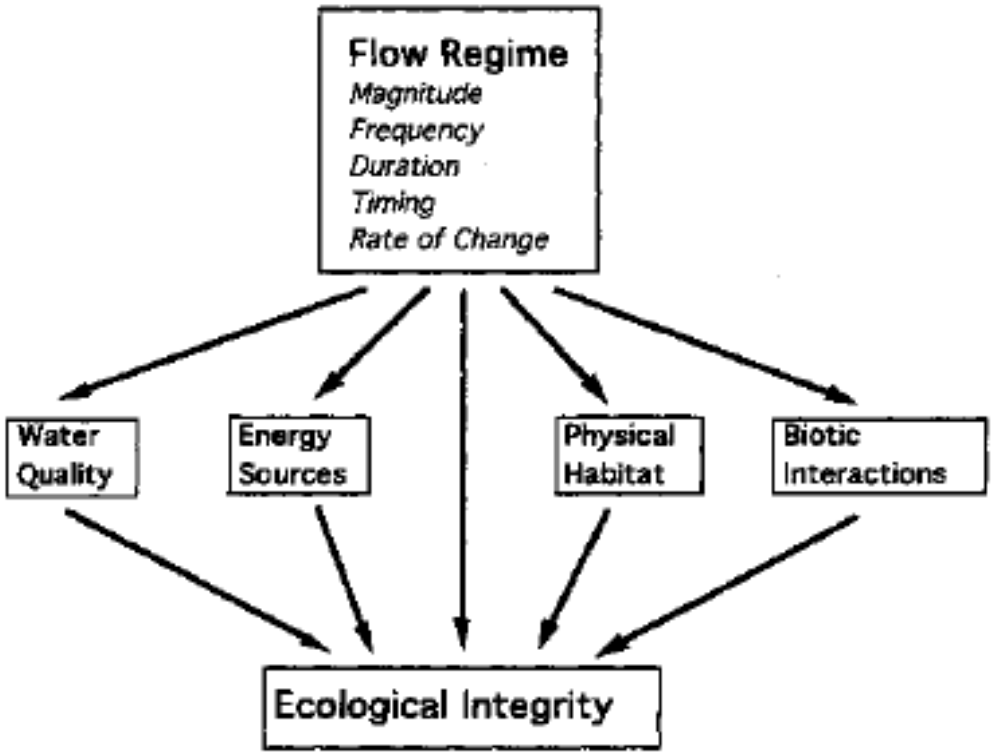
Lake Level Fluctuations in Wisconsin

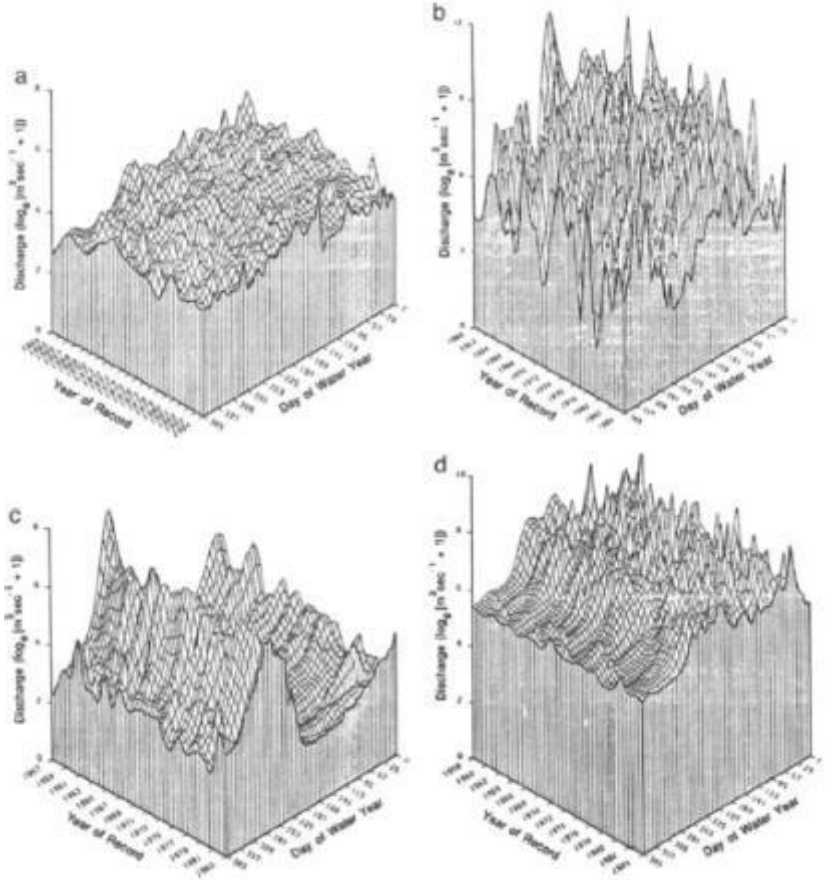
Catherine Hein

The Natural Flow Regime

A paradigm for river conservation and restoration

N. LeRoy Poff, J. David Allan, Mark B. Bain, James R. Karr, Karen L. Prestegaard,
Brian D. Richter, Richard E. Sparks, and Julie C. Stromberg



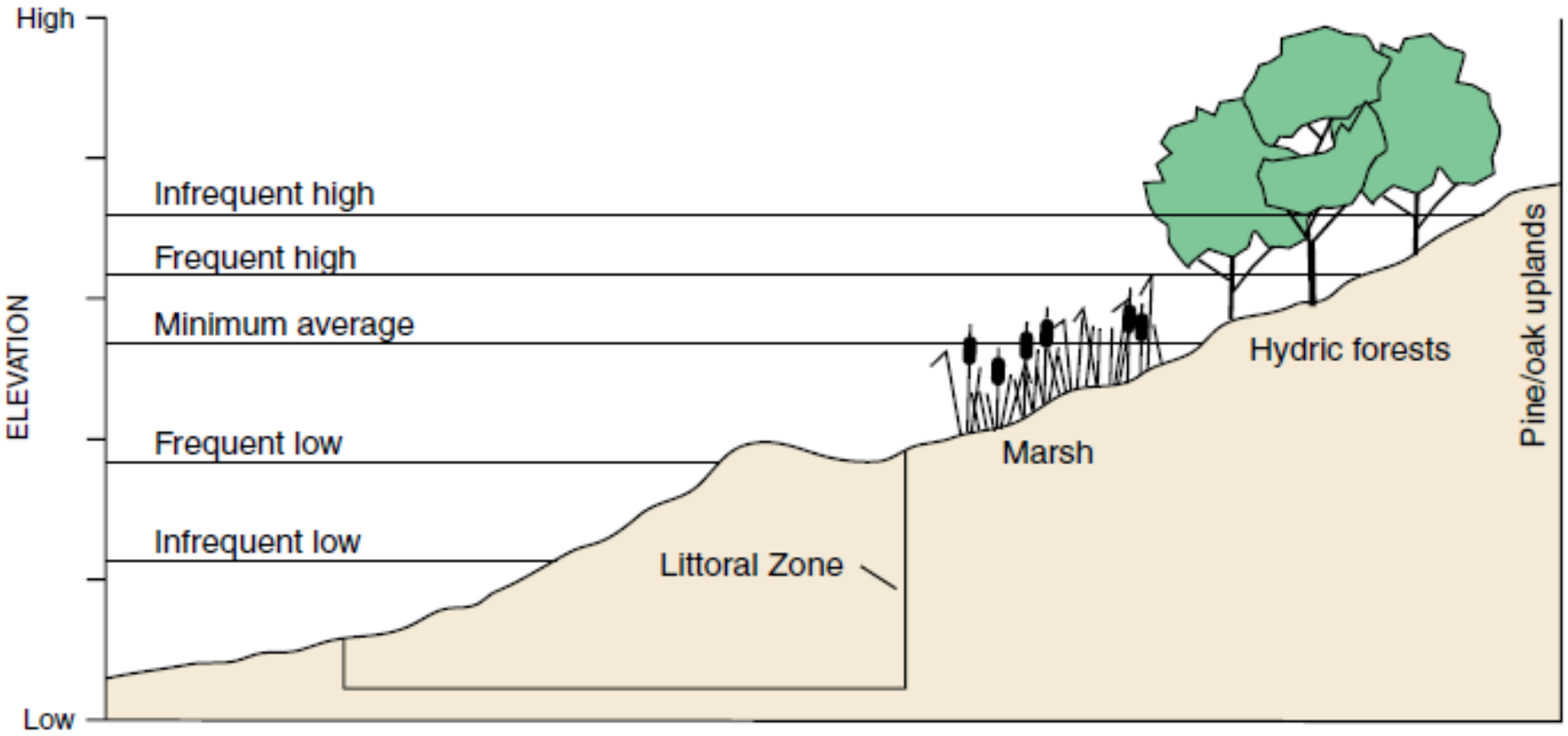


1997 BioScience

Lake Levels Fluctuate Too

Robertson et al. 2009 USGS Report 2009–5077

Natural Lake Level Regime



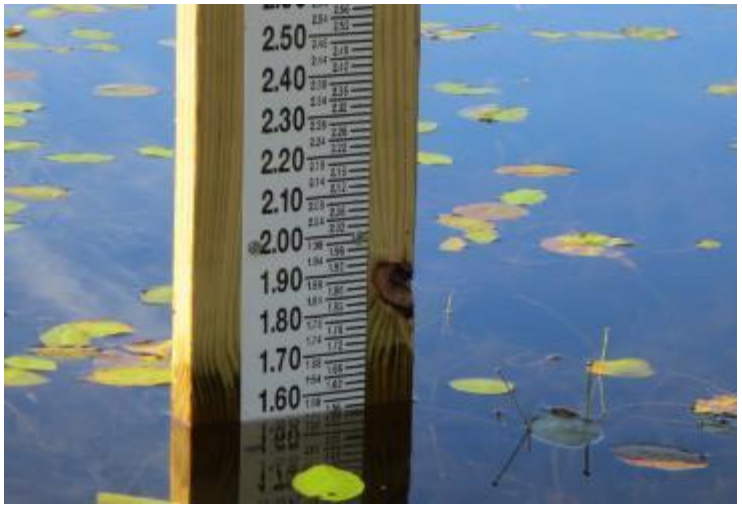
modified from McGrail et al. 1998

Lake Ecology & Management

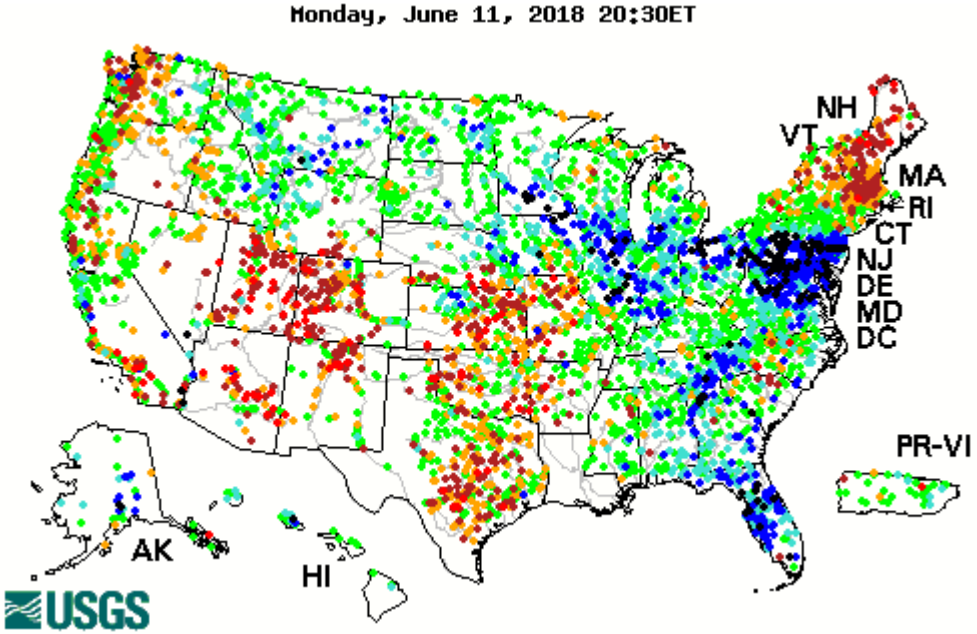
- Recreation
- Navigation
- Water quality
- Habitat
- Biological Community
- Fisheries

Long-term lake level records sparse compared to streams

Lake Staff Gauge

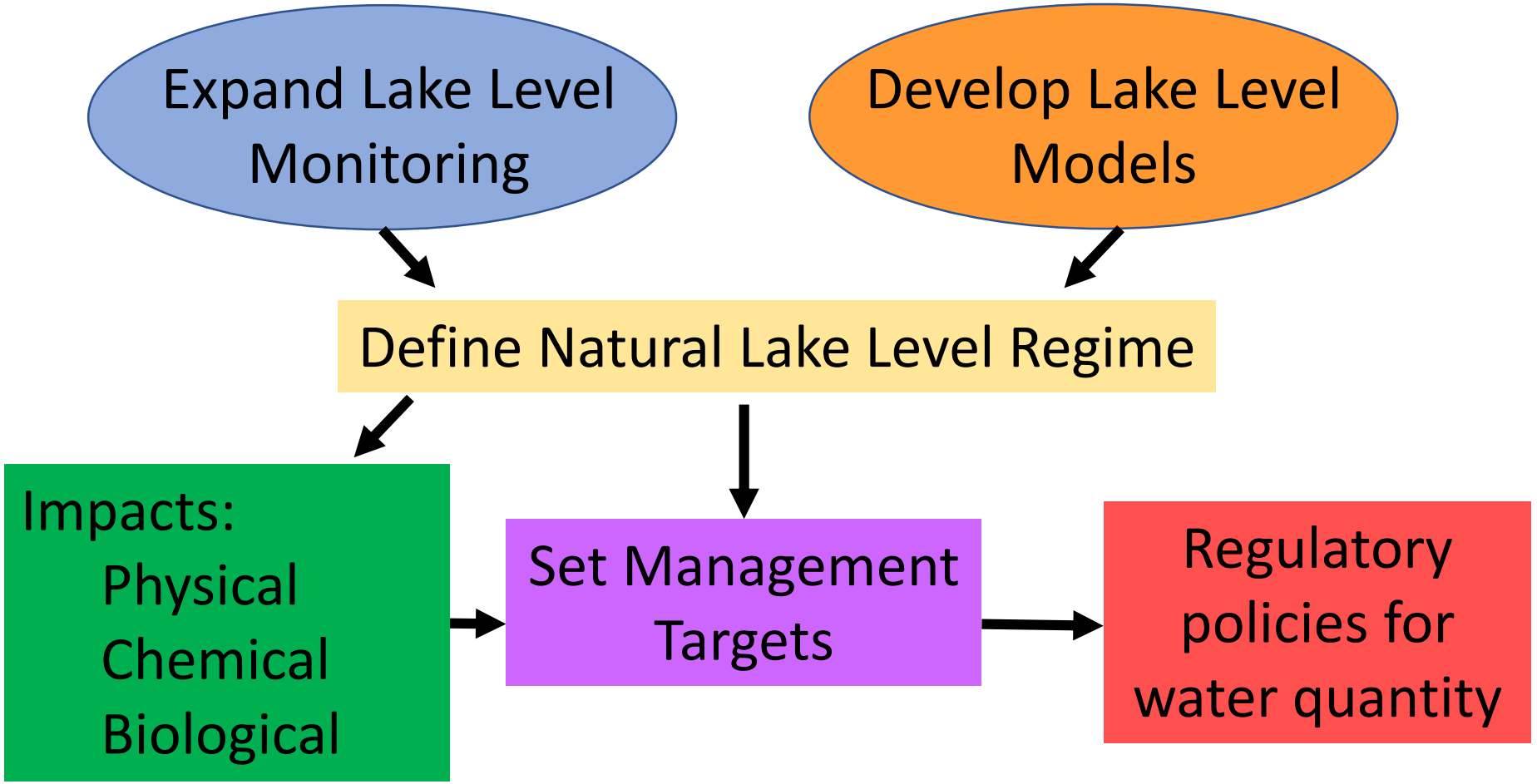


Daily Streamflow Data



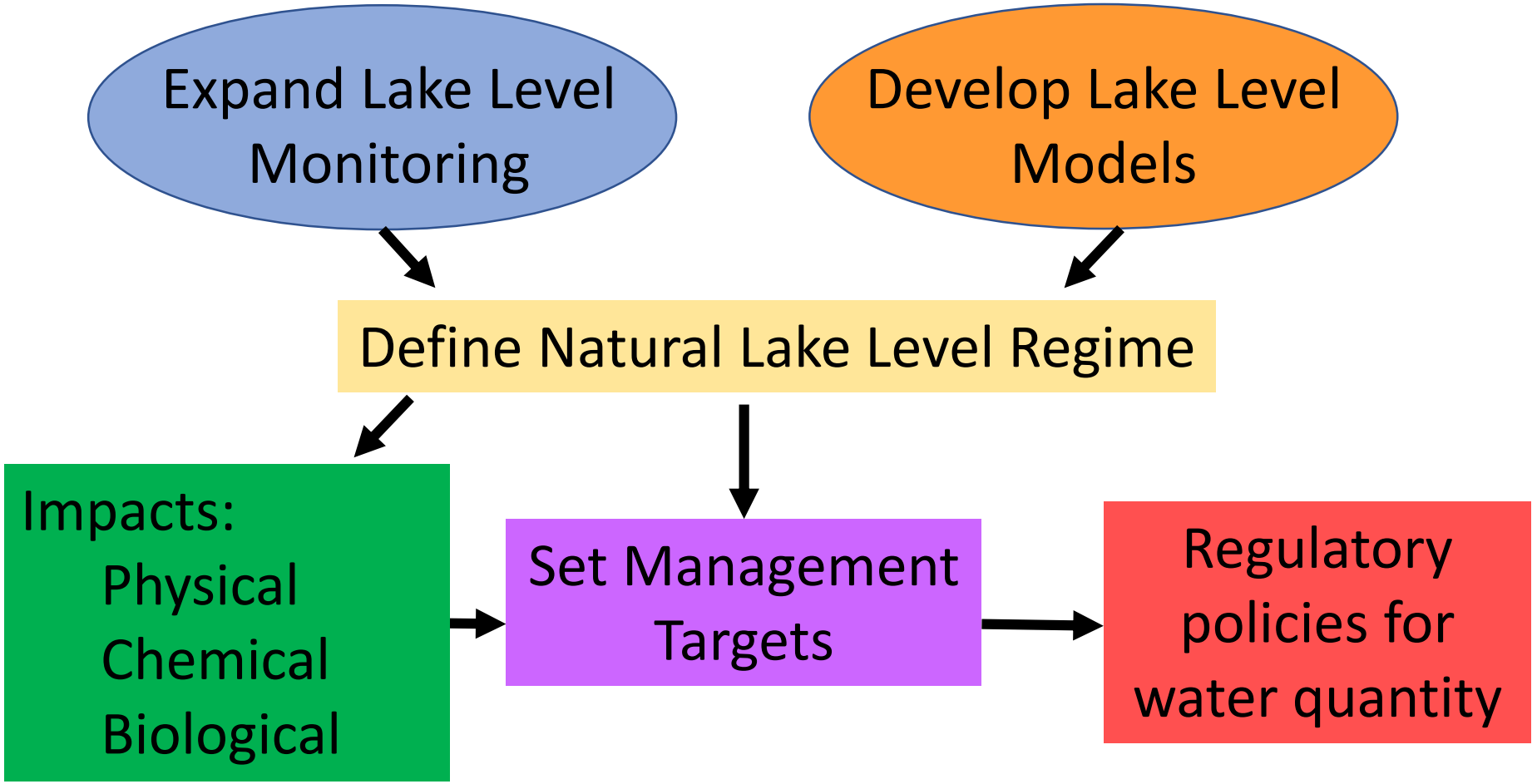
Stream Gauging Station

Future for Lake Level Research & Management



Volunteer Lake Level Monitoring

Future for Lake Level Research & Management



Understand how groundwater and climate influence water level fluctuations in Wisconsin's seepage lakes

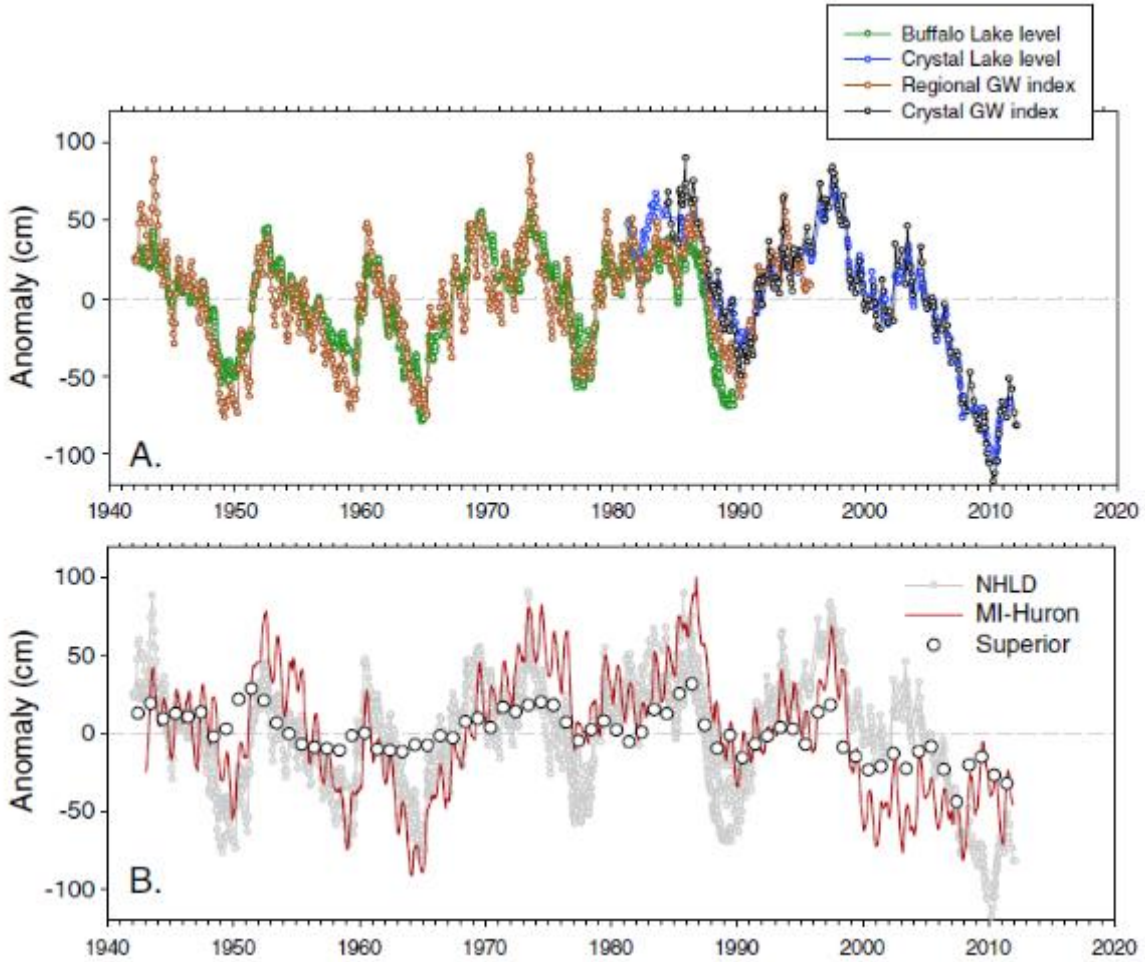
Collaborators:
Noah Lottig, Zhixuan Wu, Eric Booth, Emily Stanley, Corinna Gries, Kang Huang (UW)
Bob Smail, Matt Diebel, Andrew Rypel (WDNR)
Paul Juckem, Jordan Read (USGS)
Funding: State of Wisconsin Joint Solicitation for Groundwater Research

WISCONSIN DEPT. OF NATURAL RESOURCES

USGS science for a changing world

WISCONSIN UNIVERSITY OF WISCONSIN–MADISON

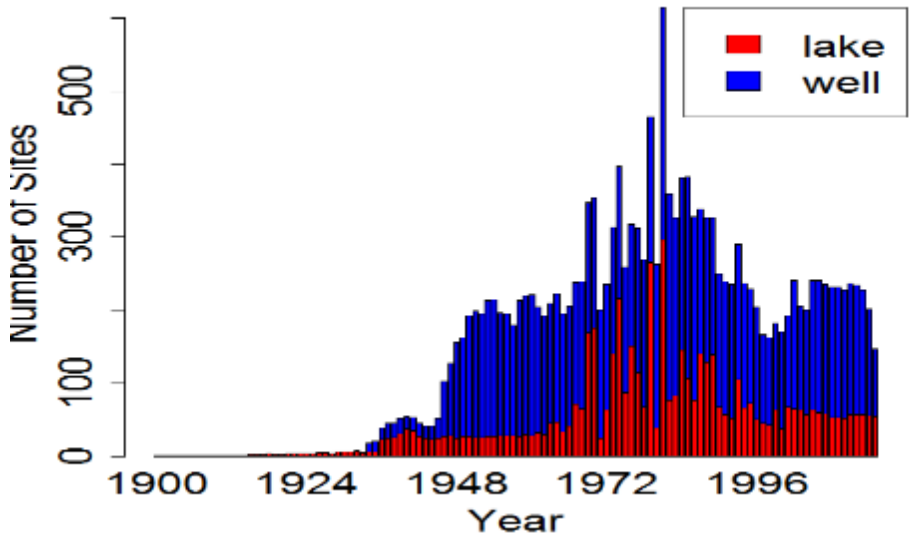
Coherent, near decadal cycle in lake and groundwater levels

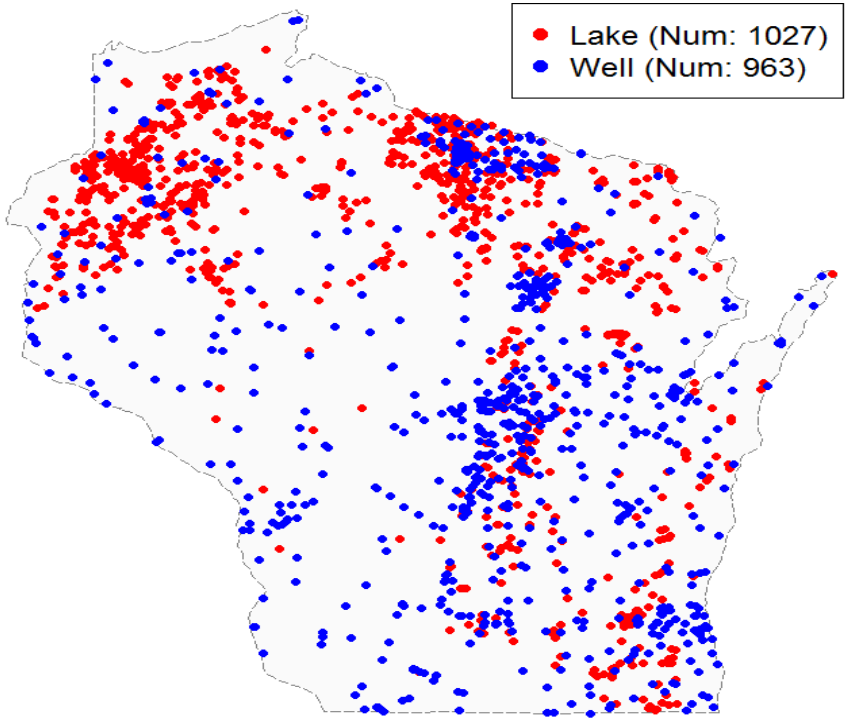


Watras et al. 2014 Geophysical Research Letters

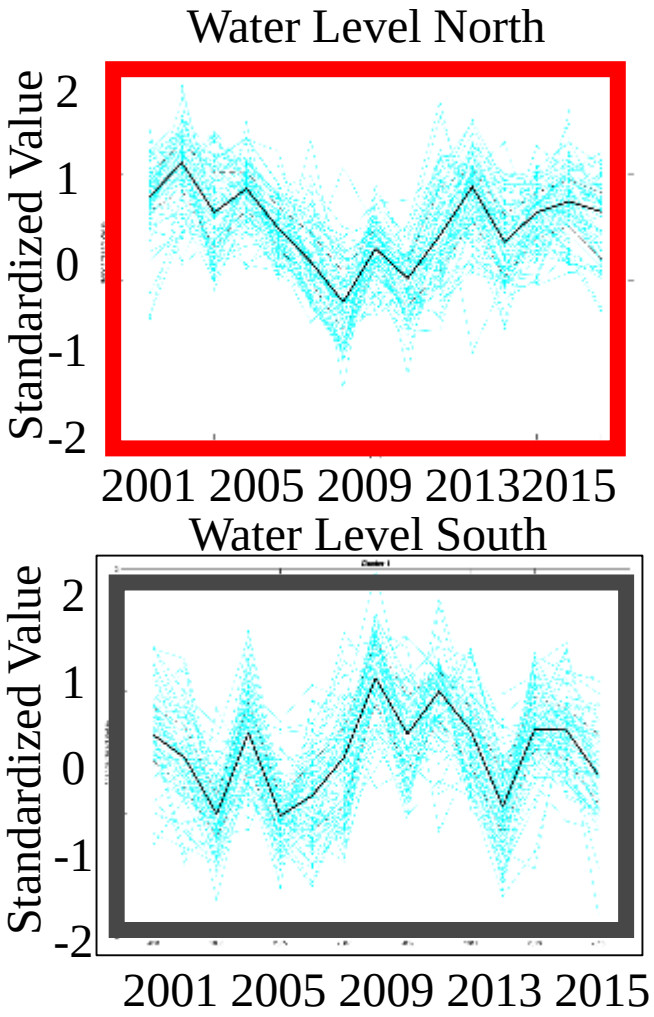
Groundwater and Lake Level Database

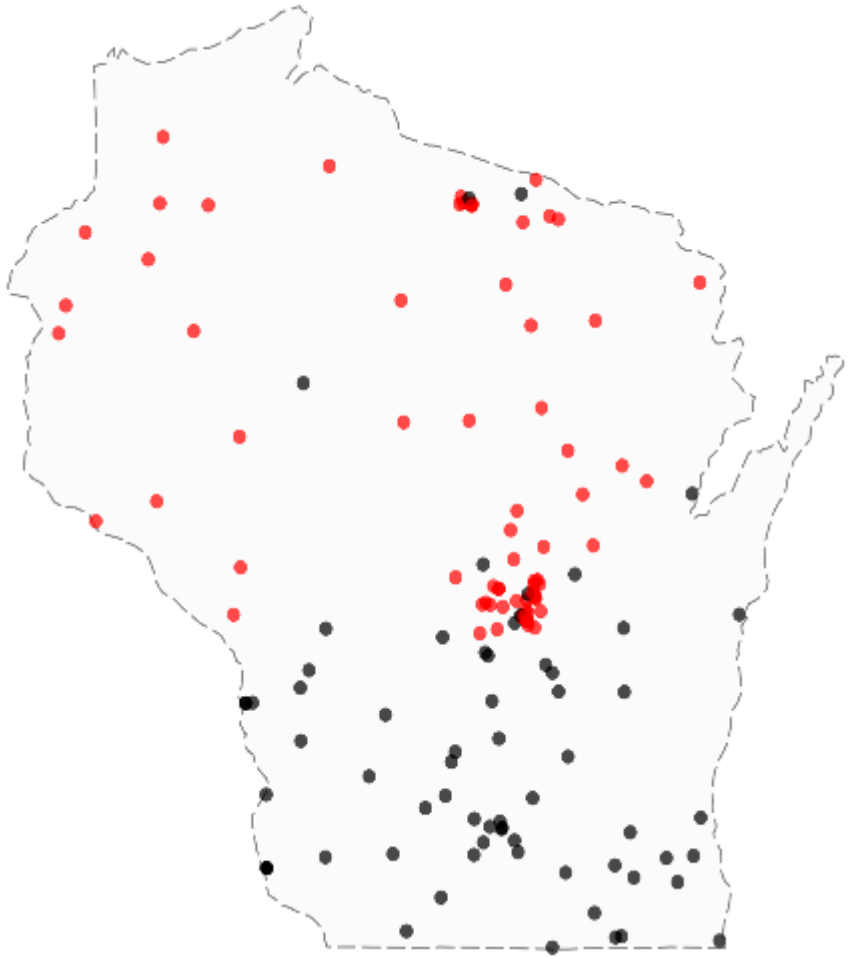
- ~1000 lakes and ~1000 wells from 1900-2015
- Data published on Environmental Data Initiative
- Eight agencies



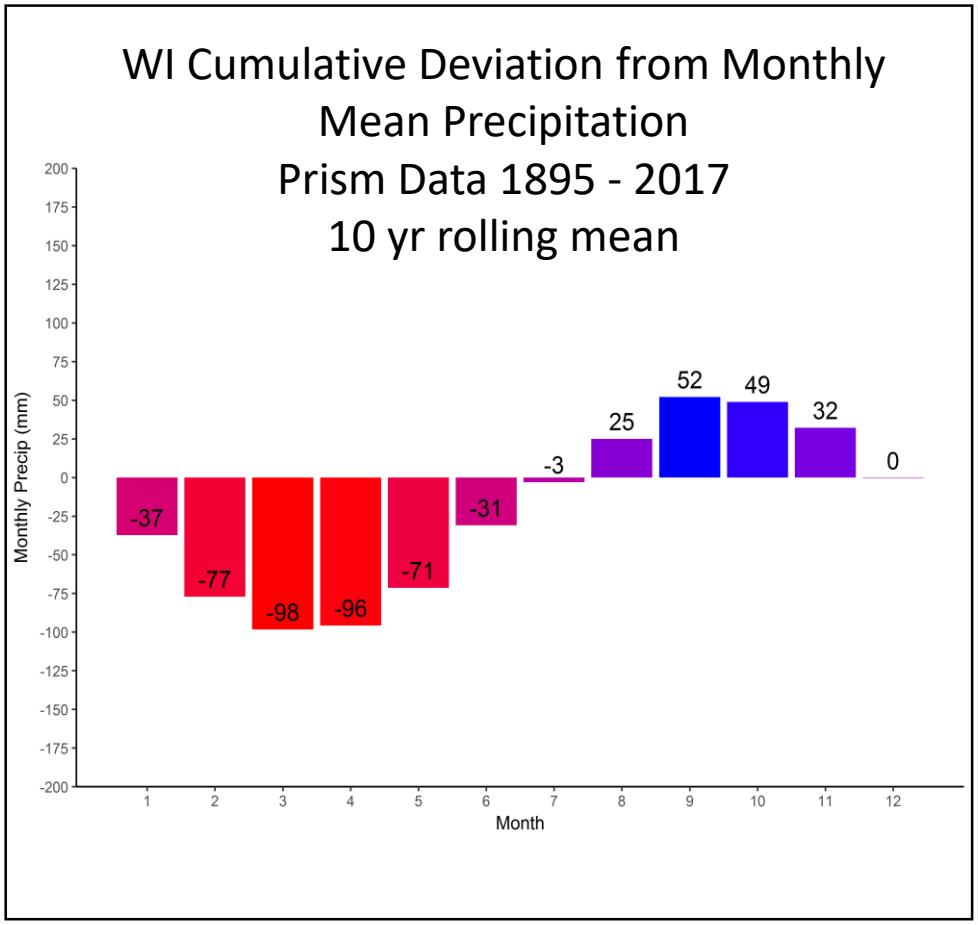


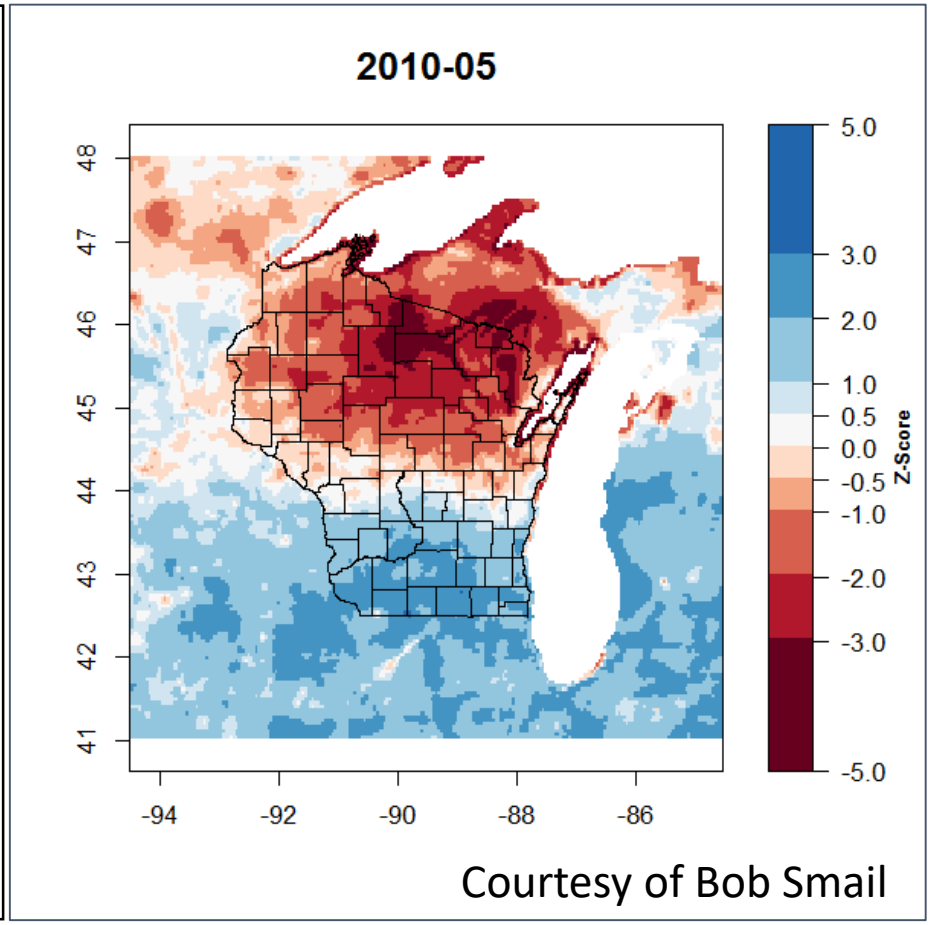
Regional patterns in groundwater and lake level coherence





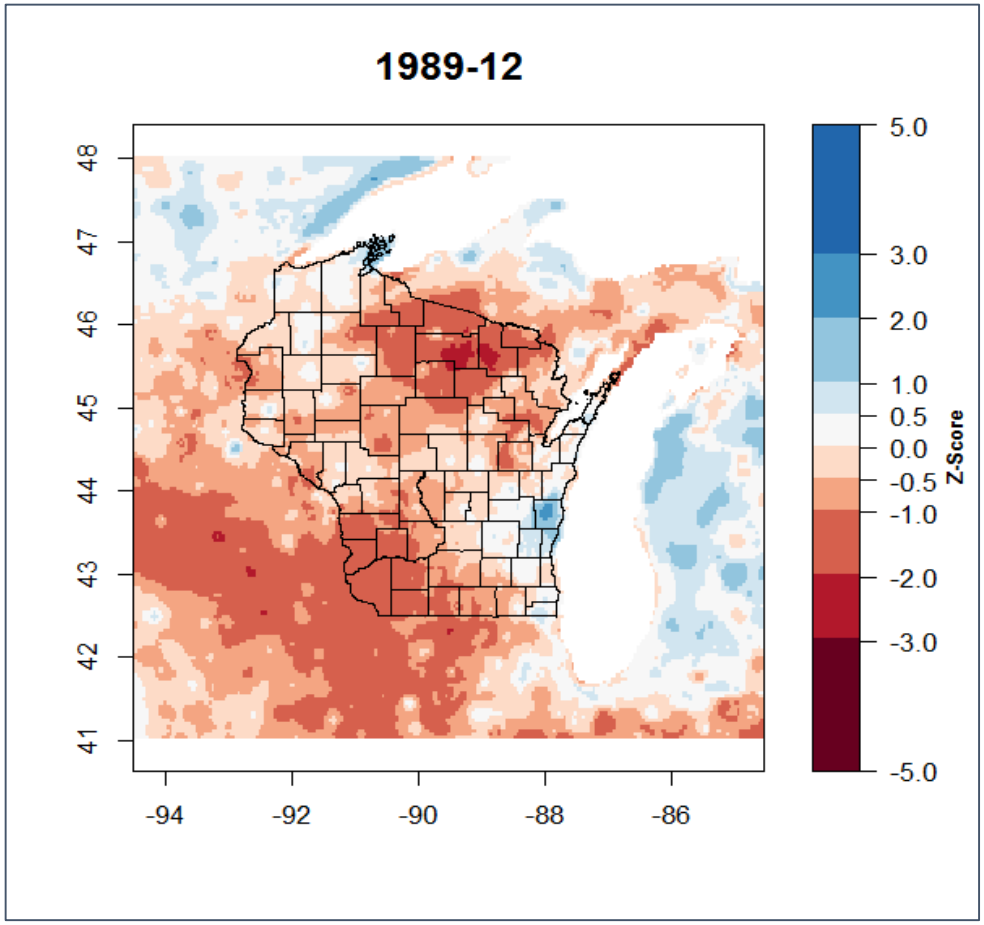
Precipitation best explains north-south divide in water levels

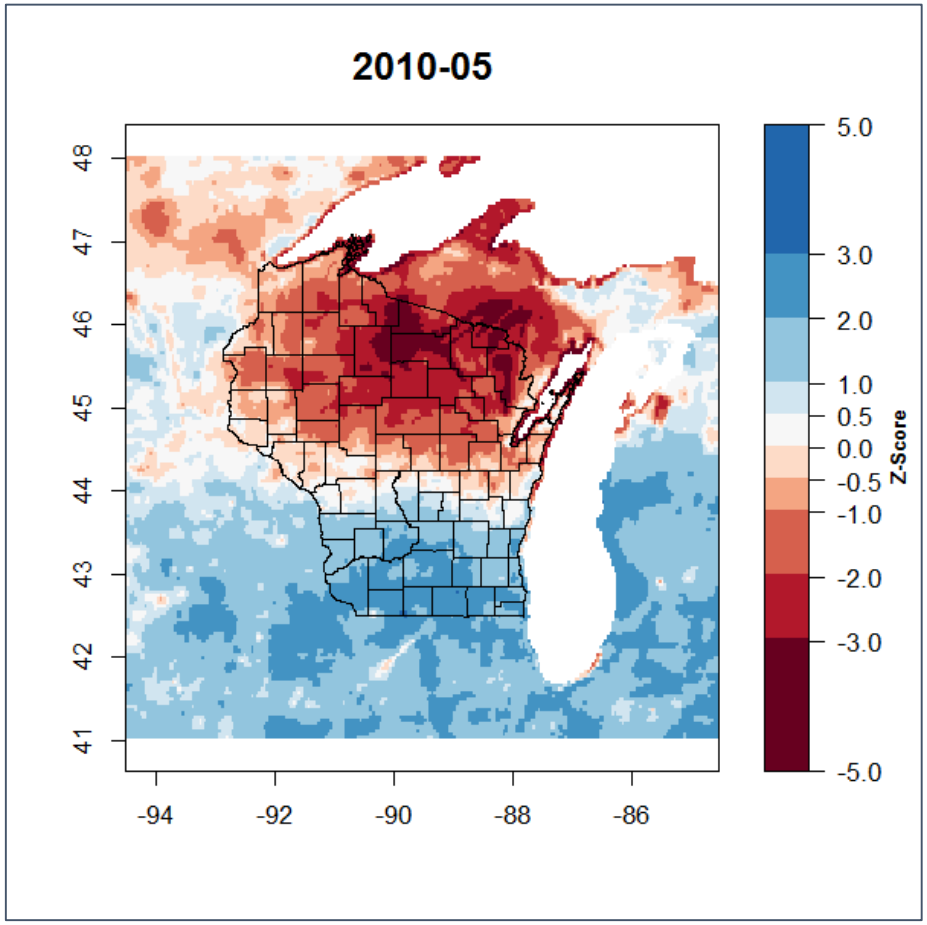




Courtesy of Bob Smail

But regional precipitation patterns change over time





Empirical Bayesian Hierarchical Model

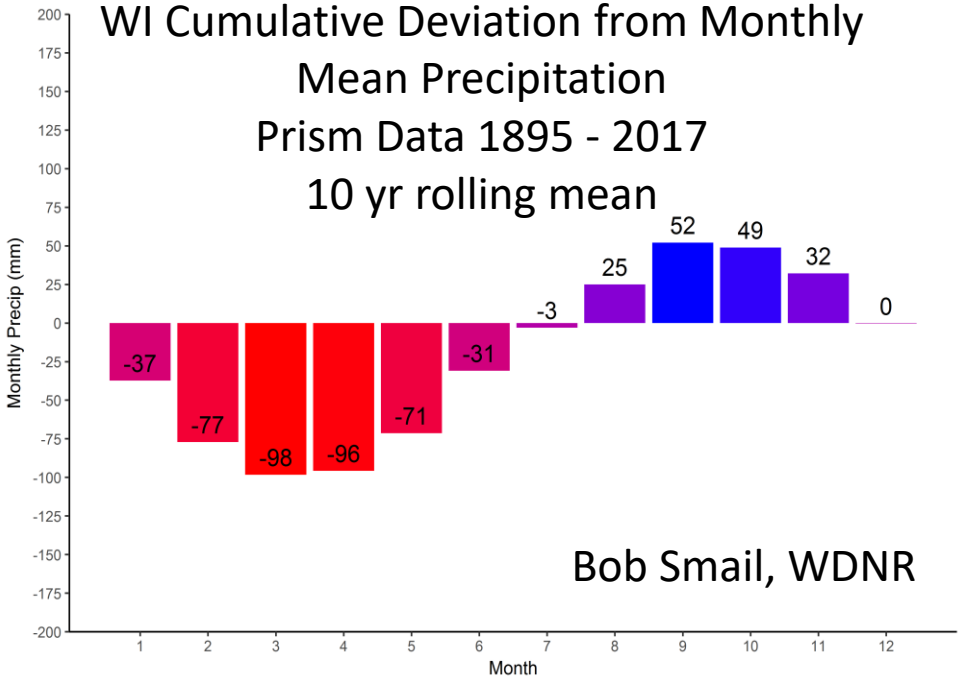
Lake Level = $\alpha + \beta$*Cumulative Deviation from 8-year Rolling Mean Precipitation

Seepage lakes with:

- 8+ years of data
- Groundwater withdrawals < 10,000,000 gals/year
- Observed precipitation range ≥ q85-q15

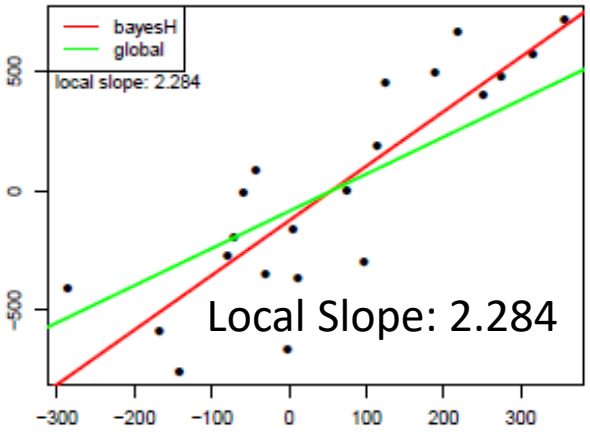
Discarded seepage lakes with:

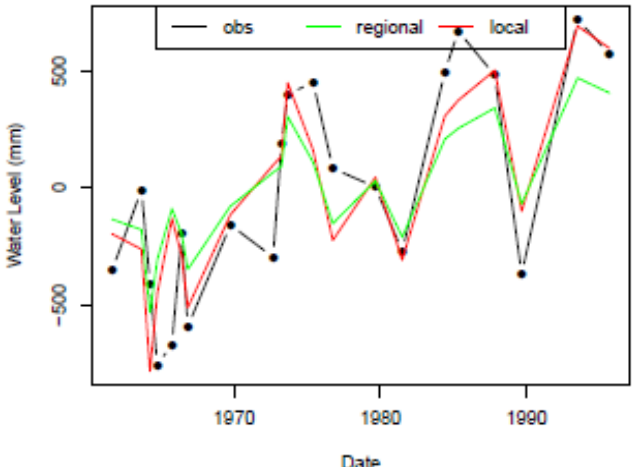
- Negative slopes
- Suspect data



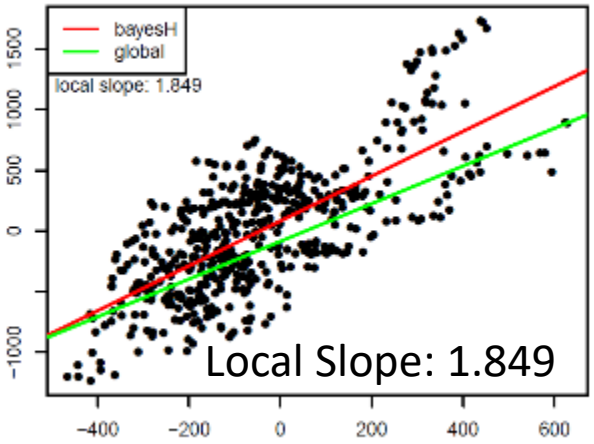
State & local empirical models perform well

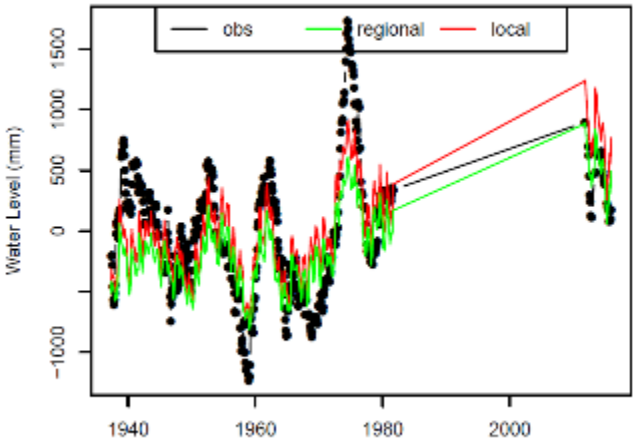
Long Lake - Waushara





North Lake - Walworth





Observed
State
Local

Lake Level (mm)

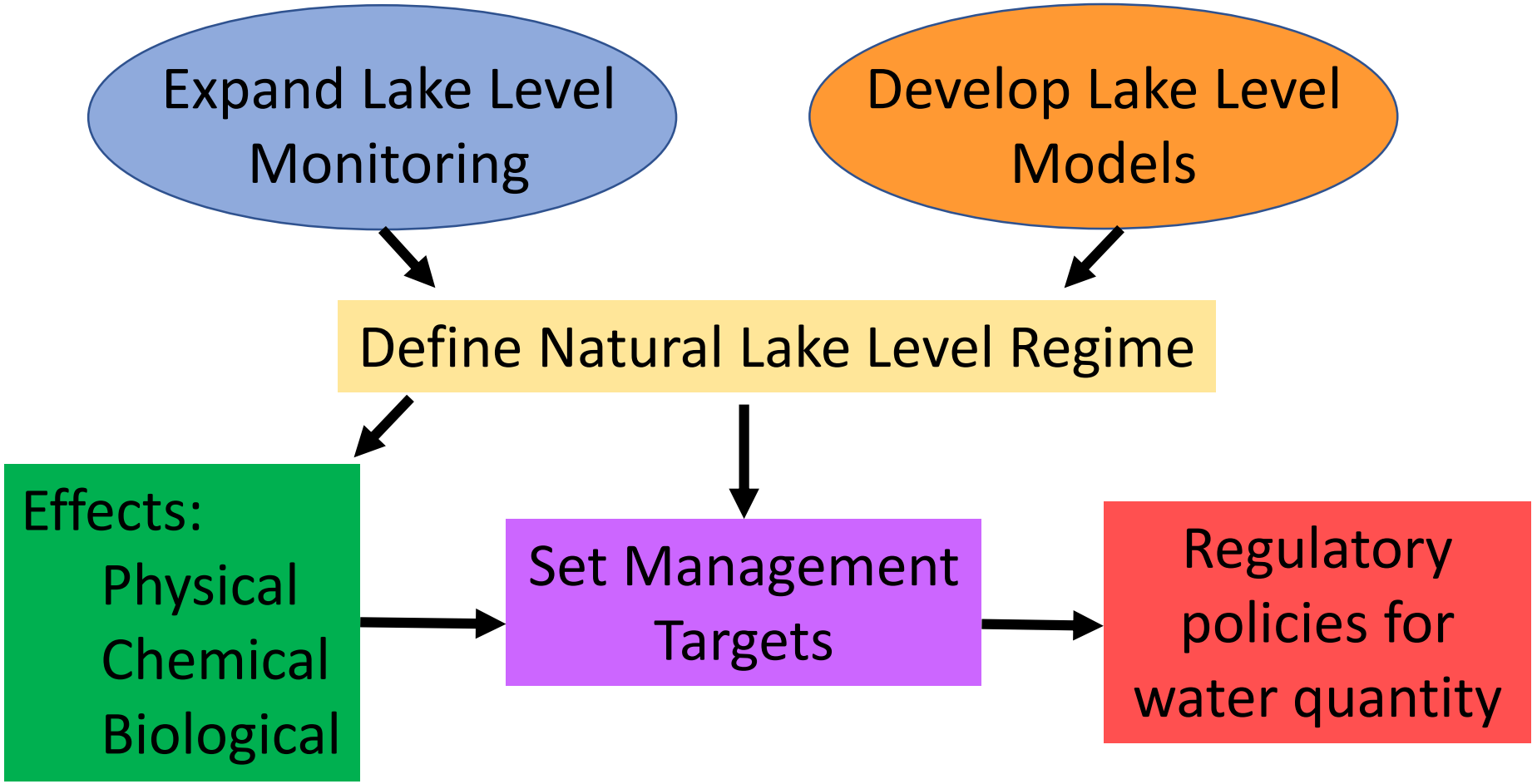
Cumulative Deviation Precipitation (mm)

Year

Predicting and Understanding Lake Levels

- Precipitation drives seepage lake level fluctuations
- Lake levels can successfully be predicted using the 8-year cumulative deviation in precipitation
- Statewide model approximates lake level fluctuations, but may need to collect lake level data to parameterize local model

Future for Lake Level Research & Management



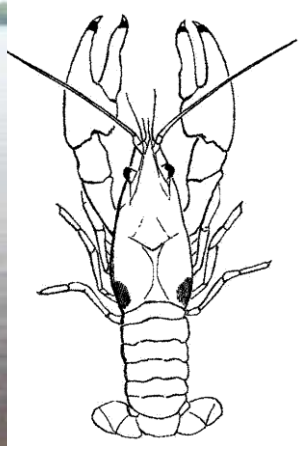
Ecosystem Effects of Lake Level Fluctuations

Water Clarity

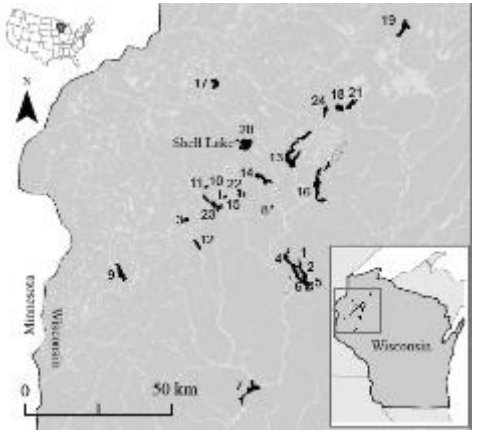
Mercury Bioaccumulation

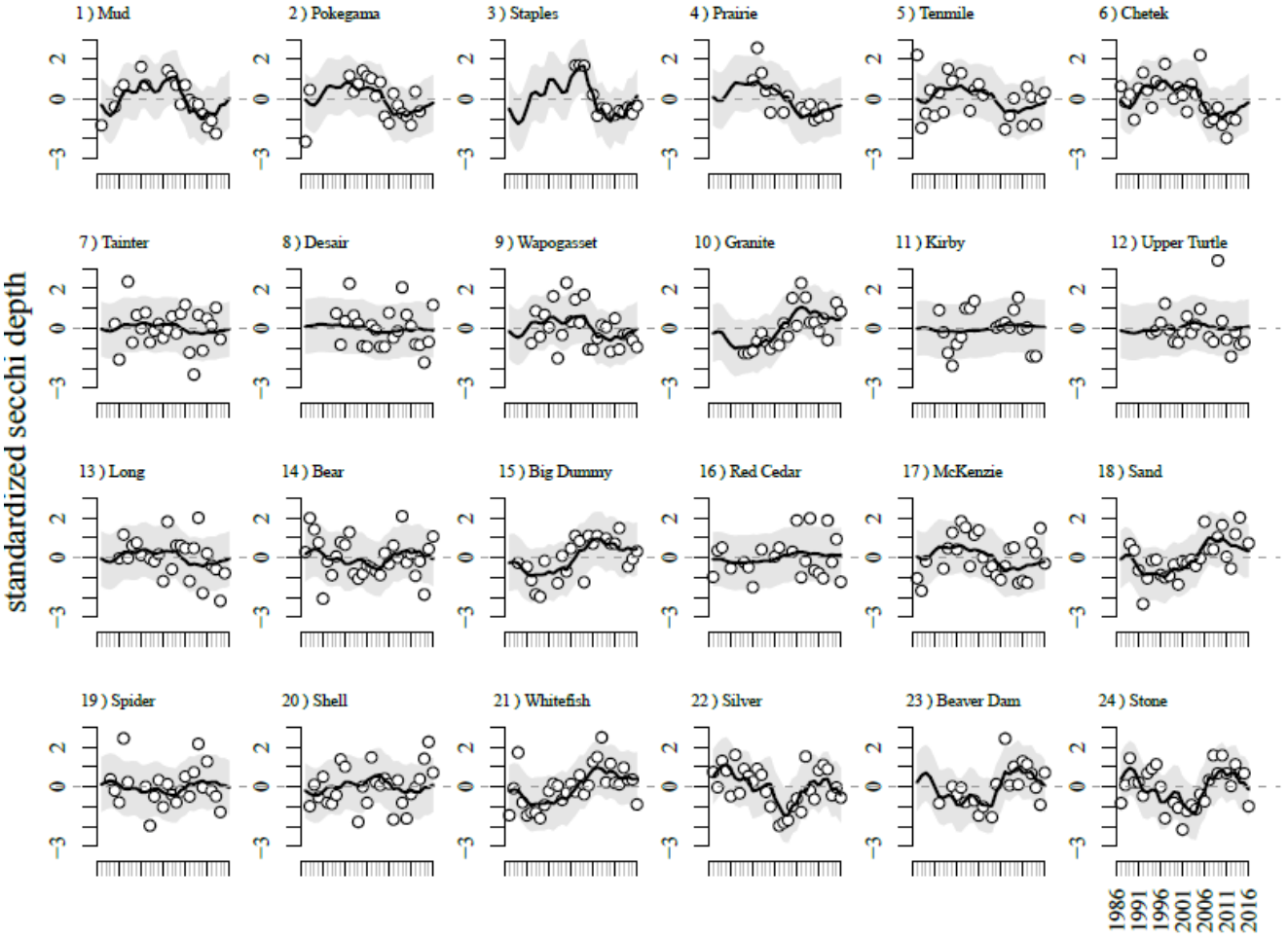
Woody Habitat & Fisheries

Cobble & Rusty Crayfish



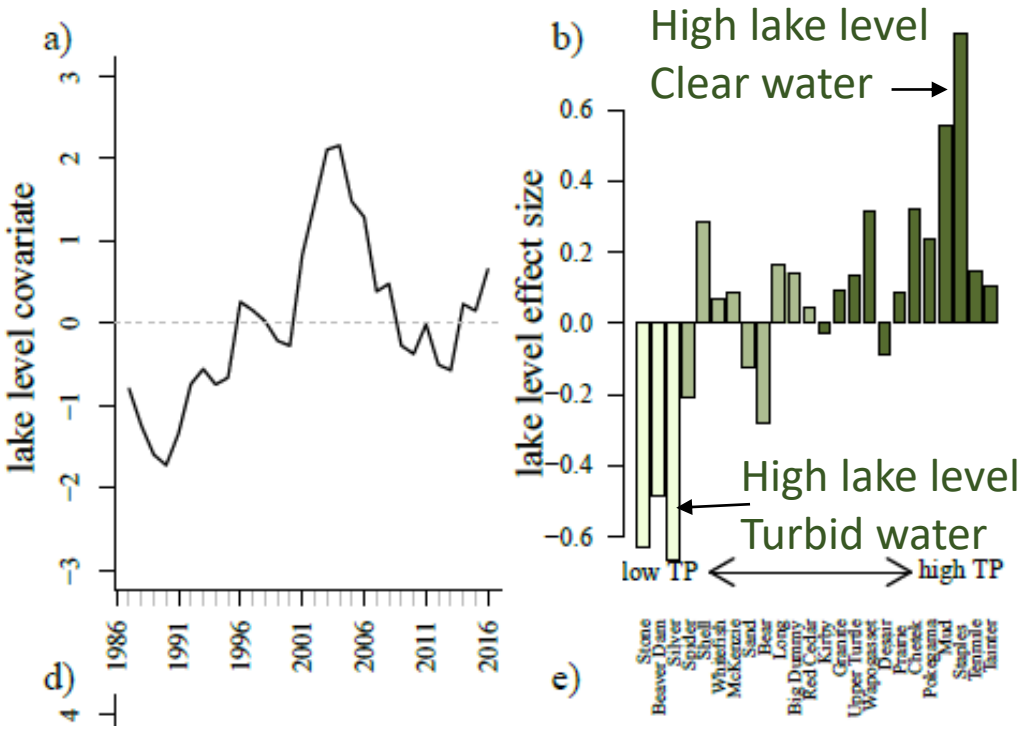
Lake levels influence water clarity





Lisi & Hein 2019 L&O

Lake levels influence water clarity



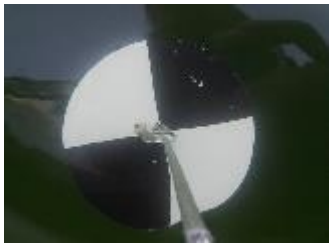
Eutrophic: water is more clear at high lake levels

Oligotrophic: water is more clear at low lake levels

Lisi & Hein 2019 L&O

Influence of drought on water clarity

More Clear



- Reduced phosphorus loads
- Reduced shoreline erosion
- Ultraviolet bleaching
- Dimictic, Oligotrophic lake
- Ex. Silver Lake

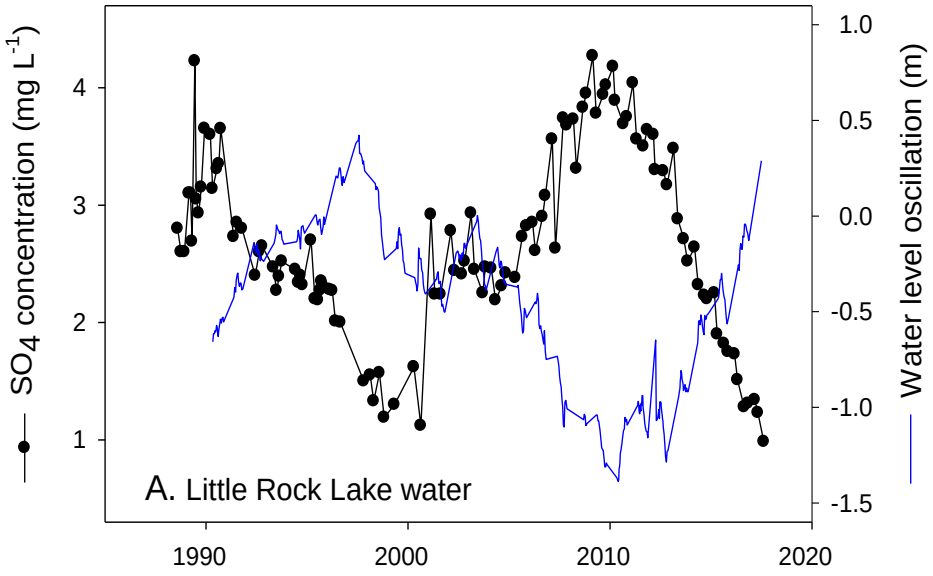
Less Clear

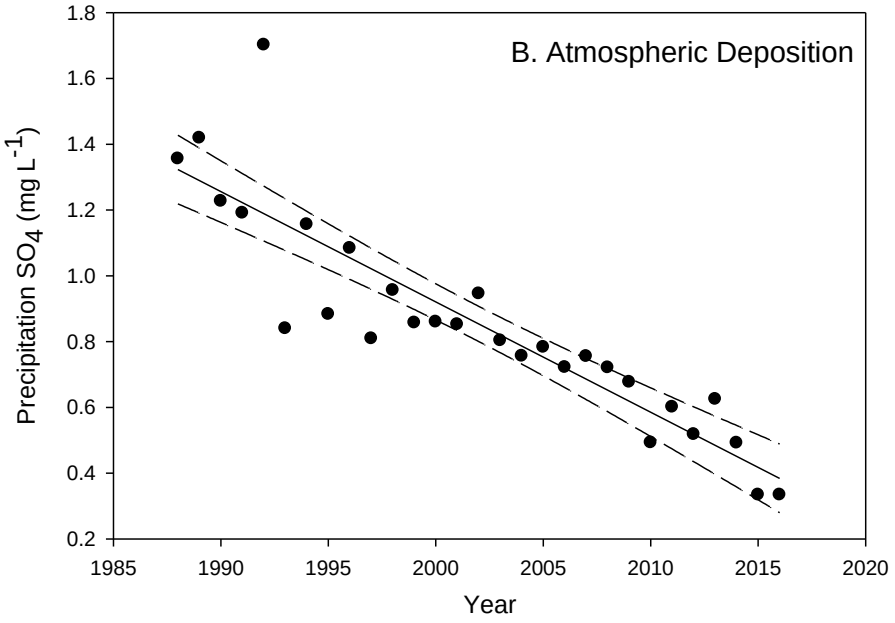
- Warmer surface water
- Internal nutrient loading
- Concentration of nutrients
- Polymictic, eutrophic lakes
- Ex. Shell Lake, Anvil Lake

Juckem & Robertson 2013 USGS 2013-5181

Mosley 2015 Earth Science Reviews

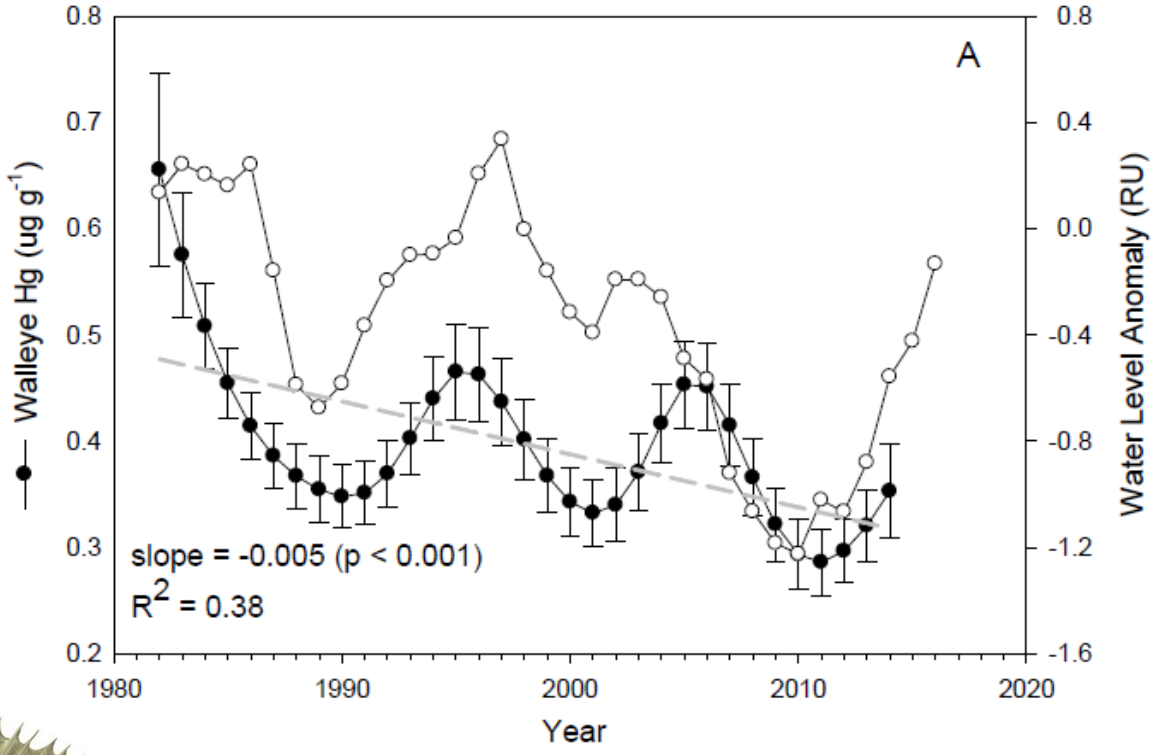
Lake water sulfate (and pH) now track the water cycle rather than atmospheric deposition





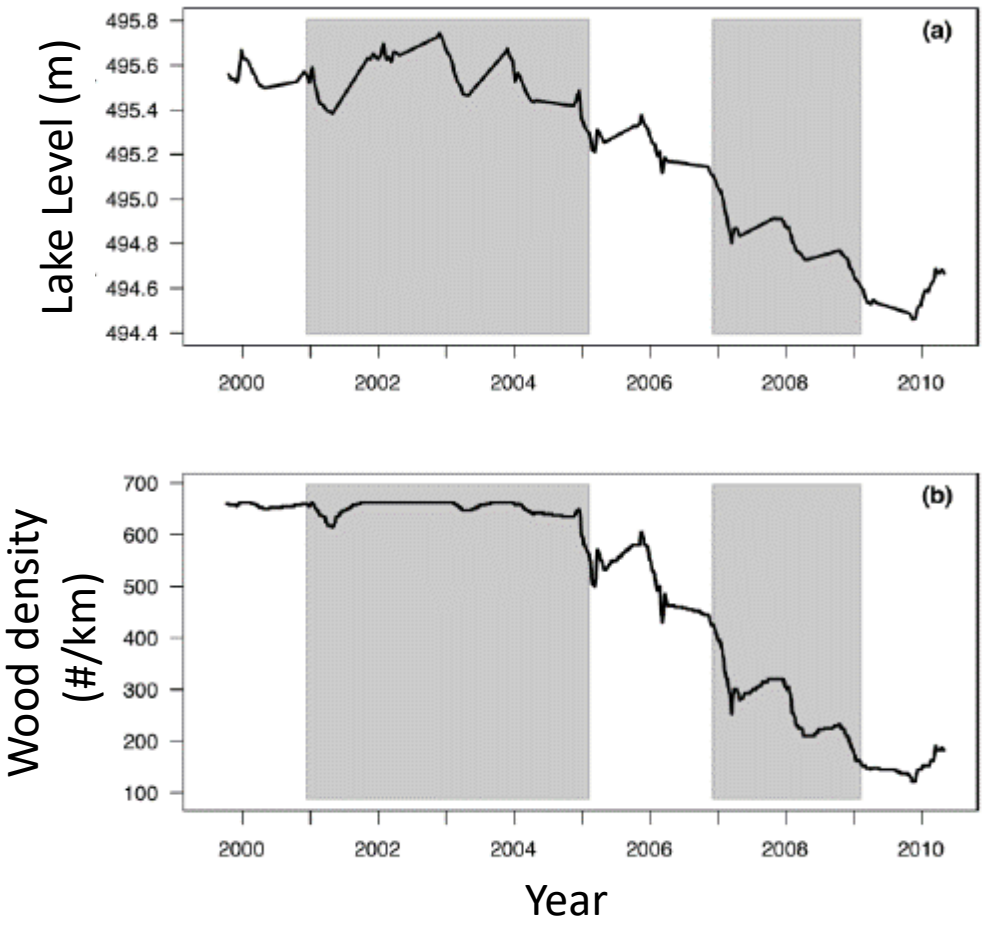
Watras et al. 2018 Can. J. Fish. Aqu. Sci.

Higher mercury concentrations in walleye in high water years



Watras et al. 2018 Can. J. Fish. Aqu. Sci.

Low lake levels decrease available coarse woody habitat and impact fisheries

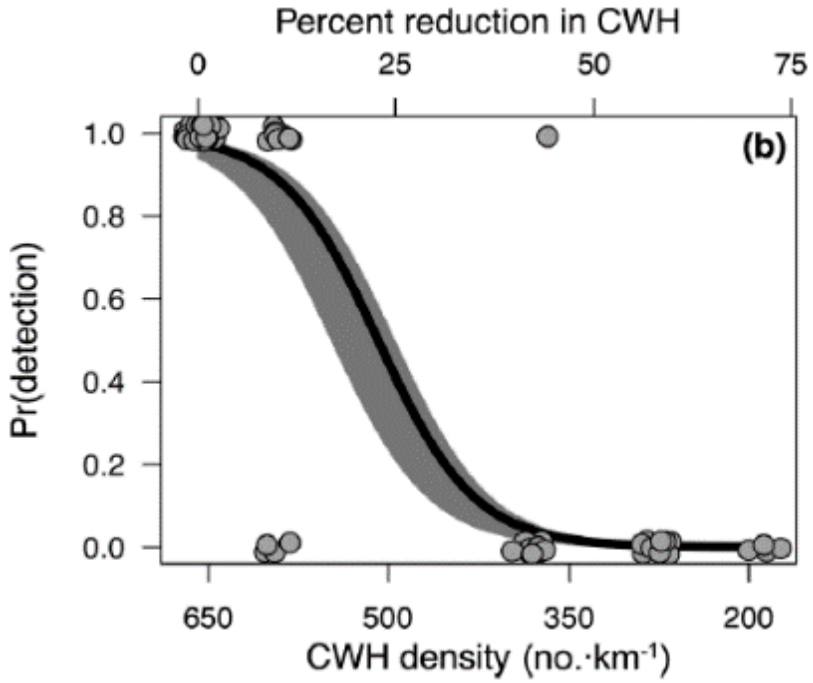


Lake levels in Little Rock Lake declined by >1.1 m and 76% of coarse woody habitat became inaccessible to fish.

Gaeta et al. 2014 CJFAS v.71

Reduced perch abundance and largemouth bass growth rates

Yellow Perch Abundance



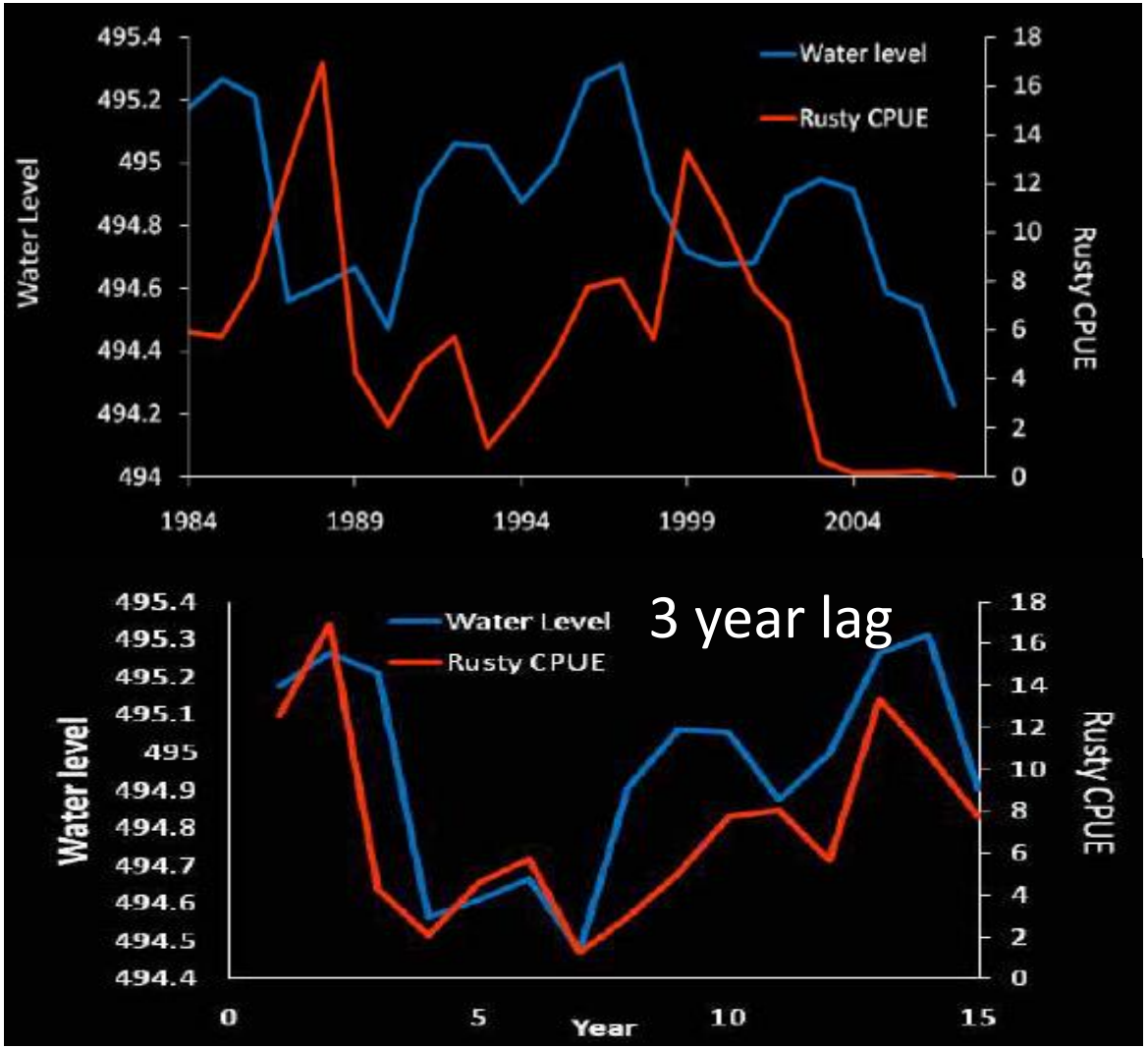
Largemouth Bass Growth

Gaeta et al. 2014 CJFAS v.71

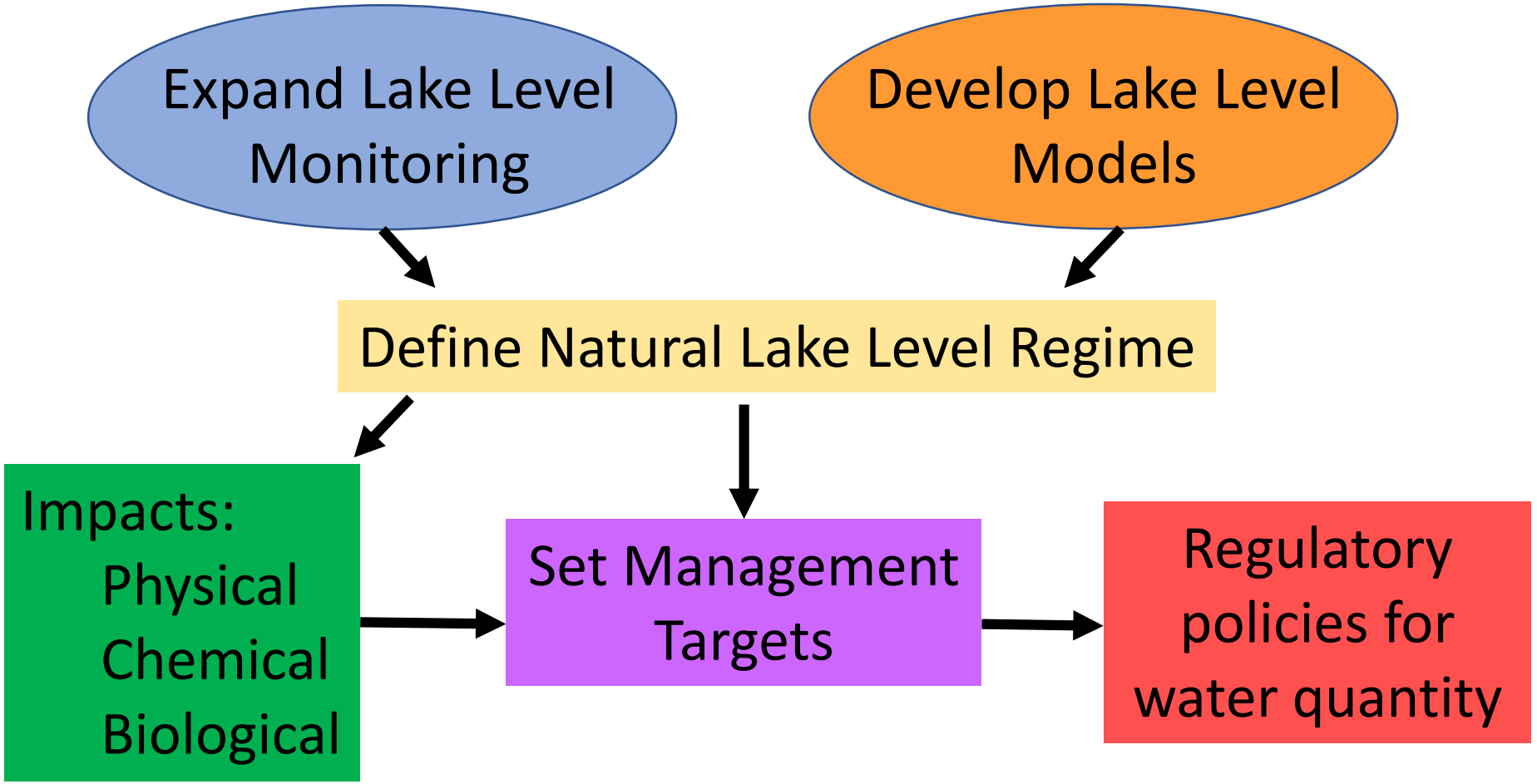
Recruitment of invasive rusty crayfish reduced when cobble exposed

Sparkling Lake, Vilas County

Courtesy of Tim Kratz
UW North Temperate Lakes
Long Term Ecological Research



Future for Lake Level Research & Management



Example Management Targets

- Species Richness: <15% areal loss in lake area at Historic P50
- Lake Mixing
- Basin Connectivity
- Max vertical extension of *Carex*: P10 – P75
- Min water depth in *Carex* during spawning of pike
- Aesthetic: Historic P90
- Water skiing: minimum area > 5 feet deep

Florida Administrative Code CHAPTER 40D-8
Keto et al. 2008 Hydrobiologia

Future for Lake Level Research & Management