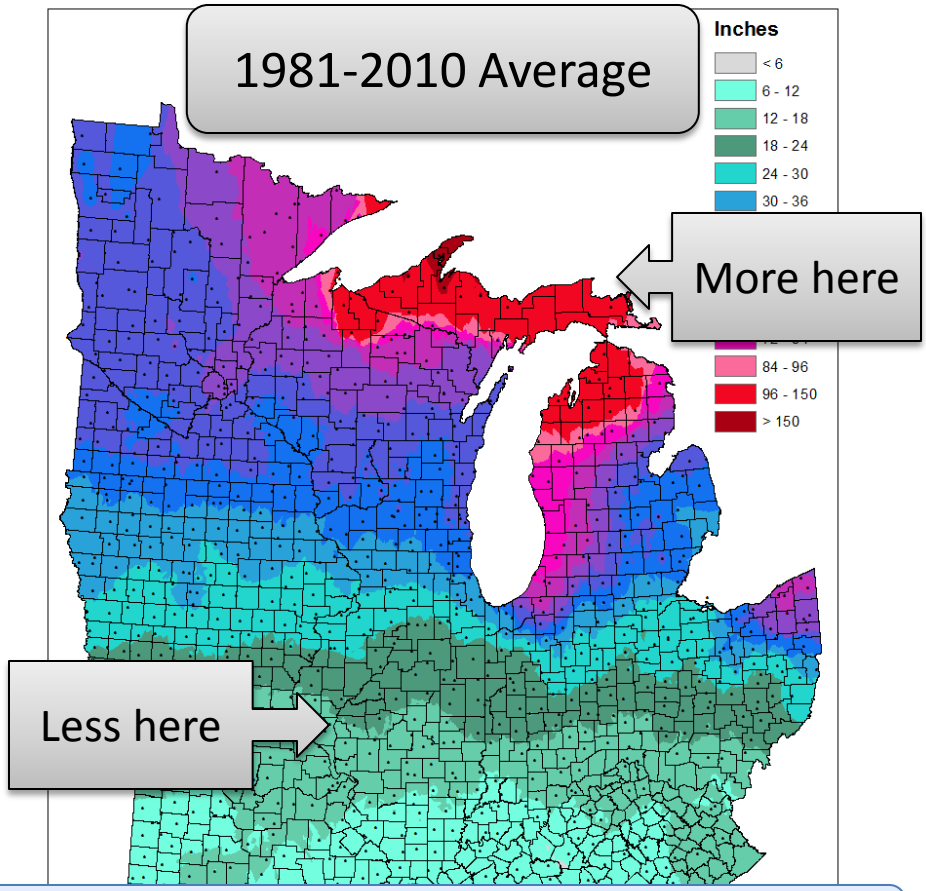
Observed Snowfall





Snowfall has generally increased across the Northern Midwest, remained stable in the central latitudes, and has decreased in the southern areas.

From MRCC

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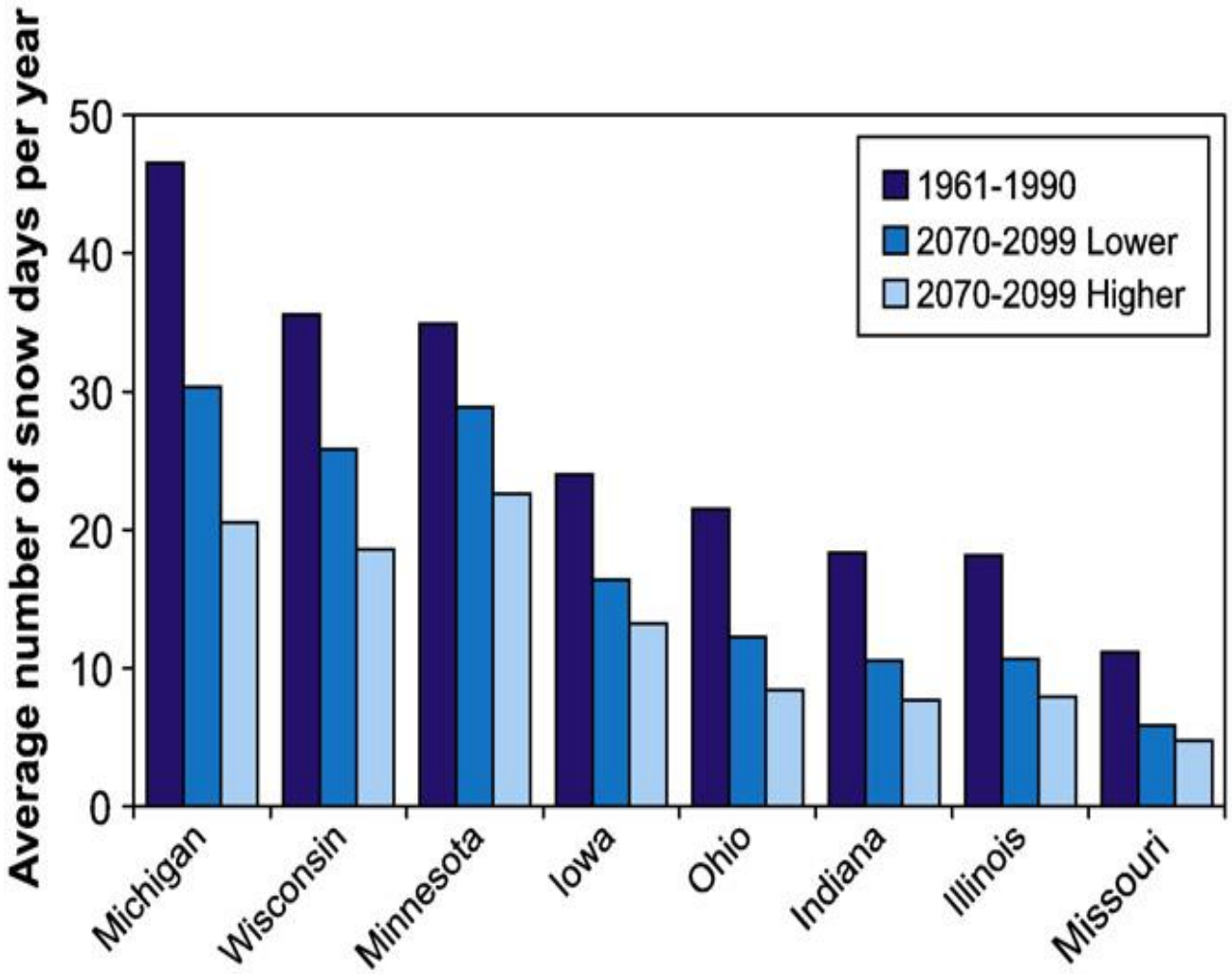
Projected Snowfall Days



In high emissions scenarios, the number of snow events per year is expected to dramatically decline in Midwestern States by the end of the 21st century.

Hayhoe et al (2010)

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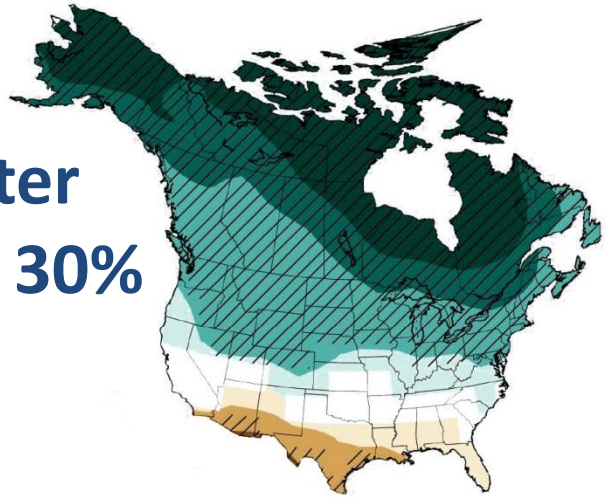
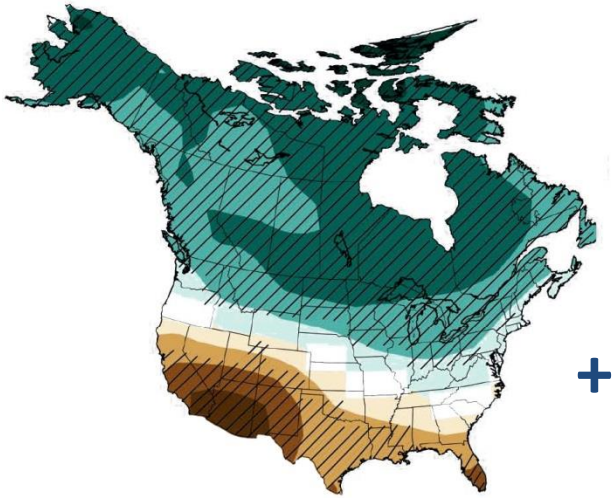
Projected Precipitation

Projected Precipitation Change, A2 Emissions, 2070-2099

Annual
+5 to 20%

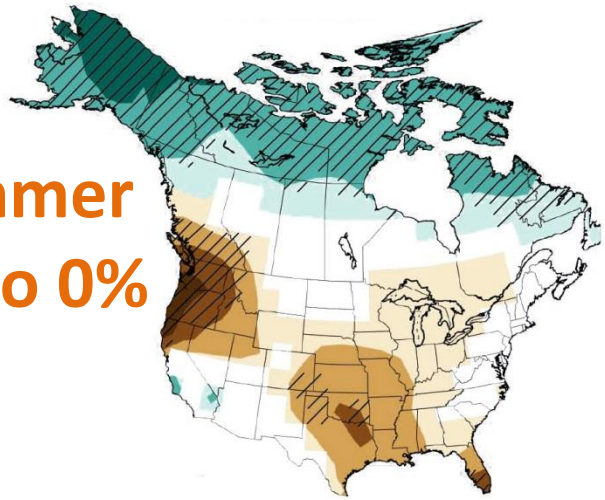
Winter
+10 to 30%

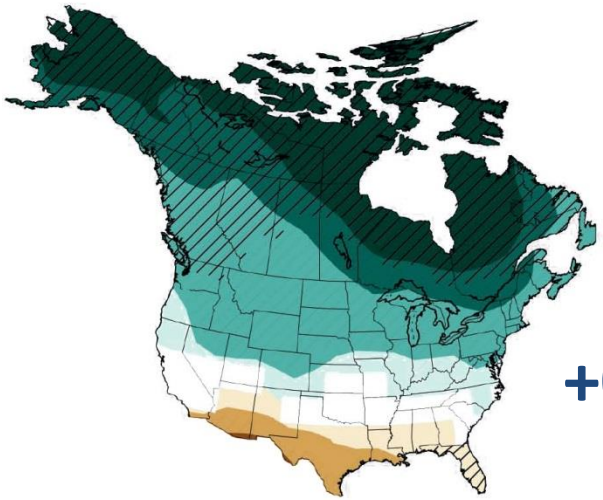




Spring
+0 to +30%

Summer
-20 to 0%





Fall
+0 to +30%

NOAA NCDC / CICS-NC

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Impacts of Climate Change in the Great Lakes Region

Changes in temperature and precipitation throughout the region will lead to many impacts in both engineered and natural environments.




Water
Energy
Forests
Agriculture
Biodiversity
Public Health
Transportation
Fish and Wildlife
Tourism and Recreation






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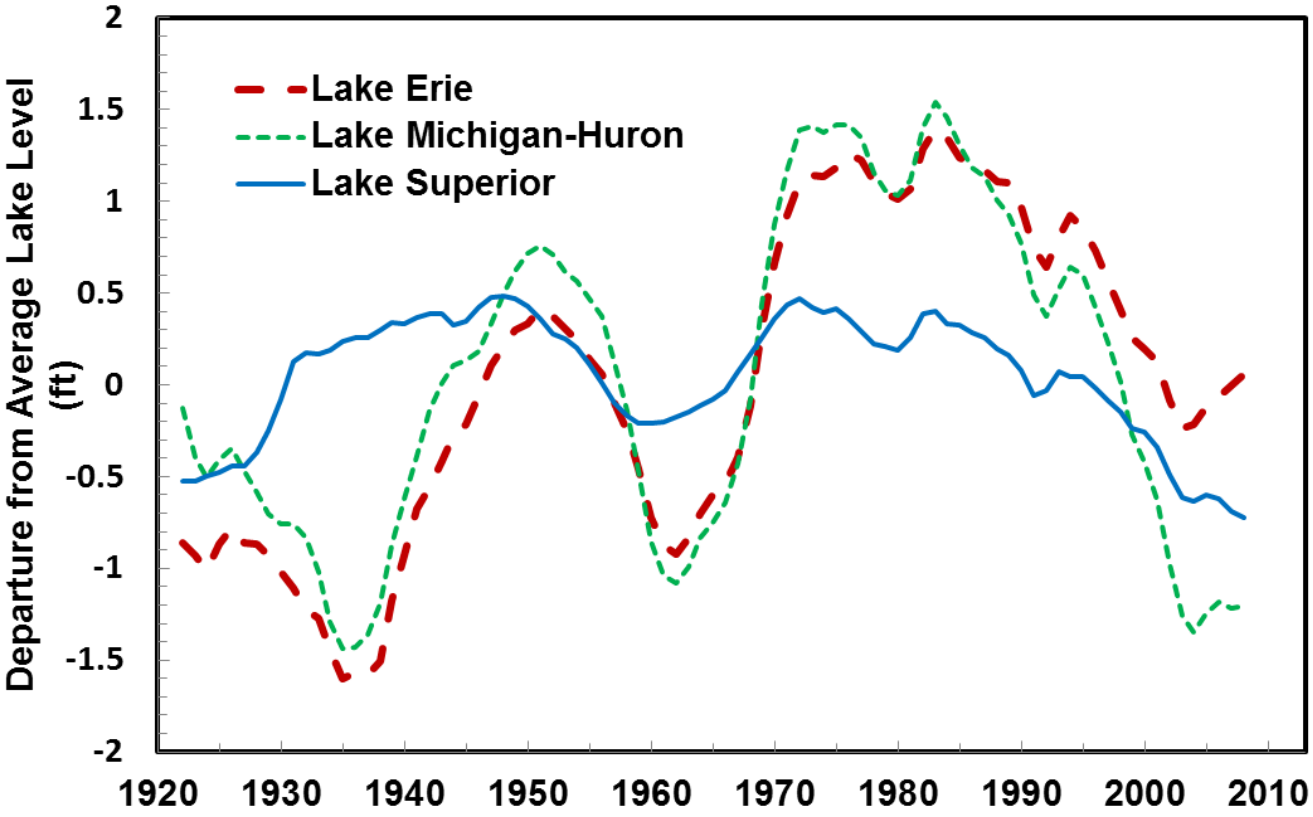
Lake Levels



Lake levels have declined since reaching record highs in the 1980s.

While most models project continued declines in long-term lake levels, there remains significant uncertainty.

Short-term variability and periods of high lake levels are still anticipated.

GLERL Great Lakes Water Level Dashboard

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Potential Impacts on Shipping

Every lost inch of water depth:

- **Reduces cargo capacity 50-270 tons**
- **Costs $10k-30k per transit.**

…but less lake ice cover allows for a longer shipping season

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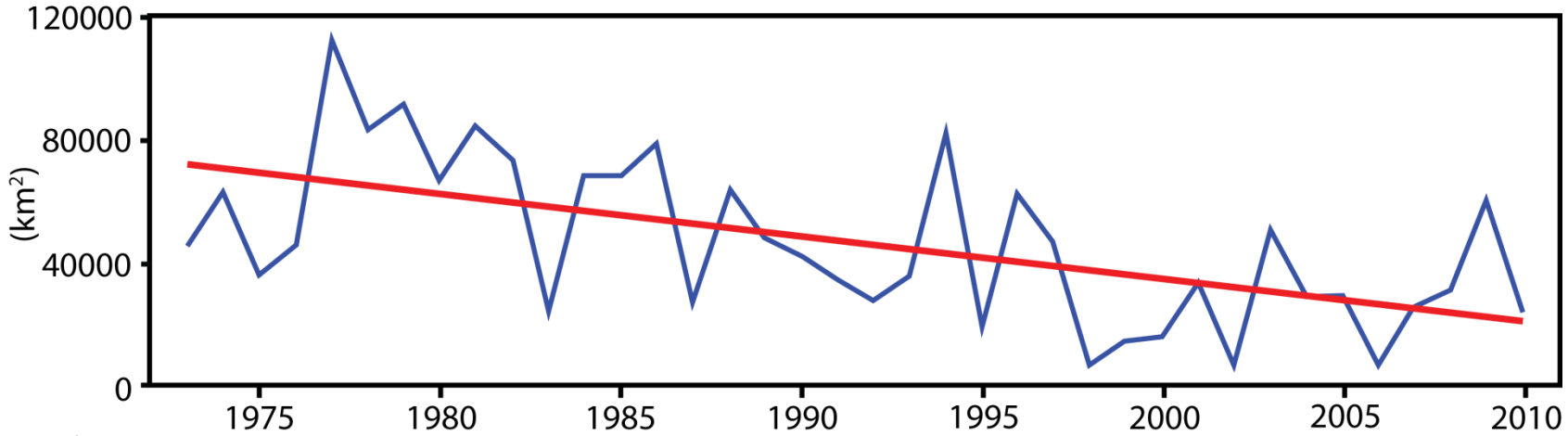
Impacts of Declining Great Lakes Ice Cover



Wang et al., 2012

- **Fishing Industry:** Ice cover protects whitefish spawning areas. Great Lakes commercial fishing is $4 billion industry.
- **Coastal Zone:** In nearshore areas, ice provides stable platform for recreation and protects wetland areas from erosion.
- **Water Levels and Navigation:** Heavy ice cover can reduce evaporation and contribute to higher water levels in the following seasons—good news for shipping.

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Flooding and Stormwater

With increased extreme precipitation events, intense, flashy runoff amplify flooding risks.

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Conspiring Changes: Water Quality

Stronger Storms → More Runoff → Greater Nutrient Loading

Warmer Lake Temperatures → Changed Lake Dynamics → Algal Blooms, Fish Kills

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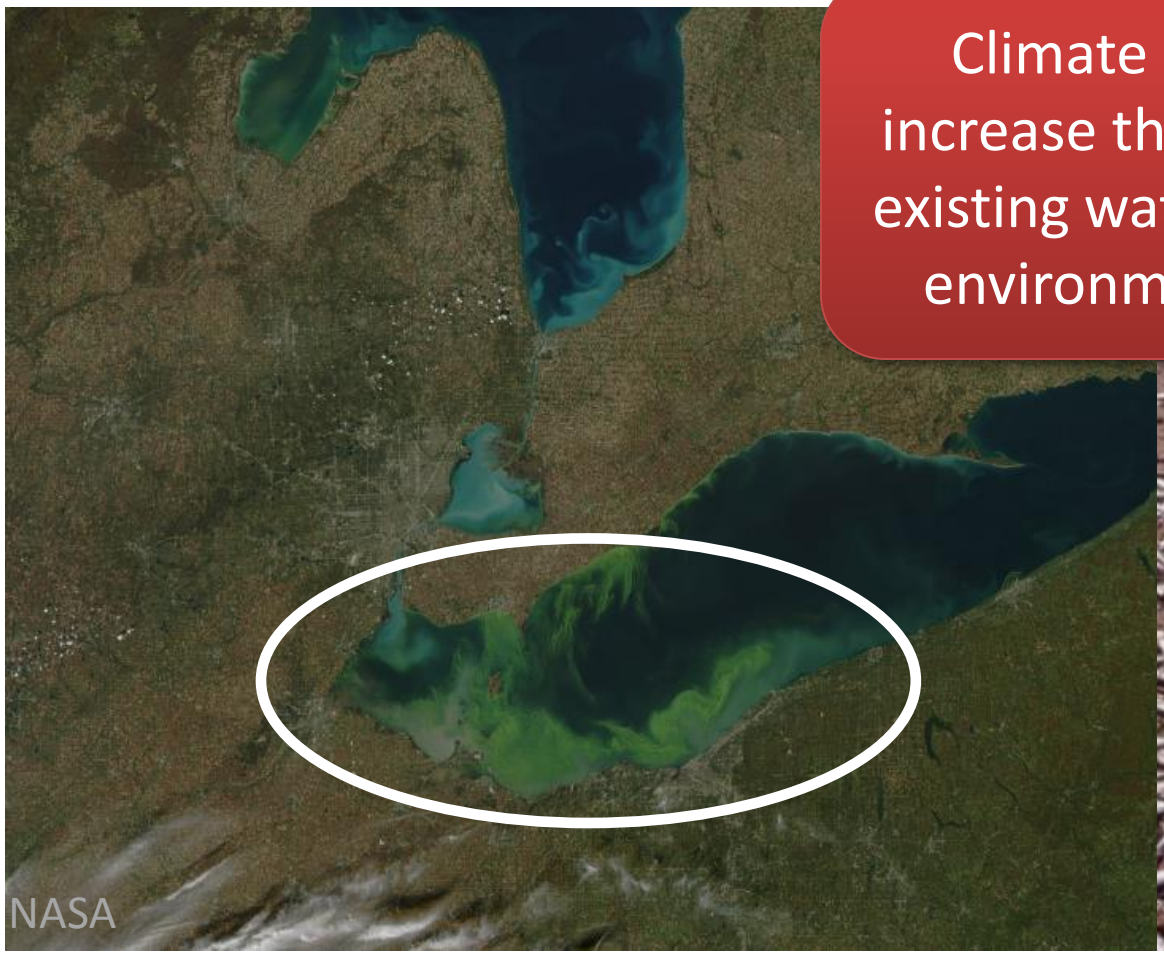
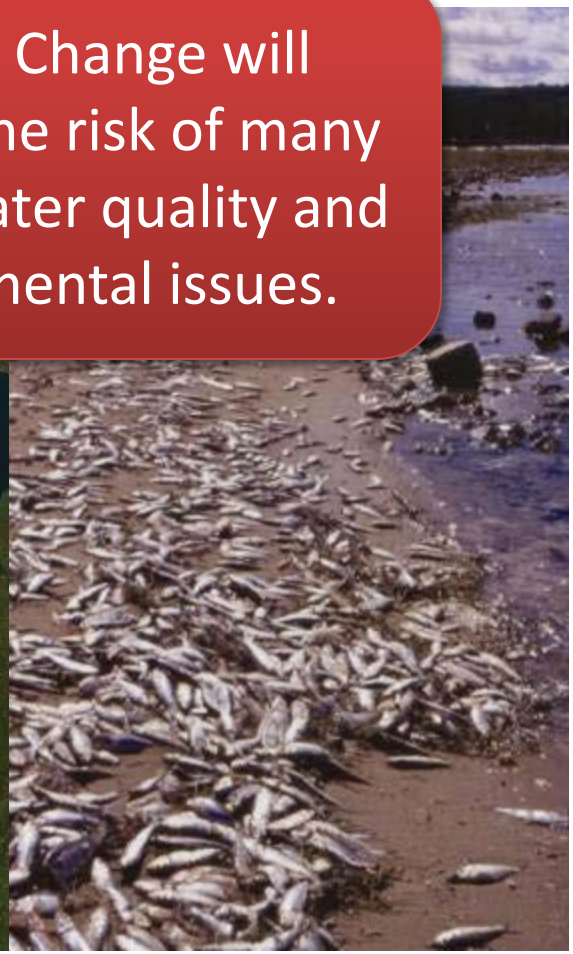
Algal Blooms and Fish Kills



Climate Change will increase the risk of many existing water quality and environmental issues.



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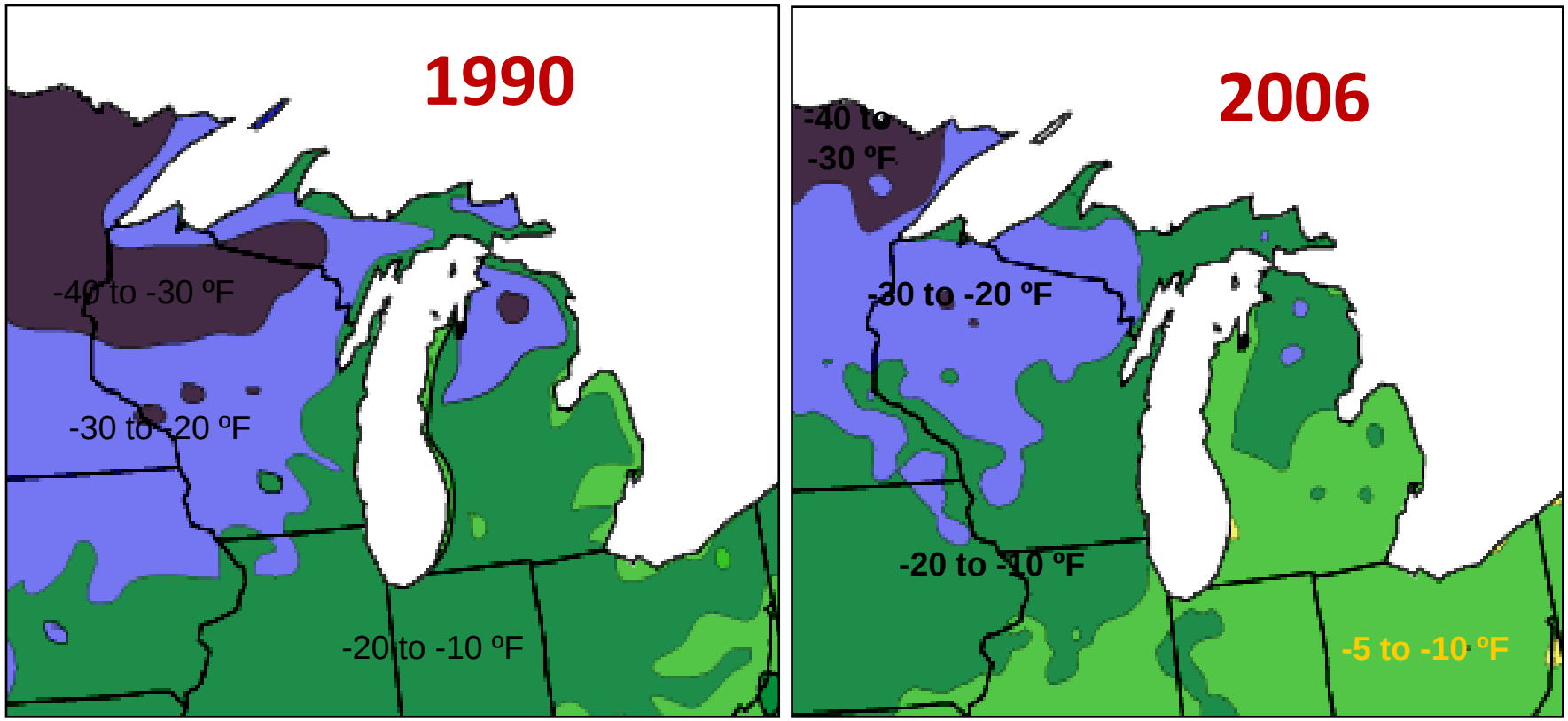
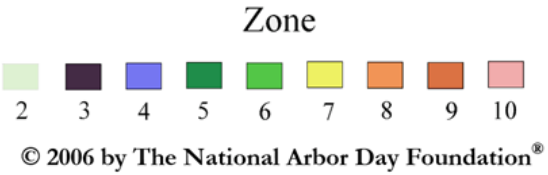
Migrating Plant Hardiness Zones





Average extreme minimum temperatures, which test the hardiness of plants to cold, have migrated north, allowing for different plant types to survive in those areas.

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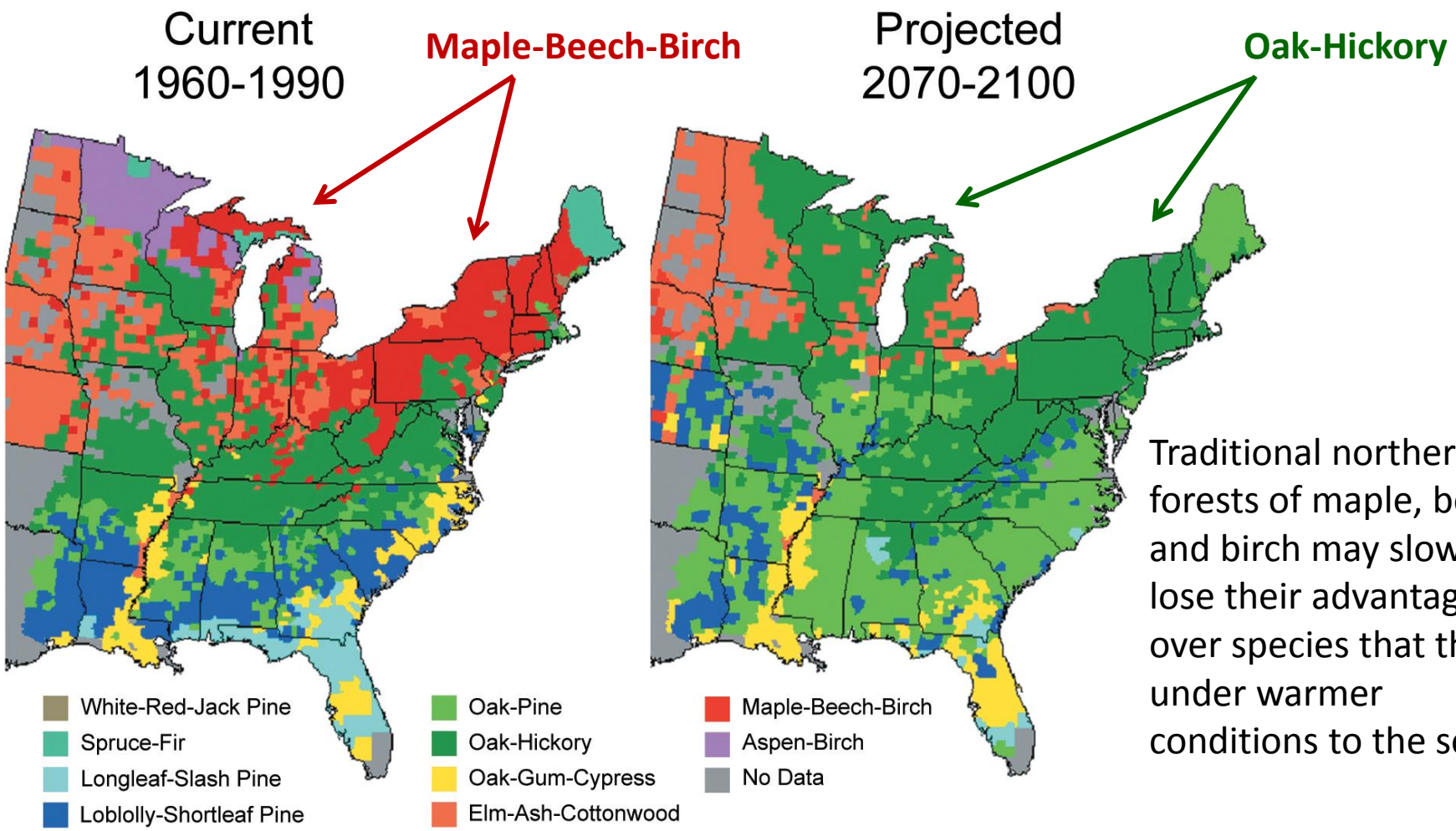
Projected Shifts in Forest Types



Traditional northern forests of maple, beech, and birch may slowly lose their advantage over species that thrive under warmer conditions to the south.

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Climate Change Impacts on Biodiversity

- Climate change will amplify existing stressors on biodiversity, including sensitivity to land and water use.

- Some species will need to migrate faster relative to other parts of the continent to keep up with the pace of warming. Large agricultural areas and the Great Lakes pose major obstacles to species migration.

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Climate Change Impacts on Agriculture

- Increasing intensity of severe storms increases the risk of runoff and erosion.

- Shifts in the timing of precipitation will affect field preparation time in spring.

- Some crops may benefit in the near future from increasing carbon dioxide concentrations until negated by warmer temperatures.

- Perennial crops may be more vulnerable to the pace of climate change and may face greater adaptation challenges.

Agriculture Vulnerabilities Example: Spring 2012 and Cherry Crops

- The early warming was extreme weather event.
- The seasonal warming fits a pattern of a more variable climate.

- The early warming followed by a normal hard freeze was devastating to cherry buds.
- **92 million dollar loss** from tart cherries alone

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How will we adapt?

Winter is a part of our "Sense of Place".
We are losing Winter as we once knew it.

-John Magnuson

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Learn More

glisa.msu.edu

GLISA is a NOAA-funded partnership between the University of Michigan and Michigan State University.

GLISA connects users and generators of scientific information to inform adaptation to climate change.

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