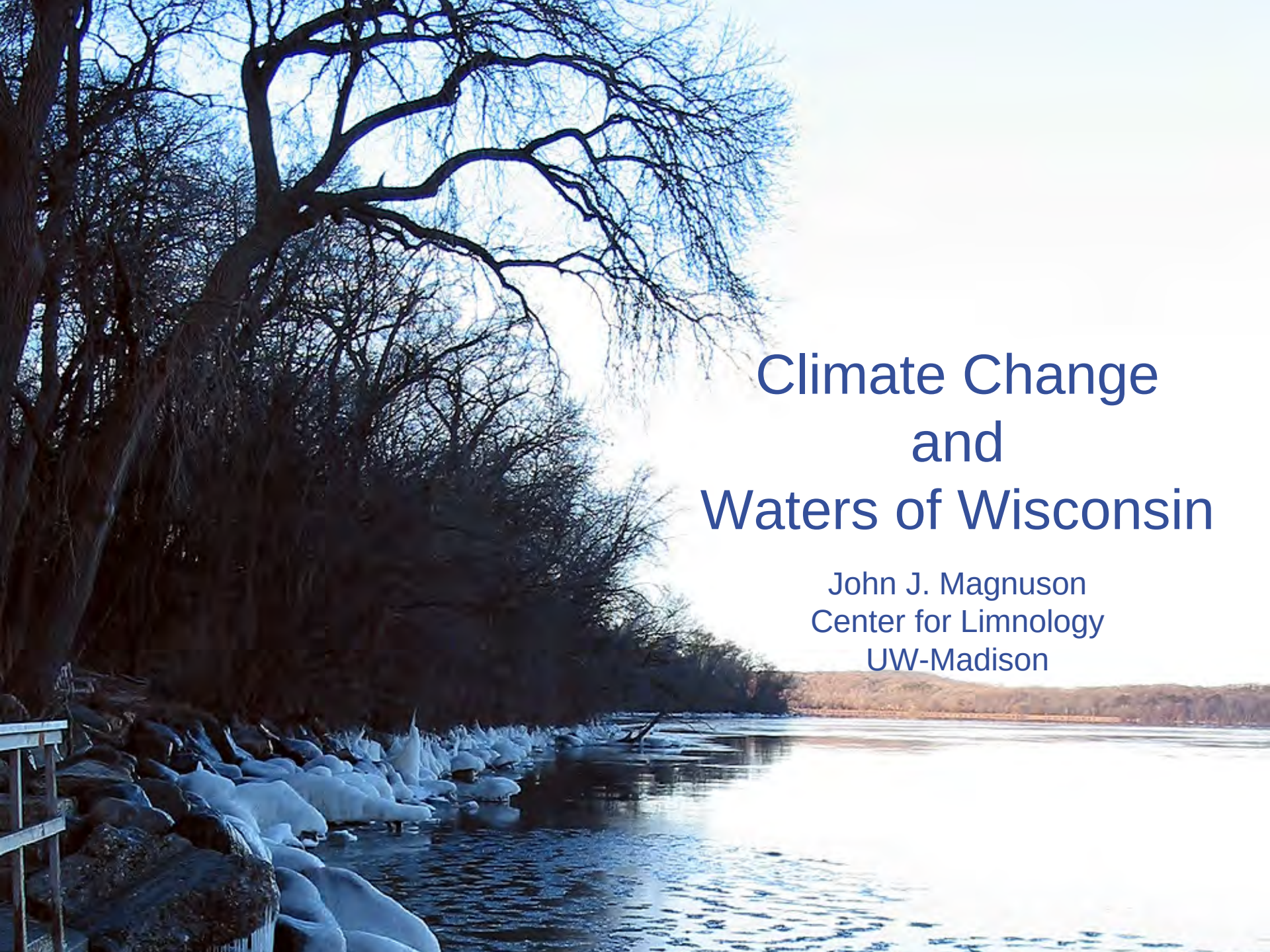
Climate Change in the Great Lakes Region
Starting a Public Discussion

Tonight:

Climate Change and the Waters of Wisconsin

Sea Grant UNIVERSITY OF WISCONSIN | WISCONSIN COASTAL MANAGEMENT PROGRAM | NOAA | UW Extension

www.seagrant.wisc.edu/ClimateChange



Climate Change and Waters of Wisconsin

John J. Magnuson
Center for Limnology
UW-Madison

How Do We Deal With Change?

Magnuson Photos

Day - Night

The Four Seasons

Dale Robertson & Jay Nelson Photos

Changes Occur Quickly and Slowly

Climate Change

Eutrophication

Mixing & Stratification Seasons

Invasions of Exotics

Land Use

Day & Night

Seasonal Succession of Ecology

Surface Waves

Seconds Minutes Hours Days Weeks Months Year Years Decades Centuries Millennia+

Time Scales of Changes

Magnuson 2007

The Long-Term Changes (Decadal to Century):

- ✓ They are handed down to us from earlier generations.
- ✓ We cause and pass them on to future generations.
- ✓ They occur slowly and sneak up on us.

- ✓ We are unwilling to face them soon enough.
- ✓ We tend to see the short-term positives with little recognition that

  “everything is connected to everything else.”

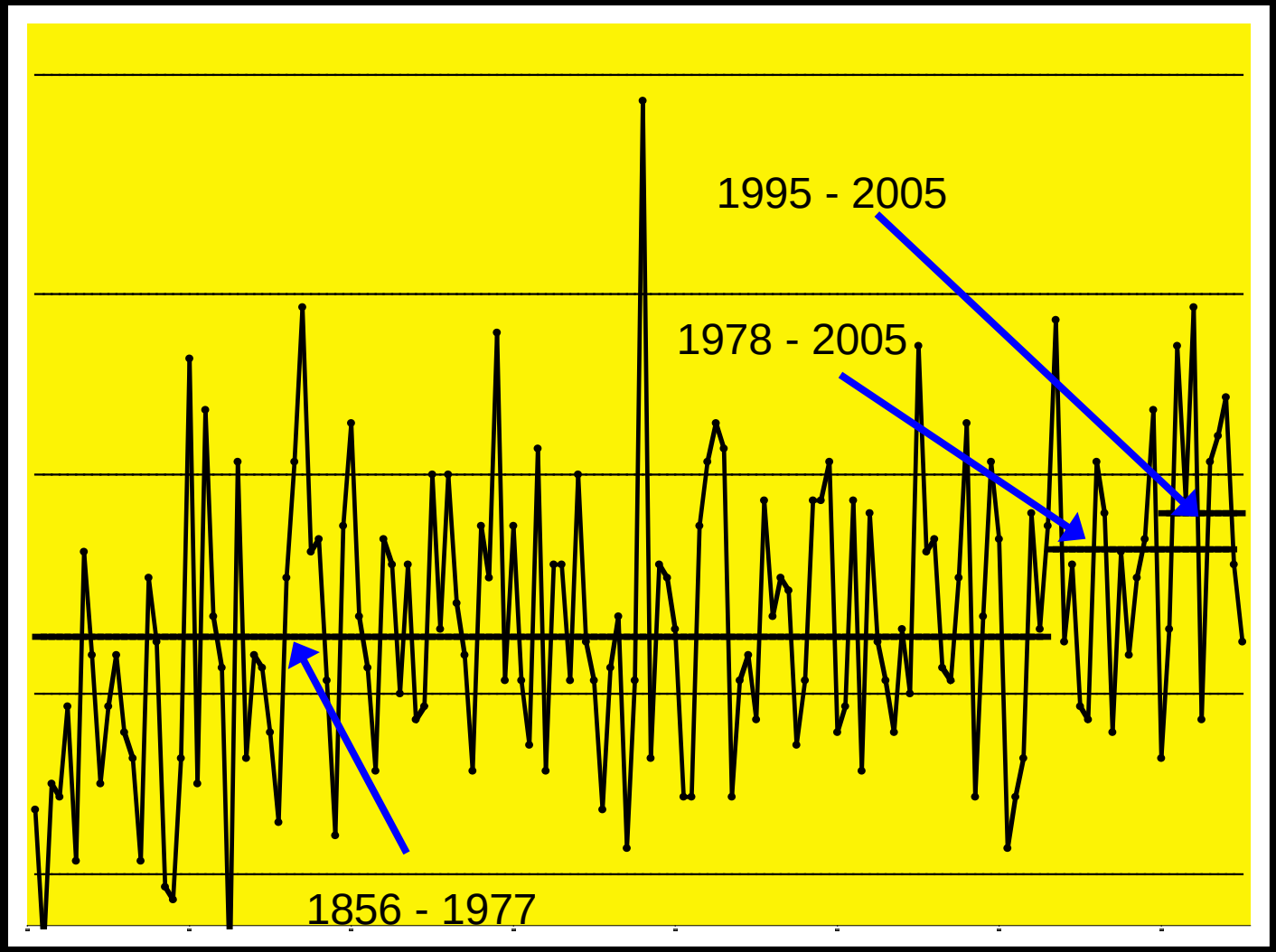
Lessons from Jared Diamond's "Collapse: How Societies Choose to Fail or Succeed"

1. Failing to anticipate a problem before the problem actually arises.
2. When the problem does arrive the group may fail to perceive it.
3. After they perceive the problem the group may fail to try to solve it.
4. When they try to solve it they may not succeed.

Diamond 2005

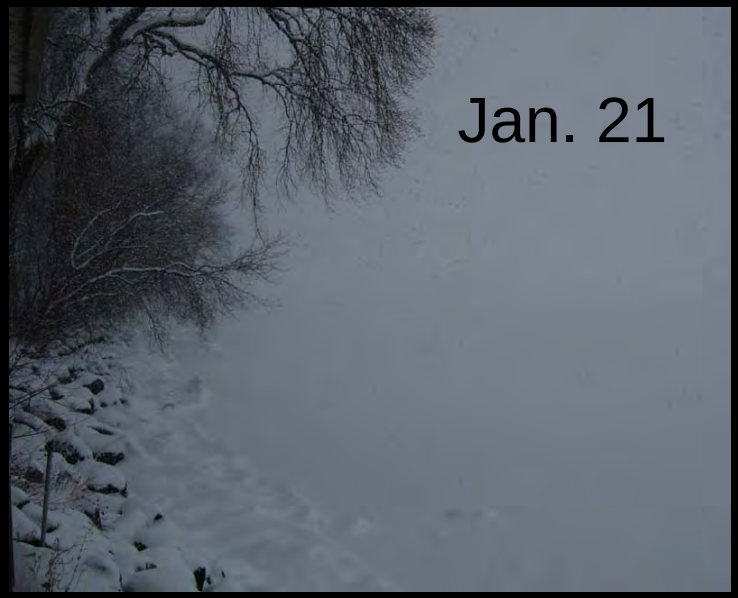

Ice Cover on Lakes -- A Miner’s Canary
Cold, Cool, and Warm Water Fishes
Water Flows and Levels
Magnuson Photo

When did Lake Mendota freeze last winter?



Balsiger 2007

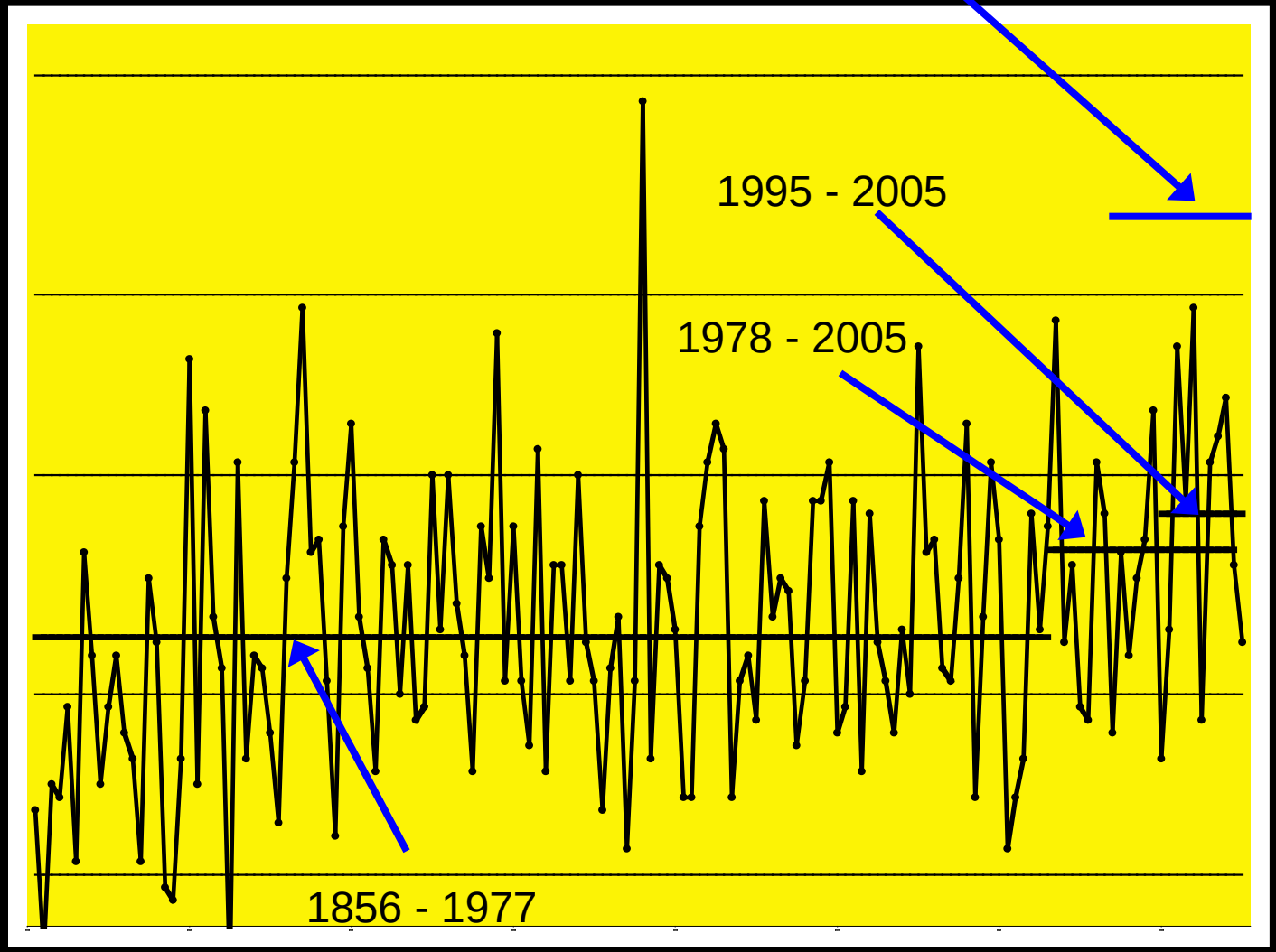
A Ground Level View of the 2007 Ice-on



Magnuson Photos


Lake Mendota Ice-on Day, January 20, 2007
Peter W. Schmitz

January 20, 2007



Feb 1

Jan 15

Jan 1

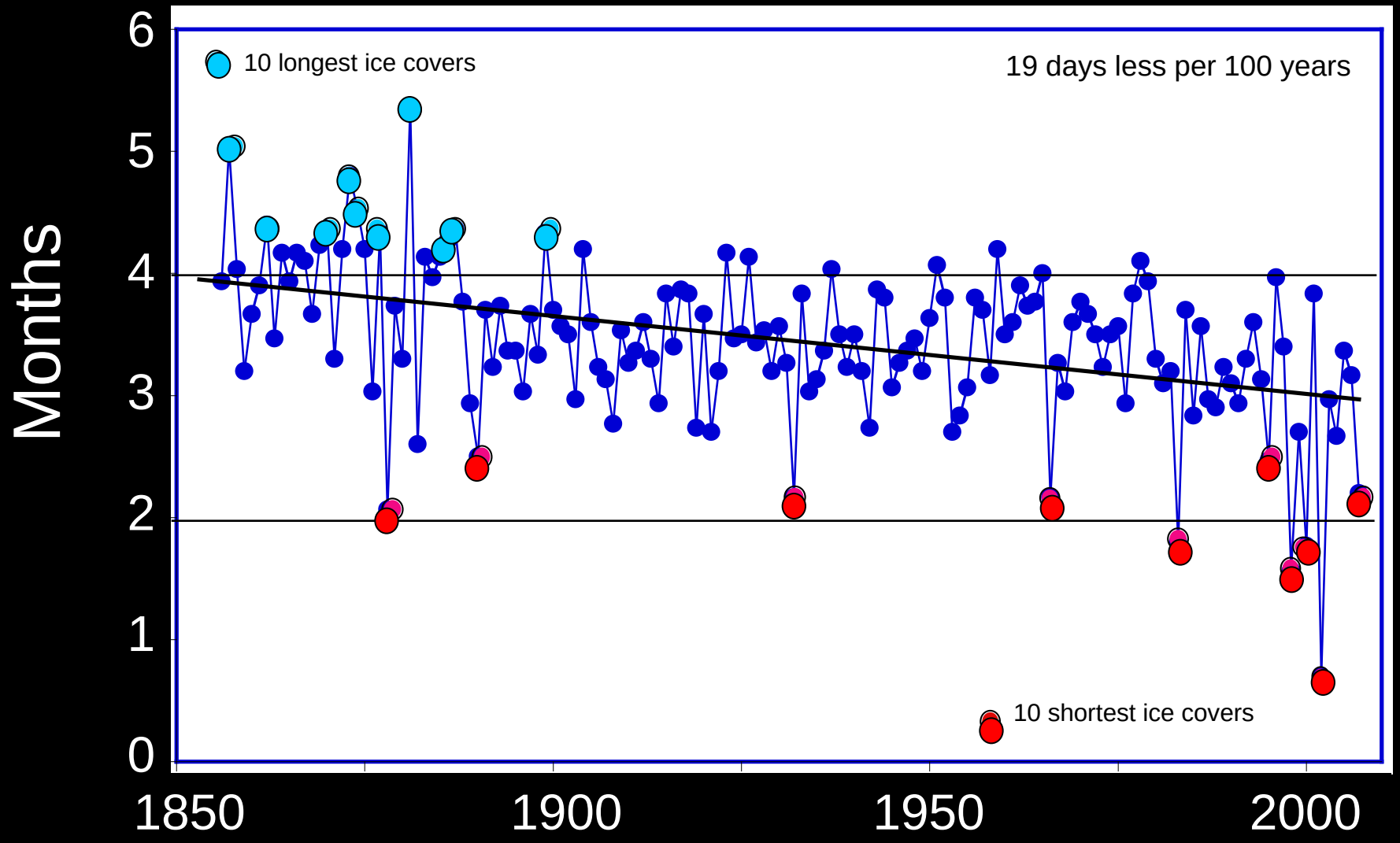
Dec 15

Dec 1

1855 1900 1950 2000

Balsiger 2007

Ice Duration on Lake Mendota

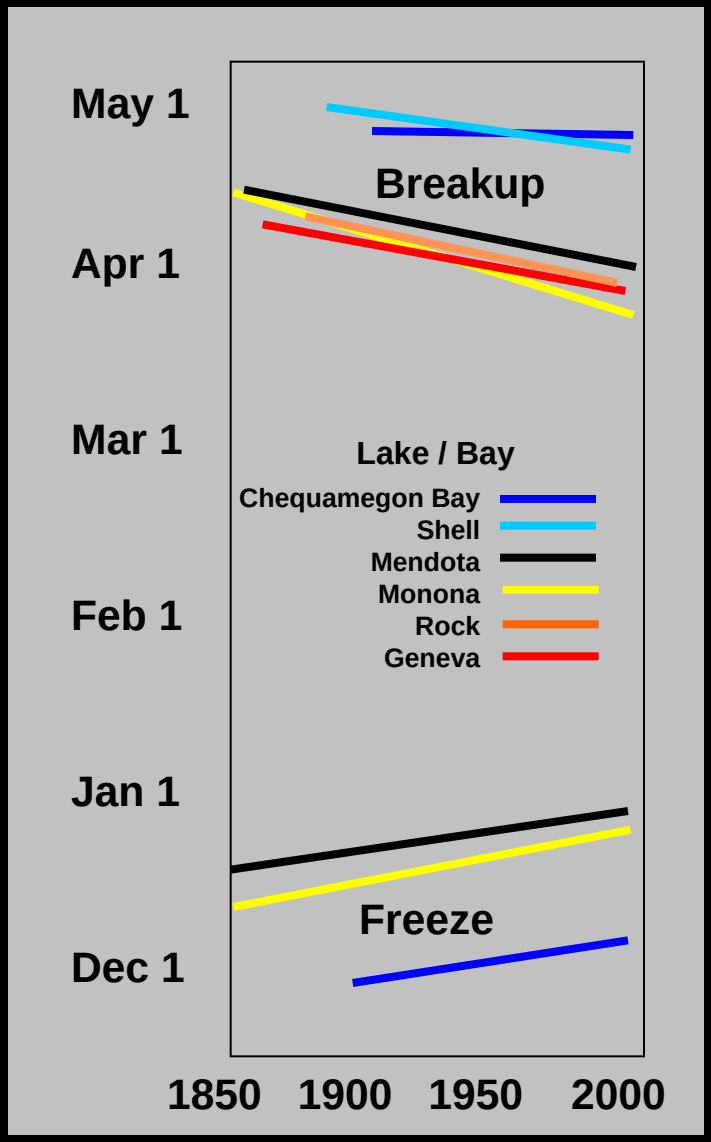


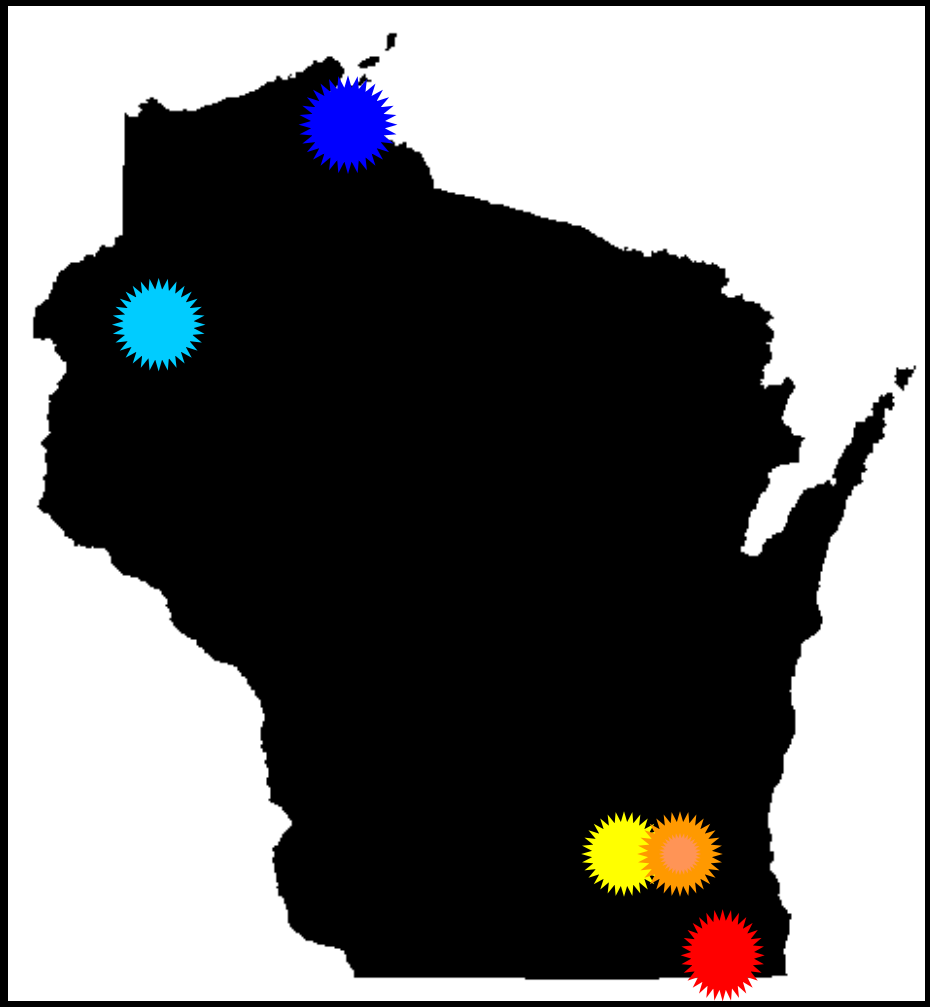
Magnuson 2007

The Invisible Present

The Invisible Place

Changes in Ice Dates Around Wisconsin





Magnuson 2004

Changes around the Northern Hemisphere

(36-37 of the 39 time series are in the direction of warming)

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

Changes around the Northern Hemisphere

Suwa Ko, Japan

(36-37 of the 39 time series are in the direction of warming)

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

Magnuson photo

Omiwatari on Suwa Ko on January 12, 2003

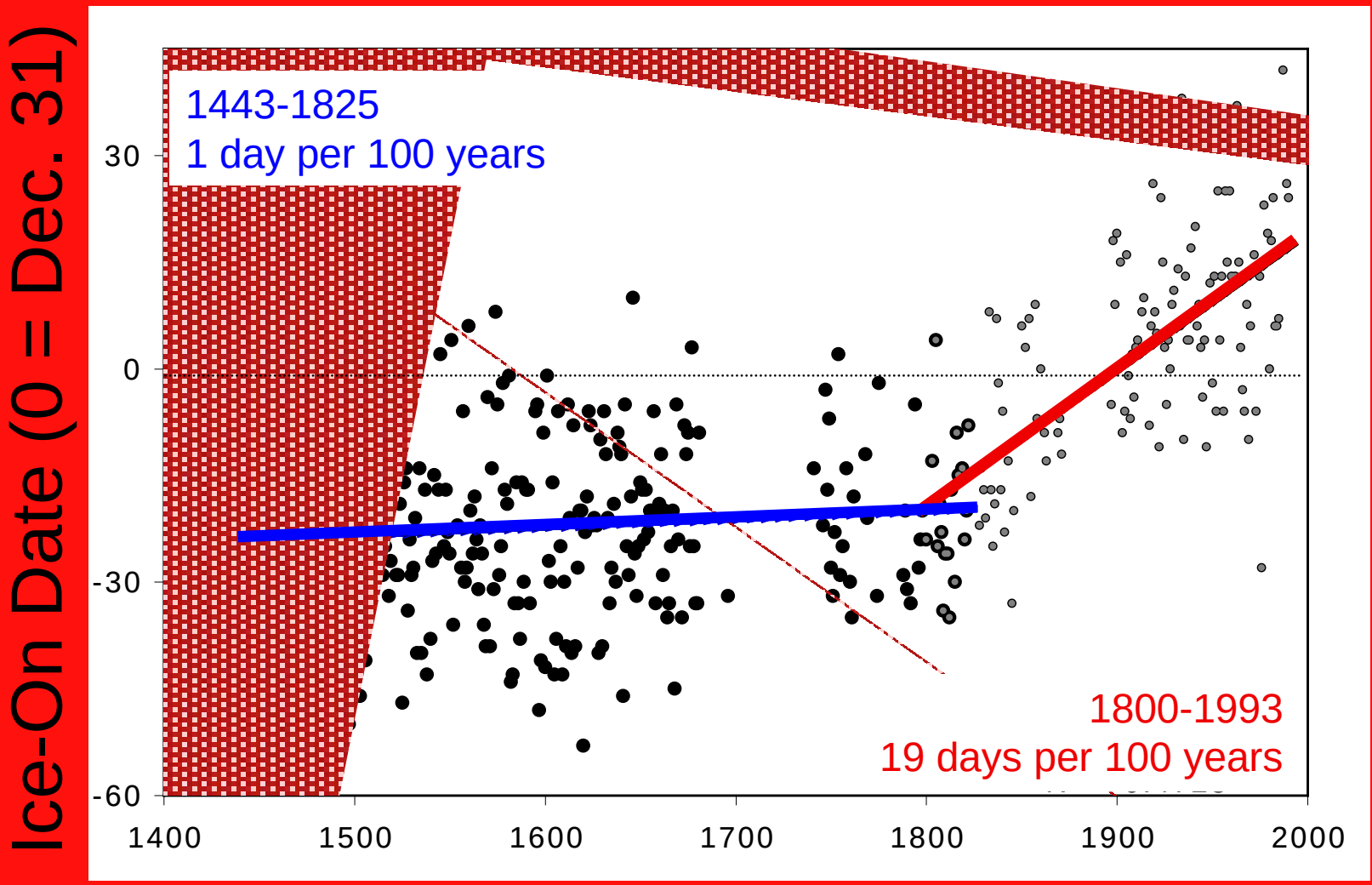
Takayuki Hanazato photo

Lead Shinto Priest Examining Contested Ice Dates

Magnuson photo

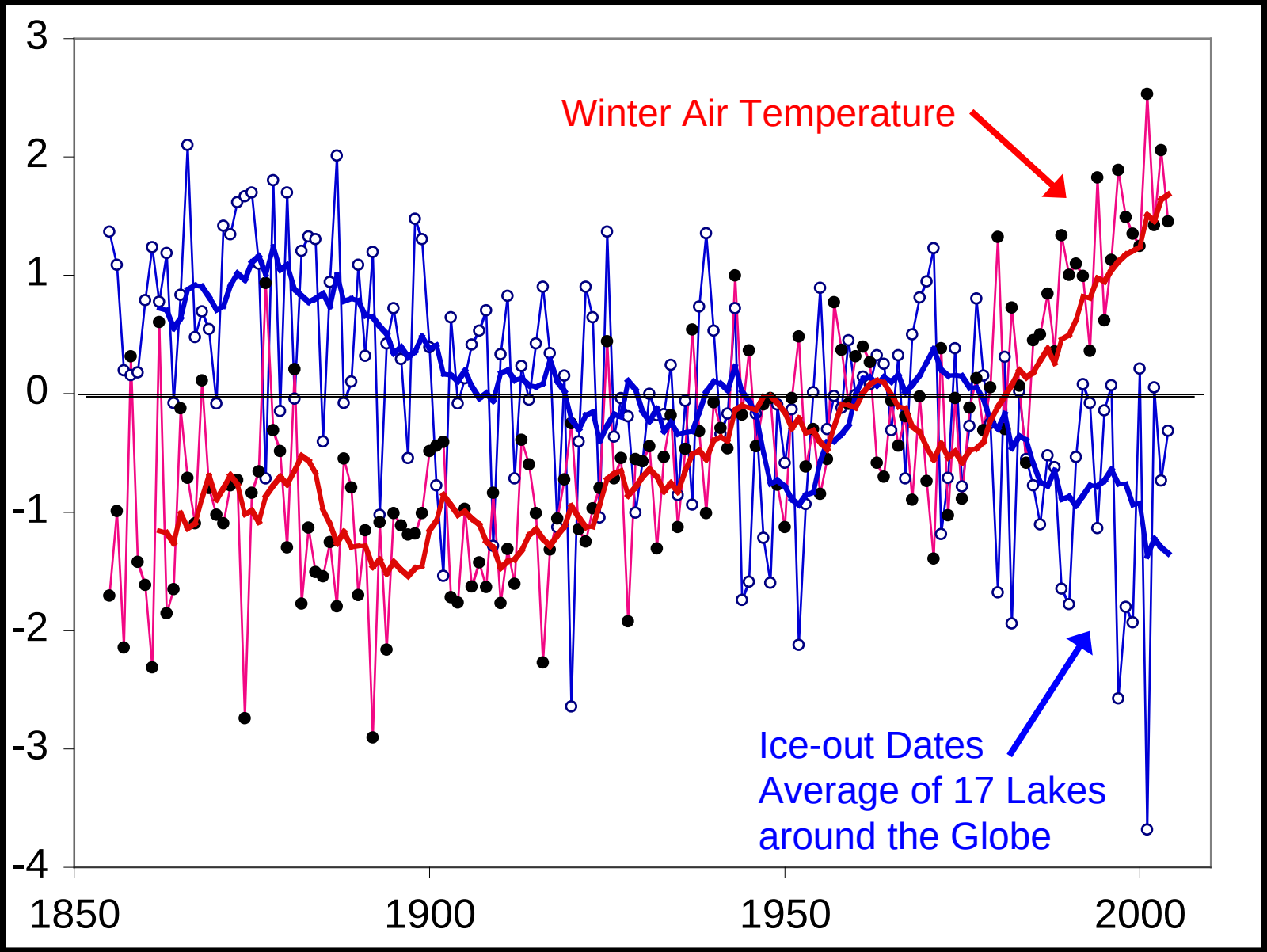
Lake Suwa, Japan, Ice-on Time Series from 1443 - 1993

(30 days subtracted from years before 1880)



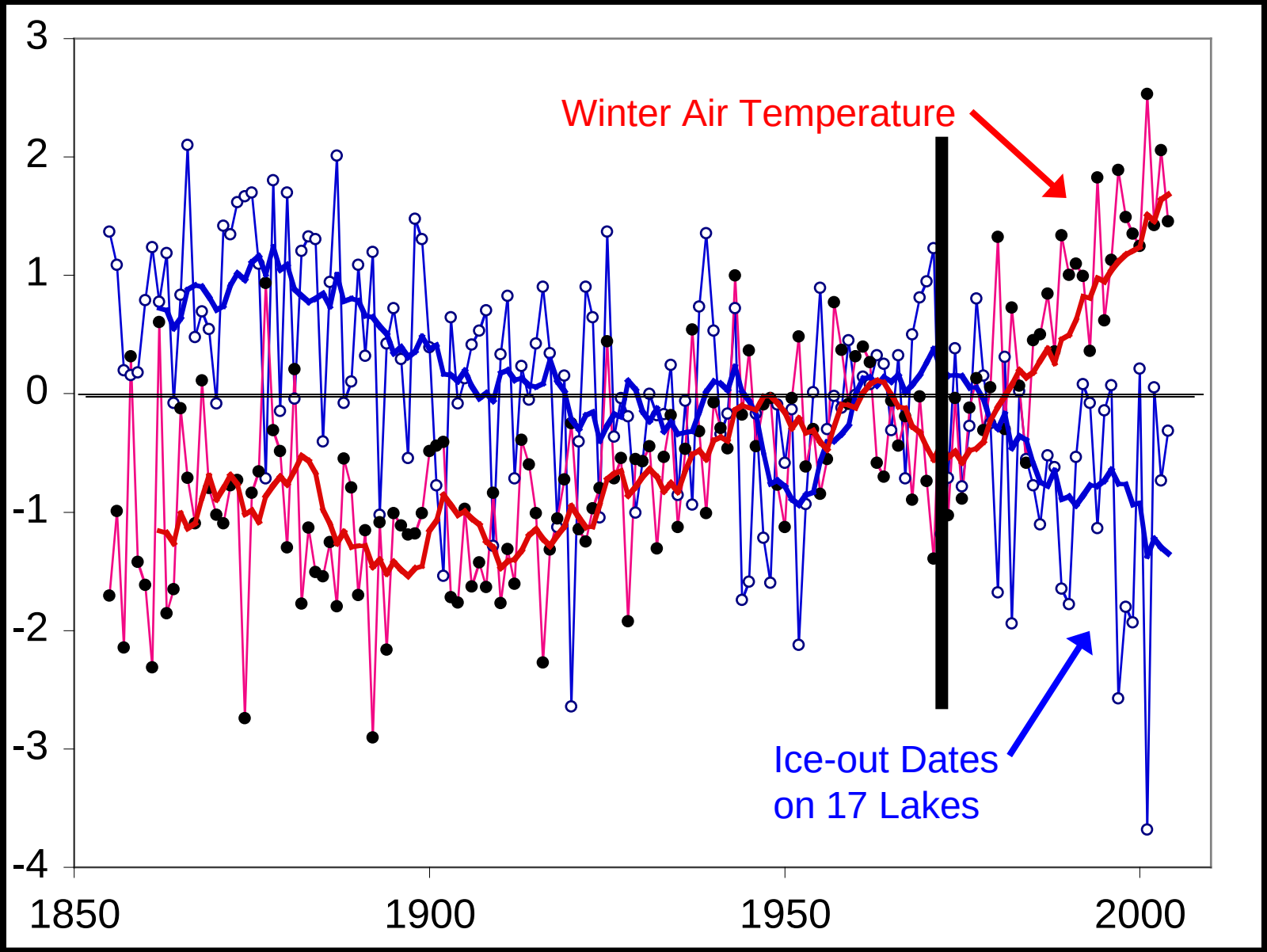
Magnuson 2007 Preliminary

Northern Hemisphere
Relation between Ice-out Dates and Air Temperatures



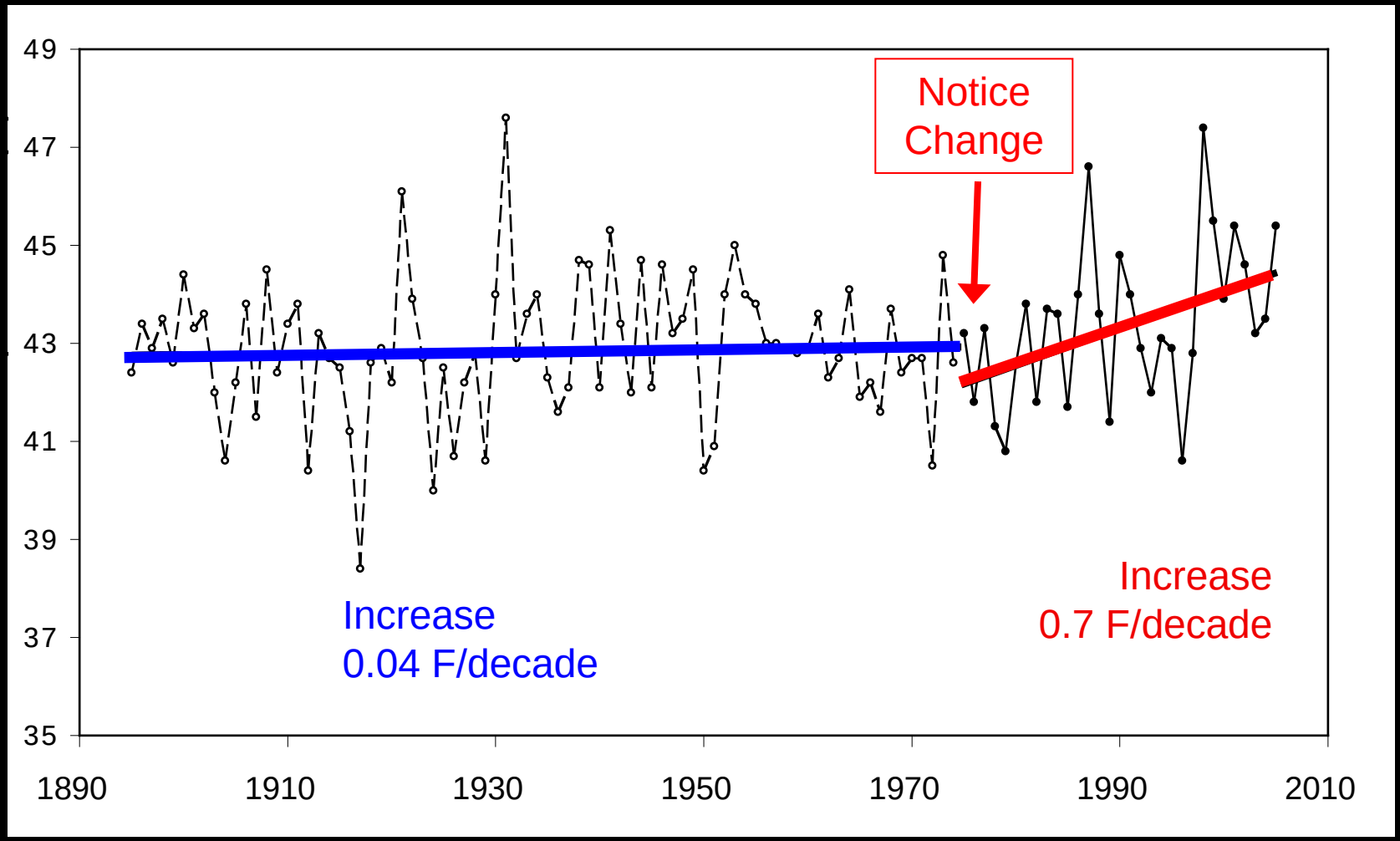
Benson et al. 2007 preliminary

Northern Hemisphere
Relation between Ice-out Dates and Air Temperatures



Benson et al. 2007 preliminary

Wisconsin Air Temperatures 1895-2005



Magnuson: Data from State Climatology Office

Ice-Off Dates for Wisconsin Lakes 1975 to 2007

Ice-Off Date

May 1

Apr 1

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

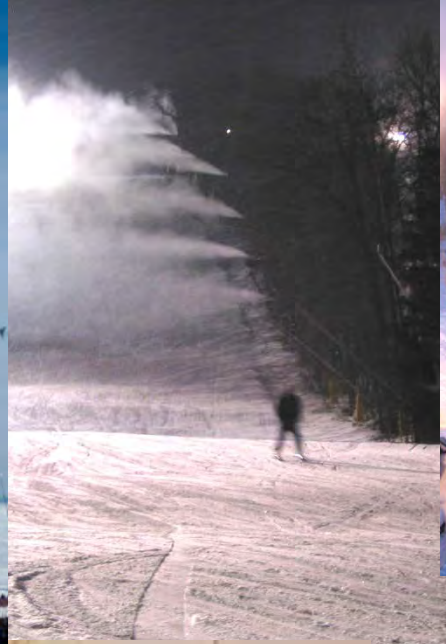
Mar 1

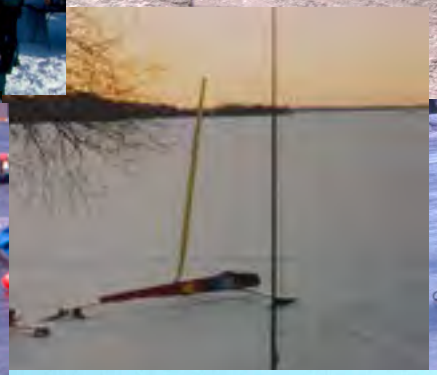
Wisconsin average
3.3 days earlier
per decade

Feb 1

Jan 1

Winter is a part of our "Sense of Place."

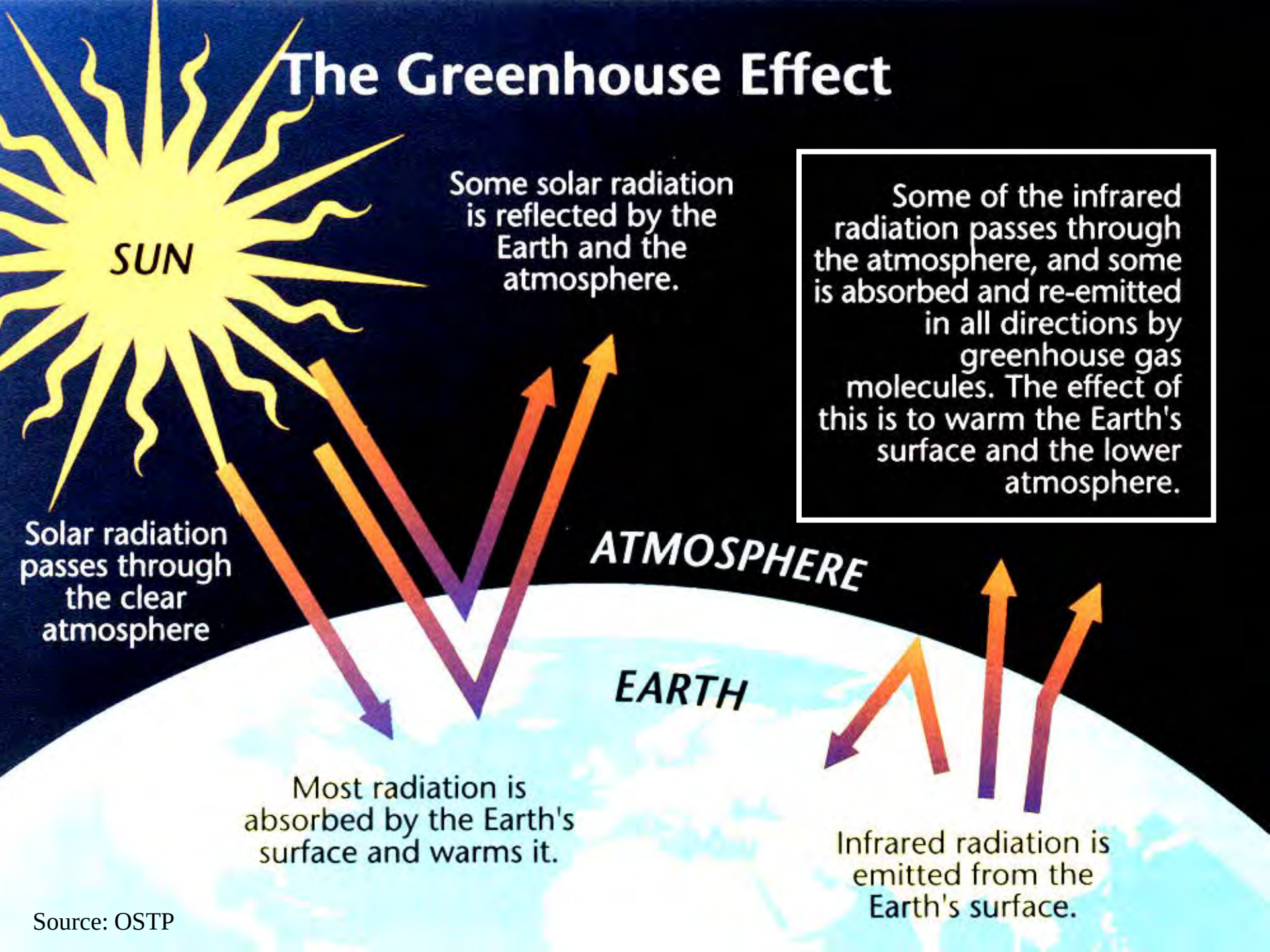




We are losing winter as we knew it!

Magnuson

What is Happening?


The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

Source: OSTP

Climate Change Science

The IPCC
Intergovernmental Panel on Climate Change

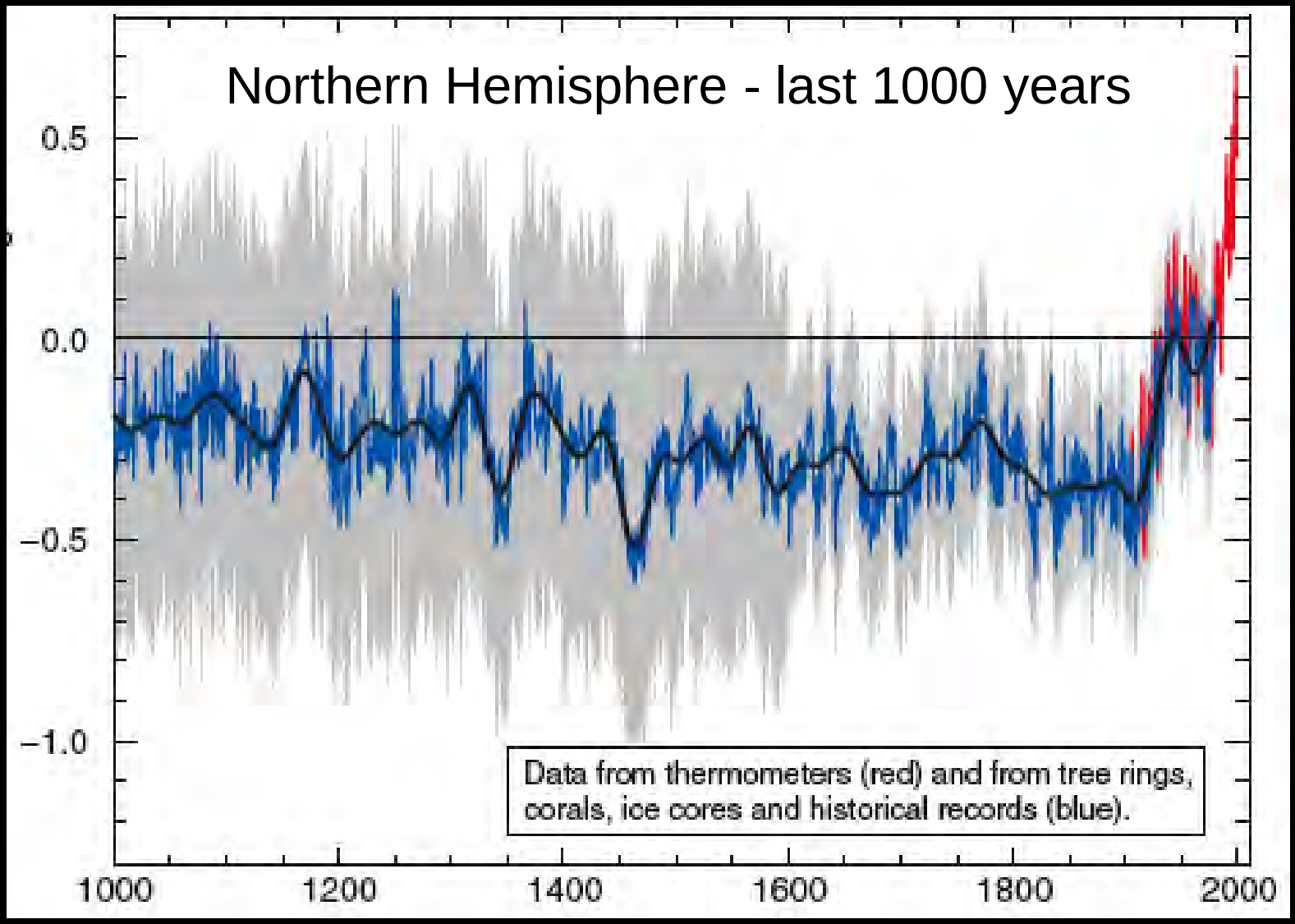
1990 1st Assessment

1995 2nd Assessment

2001 3rd Assessment

2007 4th Assessment

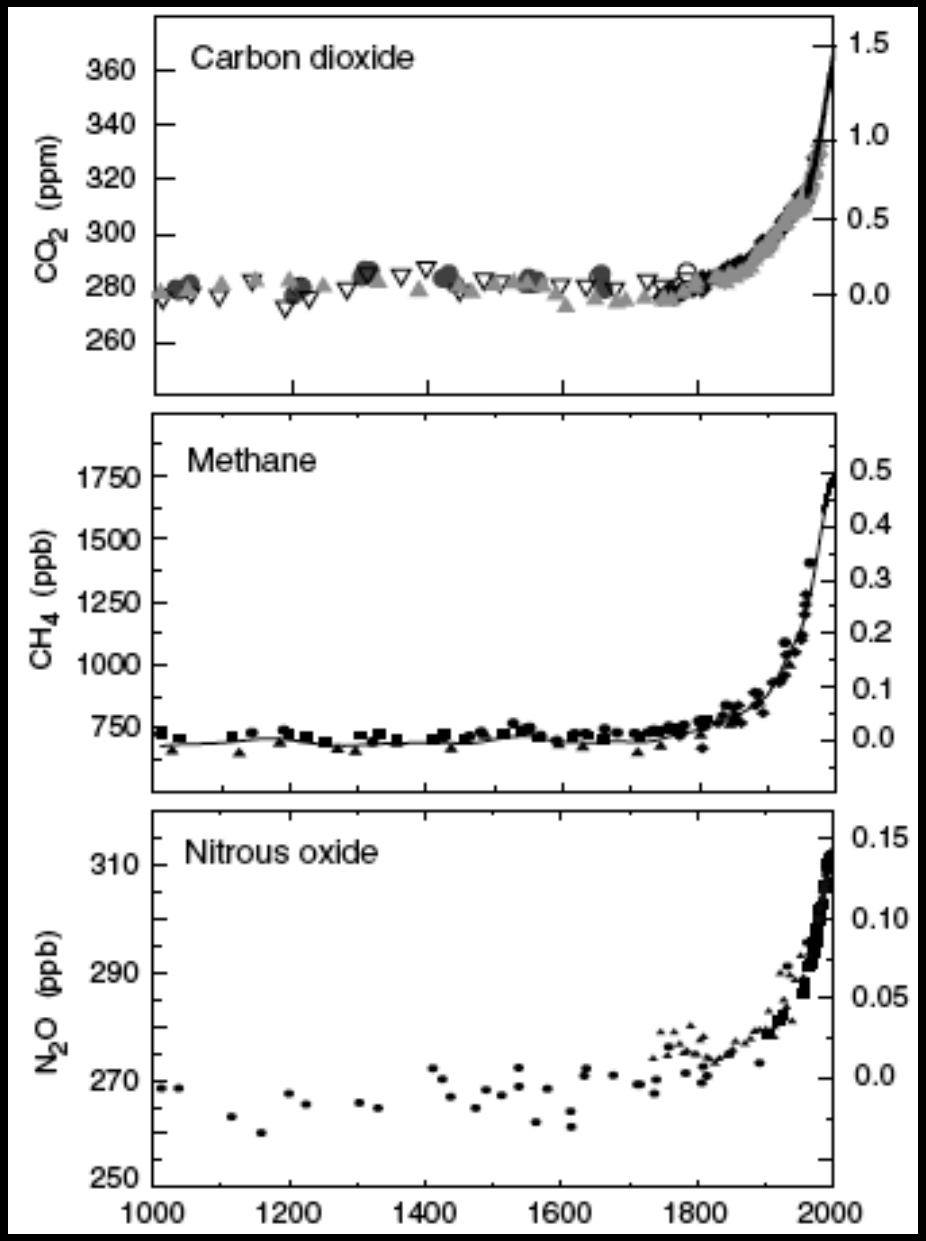
Variation in Earth Surface Temperatures



IPCC 2007

Greenhouse Gas Concentrations

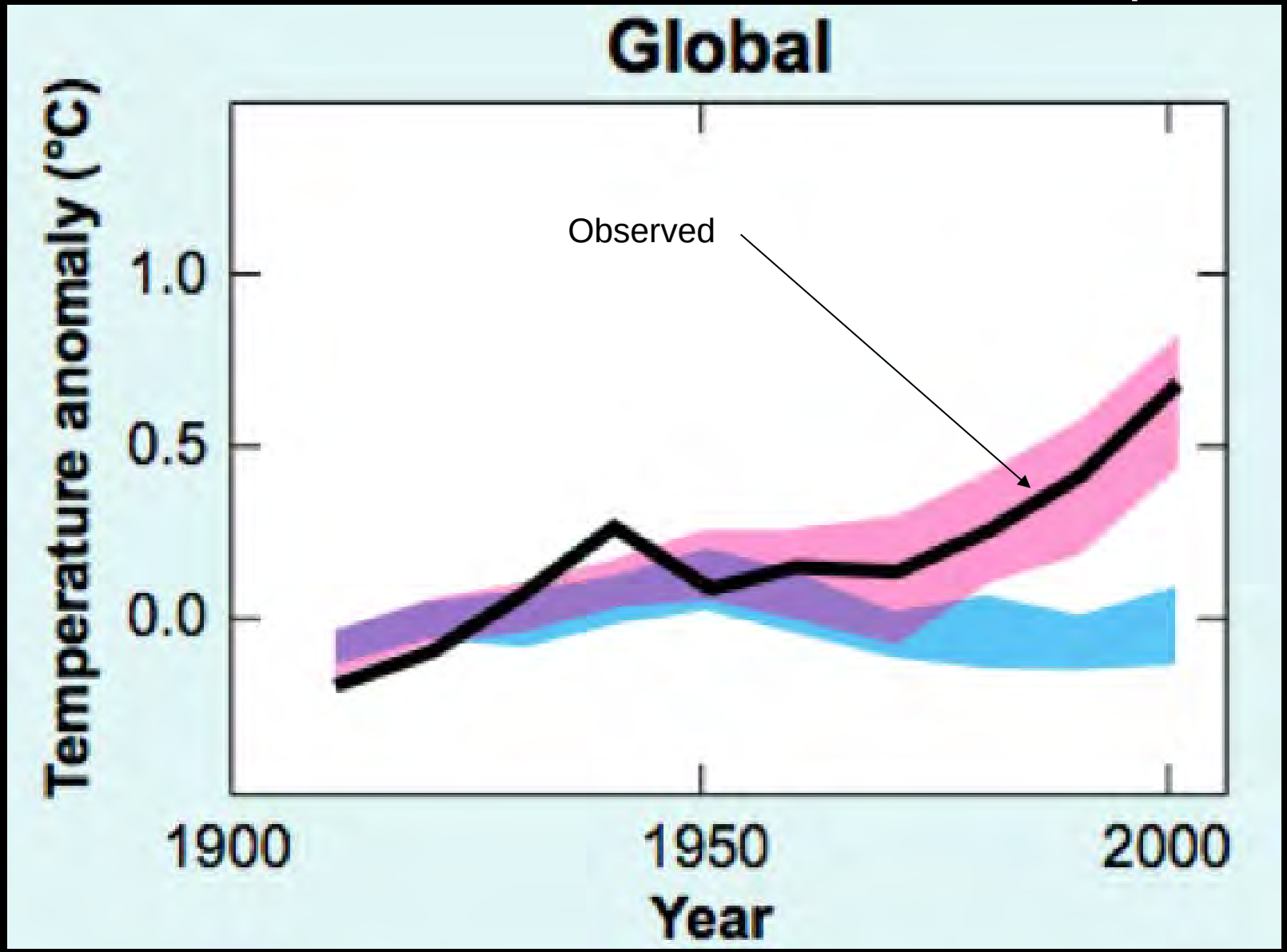
Atmospheric Concentrations



Radiative Forcing (Wper m^2)

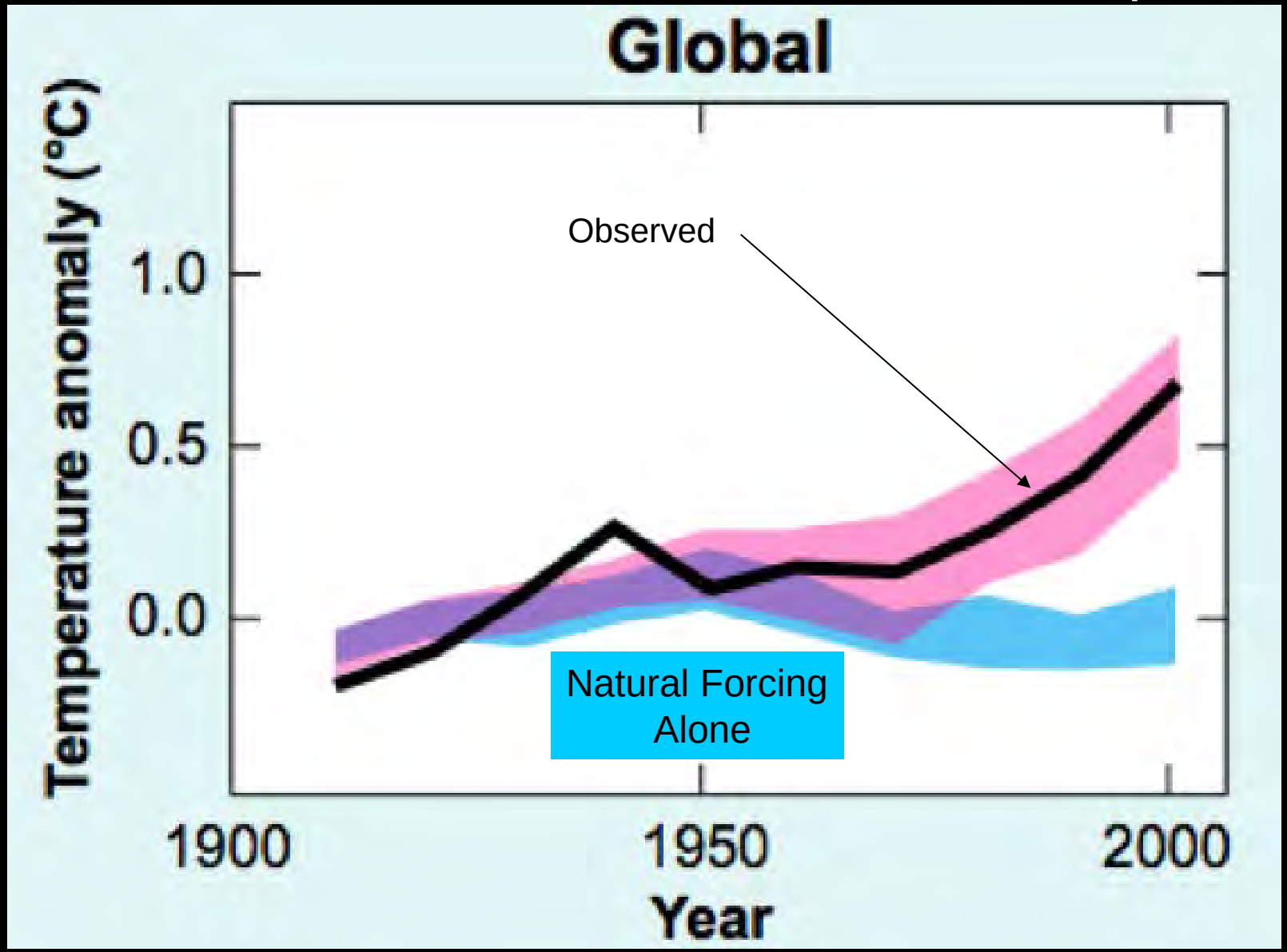
IPCC 2007

Simulated Annual Mean Surface Air Temperatures



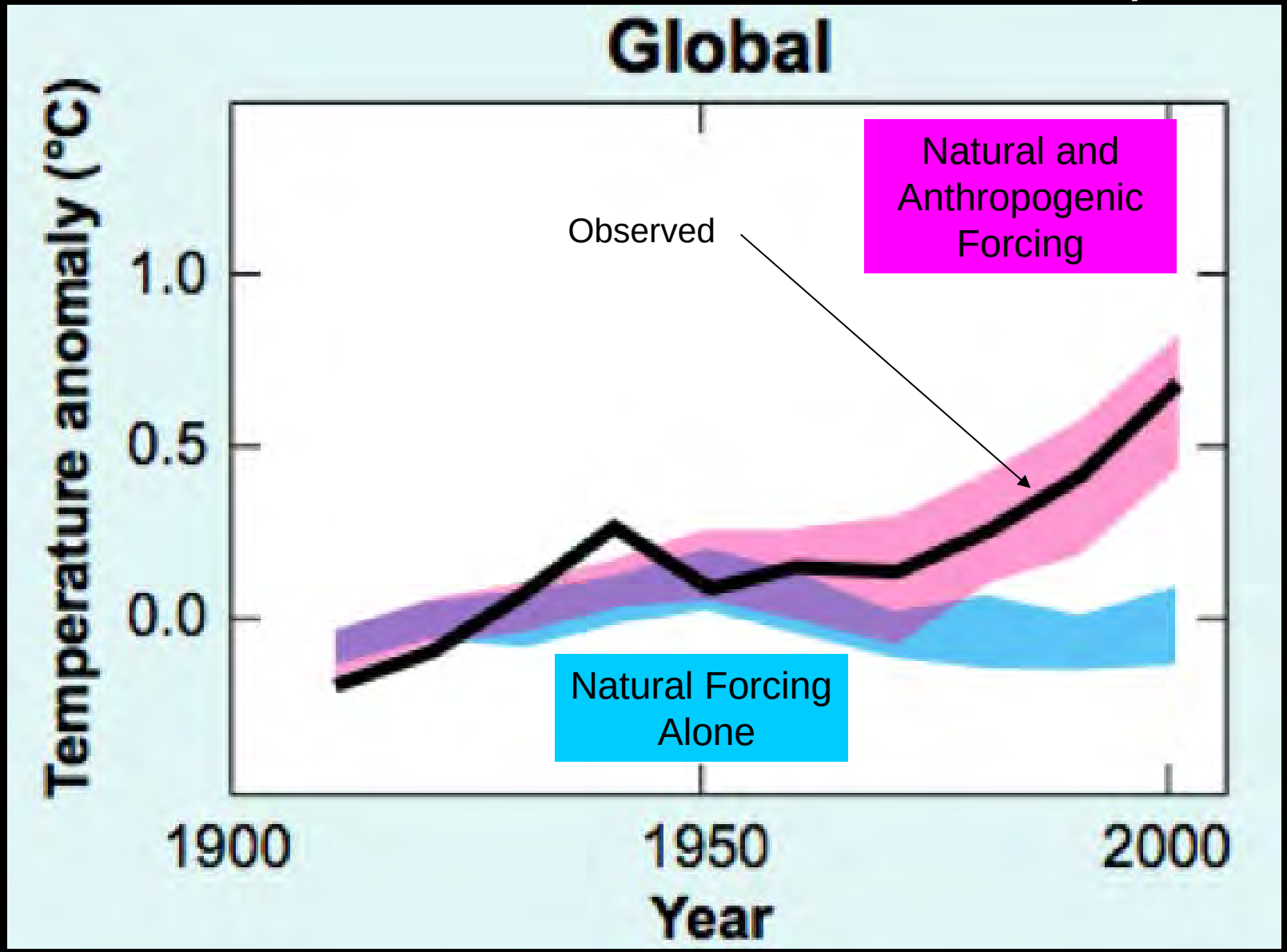
IPCC 2007

Simulated Annual Mean Surface Air Temperatures



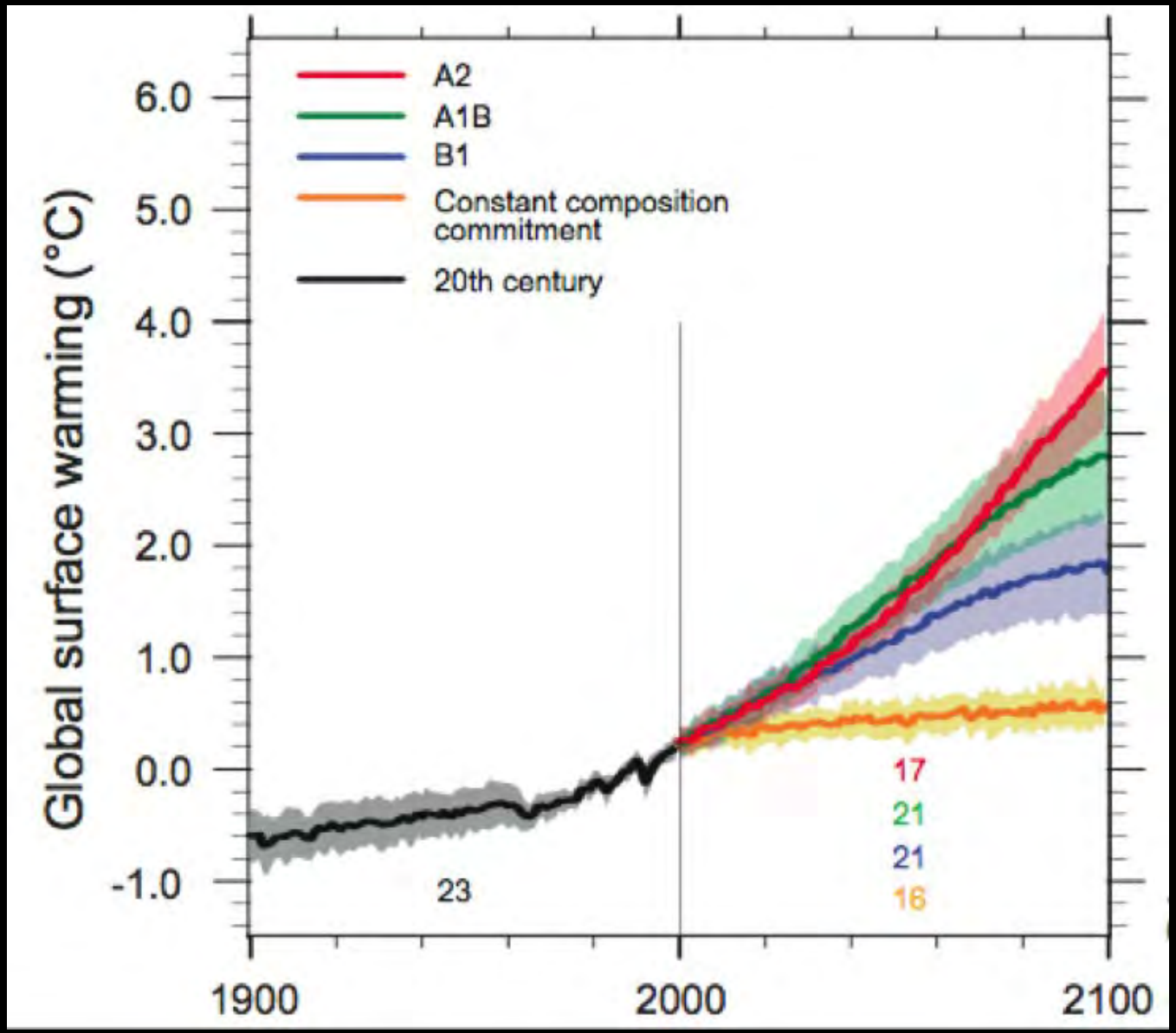
IPCC 2007

Simulated Annual Mean Surface Air Temperatures



IPCC 2007

Temperature Change in IPCC Scenarios



7.2°F

3.2°F

IPCC 2007


Confronting
Climate Change in the
Great Lakes Region
Past, Current, and Future Climate Change
http://www.ucsusa.org/greatlakes
2003 updated 2005
U.S. Army Corps of Engineers, Detroit District

Wisconsin

By the end of this century scenarios for

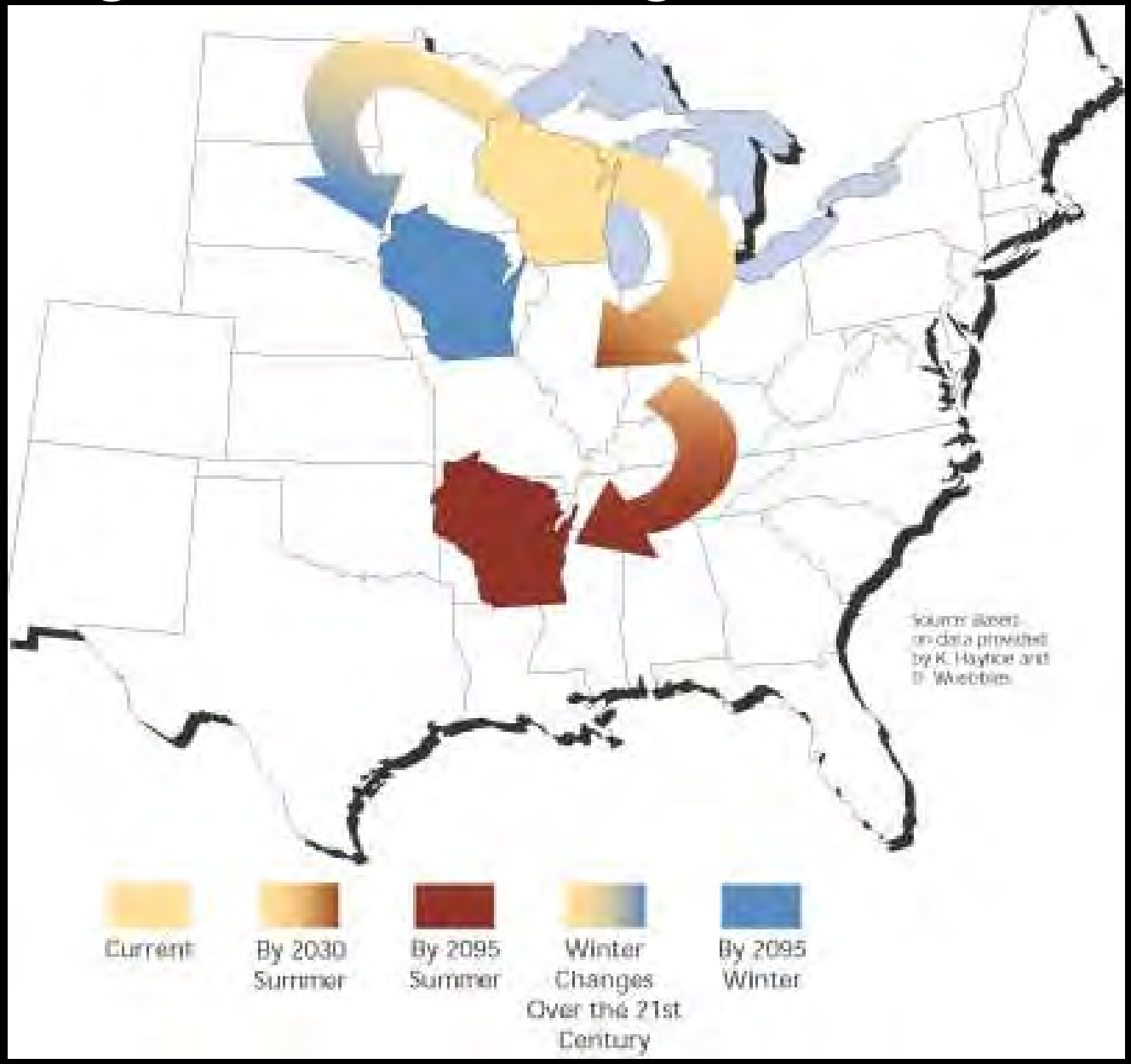
Summer Temperatures: 8 - 18°F Warmer

Winter Temperatures: 6 - 11 °F Warmer

Extreme Heat More Common

Extreme rainfall Events: 50 - 100% more common

Moving States - Going to Arkansas?



UCS/ESA 2003

Changing Summers in Great Lakes Region

Check out Minnesota and Illinois

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Current

By 2095

Kling et al. 2005 Confronting Climate Change in the Great Lakes Region, UCS & ESA

Observed Northward Movement of the April 15 Lake Breakup 1975 to 2004 by 5-Year Intervals

Breakup Date from

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Jenson, Benson, Magnuson et al. 2007

Do Fishes Care about Climate Change?

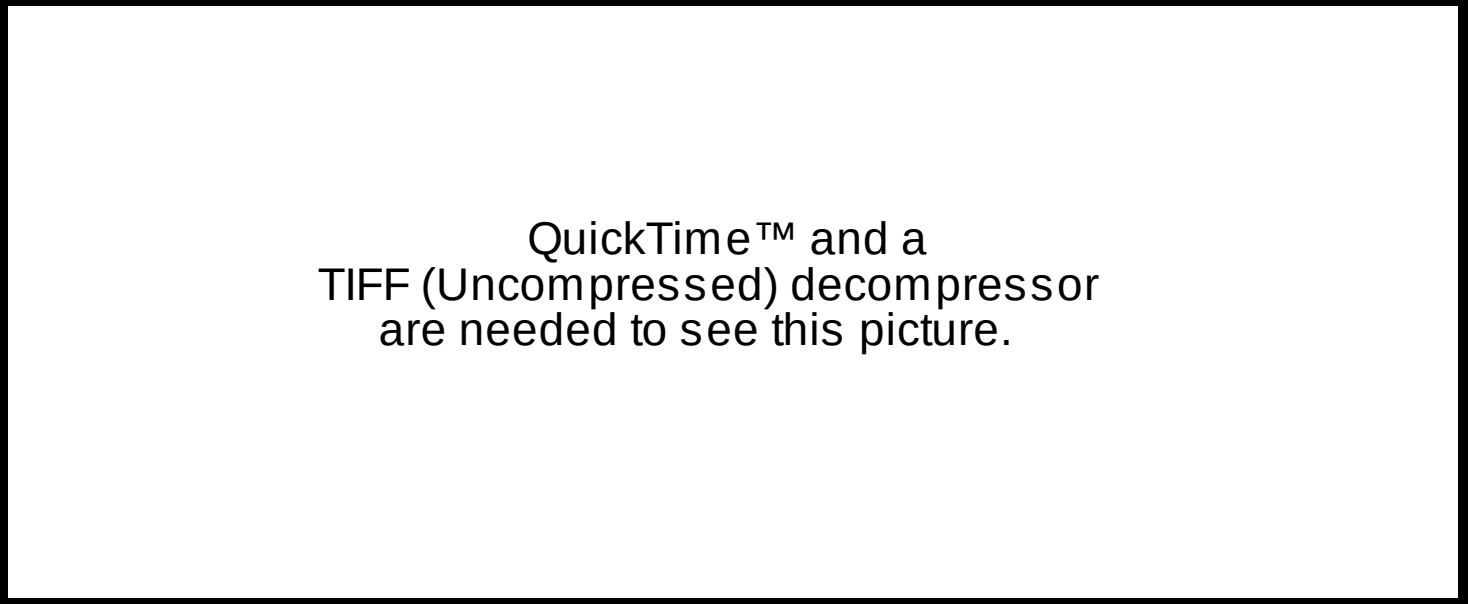
Warm Water Fishes

Cool Water Fishes

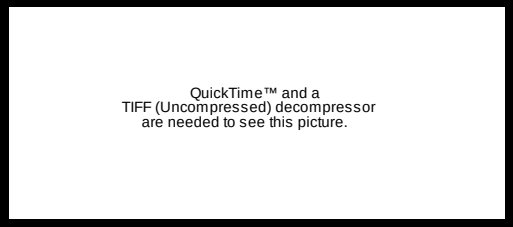
Cold Water Fishes

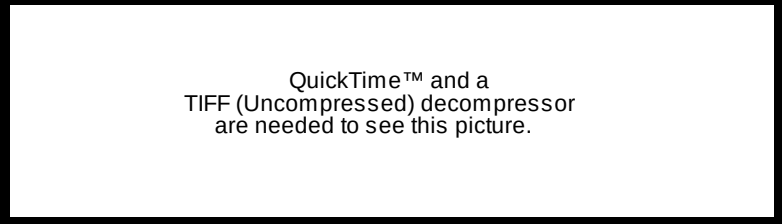
Magnuson 2007

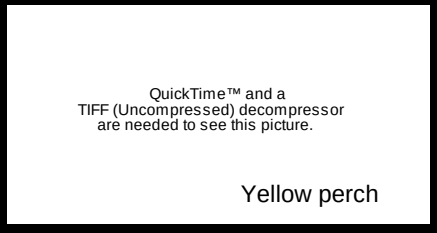
White Sucker Cool Water Fish



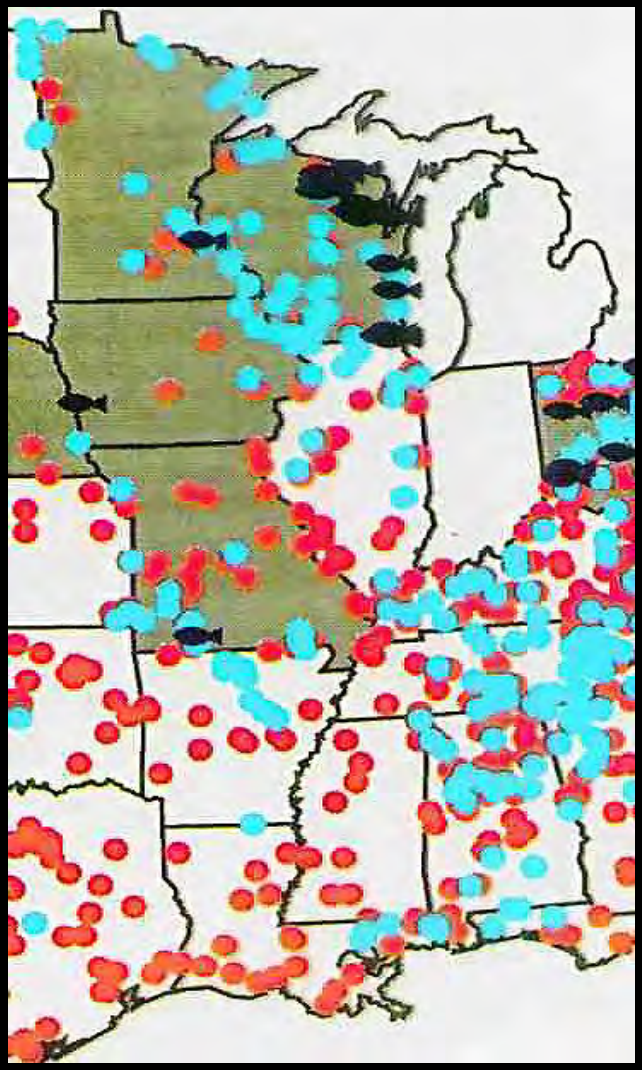
Cool Water Game Fishes





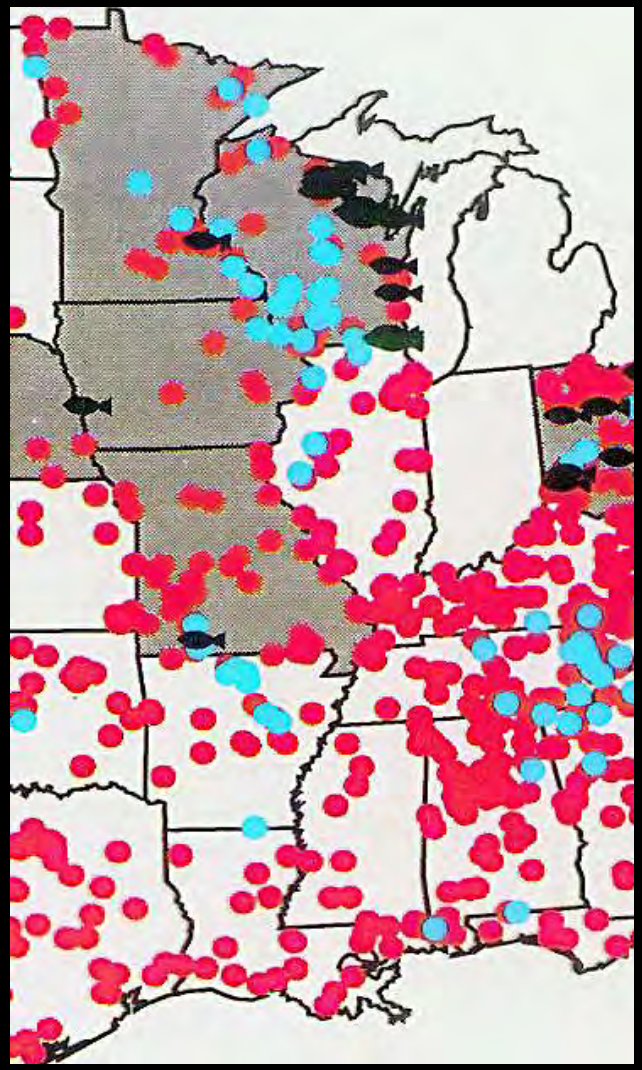


Where White Sucker could Persist



NO

YES



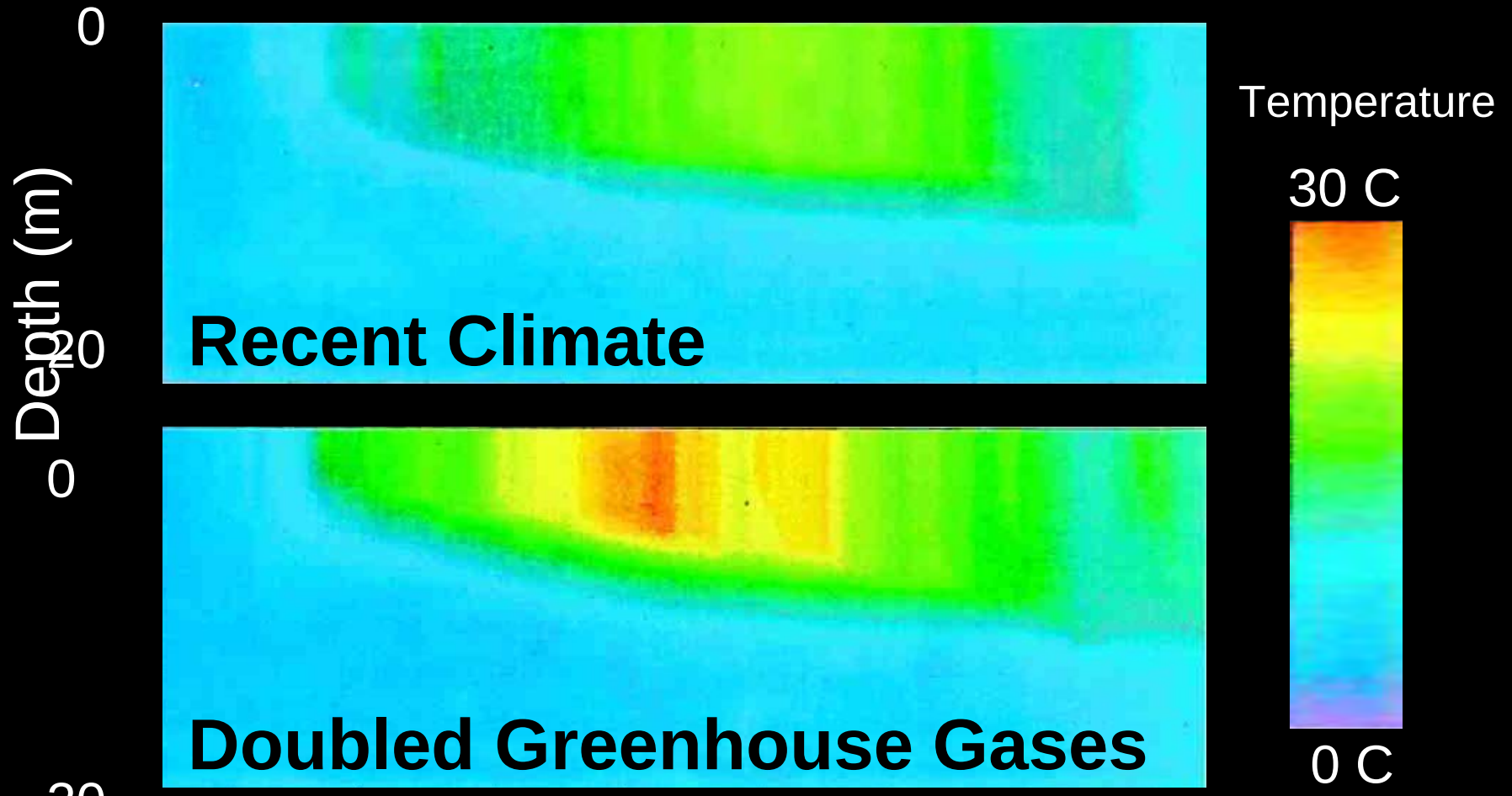
Base Climate

Doubled Greenhouse Gases

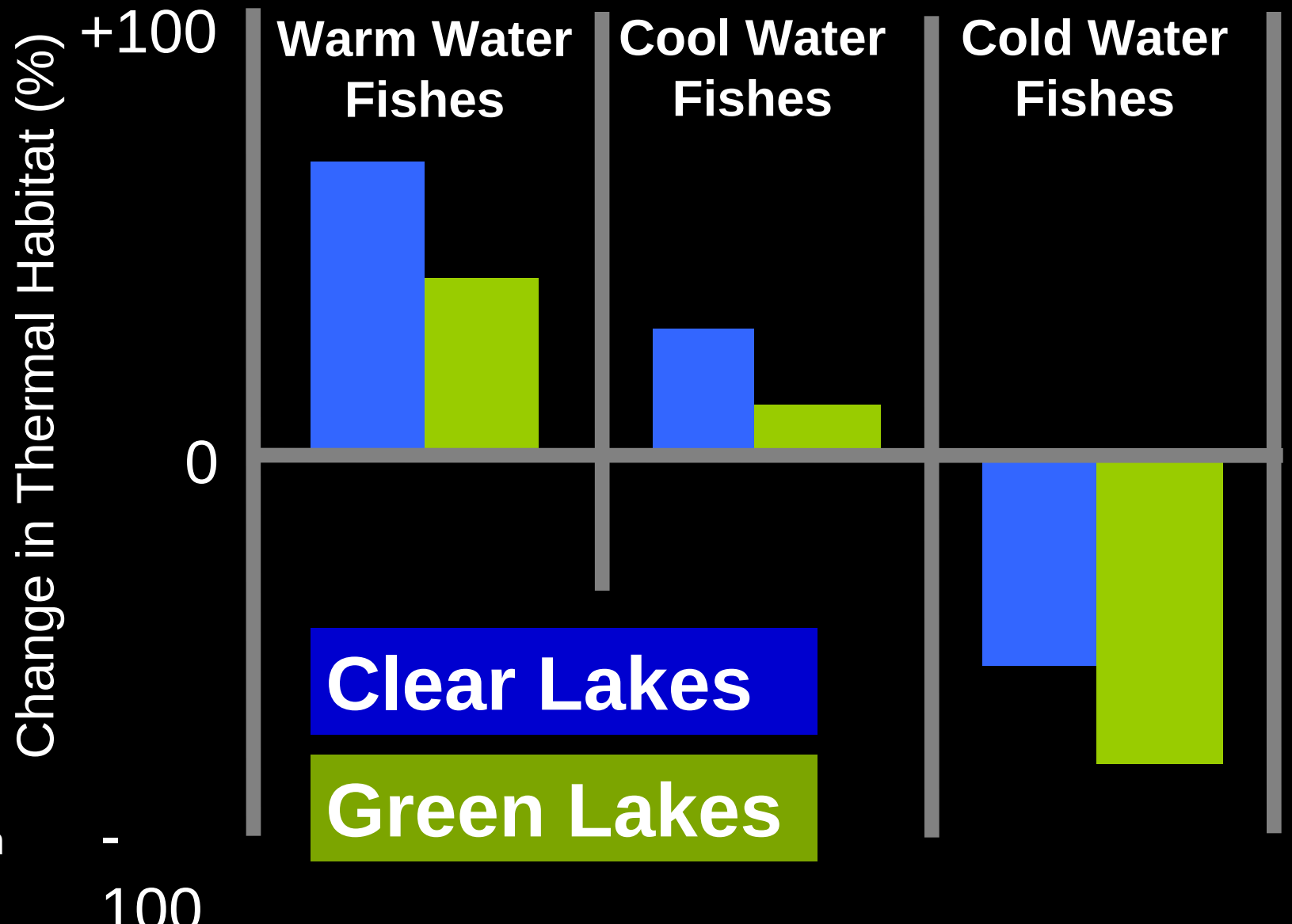
John Eaton and others


How about for Lakes?
Sparkling Lake (Vilas Co.)
Wisconsin

Water Temperatures
Sparkling Lake, Wisconsin



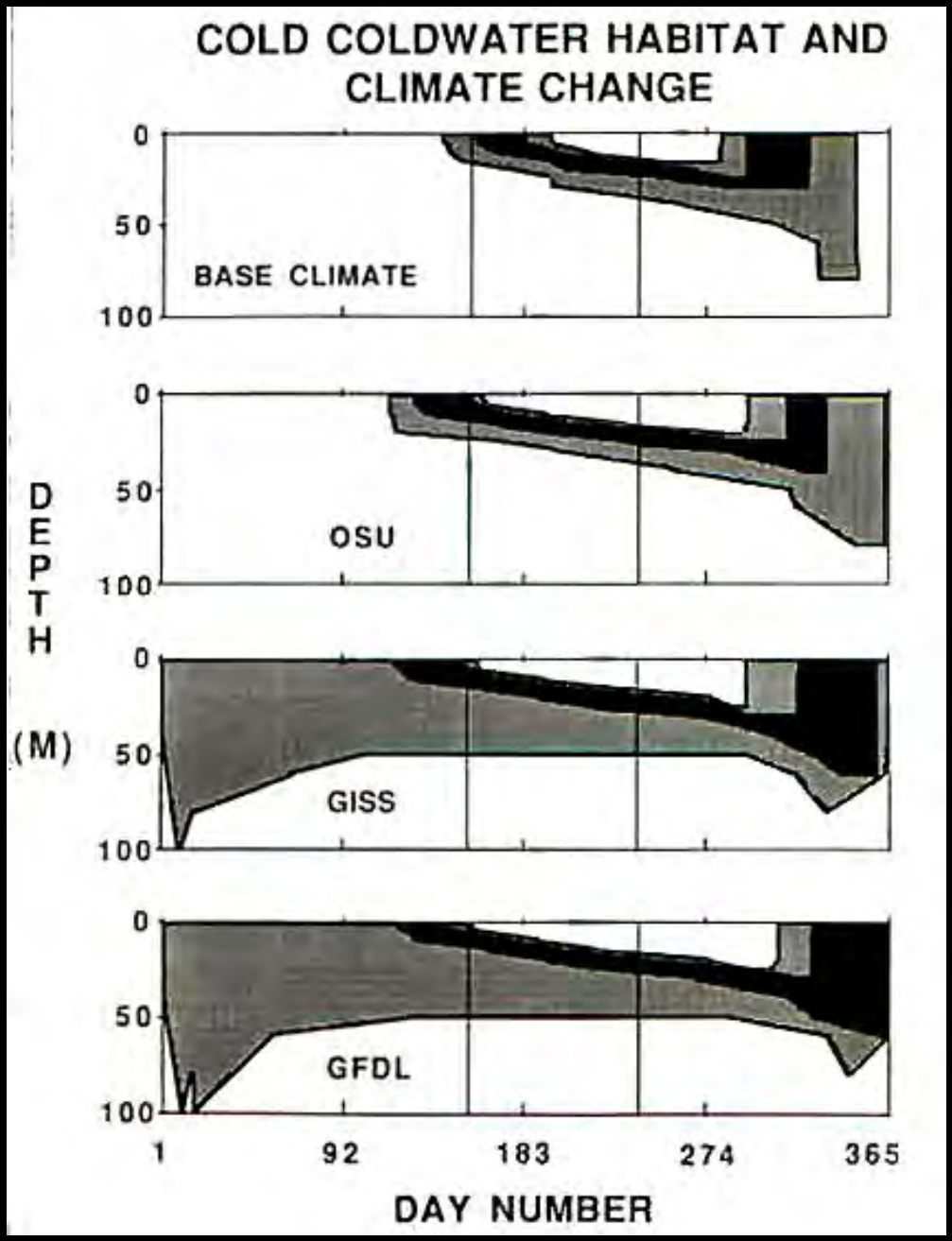
Minnesota Inland Lakes: Simulated Change in Thermal Habitat with CO_2 Doubling



Stefan et al.

Lake Trout

Lake Michigan



Magnuson, Meisner, and Hill 1990

What can Happen to the Fishes?

- Extinctions and extirpations at southern boundaries.
- Northward movement of northern boundaries by 500km with CO_2 doubling.
- Greater losses of fishes in streams and shallow ponds than in deep lakes.
- Invaders will cause extinction of some resident species and changes in water quality.
- The Great Lakes refuge for cold water species.

Magnuson 2007

Effects of Global Warming on Water Cycle

Global Warming (temperature increase) → Speeds up Global Water Cycle

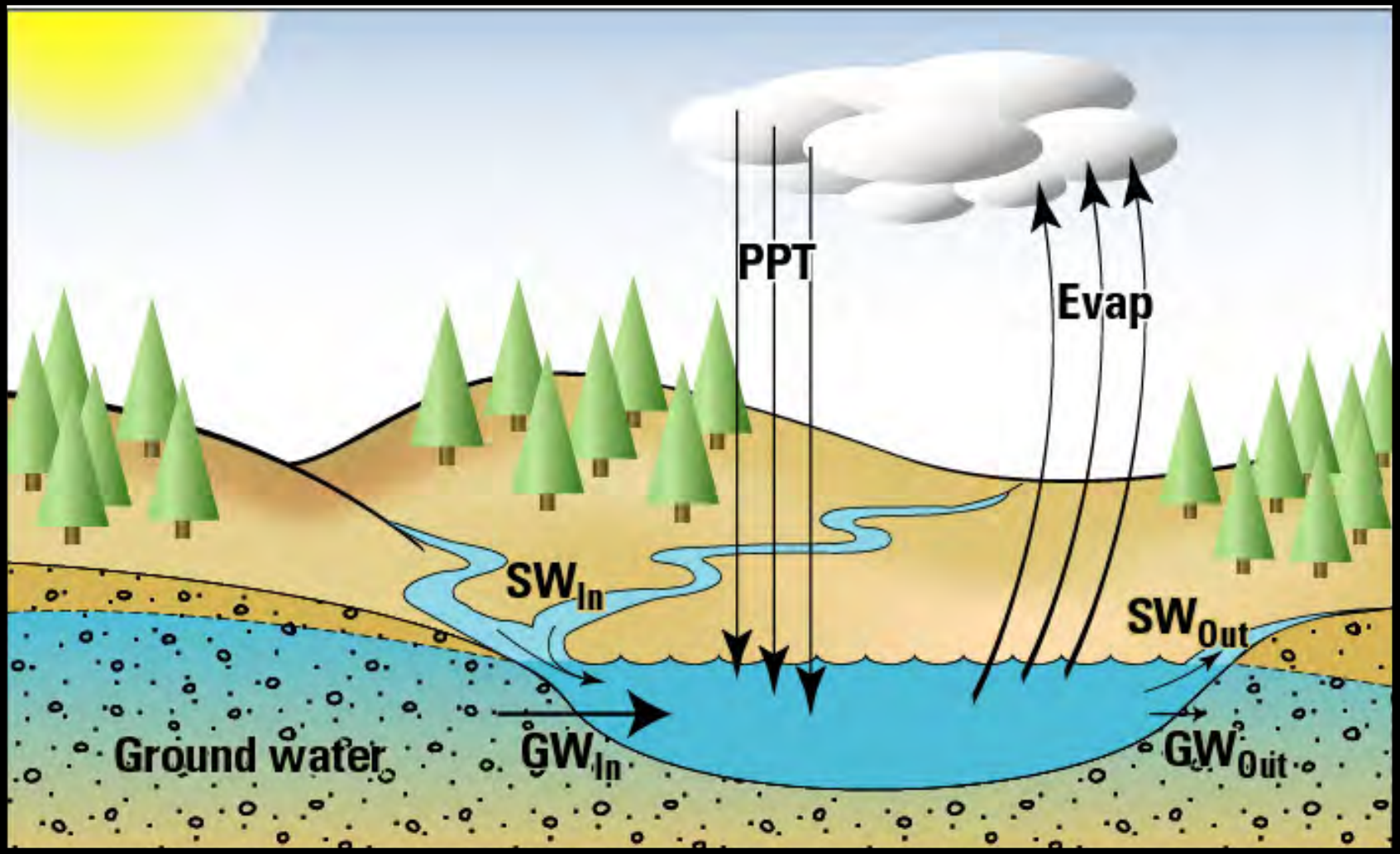
↓

More Extreme Weather Events

- Droughts
- Storms
- Floods

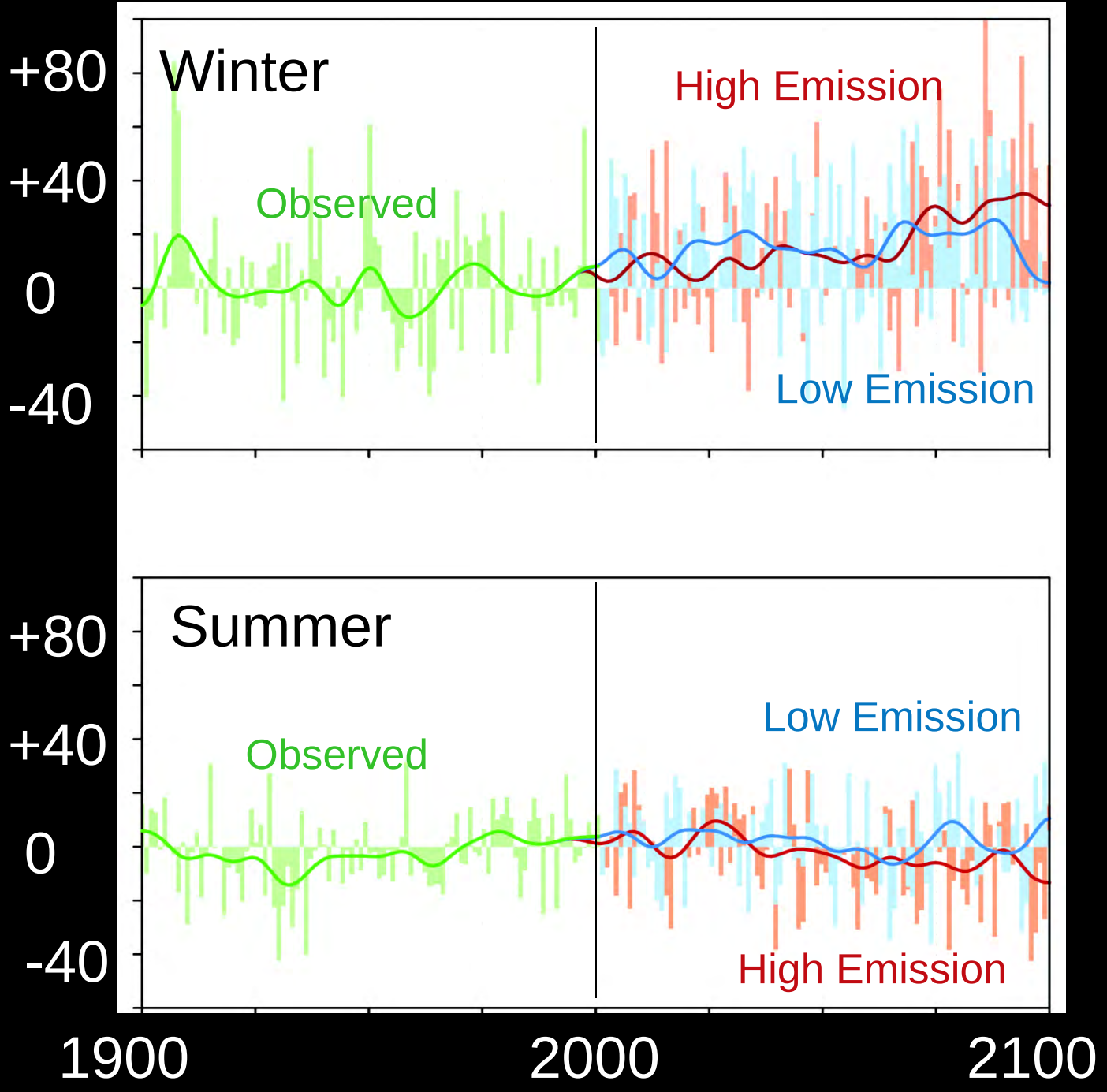
Magnuson 2007

Changes in the Hydrologic Cycle



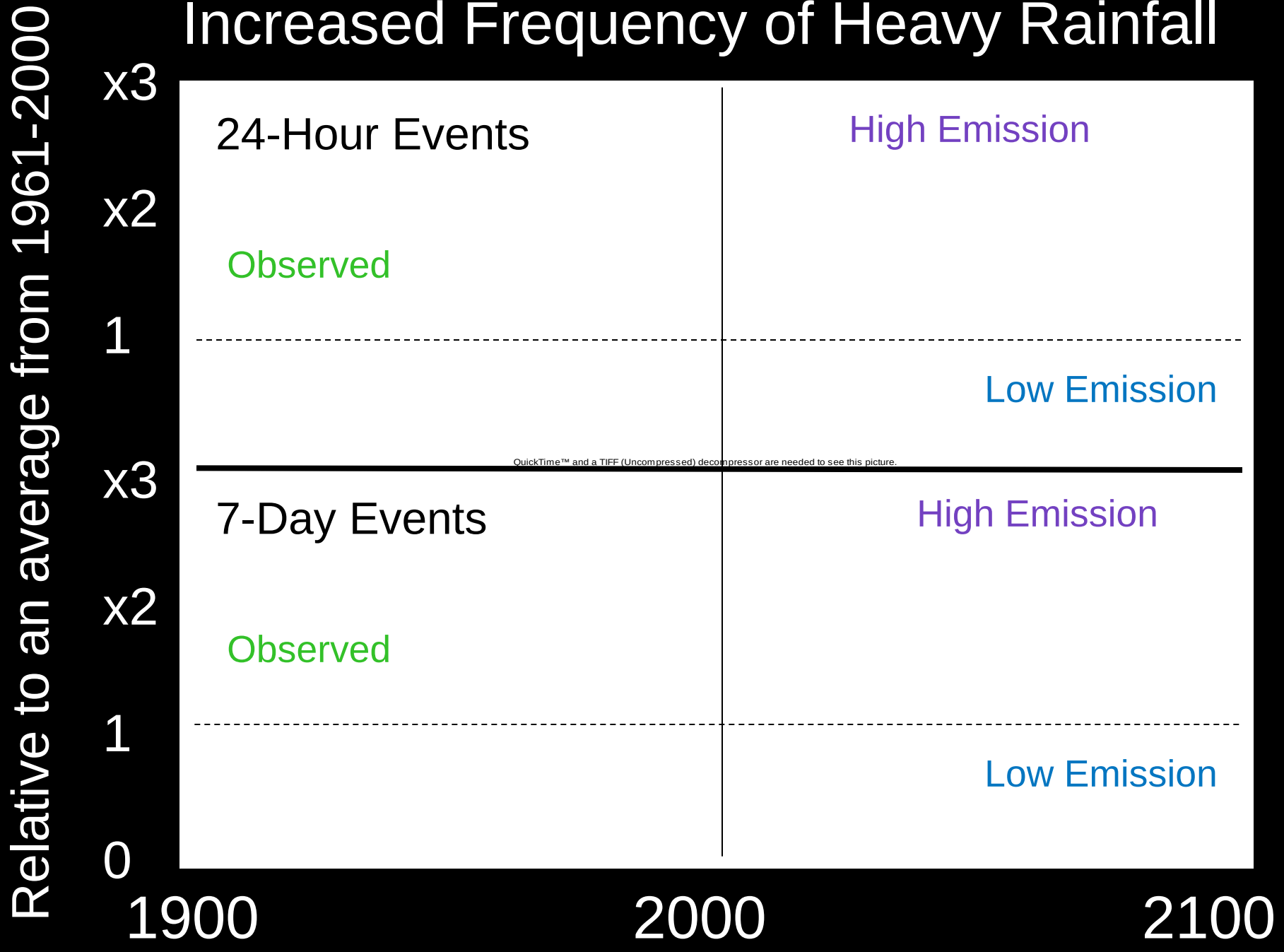
Krohelski 2003

Observed and projected change in average daily precipitation (%)



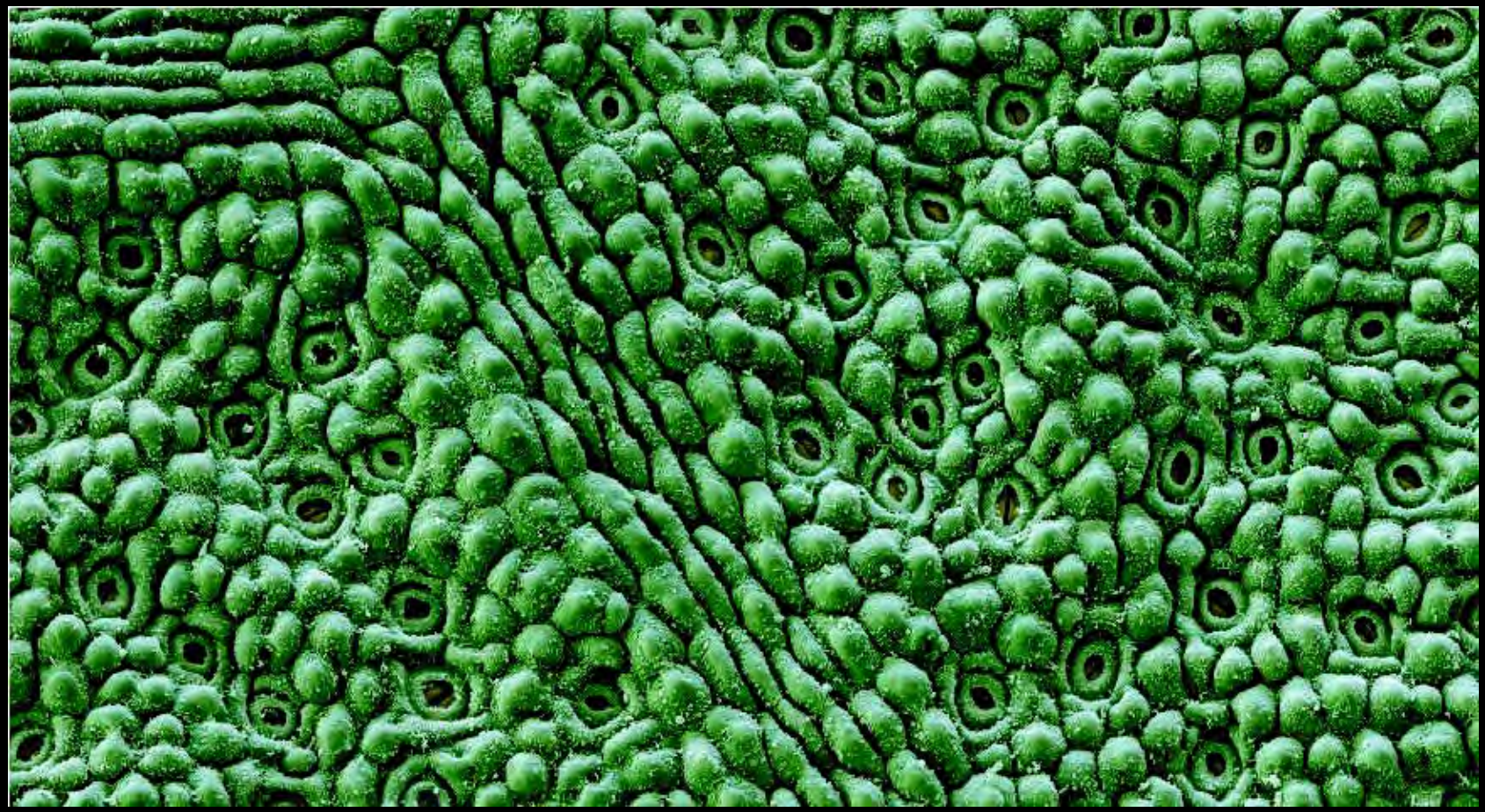
UCS/ESA 2003

Increased Frequency of Heavy Rainfall



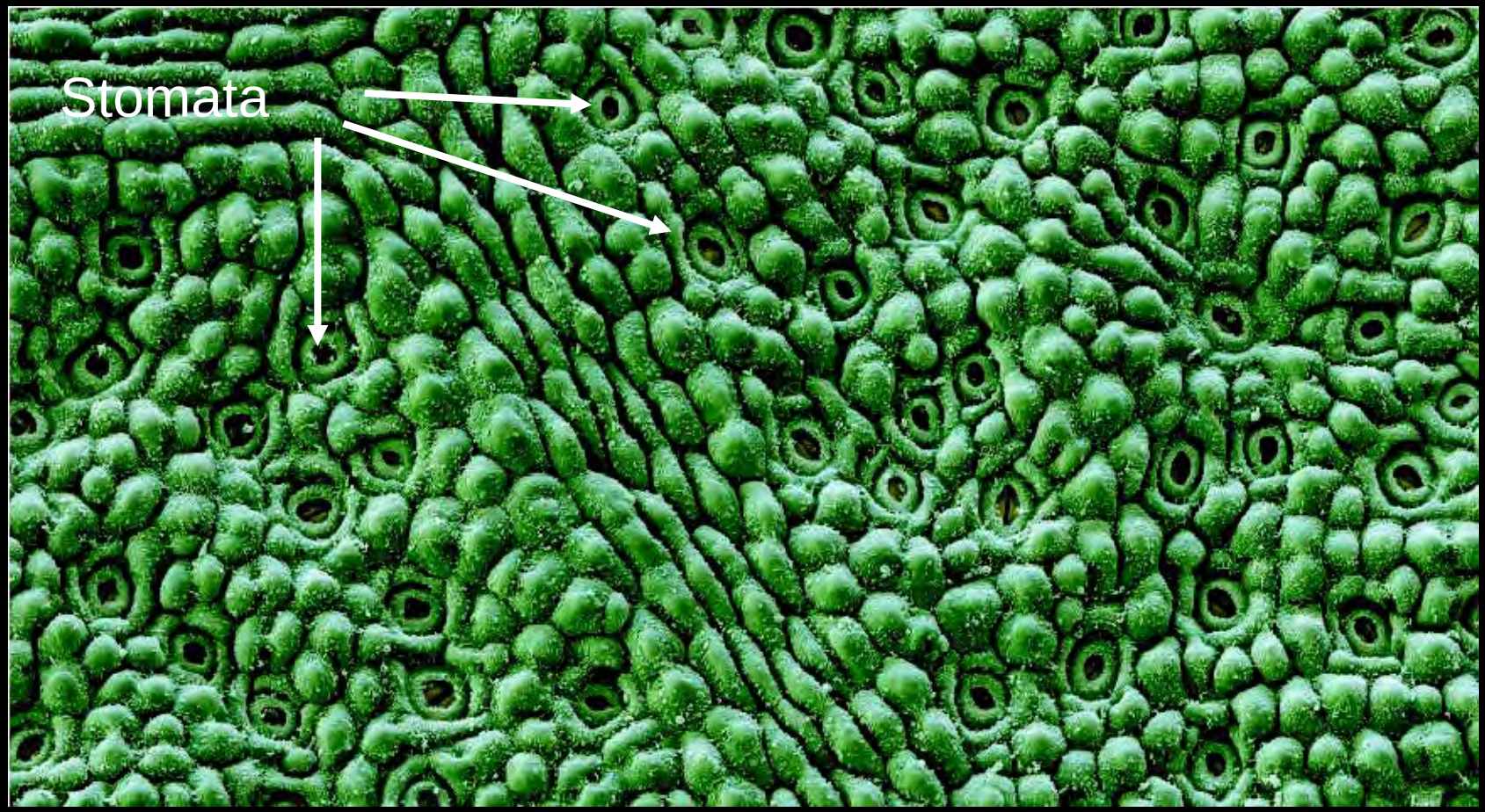
UCS/ESA 2003

Another Cause of Increase in Water Levels and Flows



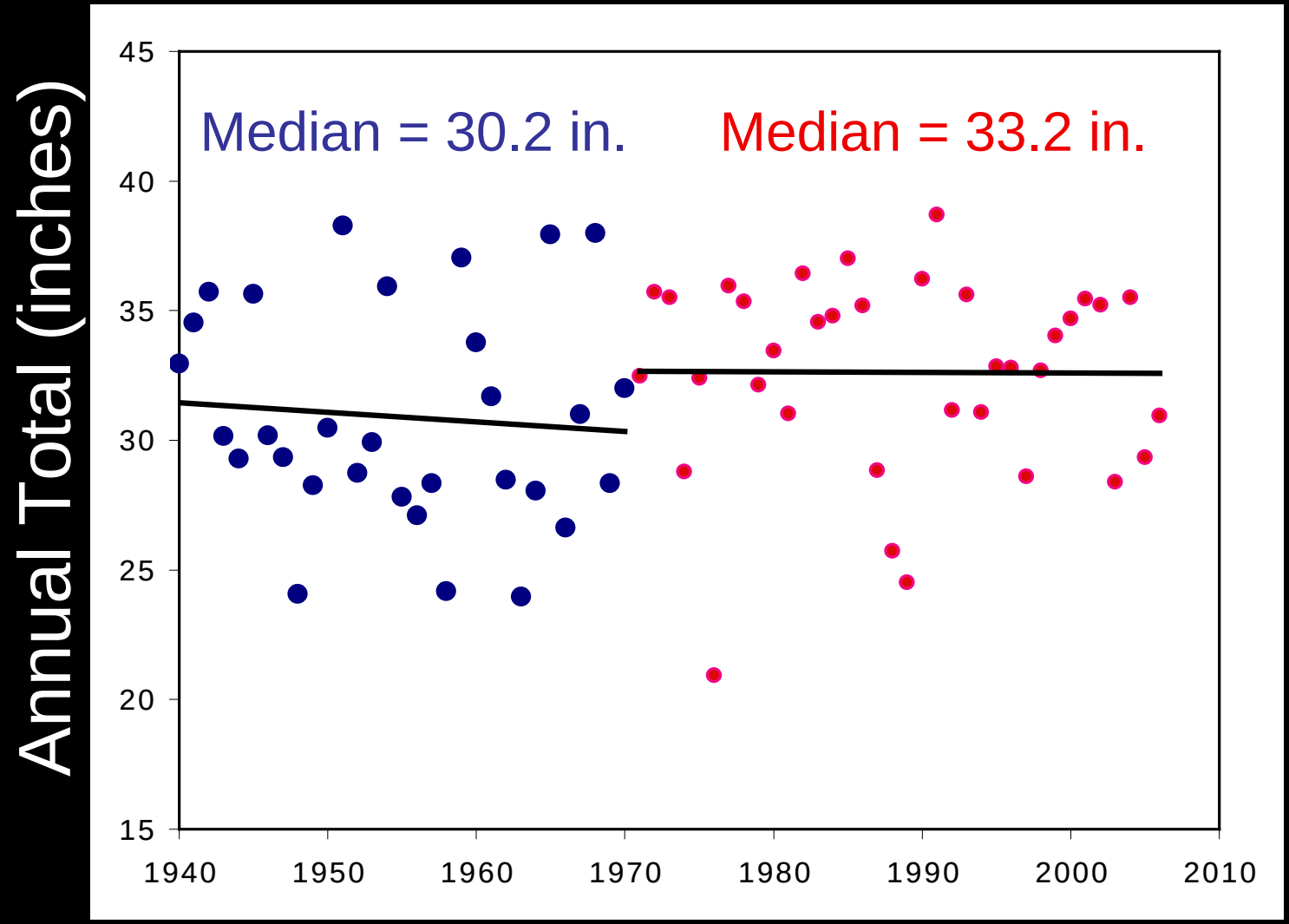
(Don Matthews Nature Feb 2006, see also Gedney et al.Nature Feb. 2006))

Another Cause of Increase in Water Levels and Flows



(Don Matthews Nature Feb 2006, see also Gedney et al.Nature Feb. 2006))

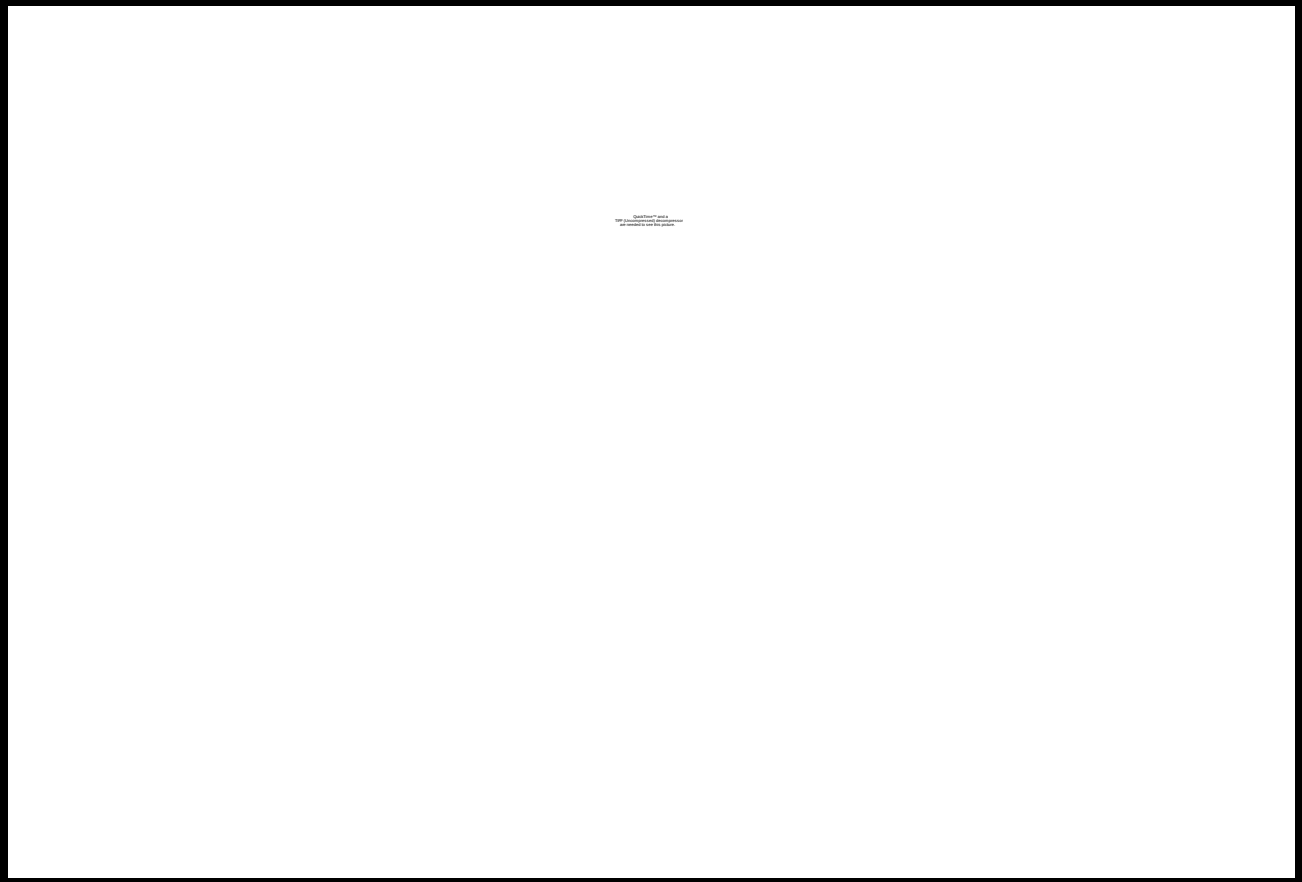
What happened to precipitation in Wisconsin?



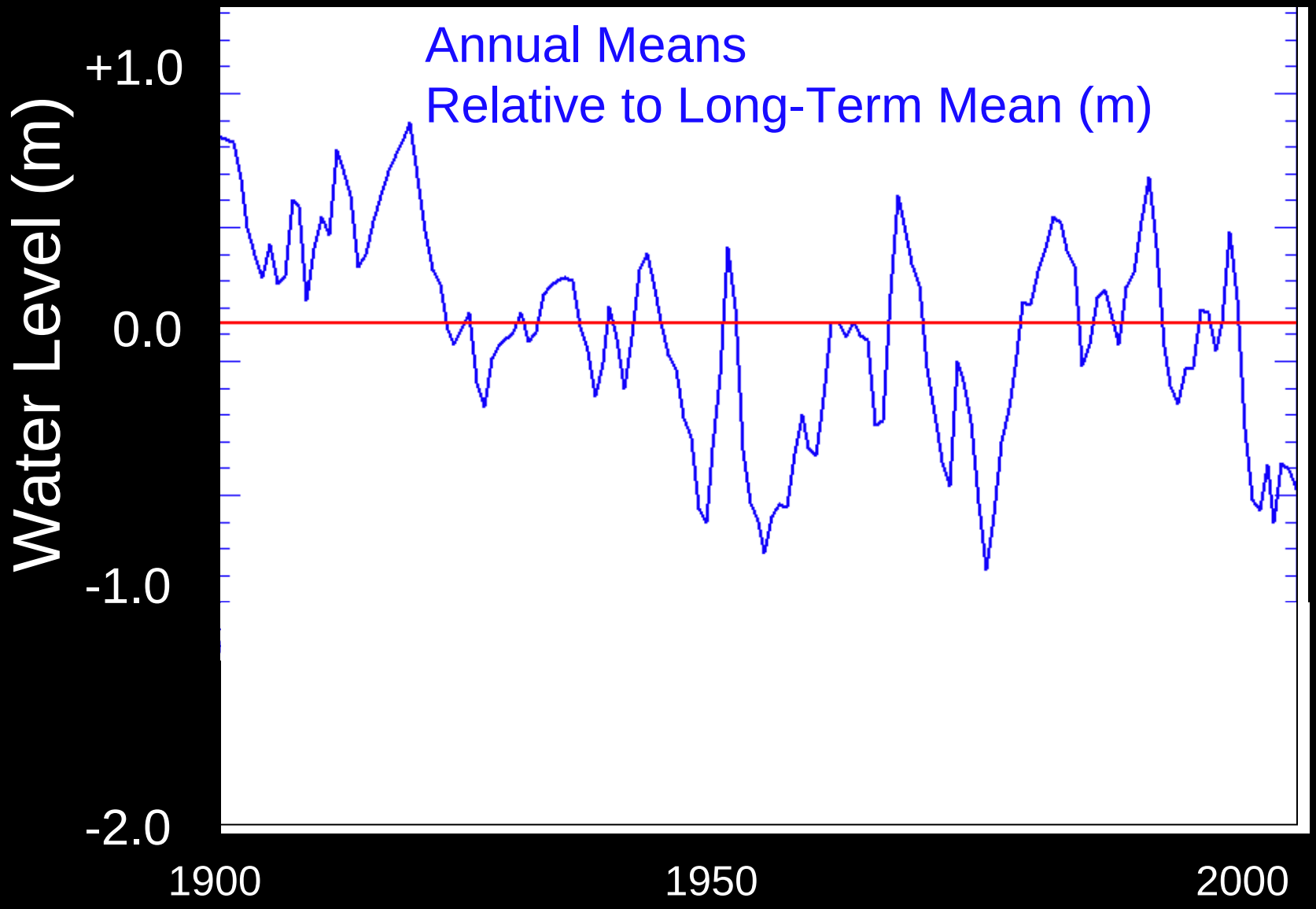
Magnuson 2006: Data from Wisconsin State Climatology Office

What is Happening to Water Levels and Flows?

Great Lakes Water levels

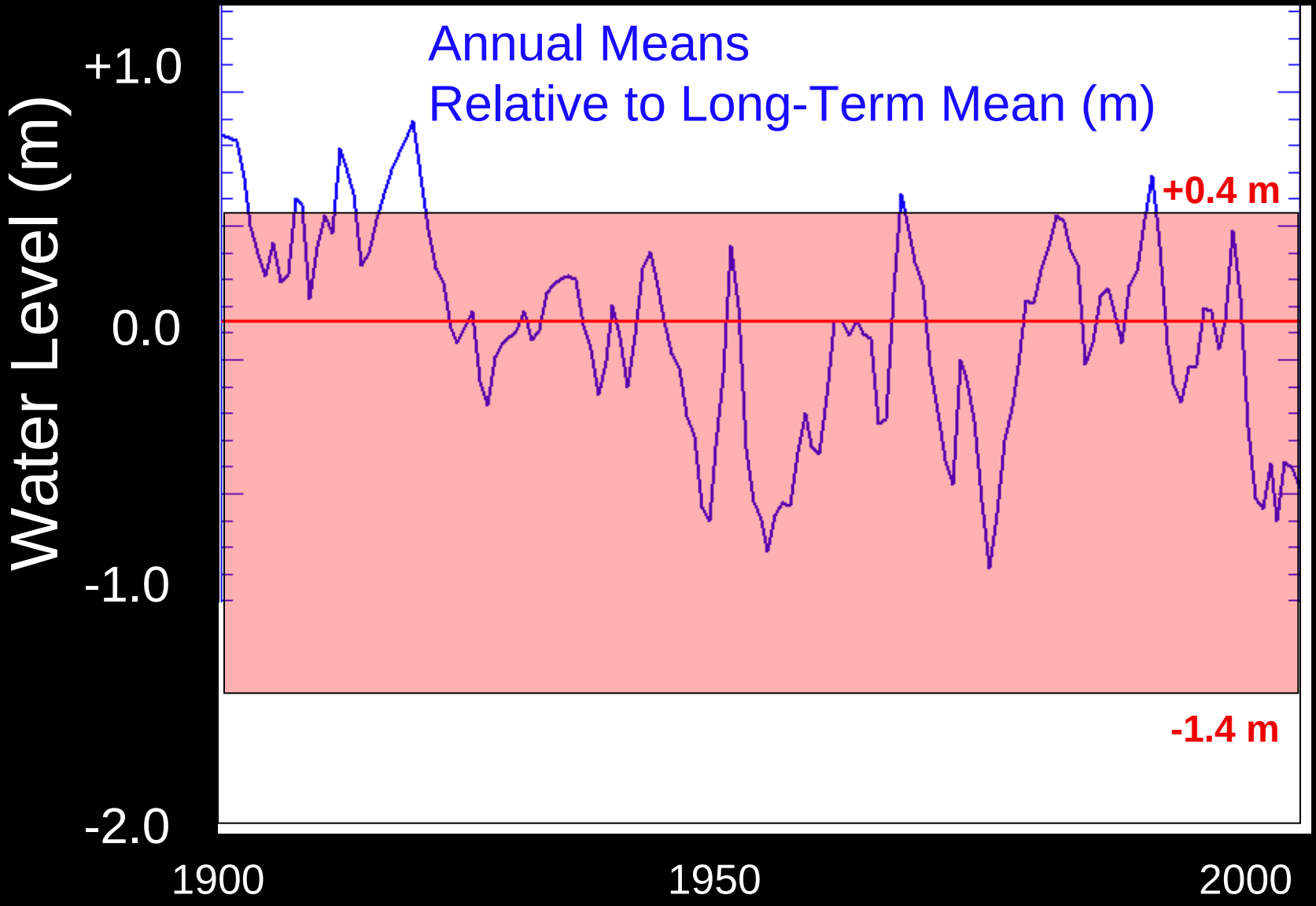


Lake Michigan Historical Water Levels



NOAA 2007

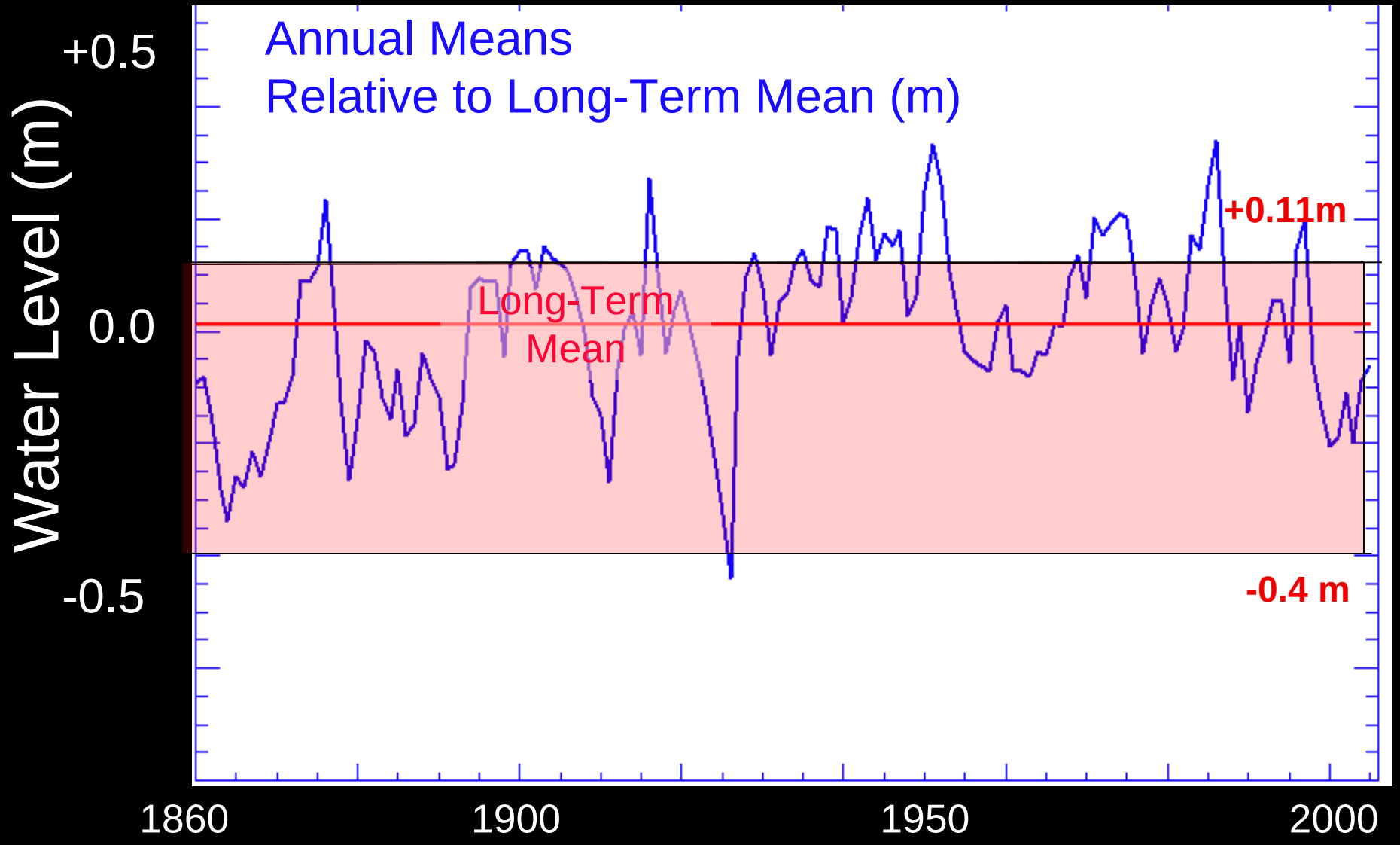
Lake Michigan Water Level Scenarios for 2090



2090 = Lofgren et al. 2002

Lake Superior Water Levels

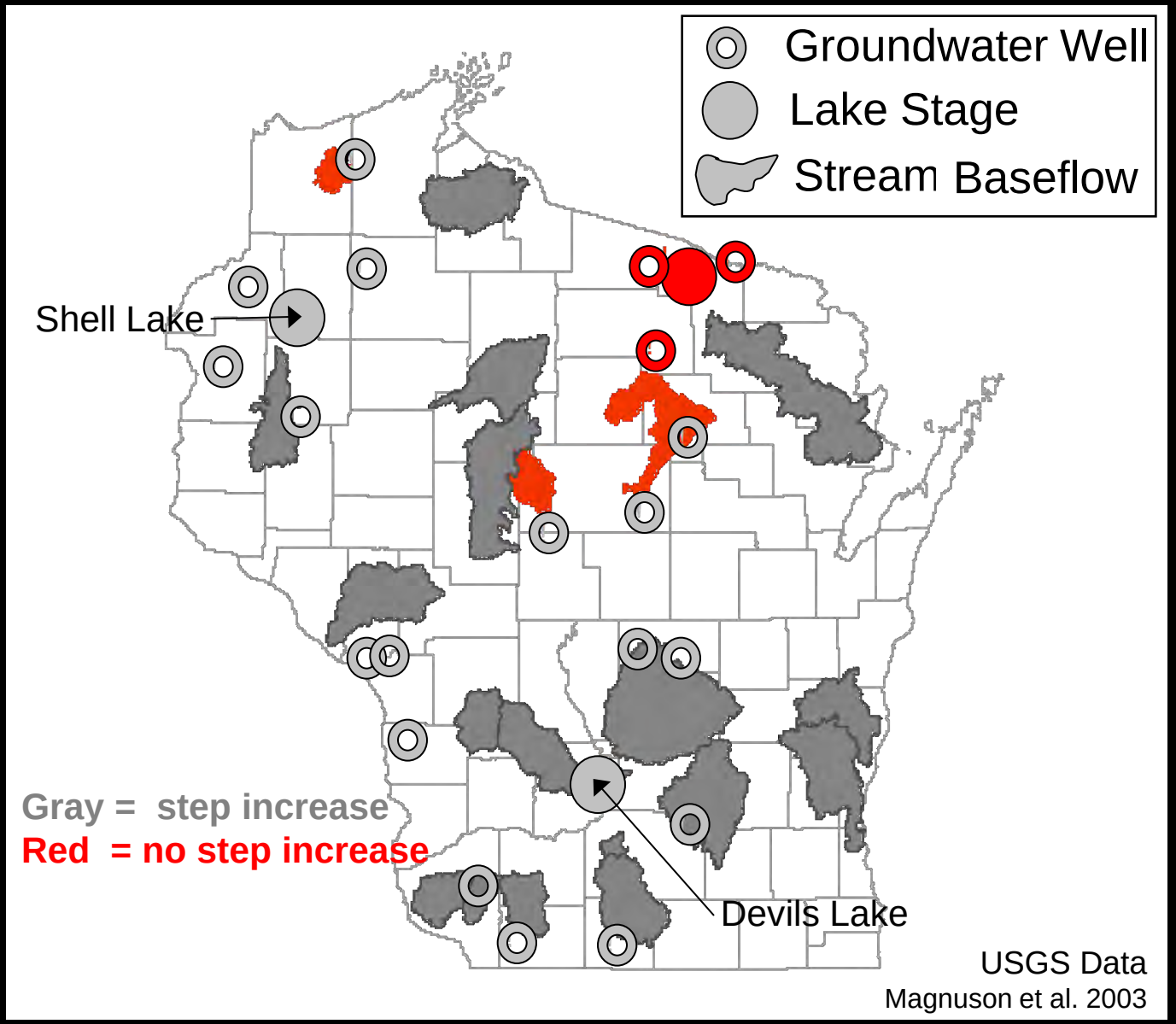
Lake Superior Water Level Scenarios for 2090



Lofgren et al. 2002

Waters Levels and Flows in Inland Waters

Step Increase in Lake Stage, Stream Flow, and Groundwater Levels after 1970

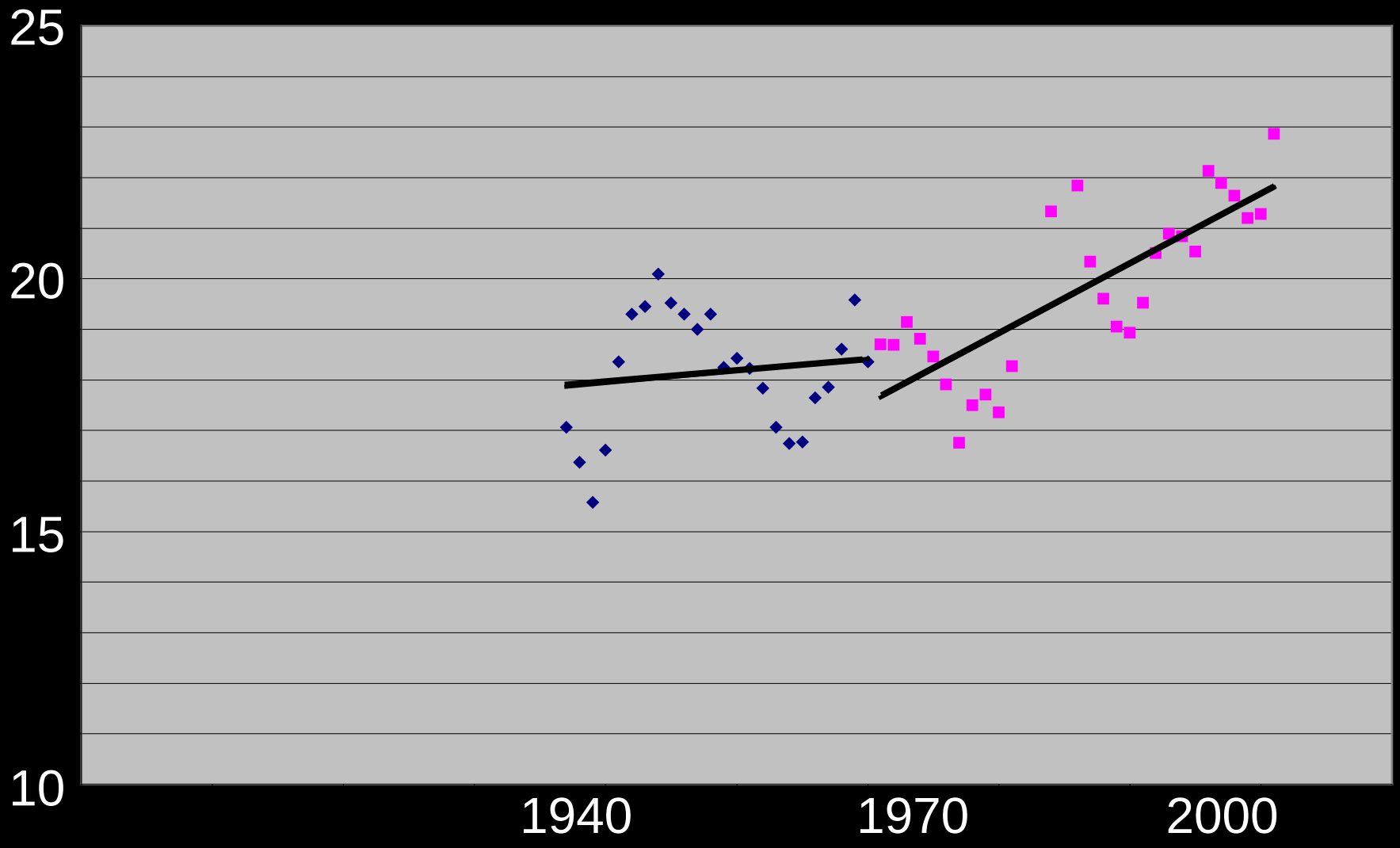


Lake Stage Gages

Shell Lake (WI) June 2002

Krohelski 2003

Shell Lake Annual Average Stage (feet)



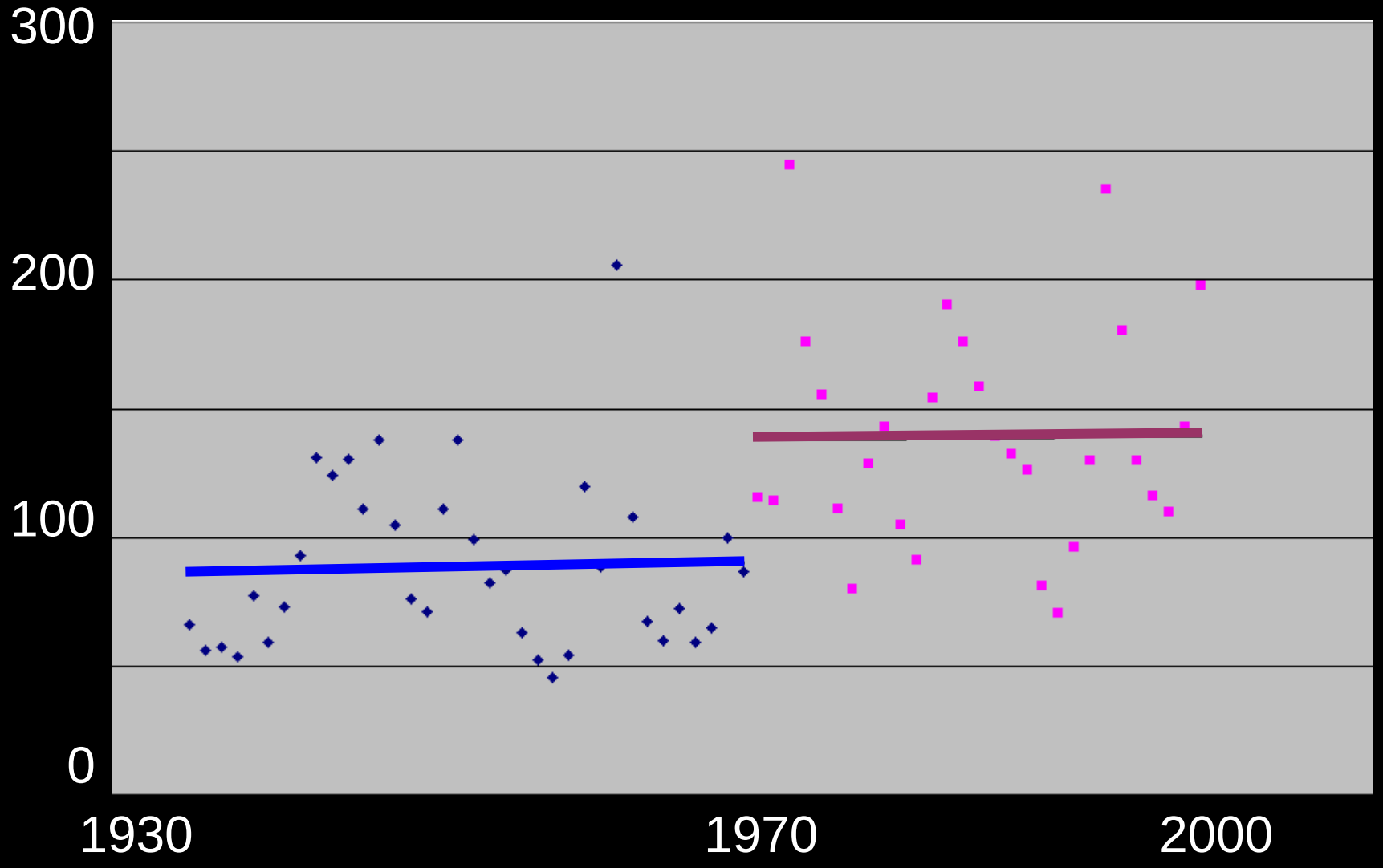
Krohelski 2003

Fish Lake July 2000

Stream Flows

Krohelski 2003

Grant River near Burton, Wisconsin (Baseflow)



Krohelski 2003 USGS Station

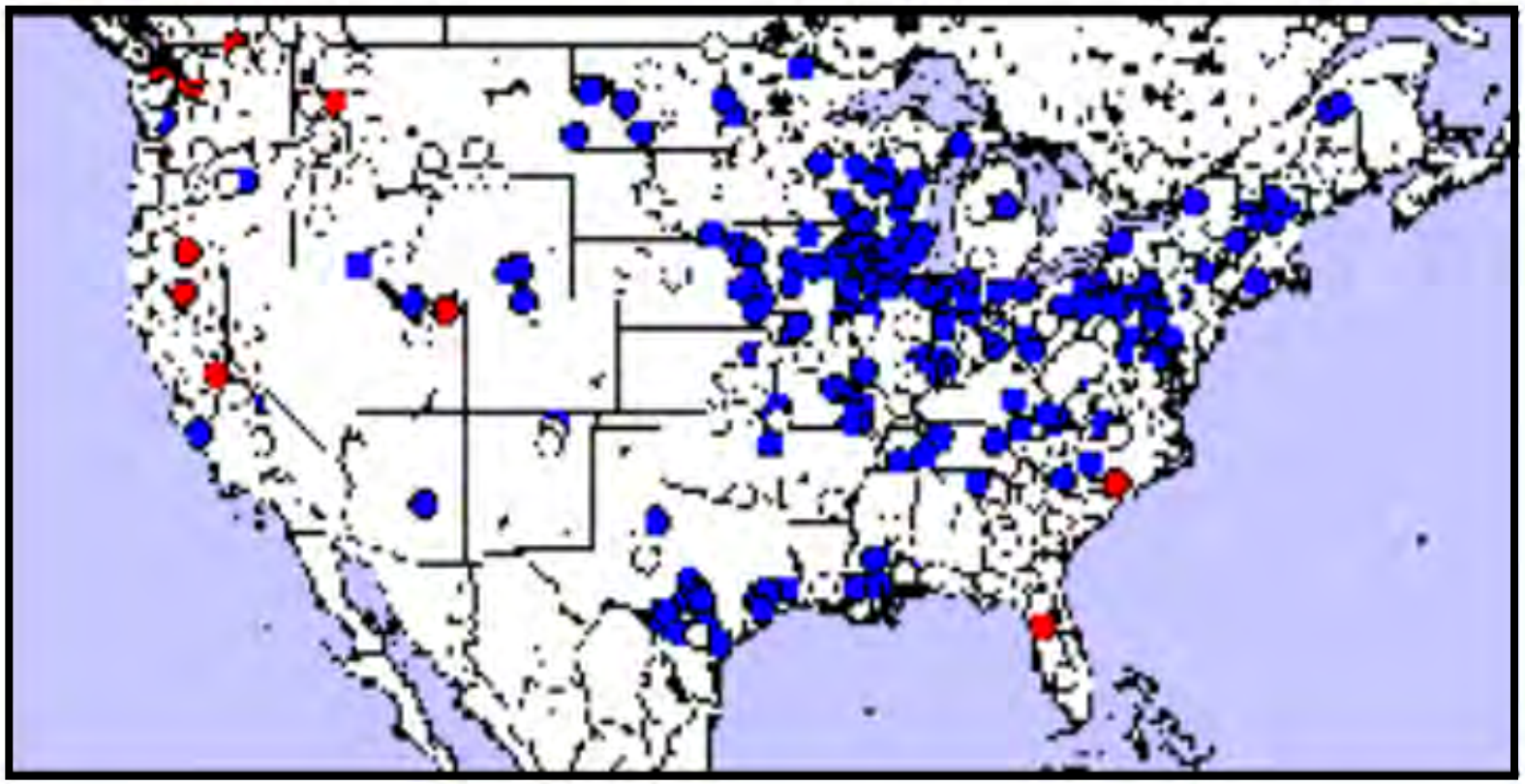
Driftless Area – Southwest Wisconsin

Before

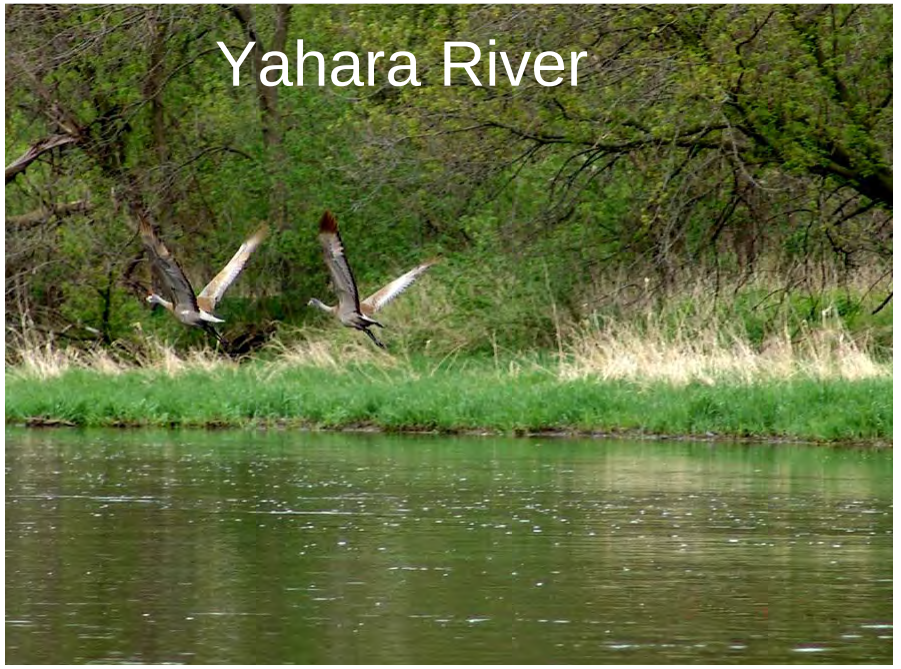
After

Krohelski 2003

Stream-flow Sites with Significant Increases in Minimum Daily Flow between Two Periods (1941-70 and 1971-99)

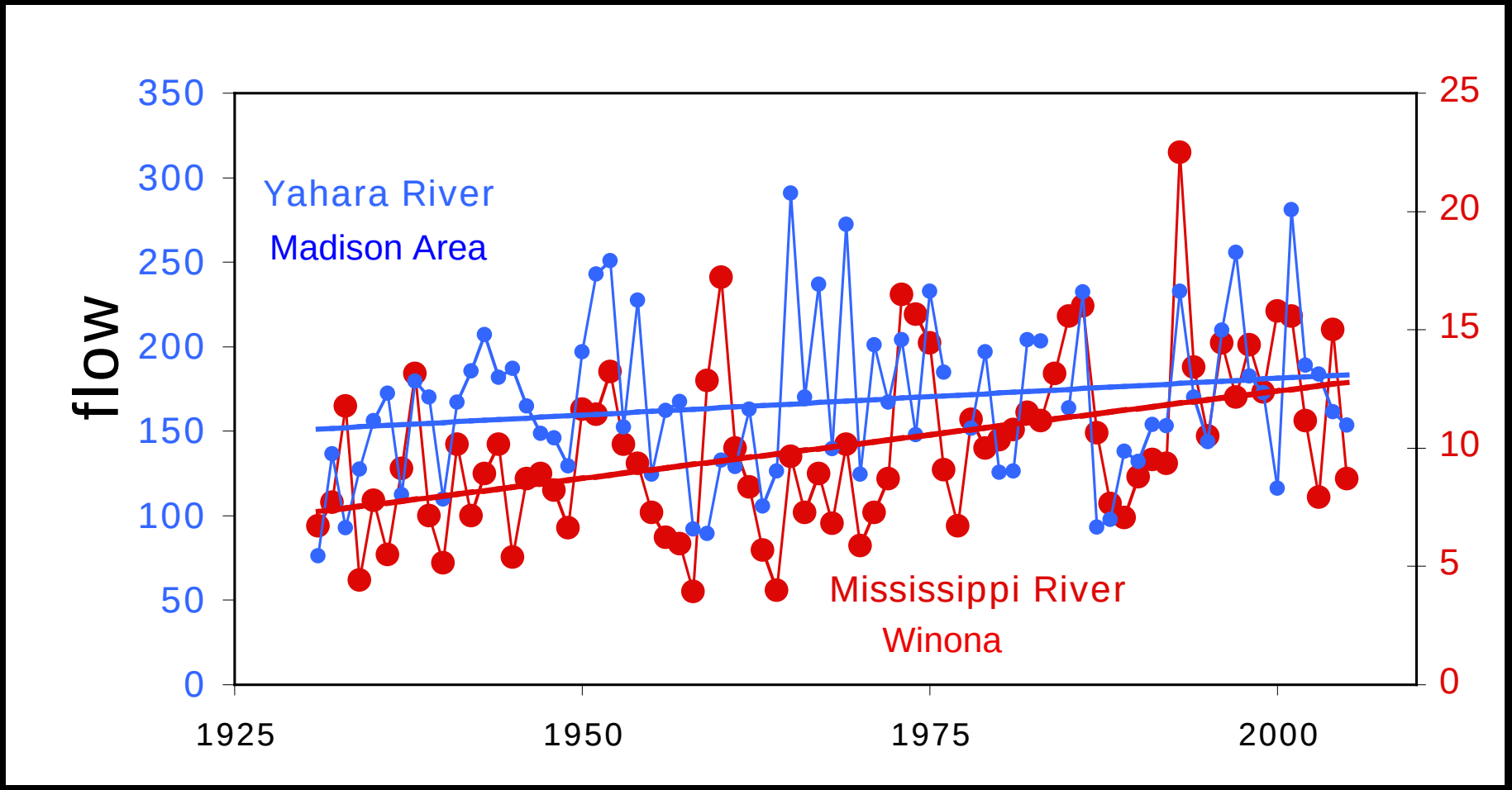


McCabe and Wolock



Magnuson Photos

Yahara and Mississippi River Flow



Magnuson 2007 USGS Data

Wisconsin Water Levels and Flows Conclusions

- Lake stage (seepage lakes), baseflow in streams, total annual flow in streams, and the groundwater table have gone up in Wisconsin since early 1970s.

- Reasons for the increases are varied and include changes in precipitation amount and intensity, CO_2 changes in plant physiology, and perhaps the shorter winters.

- The above changes are generally true for the east central North America, but most of the world is drying out, i.e., US southwest and Great Plains, Africa, Australia, etc.

- Remember Climate Change versus Weather

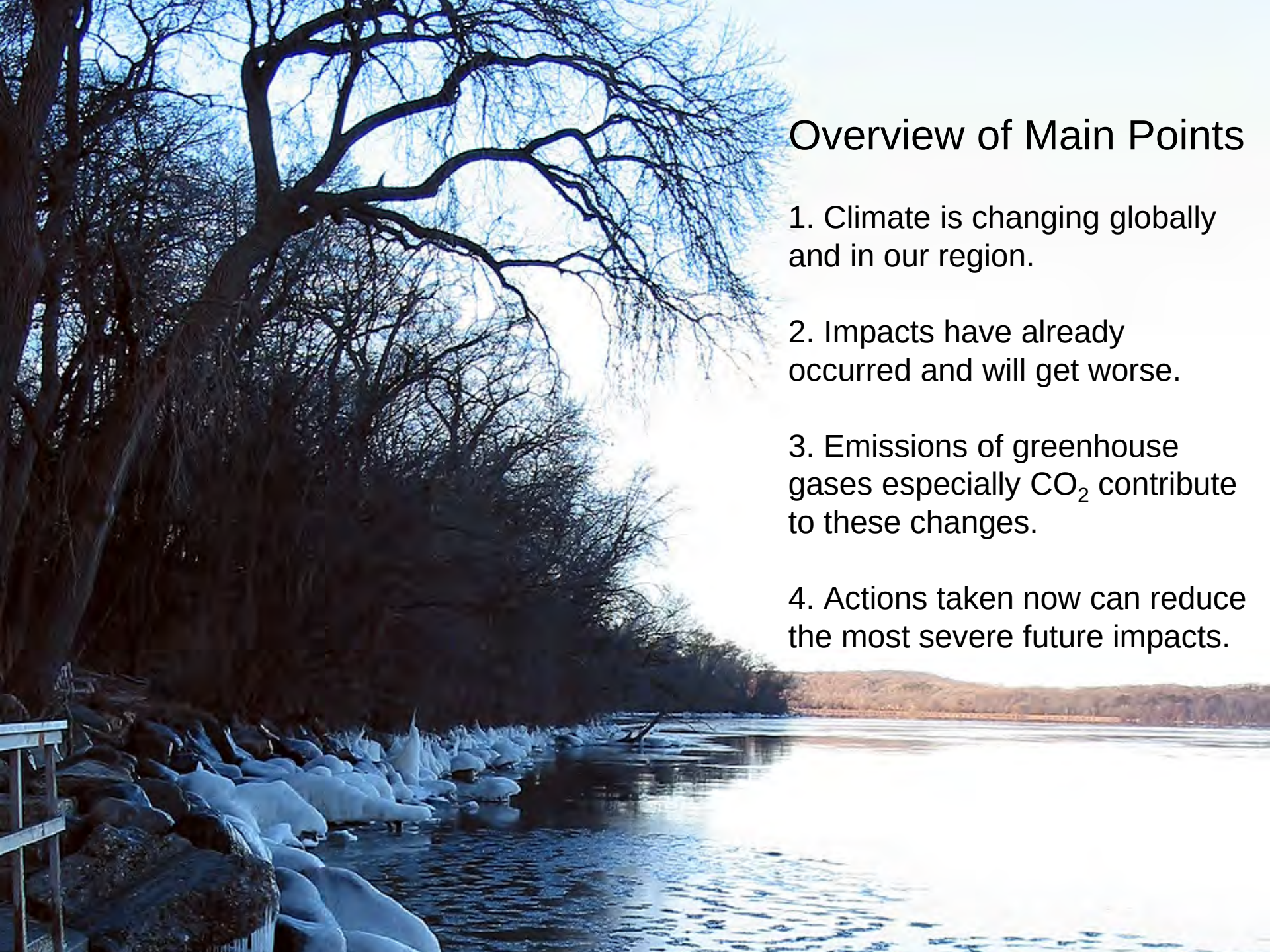
Magnuson 2007

What to do?
Relevant Time Scales are Long Term.

- Include Climate Change and Variability in planning and making decisions concerning natural resources, agriculture, energy production, cities, and other activities.

- Reduce greenhouse gas emissions in all sectors.

Magnuson 2007



Overview of Main Points

1. Climate is changing globally and in our region.

2. Impacts have already occurred and will get worse.

3. Emissions of greenhouse gases especially CO_2 contribute to these changes.

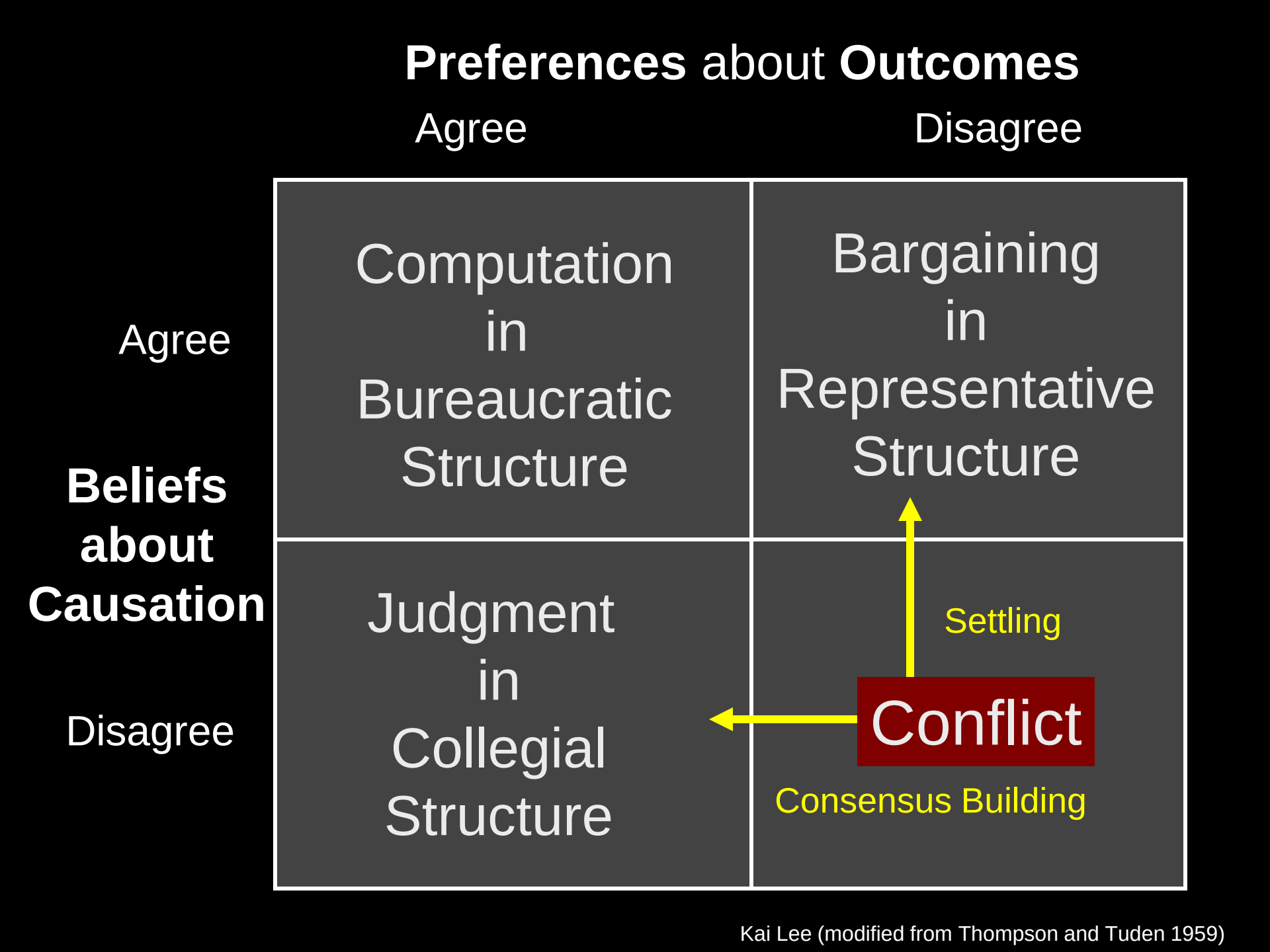
4. Actions taken now can reduce the most severe future impacts.

How Do Natural and Social Scientists Deal with Uncertainty

Kai Lee 1993. Compass and Gyroscope

Compass = Science and its Idealistic Application in Adaptive Management.

Gyroscope = Bounded Conflict as a Pragmatic Application of Politics Disciplines the Discord of Unavoidable Error.



Kai Lee (modified from Thompson and Tuden 1959)

Ways to Think about Uncertainty

Uncertainties will continue to change.

Do and apply science.

Risk averse versus risk prone behavior.

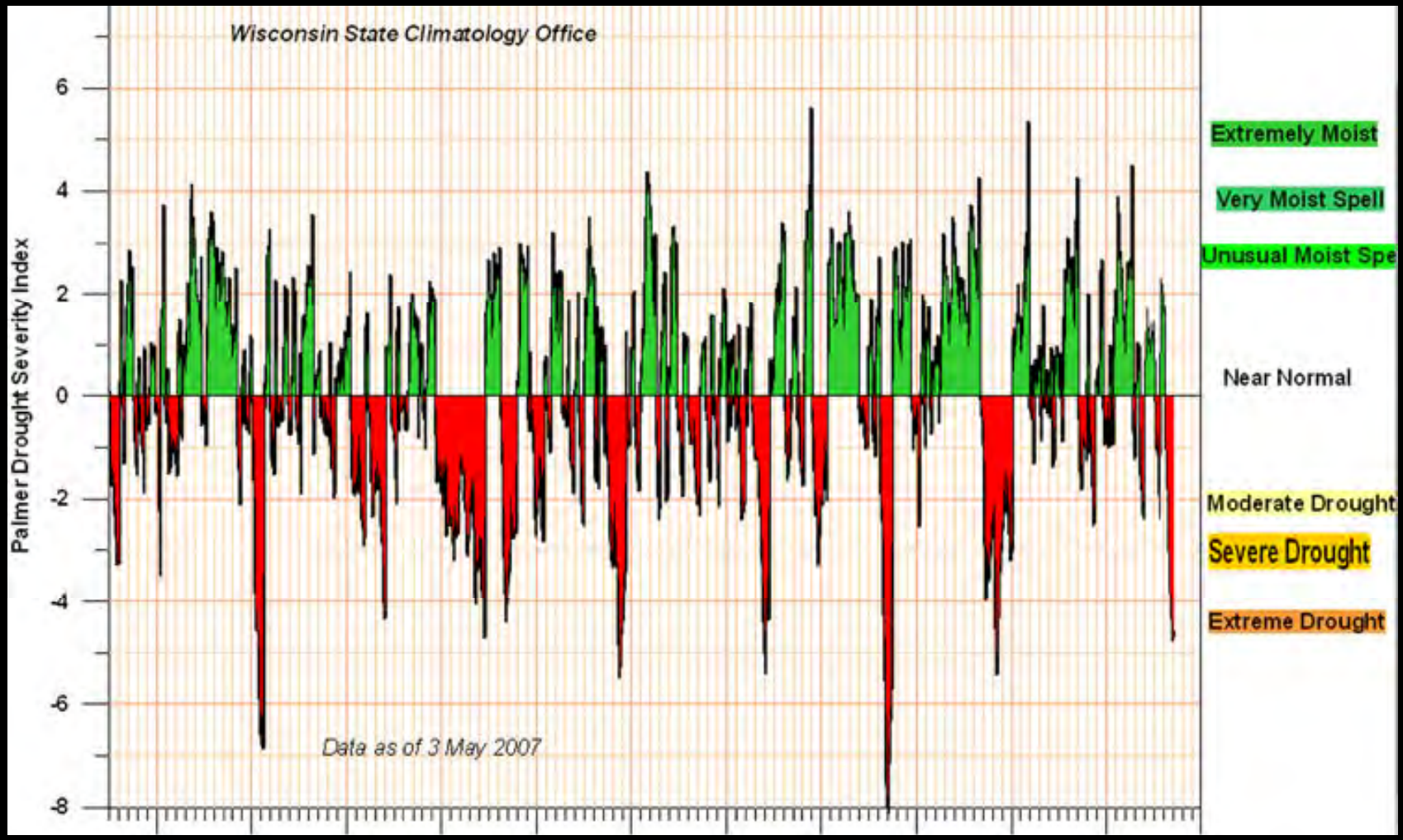
Do right thing regardless.

Preserve future options.

All decisions are long term.

Reflect on other Issues for wisdom.

Palmer Drought Index NW Wisconsin



Palmer Drought Index All of Wisconsin