“The water is so low it doesn't even reach the shore”
Declining Lake Levels and Climate Change

Twin Lakes, Waushara County (D. Casper)

WI Lakes Convention
Tim Asplund, WDNR: April 1, 2010

Acknowledgements

- John Magnuson, Barbara Benson, Tim Kratz, Susan Knight, UW Madison
- Scott Provost, Pamela Toshner, Dick Lathrop, Frank Koshere, Carl Watras, Paul Garrison, WDNR
- Sandy Gillum, Vilas Co. Lake Association
- Brian Ewart, Berry Lake Association
- Bill Rose, Dale Robertson, USGS
- George Kraft, Samantha Kaplan, UWSP

Pigeon Lake, Bayfield Co.

Photos from F. Koshere, WDNR

R. Lathrop

Fallison Lake, Vilas County

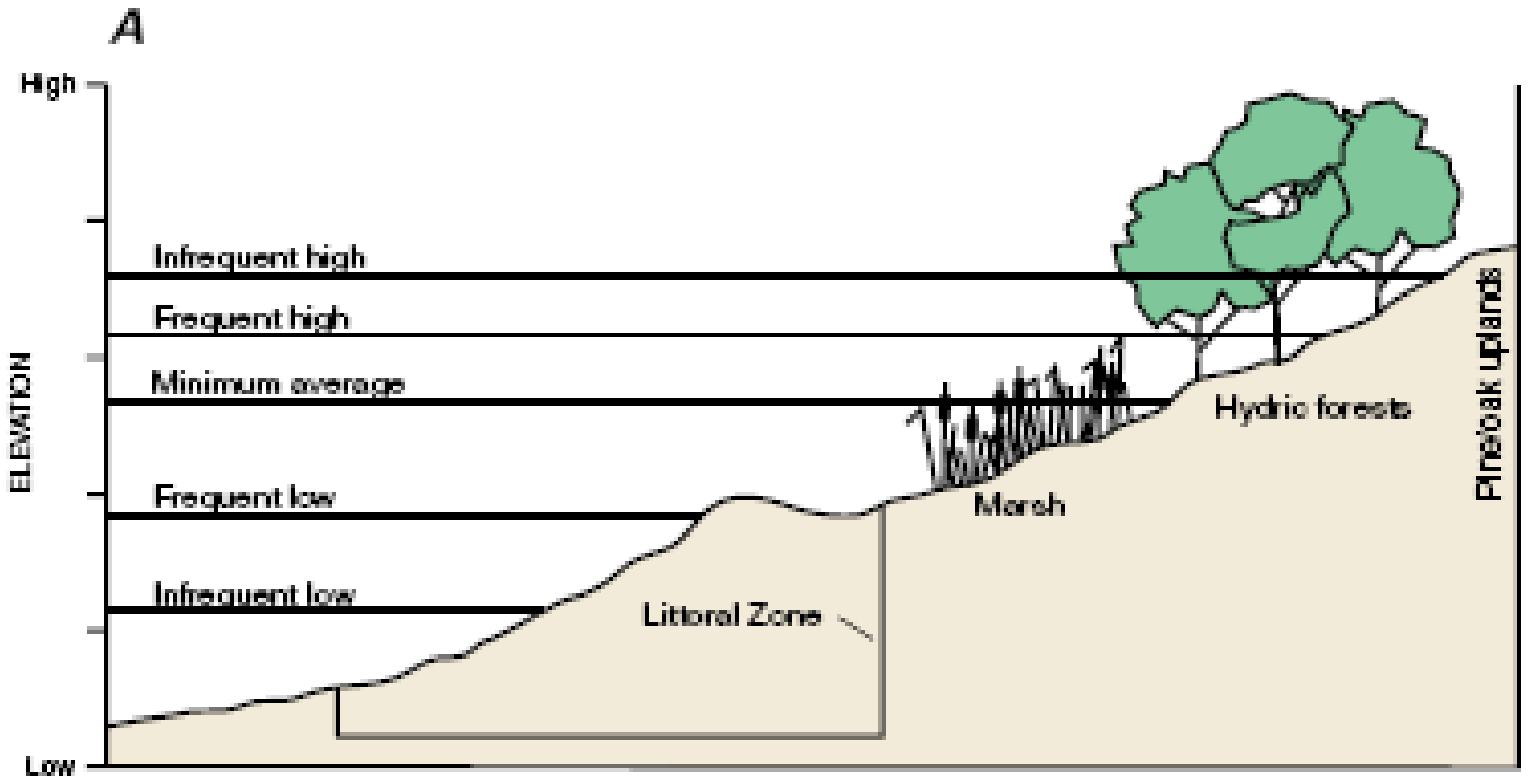
Sandbar Lake, Bayfield County

Anvil Lake, Vilas Co.

Many factors affect water levels

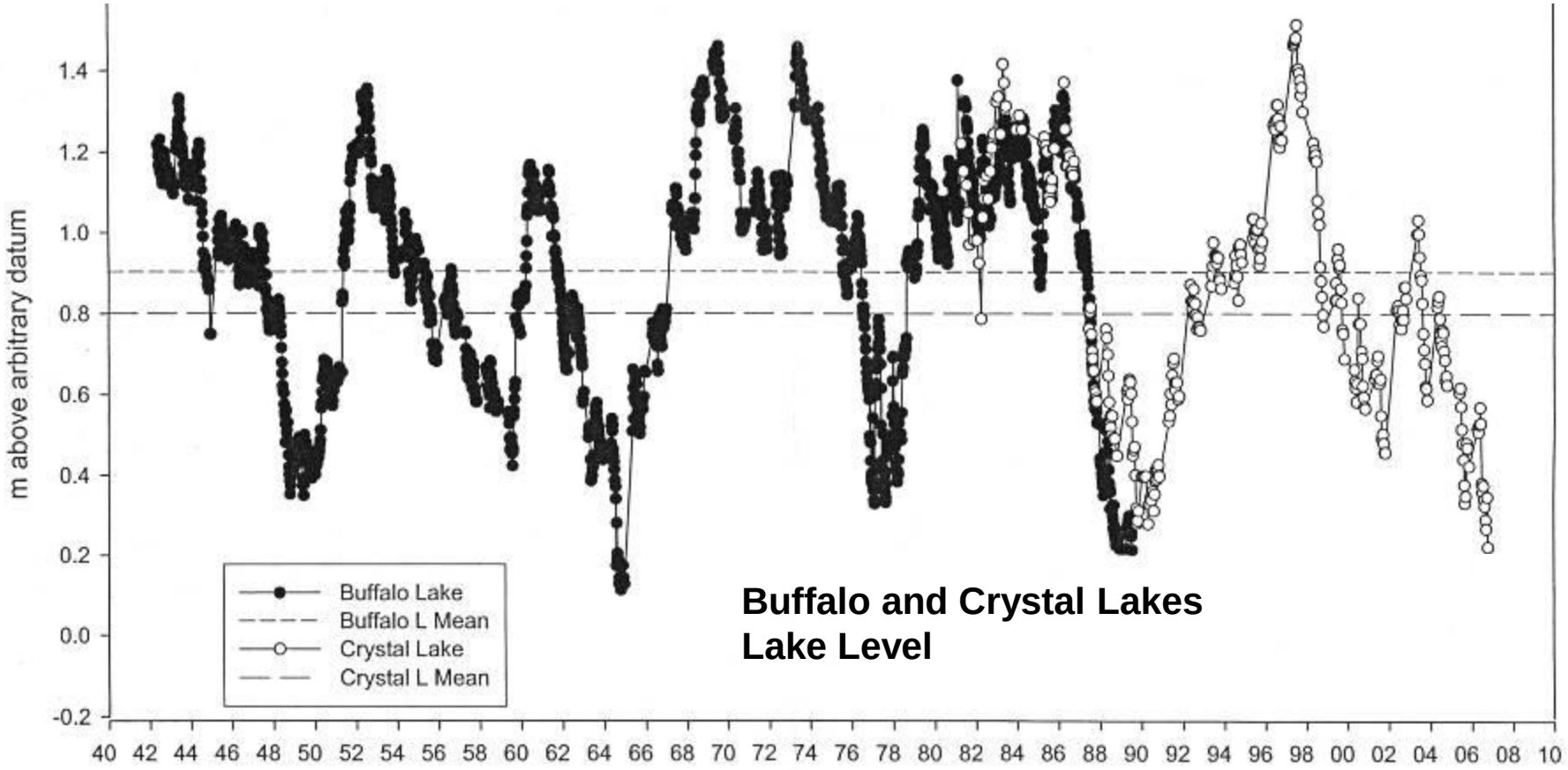
- Natural variability (weather)
- Short term drought (and wet) cycles
- Lake morphology and hydrology
- Landscape position
- Water level control structures (dams)
- Climate change
- Human water use (i.e. water withdrawals)

Water levels vary naturally



Source: USGS Circular 1186

Plainfield Lake, Waushara County

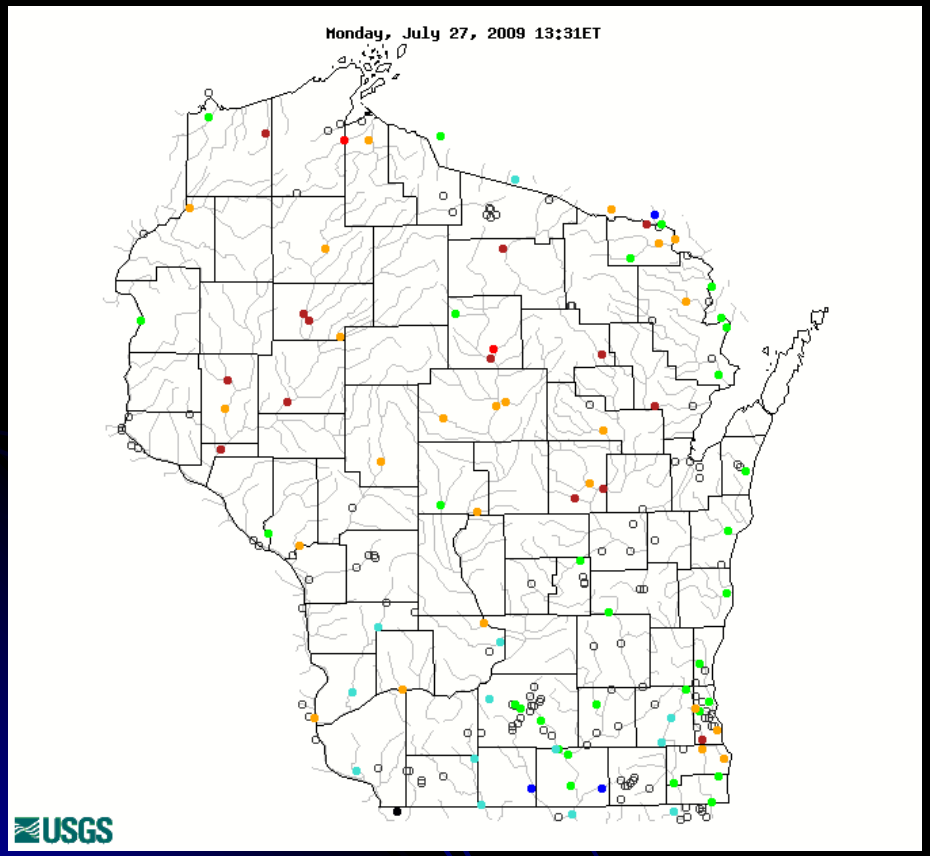


Buffalo and Crystal Lakes
Lake Level

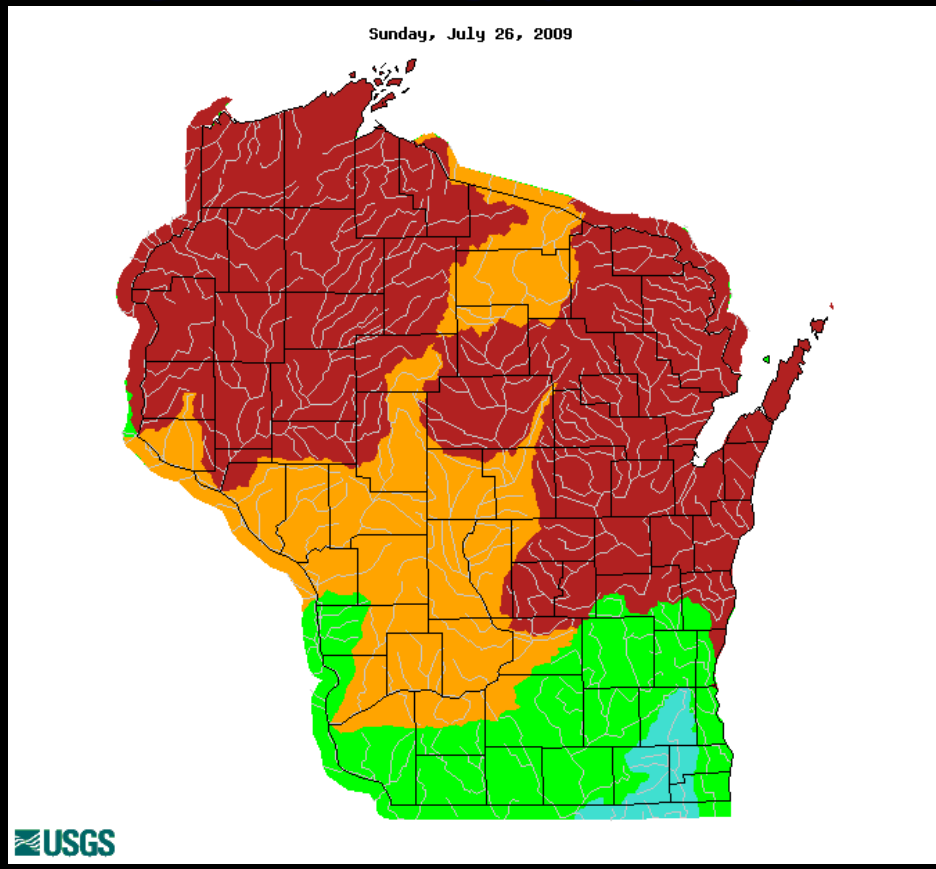
Data compiled by S. Kaplan, UWSP

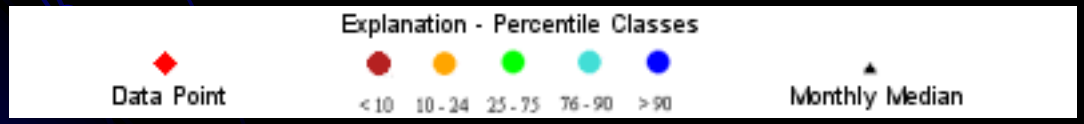
Statewide patterns and contrasts

Real-time streamflow compared to long term average (July 27, 2009)



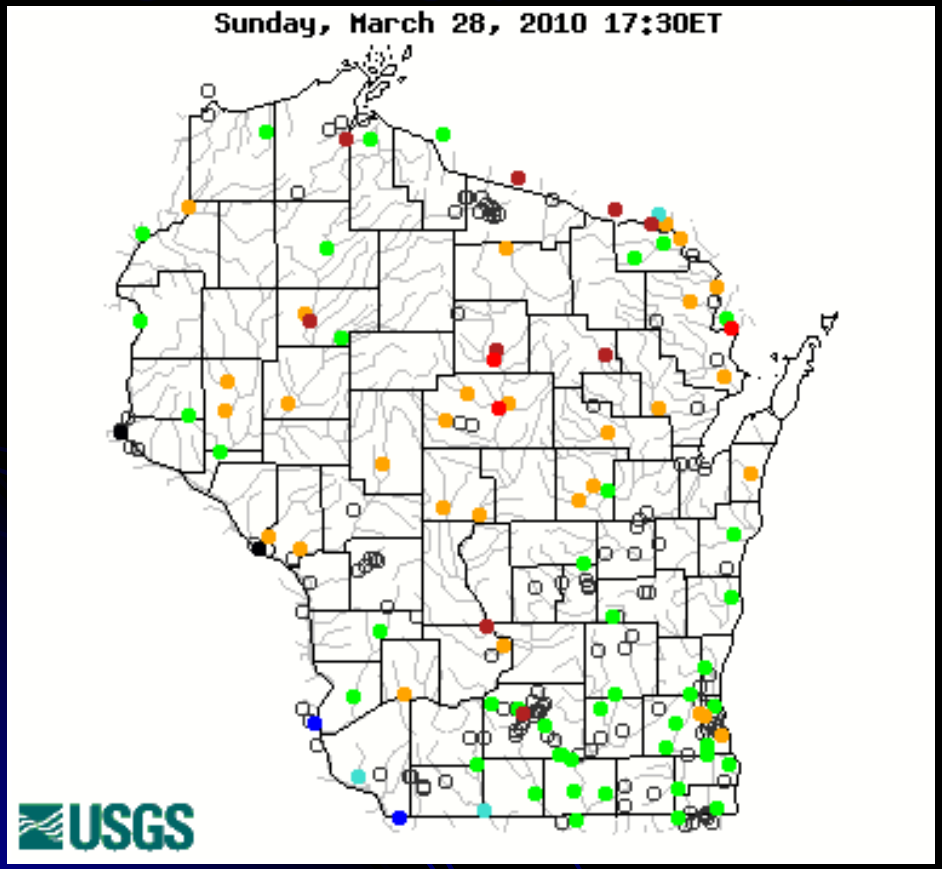
28-day streamflow compared to long term average (July 2009)



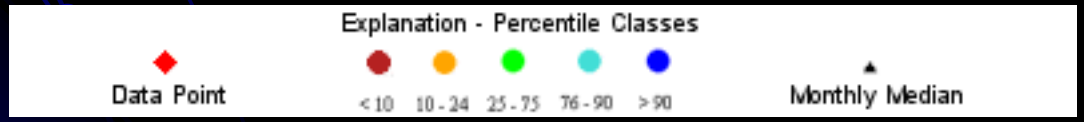


Statewide patterns and contrasts

Real-time streamflow compared to long term average (March 28, 2010)



28-day streamflow compared to long term average (March 2010)



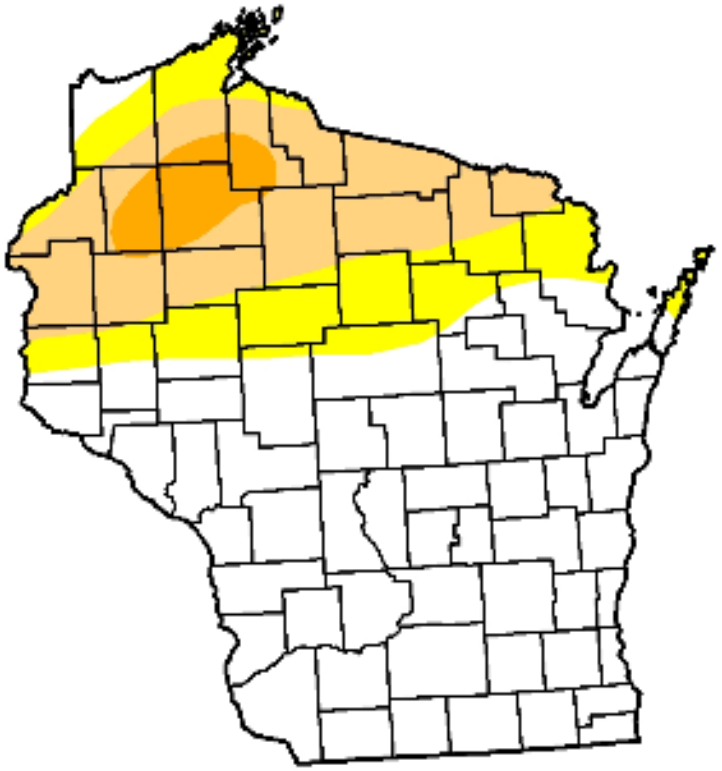
U.S. Drought Monitor

Wisconsin

March 23, 2010
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	62.0	38.0	22.6	4.0	0.0	0.0
Last Week (03/16/2010 map)	63.8	36.2	22.4	4.0	0.0	0.0
3 Months Ago (12/29/2009 map)	57.5	42.5	24.5	7.1	0.0	0.0
Start of Calendar Year (01/05/2010 map)	57.5	42.5	24.5	7.1	0.0	0.0
Start of Water Year (10/06/2009 map)	20.4	79.6	61.2	37.9	7.7	0.0
One Year Ago (03/24/2009 map)	31.5	68.5	57.6	27.6	0.0	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

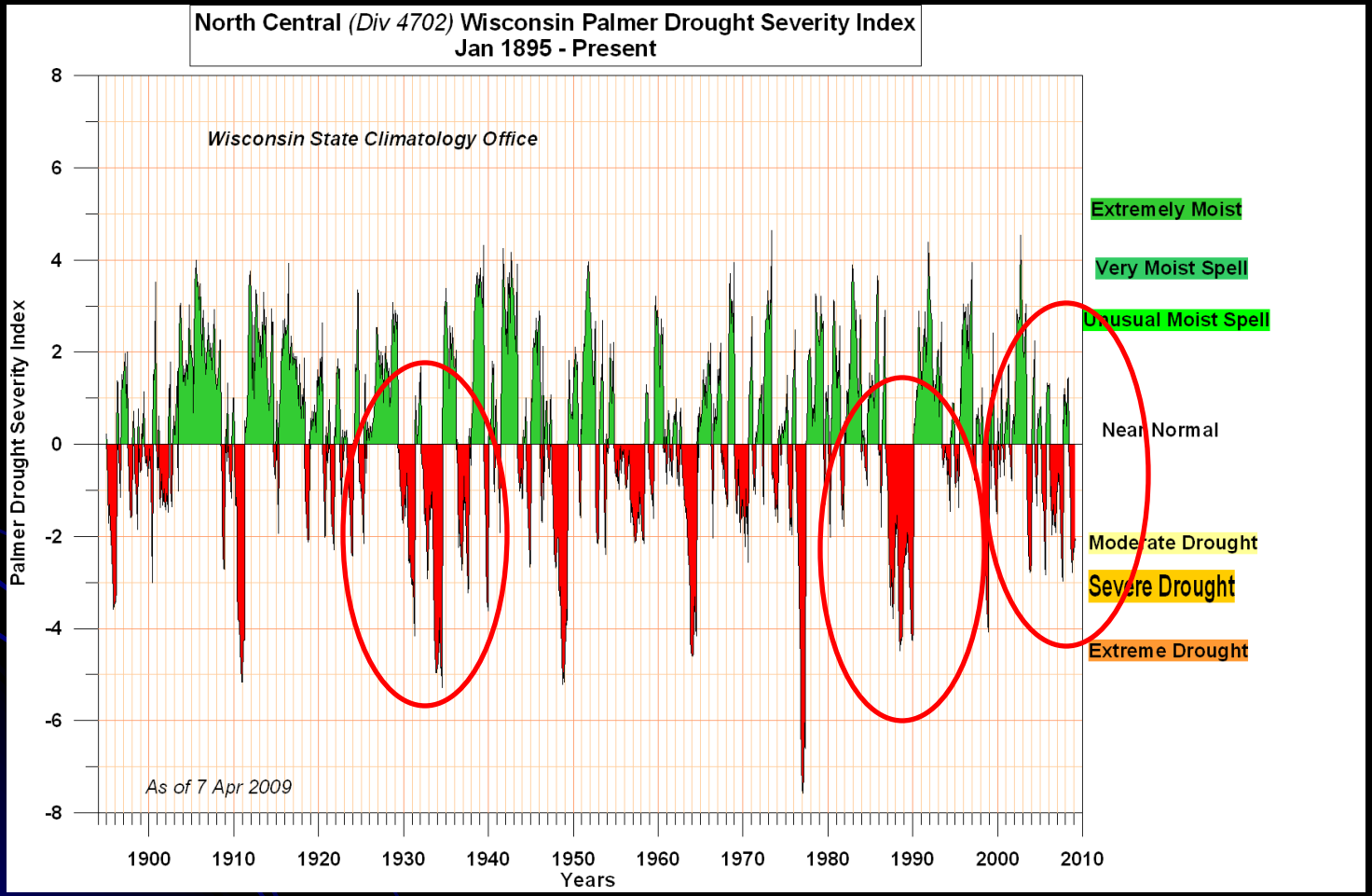
http://drought.unl.edu/dm

USDA National Drought Mitigation Center

Released Thursday, March 25, 2010

Author: Brad Rippey, U.S. Dept. of Agriculture

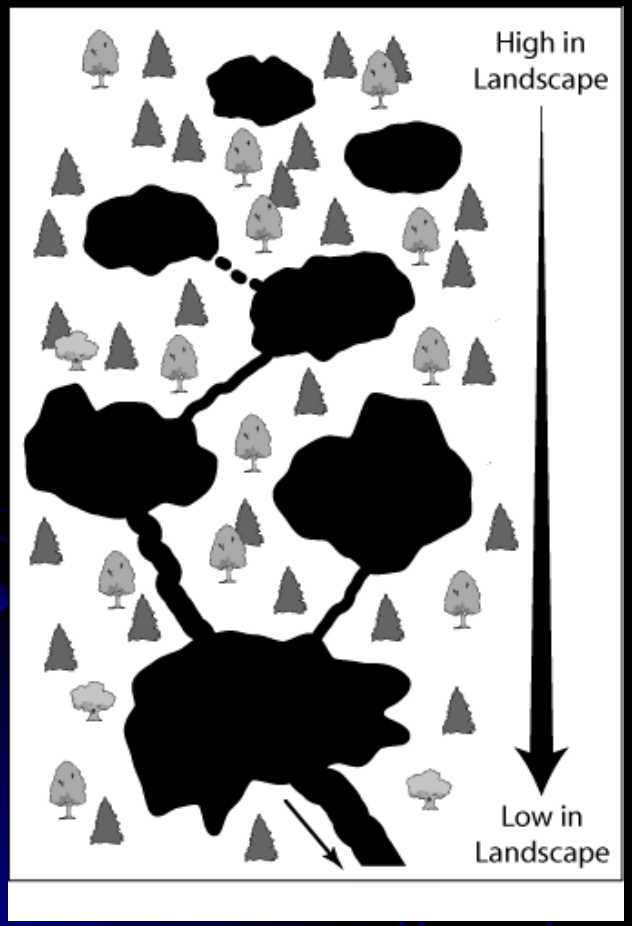
Long term perspective

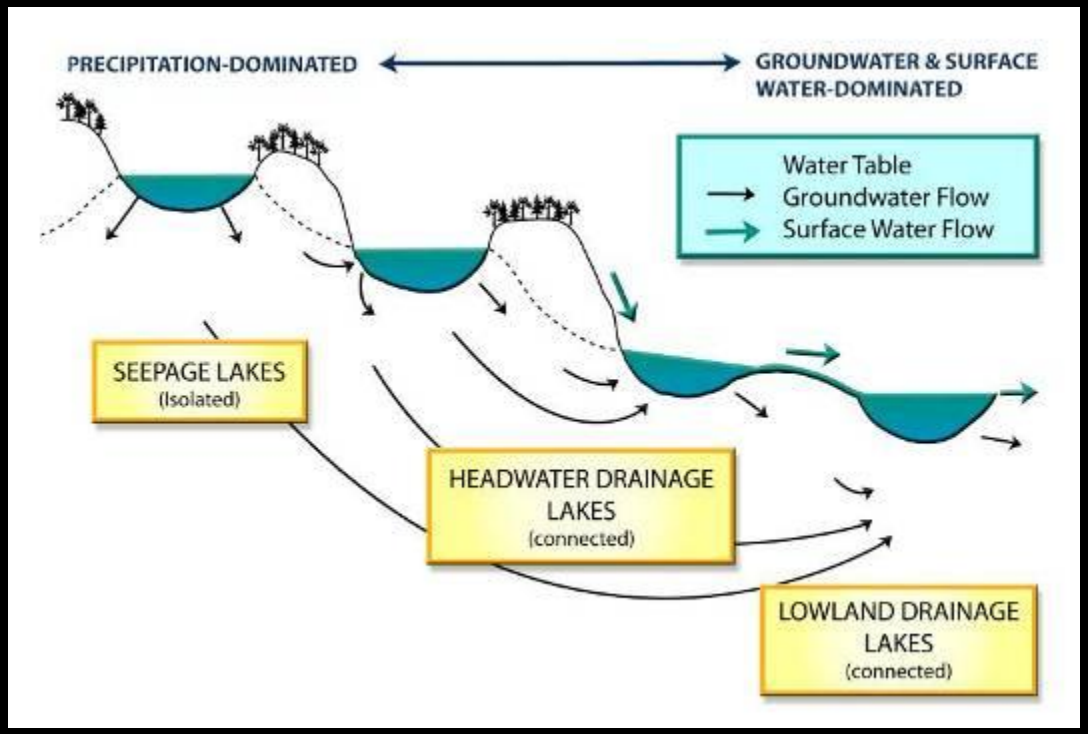


Many factors affect water levels

- Natural variability (weather)
- Short term drought (and wet) cycles
- Lake morphology and hydrology
- Landscape position
- Climate change
- Human water use (i.e. water withdrawals)

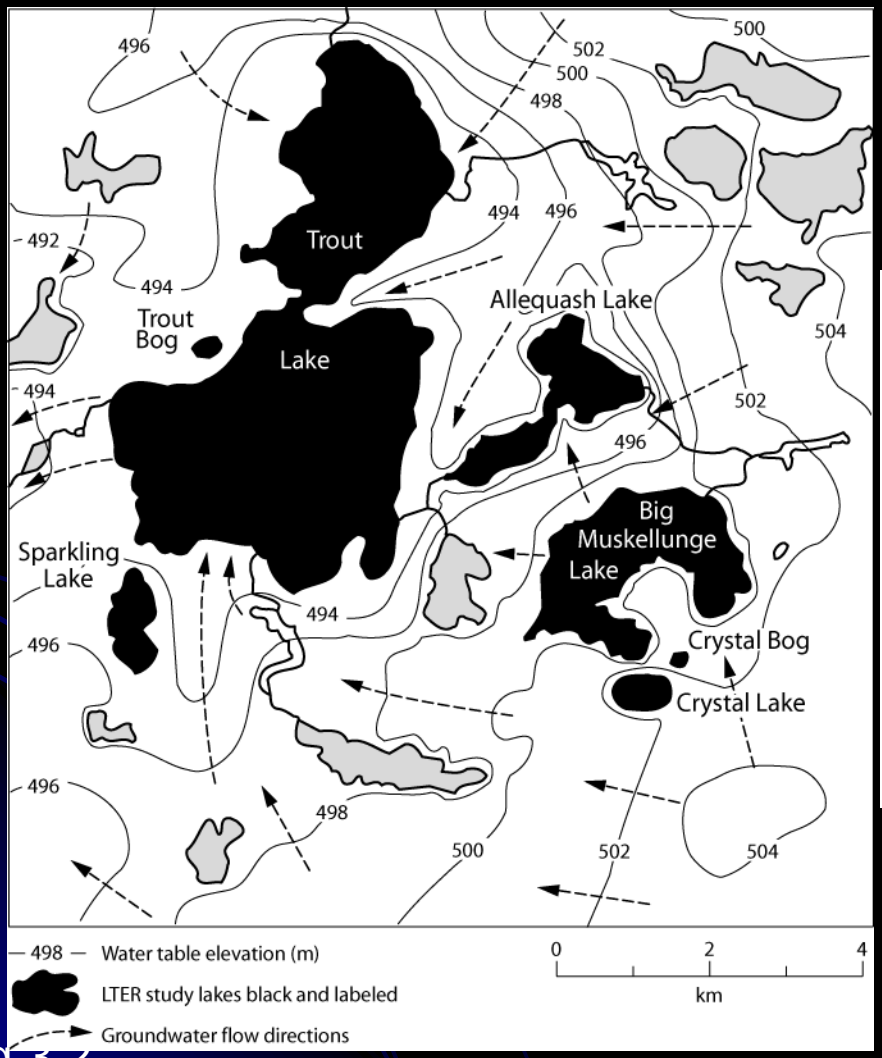
Landscape Position and Hydrology





Magnuson et al. 2006

Response of Lakes to Drought



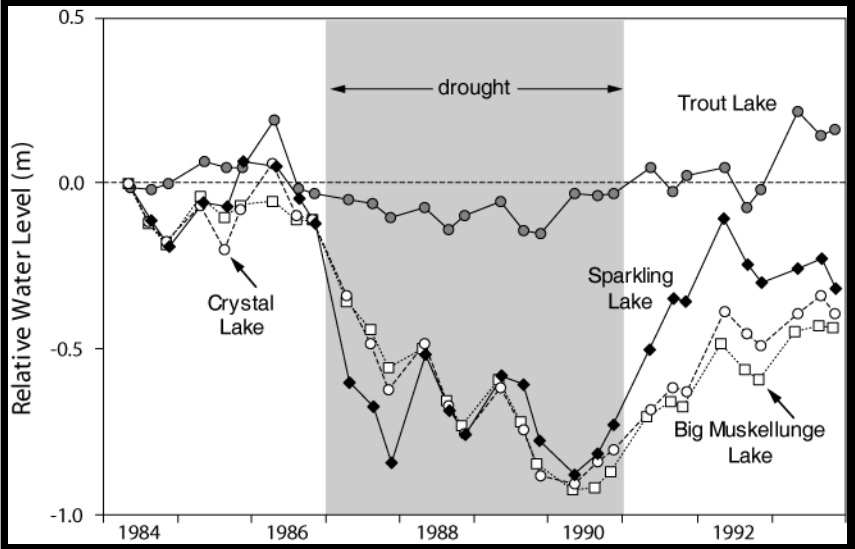
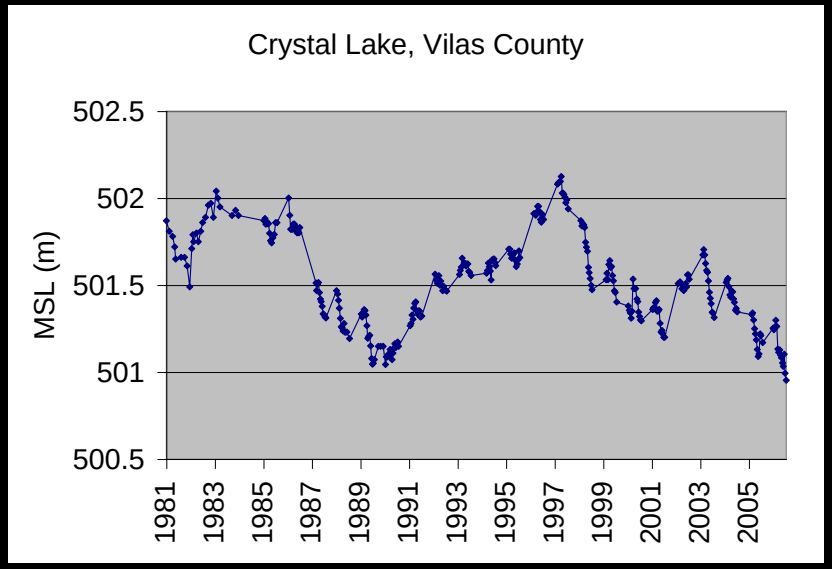
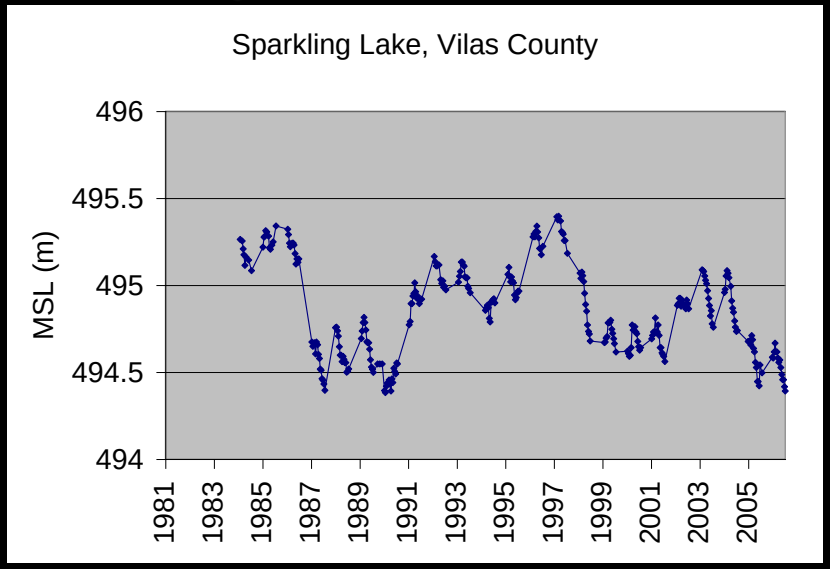


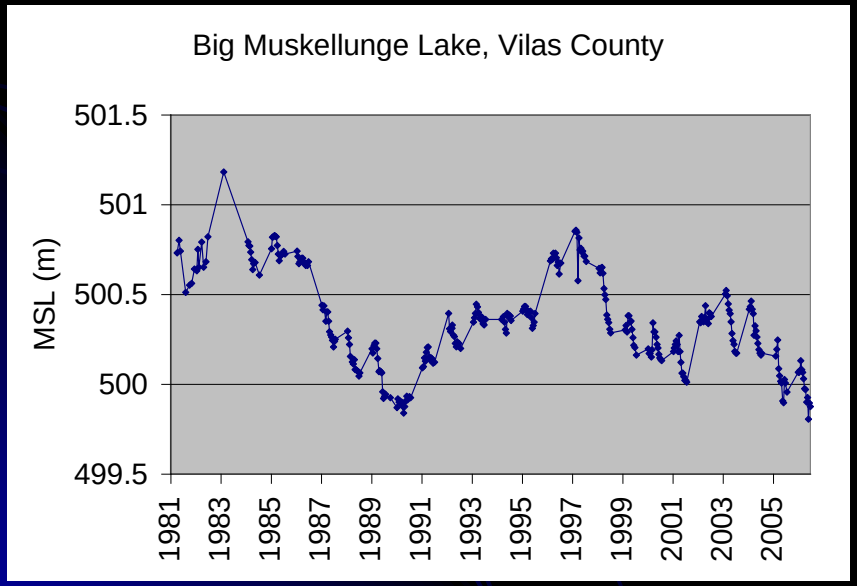
Fig 3.2

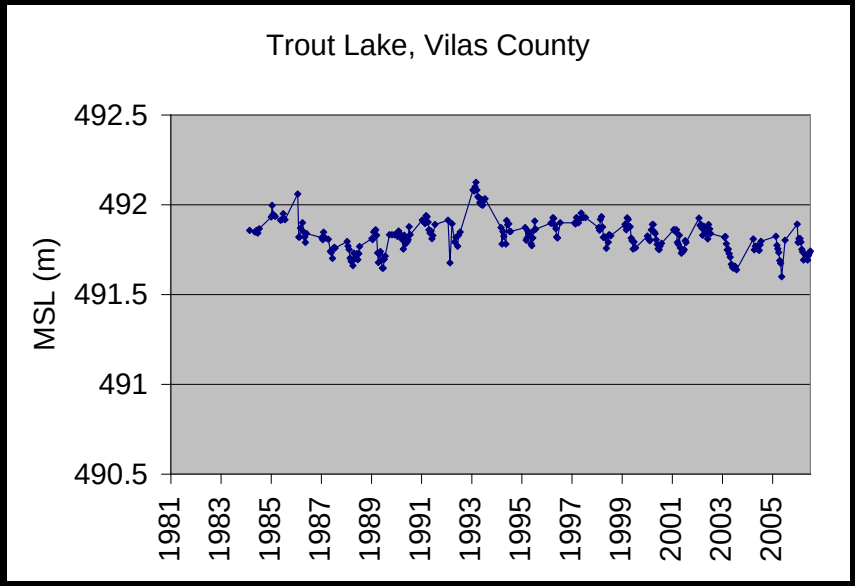
Magnuson et al. 2006

LTER Lake Levels, Vilas Co



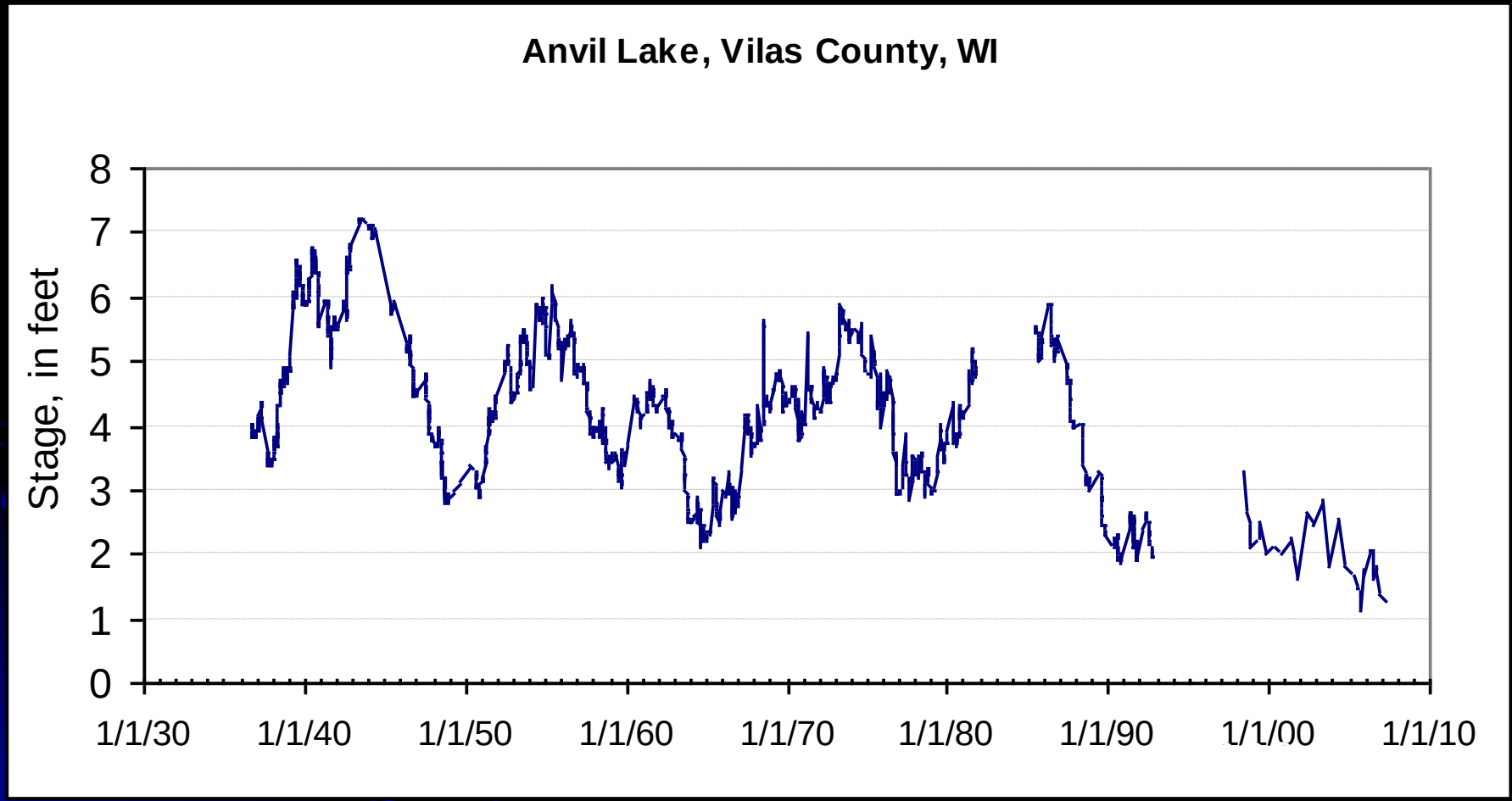






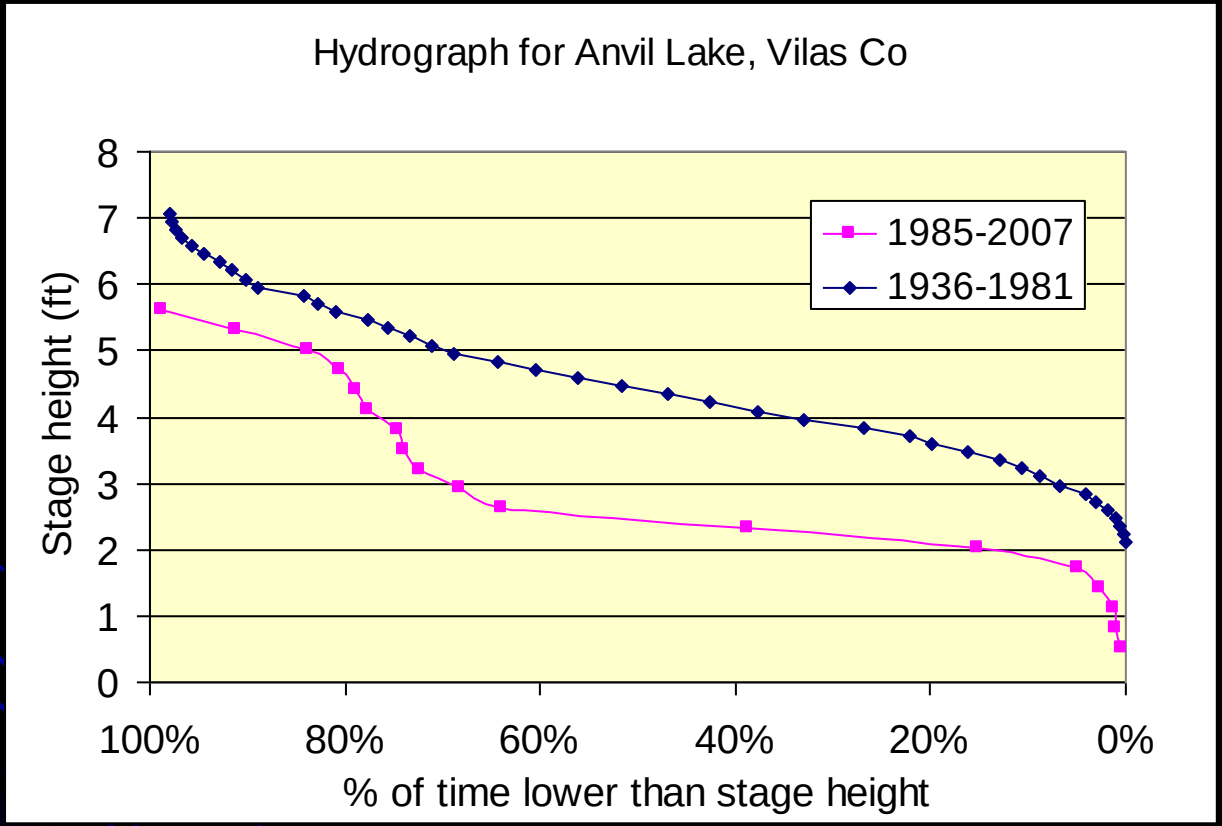
Source: NTL LTER, Center for Limnology

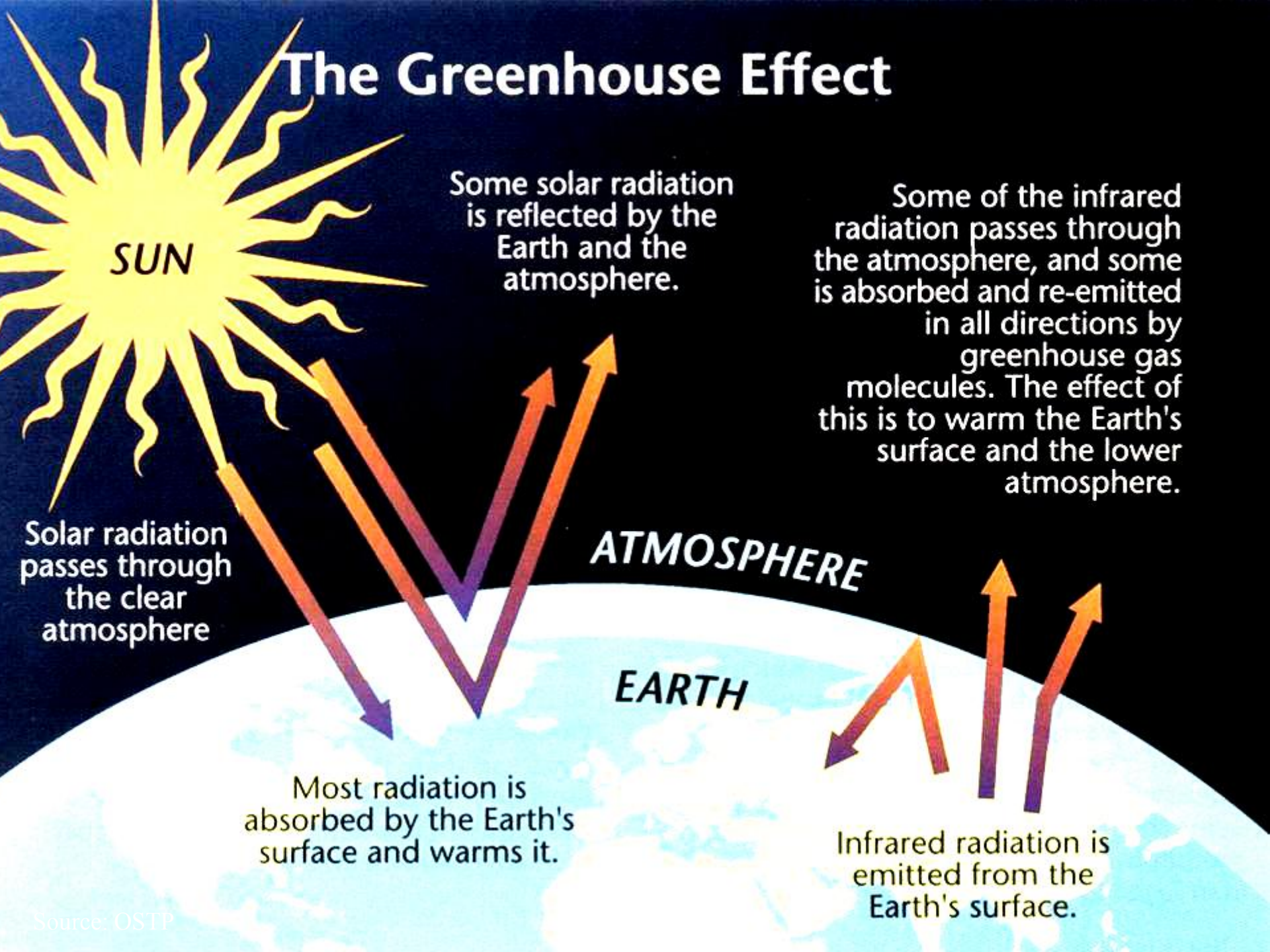
Anvil Lake Stage Record (1936 – 2006)



Source: USGS

Anvil Lake – Regime shift?

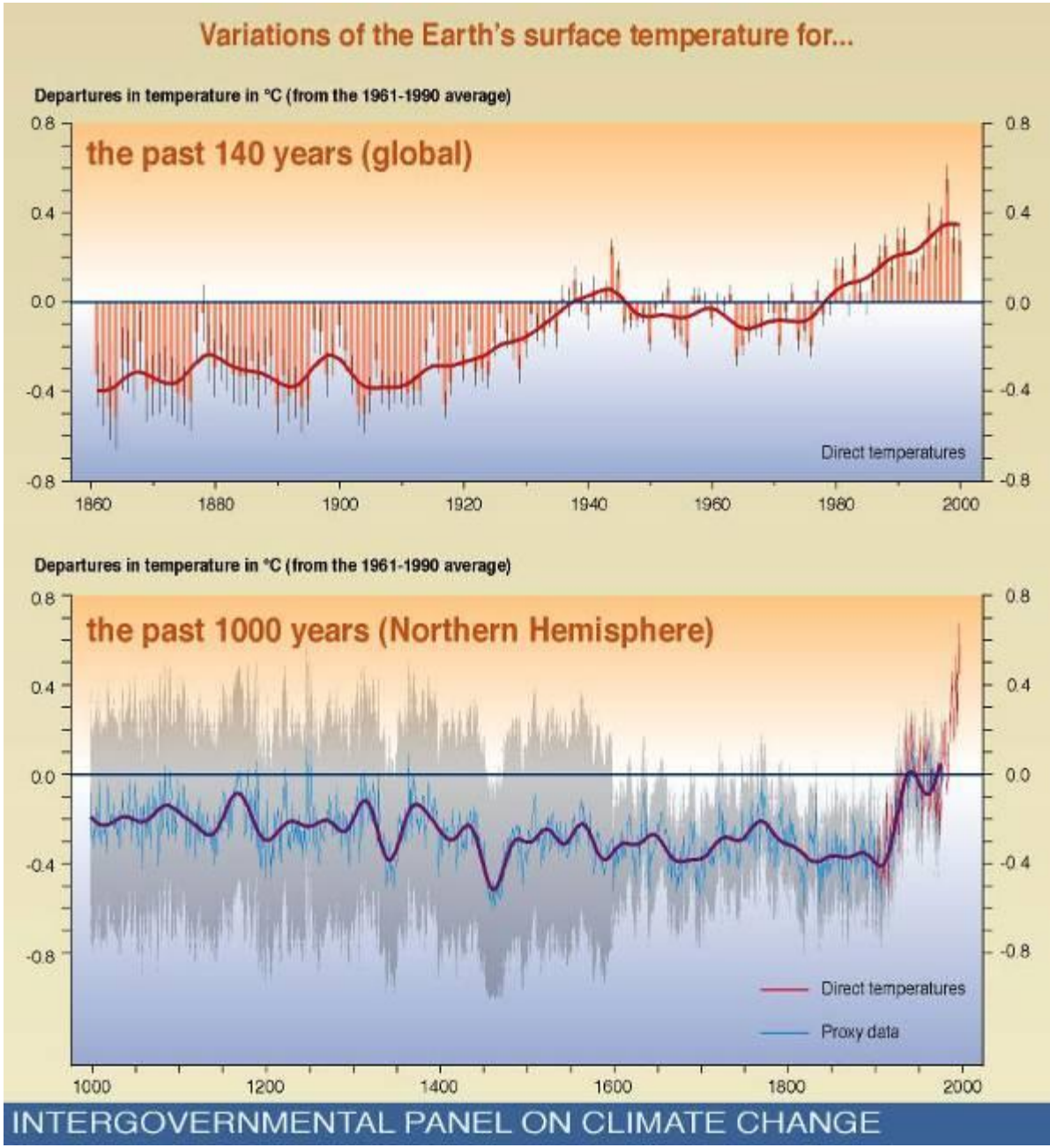



The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower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

"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level."

IPCC, 2007



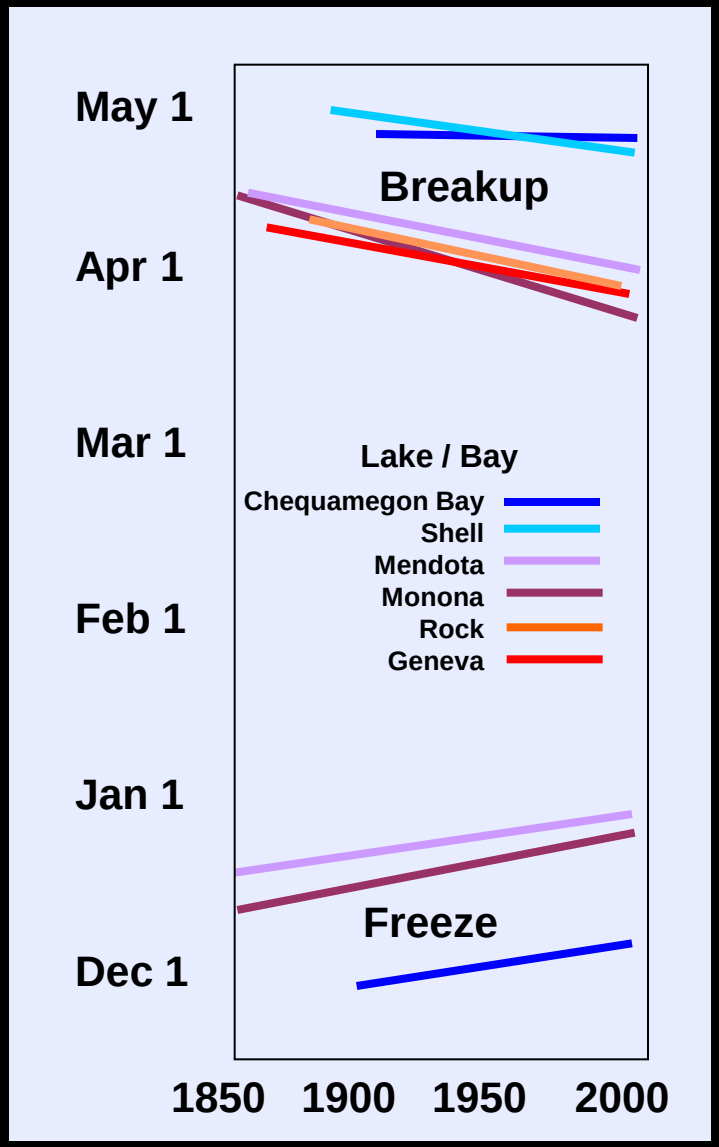
Evidence of Climate Change in the Great Lakes Region

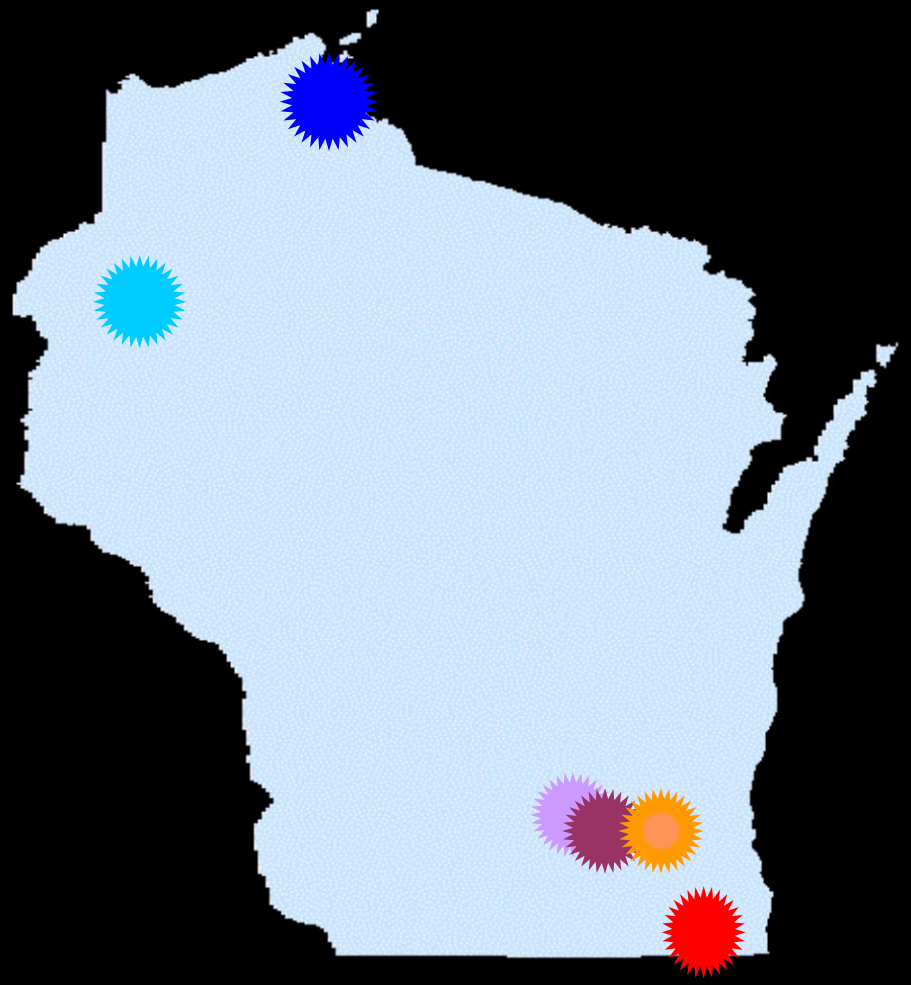
- Temperatures are rising, especially in winter.
- Extreme rainfall events (24-hr and 7-day) are becoming more frequent.
- Winters have become shorter.
- Spring is coming earlier.
- Duration of ice cover is shorter, especially on smaller lakes.

SOURCE: UCS/ESA, 2003

Source: Edge of the Wilderness Scenic Byways

Changes in Ice Around Wisconsin





Magnuson 2004

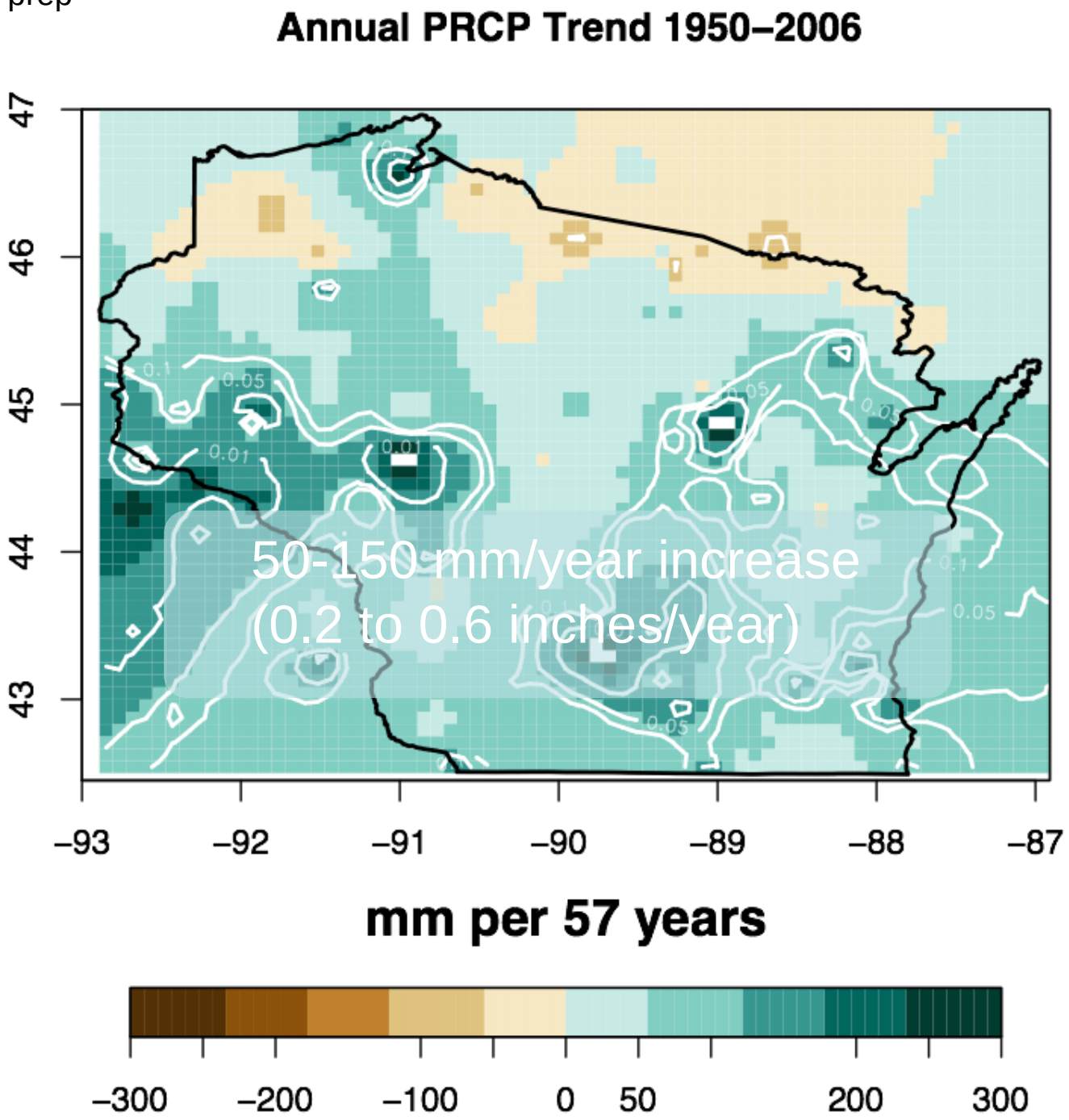
Climate change in Wisconsin: 1950-2006

Long term precipitation trends

Preliminary data from Chris Kucharik, UW-Madison

Center for Sustainability and the Global Environment (SAGE)
University of Wisconsin, Madison

Kucharik et al., in prep



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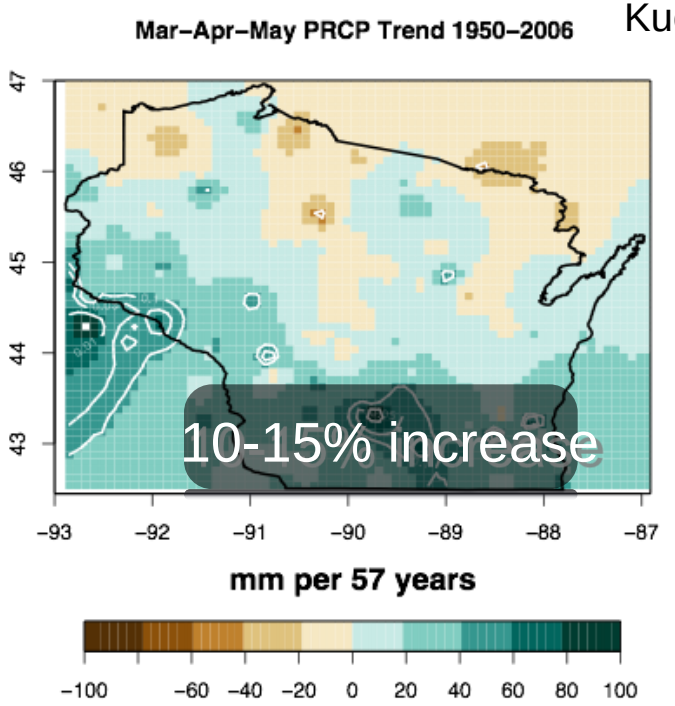
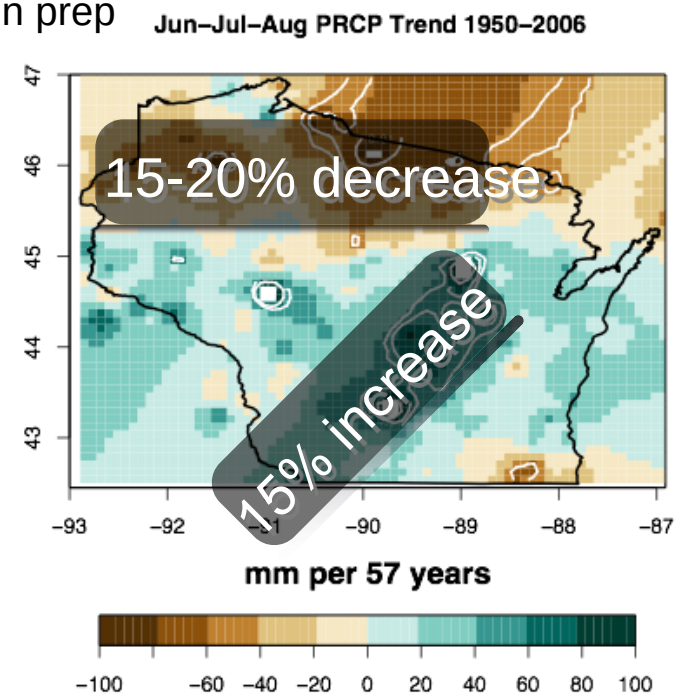
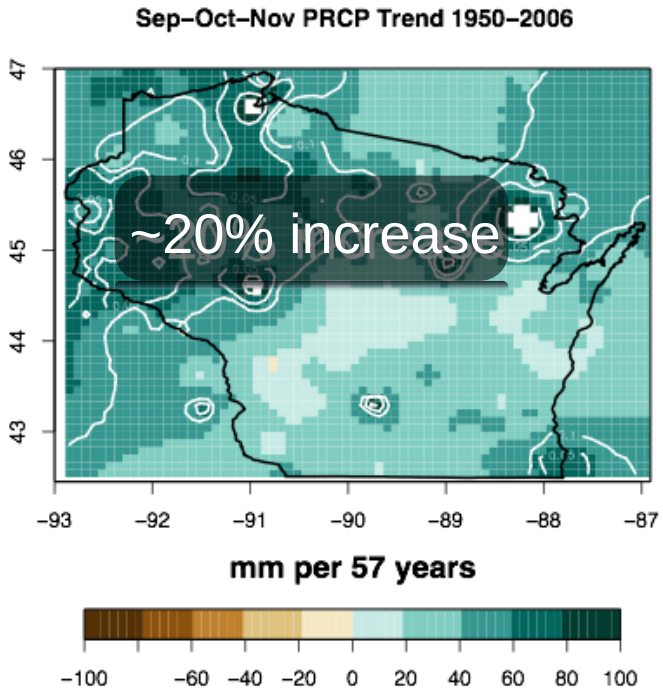
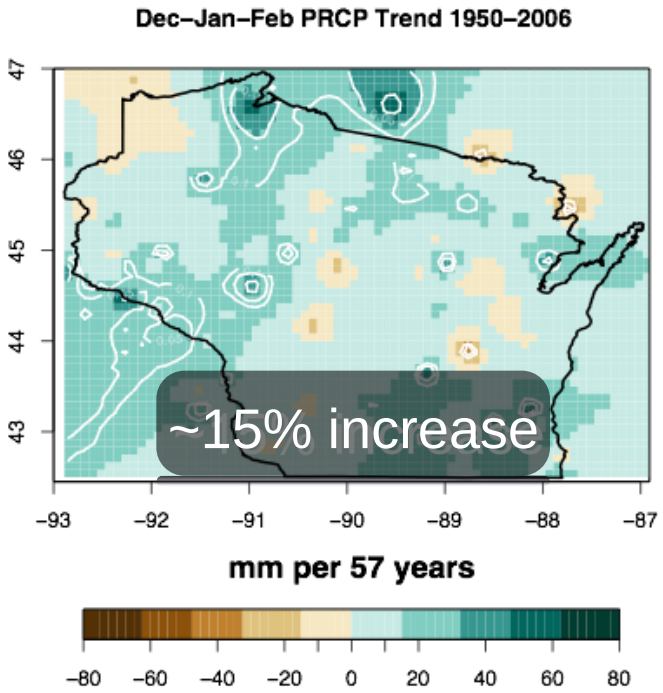
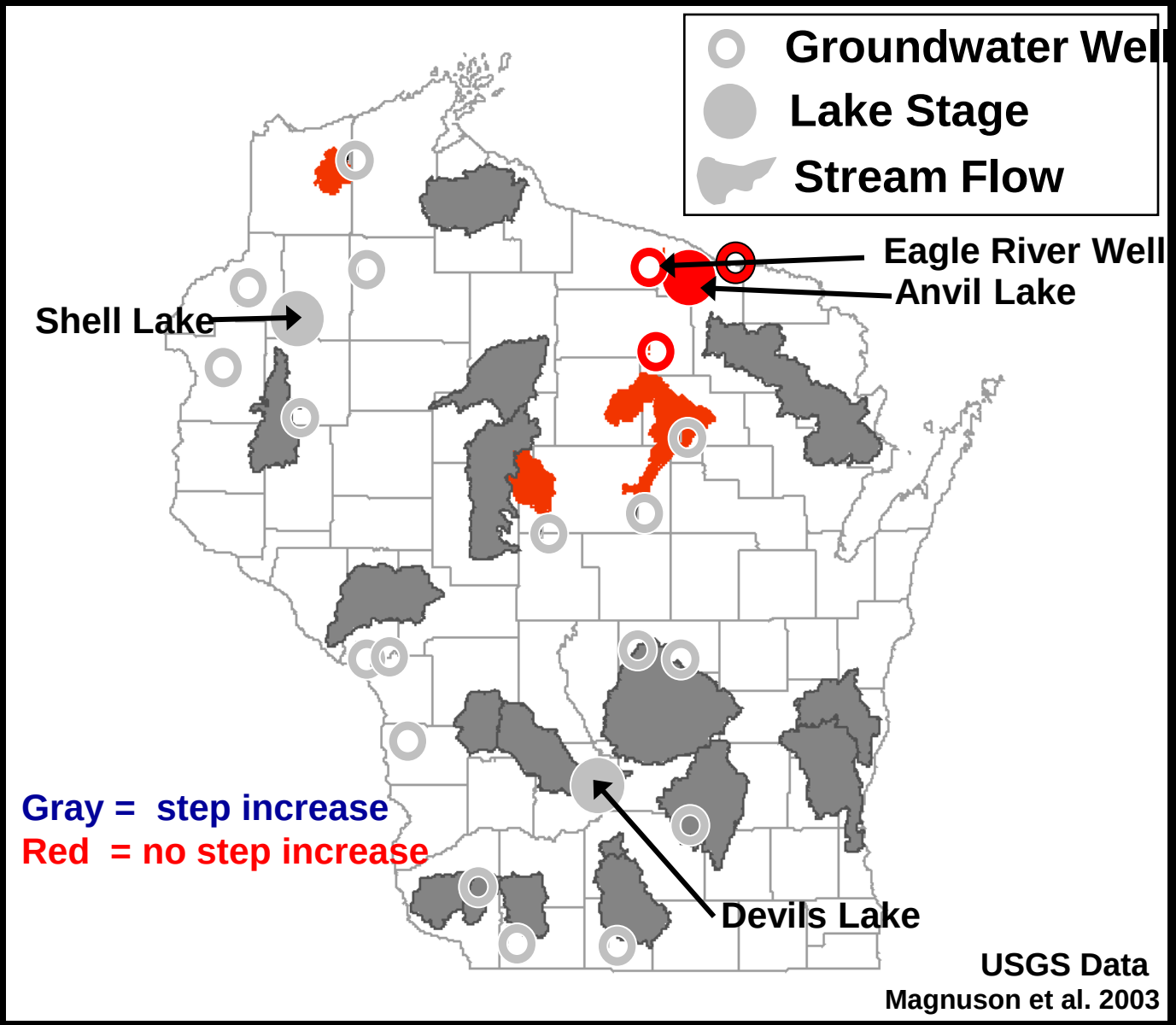






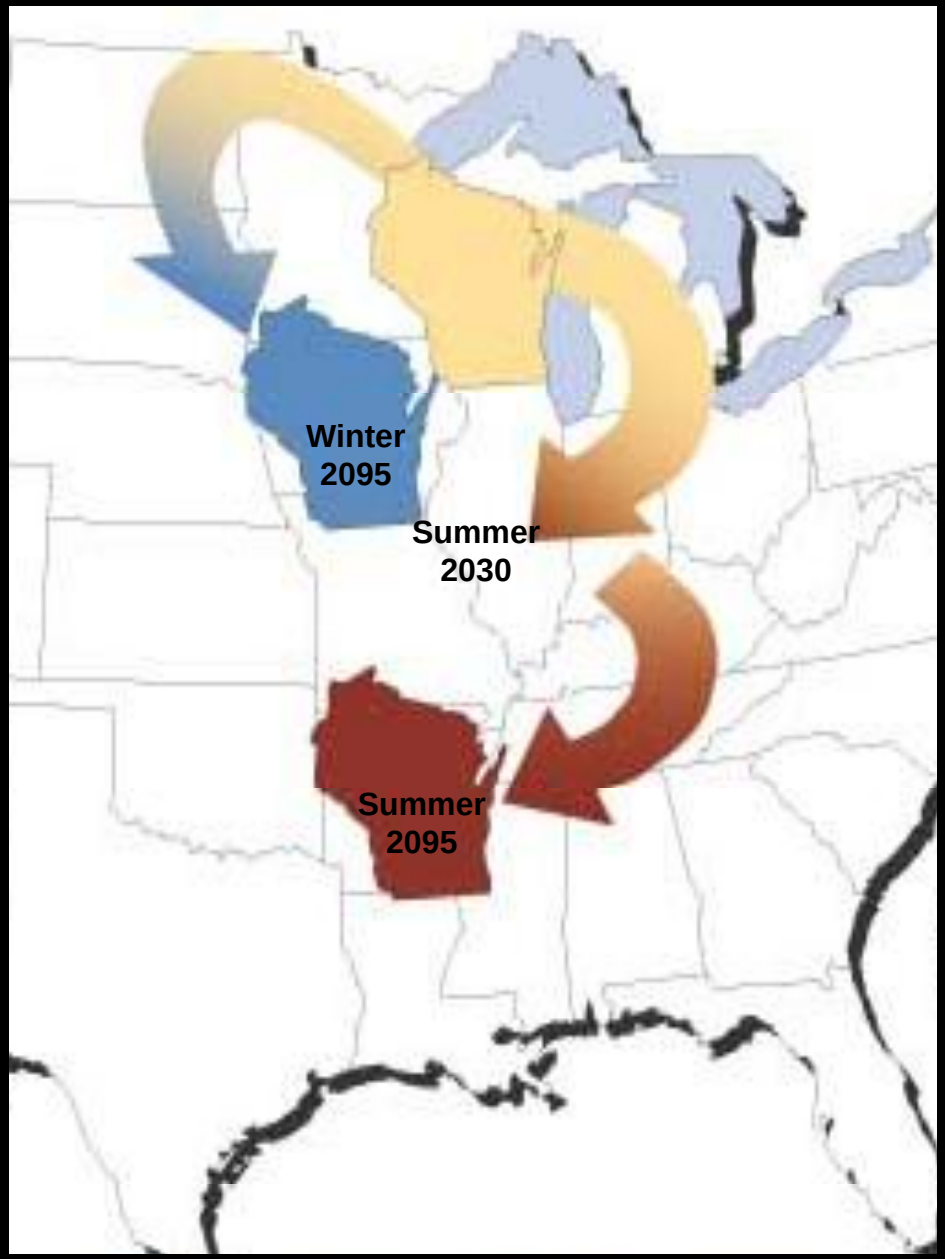


Step Increase in Lake Stage, Stream Flow, and Groundwater Levels after 1970



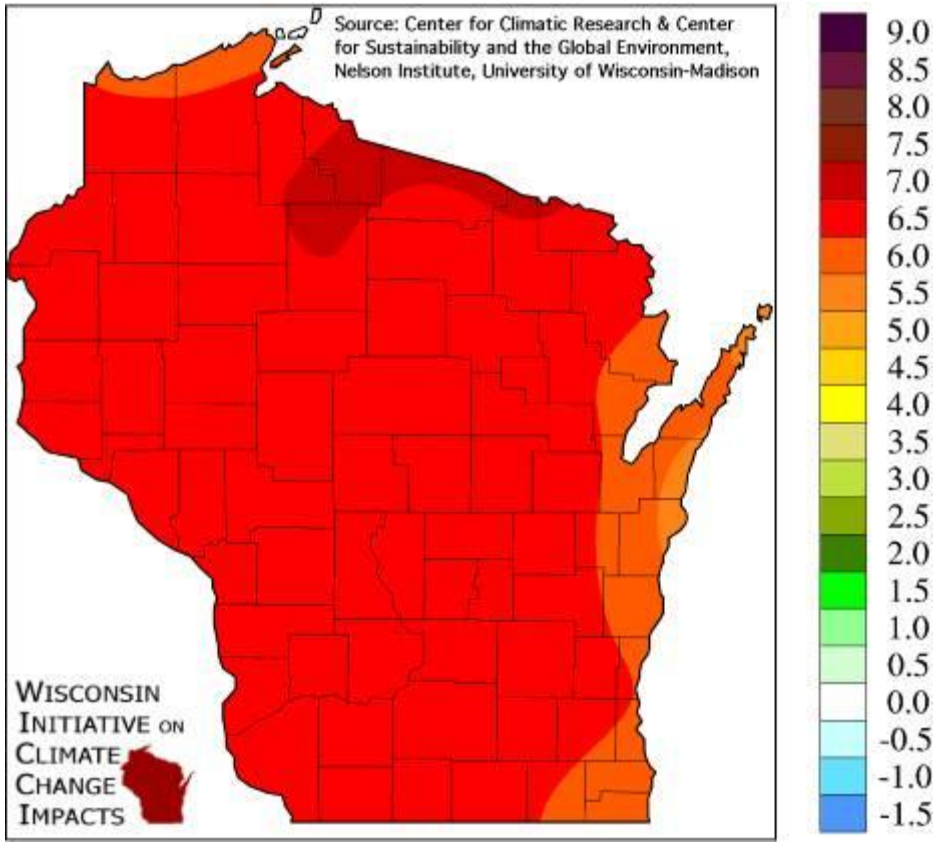
Wisconsin's Migrating Climate

But what does the future hold for Wisconsin?

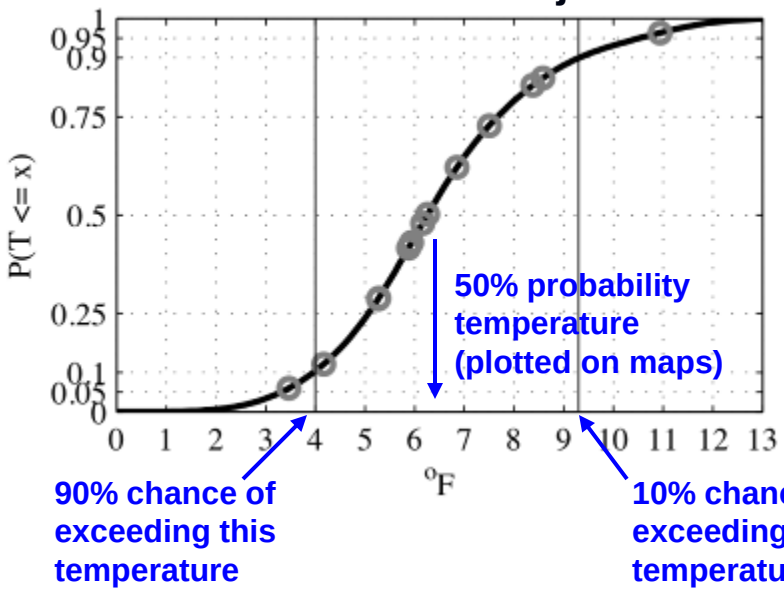


Annual Temperature Change

Projected Change in Annual Average Temperature (°F) from 1980 to 2055



Probability Distribution of 14 Global Climate Model Projections

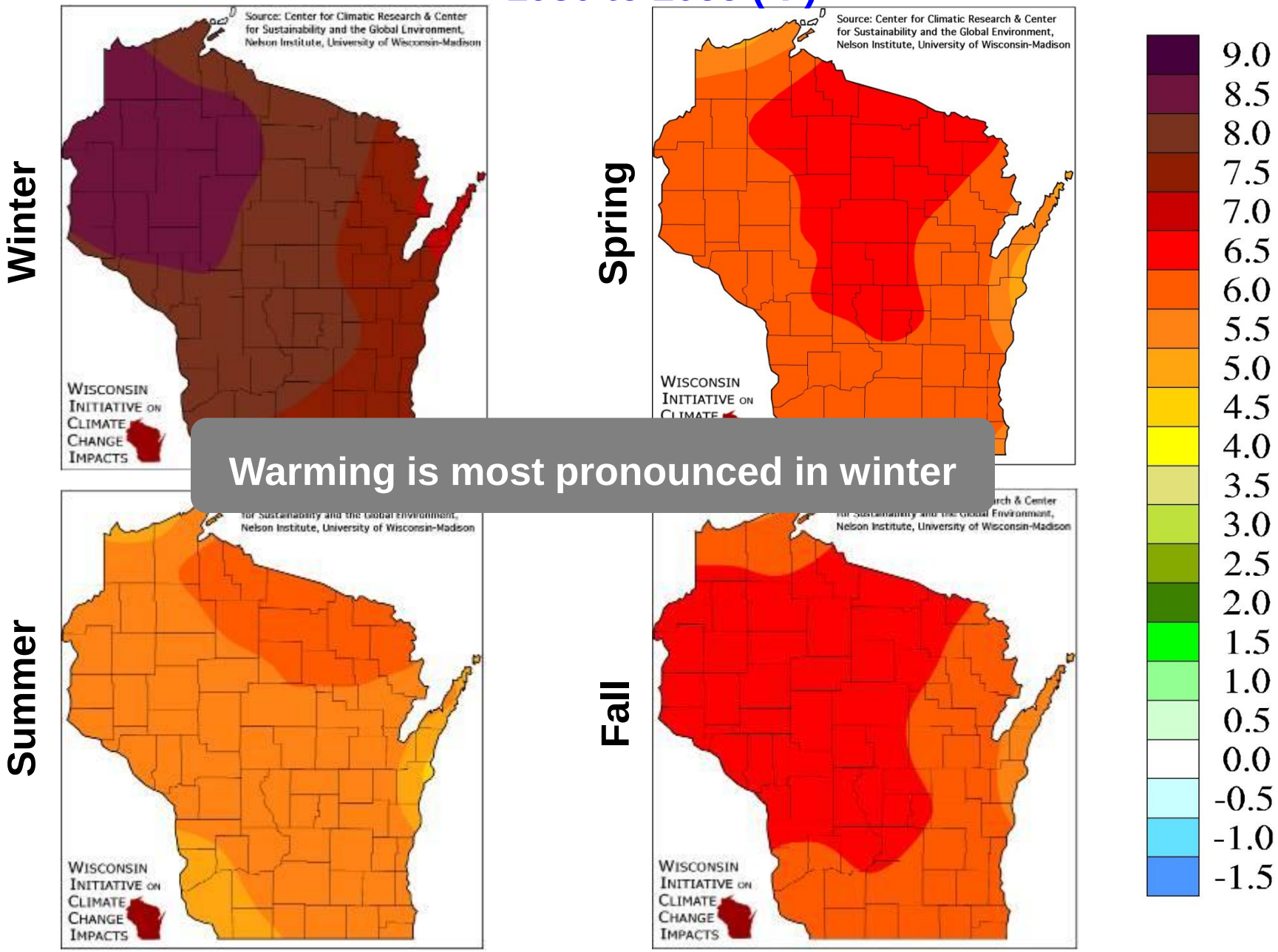


Wisconsin will warm by 4 – 9 °F by mid-21st Century

Source: Adapted from D. Vimont, UW-Madison

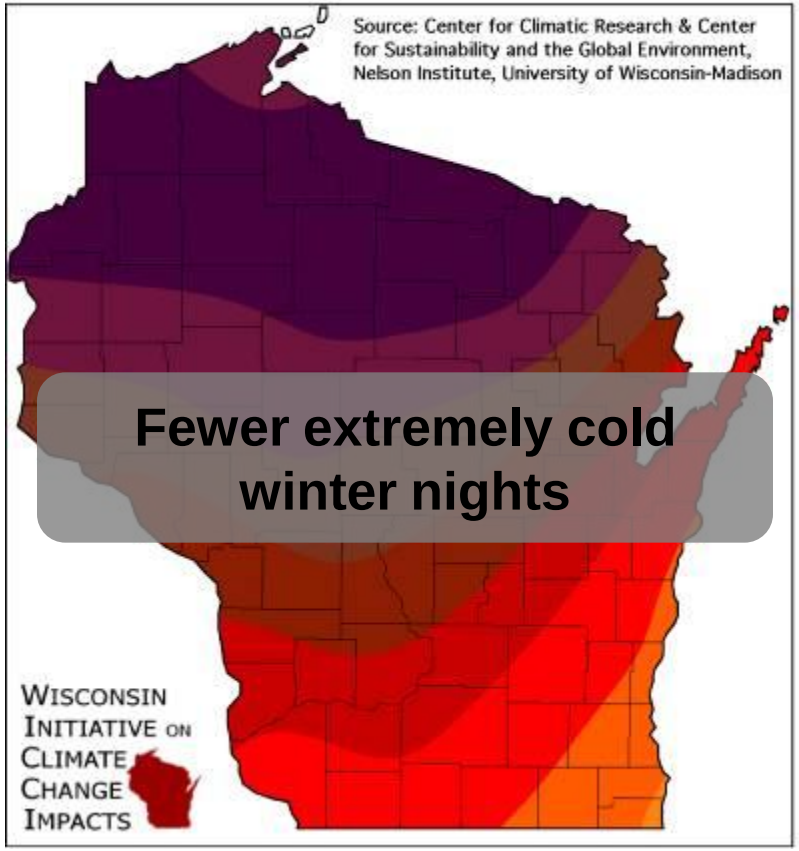
Project Change in Seasonal Temperatures

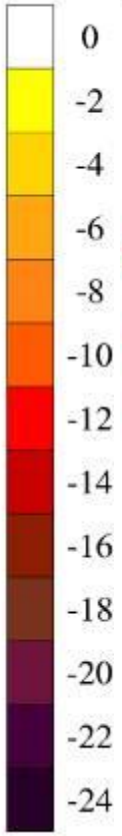
1980 to 2055 (°F)



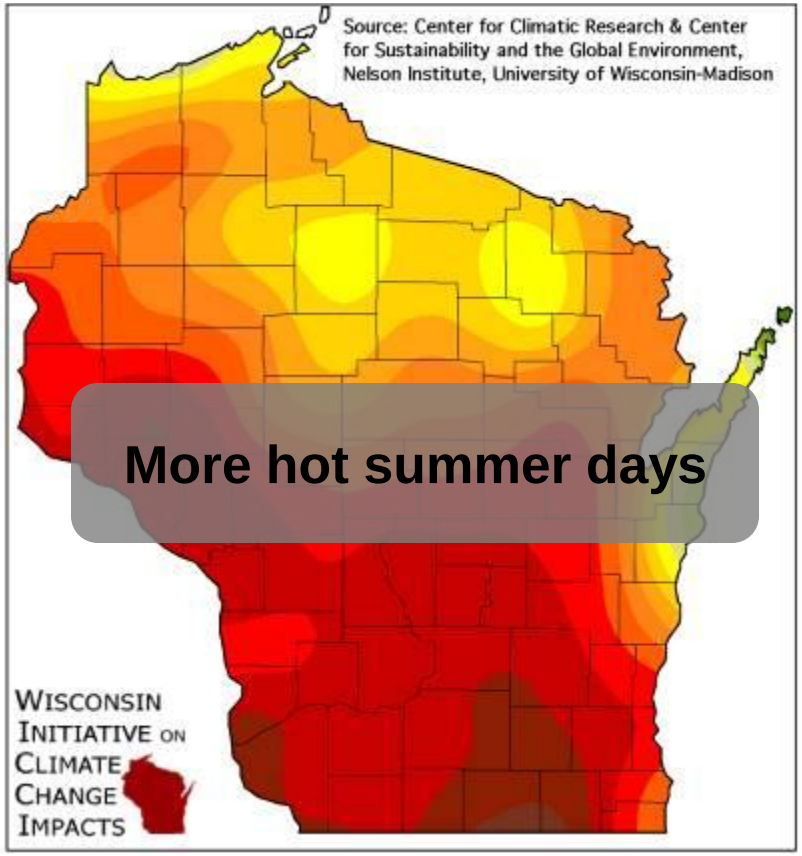
Extreme Temperature Projections

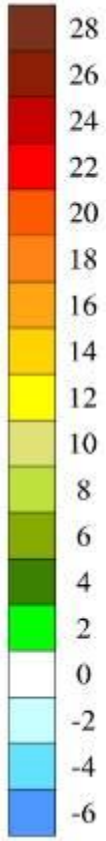
Projected change in the frequency of <0°F nights per year from 1980 to 2055





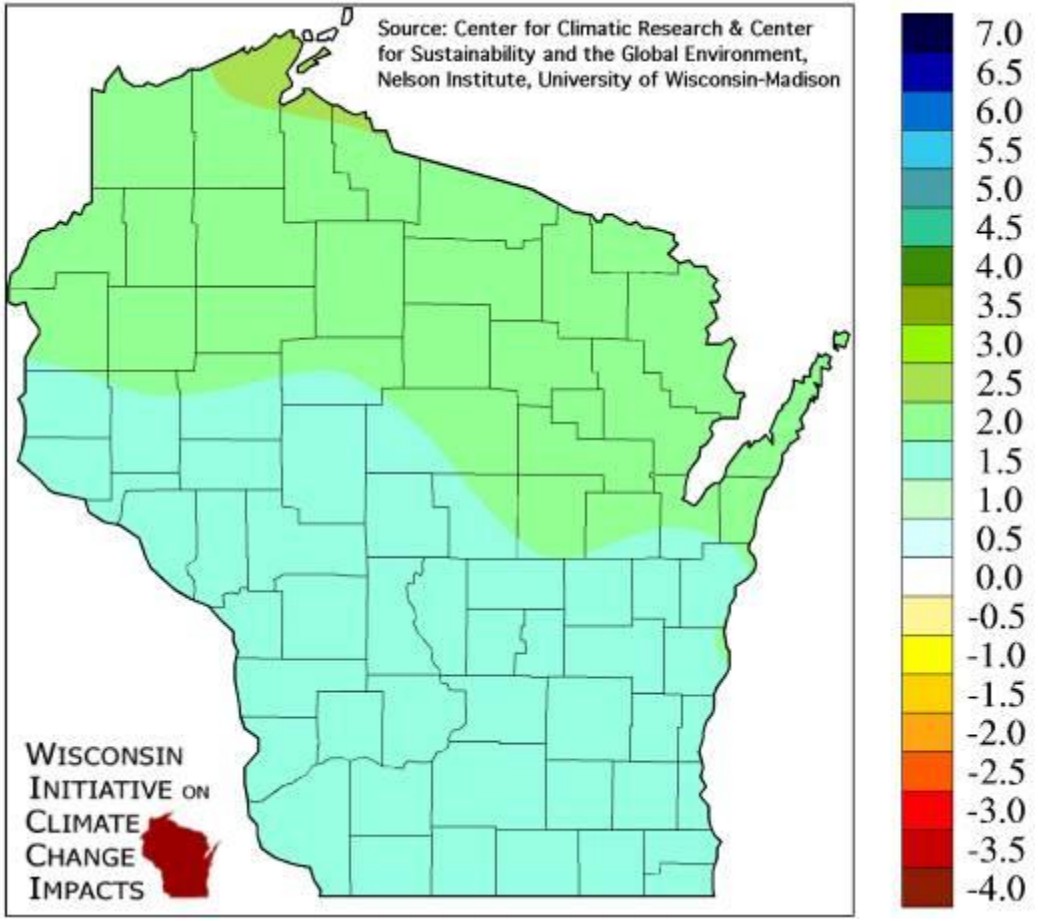
Projected change in the frequency of ≥90°F days per year from 1980 to 2055



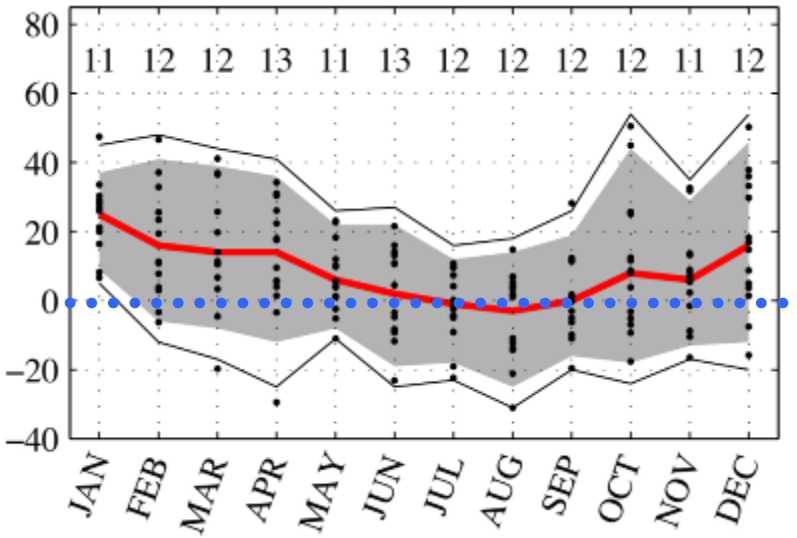


Projected Change in Precipitation from 1980 to 2055

Change in Annual Average (inches)



Probability Distributions of 14 Climate Model Projections by Month



Models predict winter and early spring will be wetter (0-40% increase).

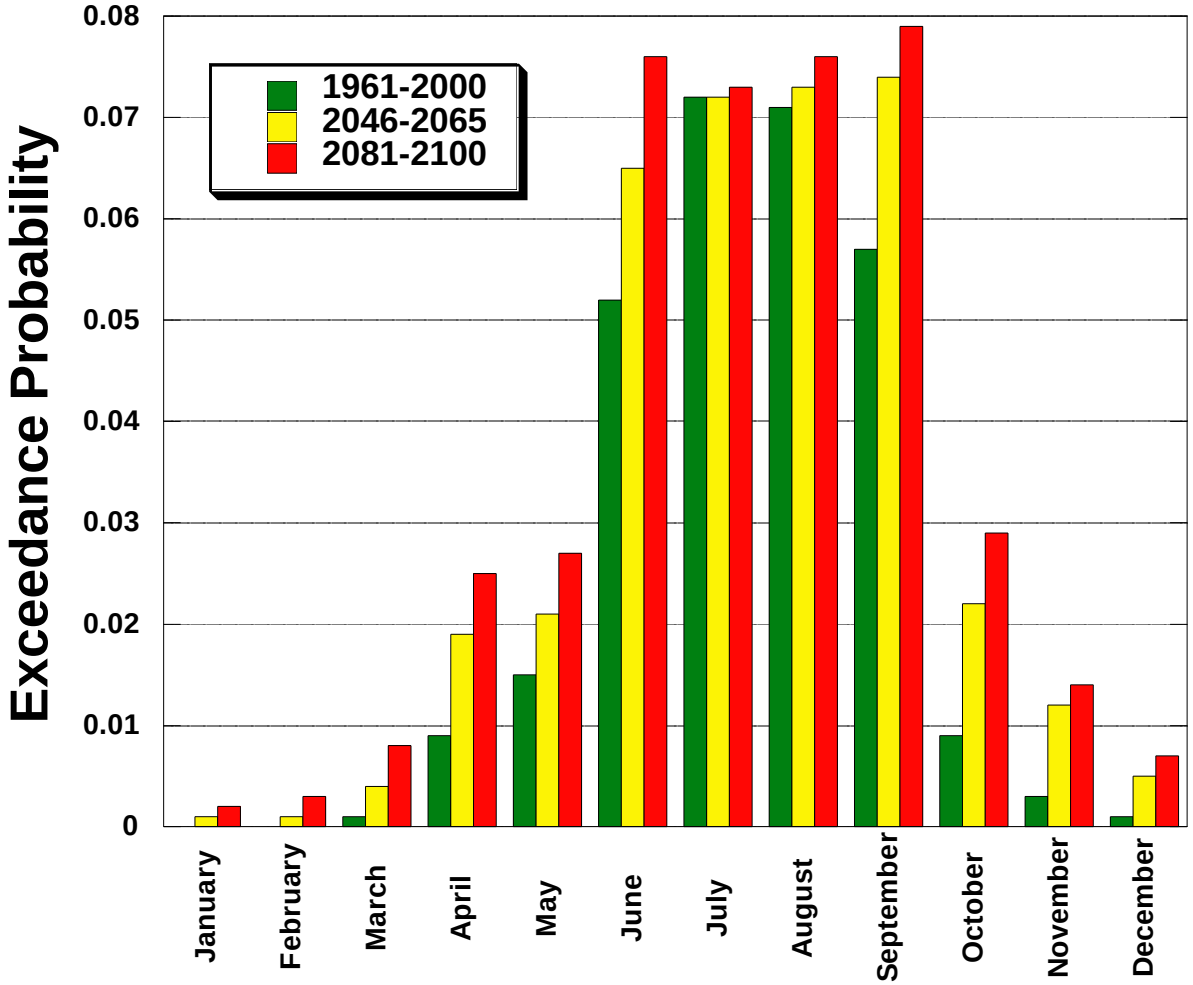
Models uncertain about amount of summer rainfall

Source: Adapted from D. Vimont, UW-Madison

Monthly Frequency of >3-inch Rainstorms in 24 hr

Madison, Wisconsin

(Future predictions averaged for all 14 GCM's)



Increase in large precipitation events during spring & fall

Source: Z. Schuster & K. Potter, UW-Madison.
Based on statistically downscaled data developed by Kucharik, Lorenz, Notaro, & Vimont, UW-Madison.

Major Drivers of Climate Change Impacts on Water Resources

- Thermal Impacts (Increased air and water temps, longer ice-free period, more ET)
- Changing rainfall patterns (seasonal and spatial variability, + or – water, less precip in the form of snow)
- Increased storm intensity (more frequent large precipitation events)

Climate change impacts on water resources

- Decreased ice duration on inland lakes and rivers (longer ice-free period)
- Changes in species distributions (natives and exotics)
- Impacts to water quality of lakes, streams, rivers, and wetlands
- Altered hydrologic processes (changing baselines and more variability)
- Extreme events (floods and droughts)

Effects of Global Warming on Water Cycle

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

↓

More Extreme Weather Events
- Droughts
- Storms
- Floods

→ Effects on lakes?

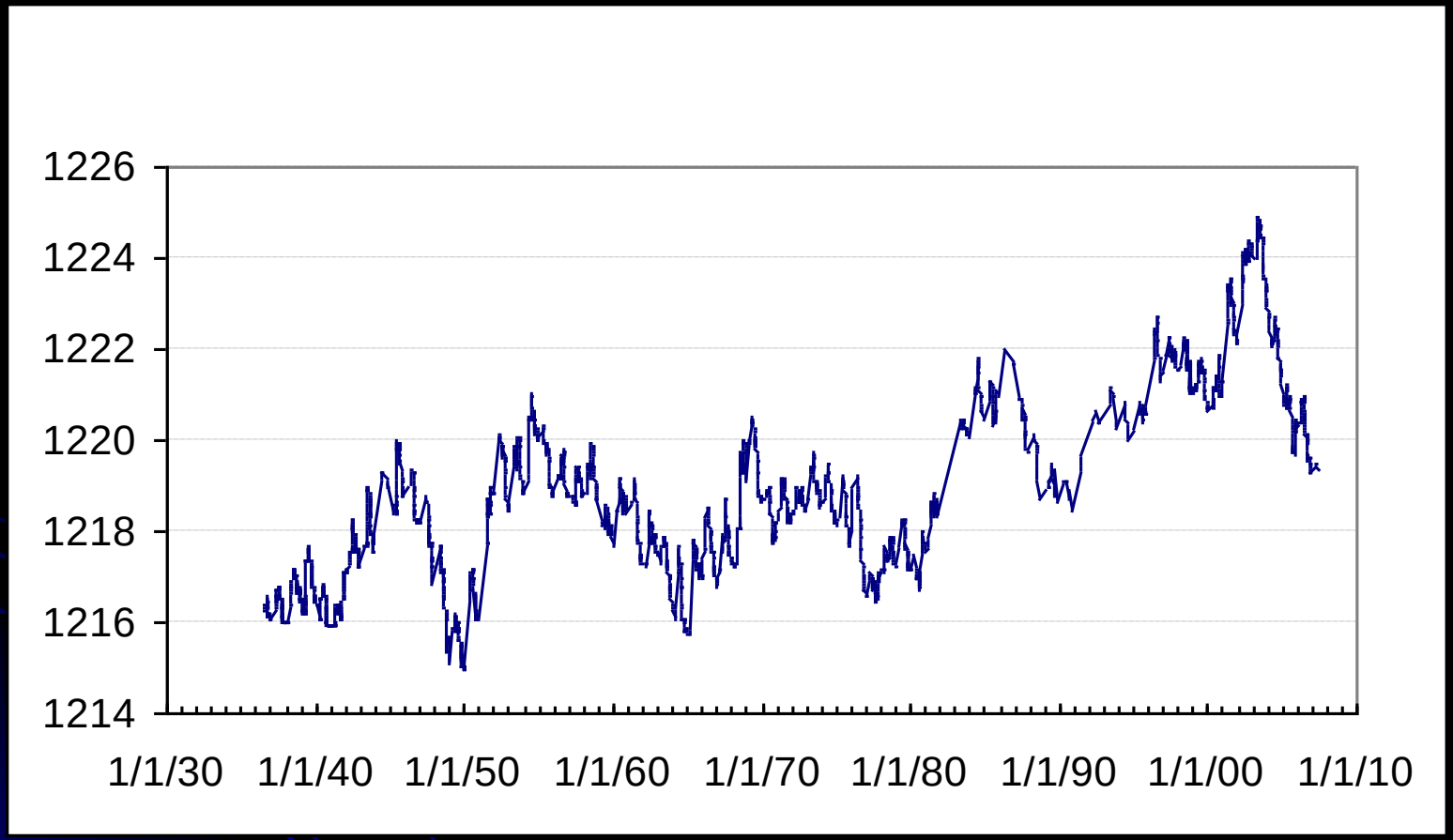
Source: John Magnuson, 2007

Water Levels – Scenario #1

- Warmer, wetter winters
- More CO_2 in atmosphere makes plants more water efficient
- More storms increases runoff
- More recharge increases baseflow and groundwater levels
- Lakes may go up

Source: John Magnuson, 2007

Shell Lake Stage Record (1936 – 2006)



Source: USGS

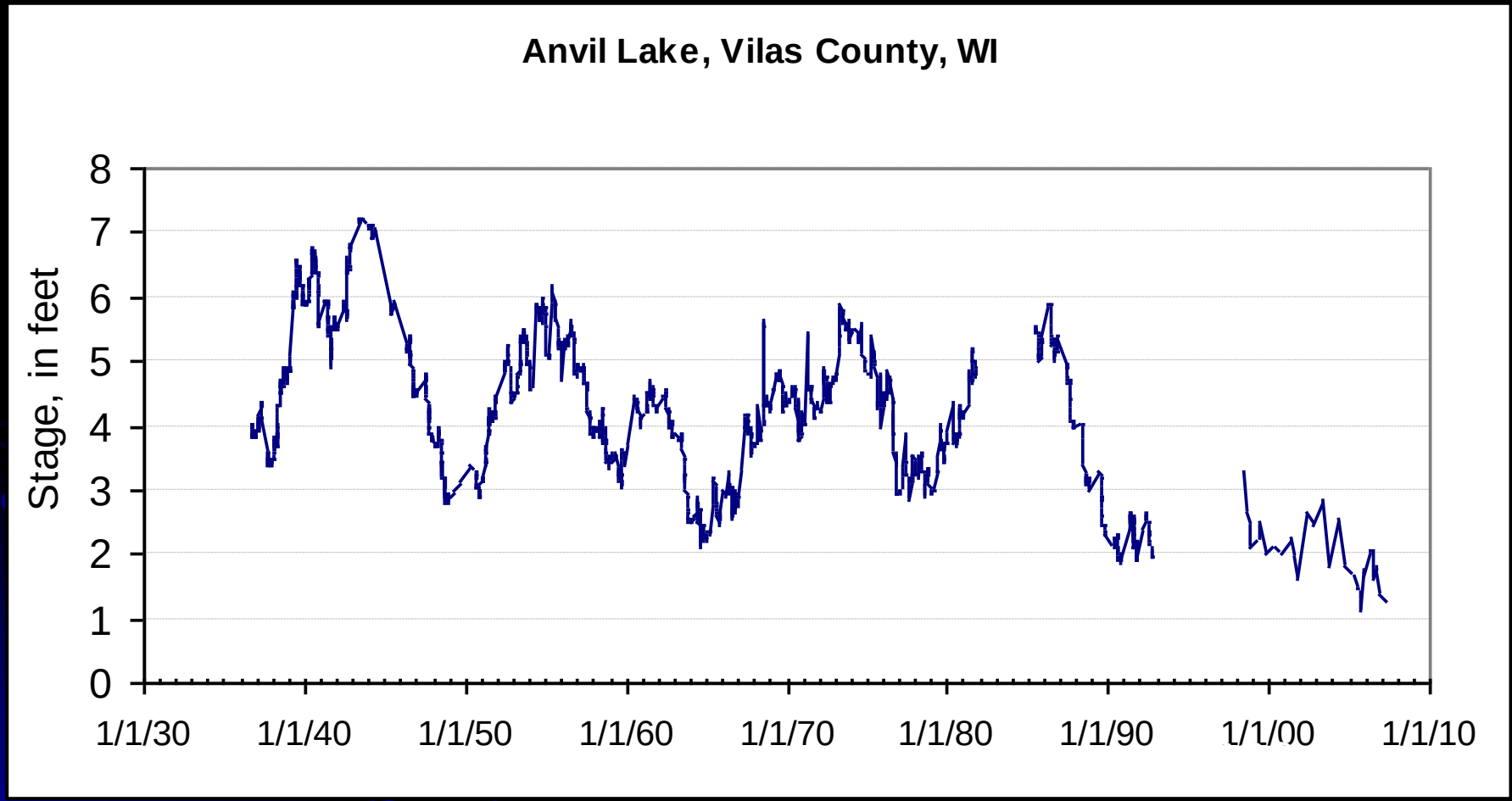
Crystal Lake groundwater flooding

Water Levels – Scenario #2

- Shorter duration of ice cover will increase evaporation in winter
- Warmer air temperatures will increase evapotranspiration
- Lower precipitation in summer will decrease soil moisture
- Lakes may go down

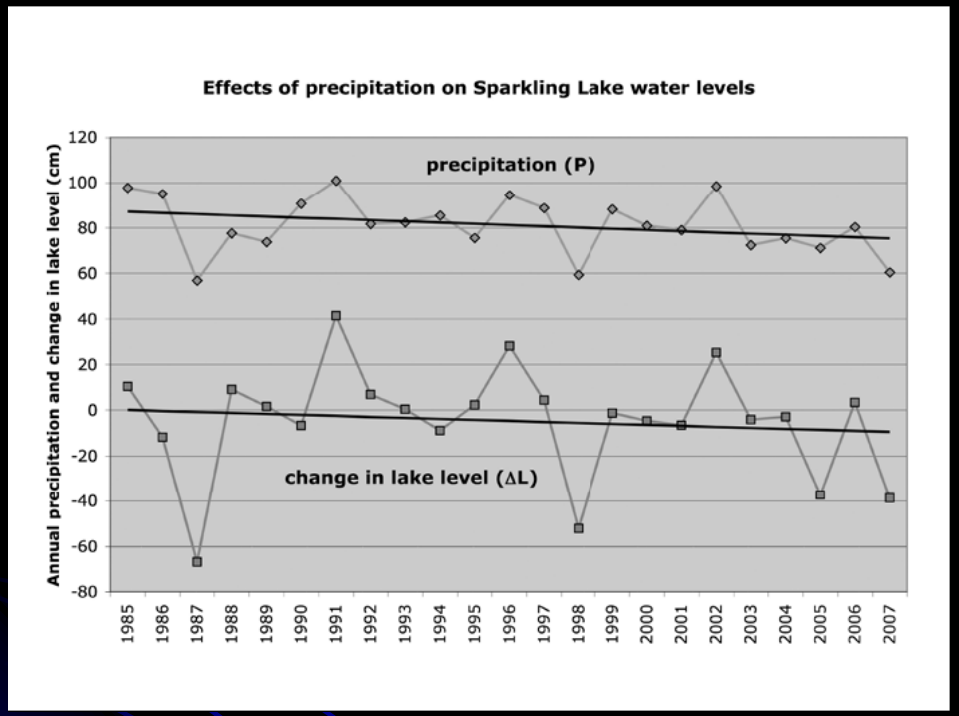
SOURCE: UCS/ESA 2003

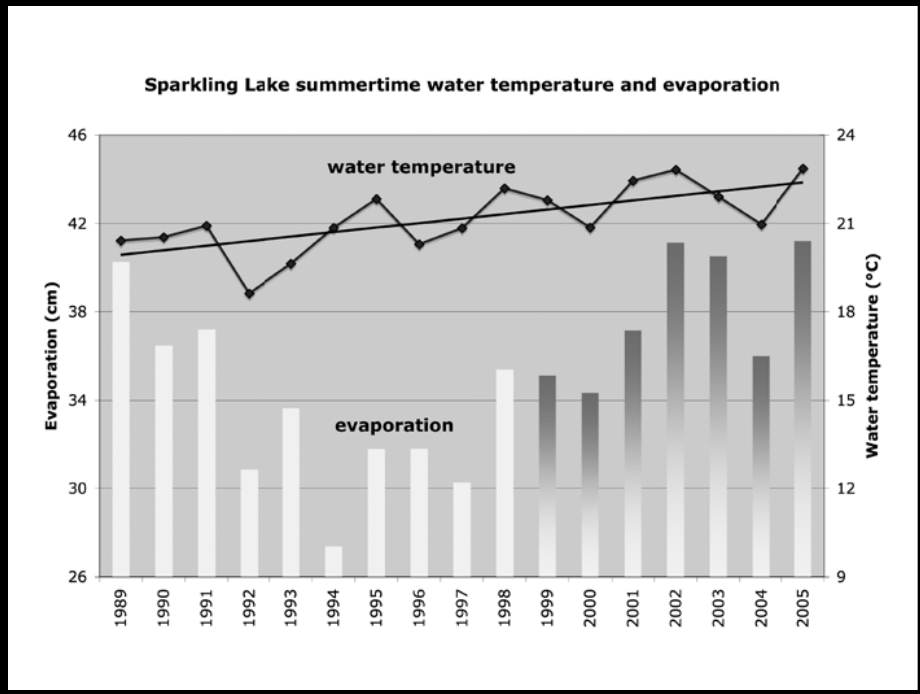
Anvil Lake Stage Record (1936 – 2006)



Source: USGS

Evaporation vs. Precipitation





From Dr. John D. Lenters
University of Nebraska-Lincoln

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Sparking Lake data courtesy of LTER

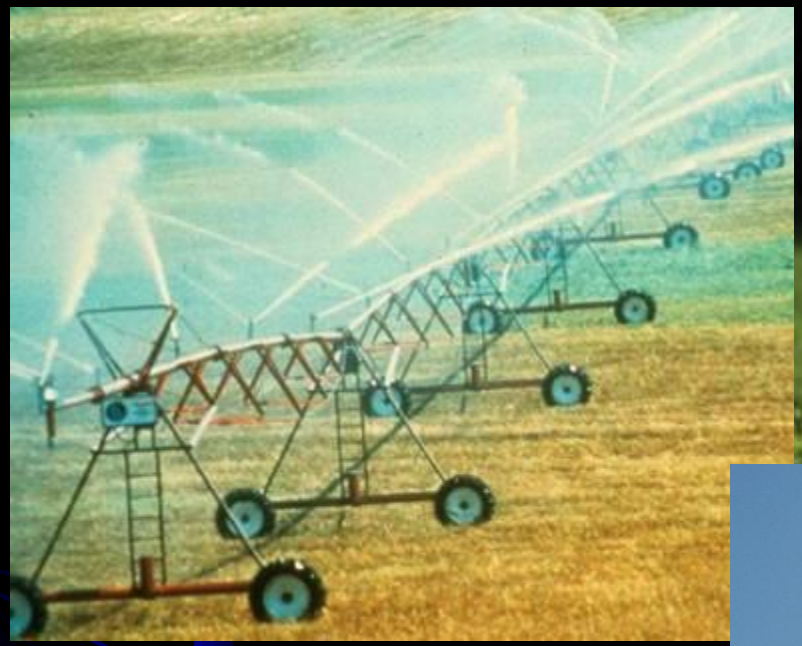
Which one is the future?

Maybe both!

Role/implications of climate change for lake levels in the north

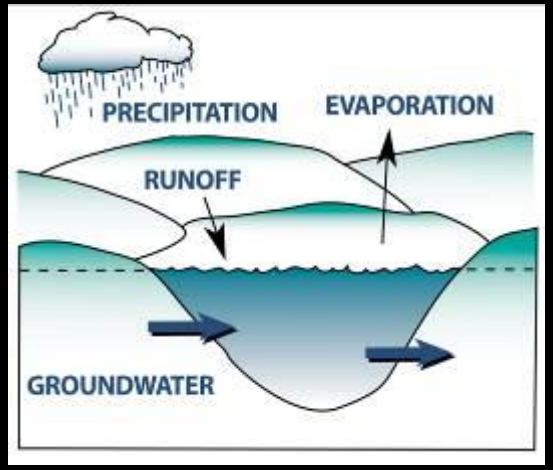
- Short term or long term?
- Factors at play
  - Changing timing of precipitation
  - Changes in snowfall and recharge
  - Increased summer evaporation
  - Decreased summer rainfall
  - High in the landscape regionally
  - Groundwater Divides

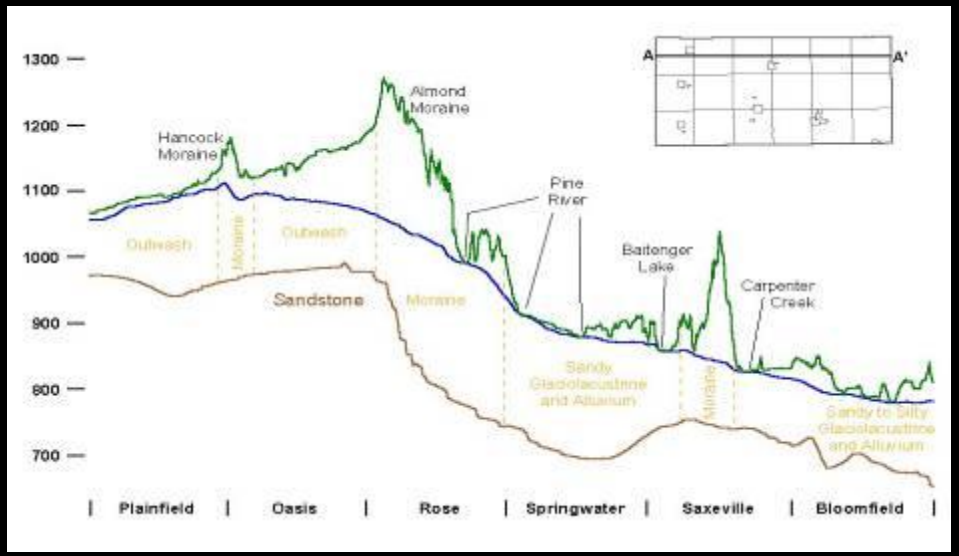
Human water use



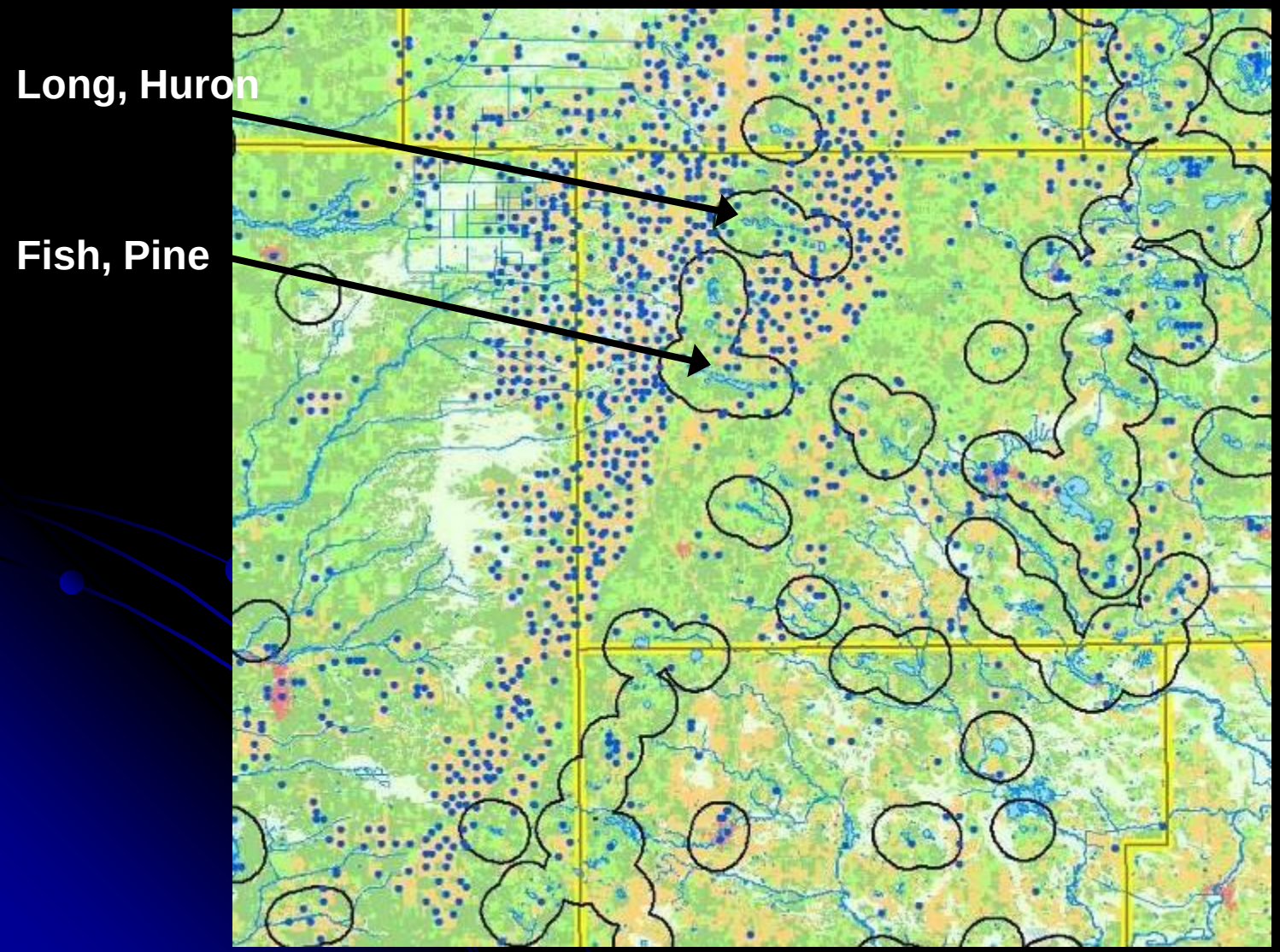
Waushara County Lakes

- Landlocked lakes, no outlet
- Sandy soils
- Lakes near major regional groundwater divide
- Recent declines after unusually high period in the 1990s
- Short-term drought in Central WI
- Major pumping center



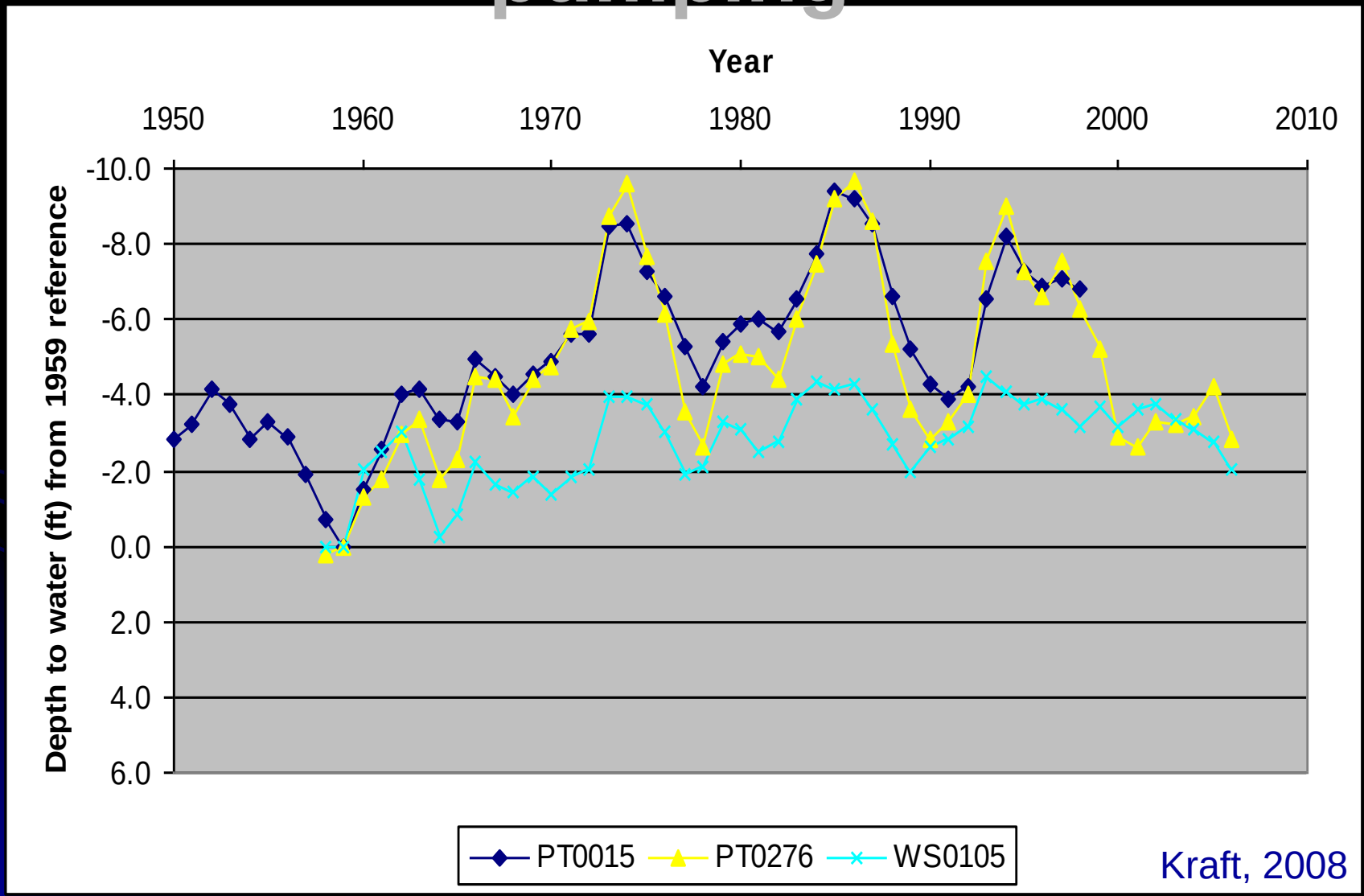


Waushara County Lakes



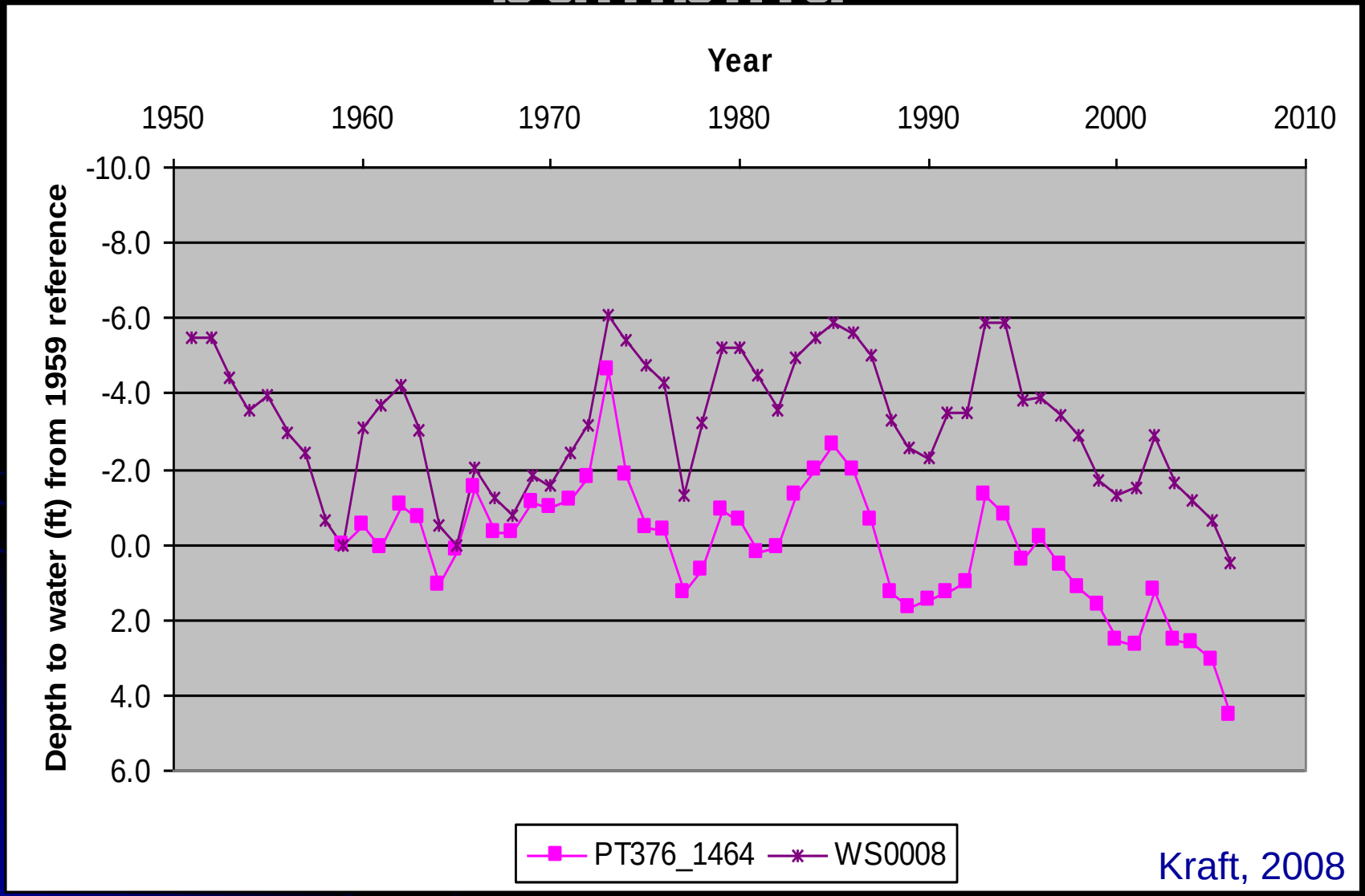

Long Lake
No Wake

Water levels unaffected by pumping



Kraft, 2008

Water levels affected by pumping



Kraft, 2008

OK, SO NOW WHAT?

- Wait it out!
- Natural variations are part of lake ecosystem
- But, larger forces at work (climate change, water use, land use)
- Solutions may be local, regional, and global
- Mitigation / Adaptation

Mitigating low lake levels

- Water level modification – caution!
- Conserve water
- Decrease inefficient water use (lawn watering, car washing, etc)
- Increase infiltration (redirect downspouts, raingardens, eliminate surfaces that can increase evaporation loss)
- Use less energy!

Adapting to low lake levels

- Understand your lake
- Careful use of lakes and lakeshores
- Protect habitat – fragile ecosystems
- Reduce nutrient inputs
- Shift boating behavior – go deep!

Wisconsin Initiative on Climate Change Impacts:

Adapting to Our Changing Environment

WISCONSIN INITIATIVE ON CLIMATE CHANGE IMPACTS

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