Non-monotonic Trends in Citizen-based Regional Lake Water Clarity

Noah Lottig, Tyler Wagner, Kendra Spence Cheruvelil, Emily Norton Henry, Craig A. Stow, John A. Downing, Katherine E. Webster

Background

- Citizen-based monitoring networks represent an alternative to the limited sampling performed by state and federal agencies.
- These networks provide the opportunity to compile and analyze data collected over large spatial and temporal scales.
- Lake water clarity (often measured as Secchi disk depth) is extensively monitored by citizens.
- This situation provides an ideal opportunity to detect trends in lake water clarity across large spatial scales and long temporal scales.
- These trends can then inform local, regional, or federal policies and management actions.

Question: What are the spatial and temporal trends in citizen monitoring Secchi data?

Research Approach

- Generate a spatial and temporally extensive database of citizen-collected, publically available lake Secchi disk depth data

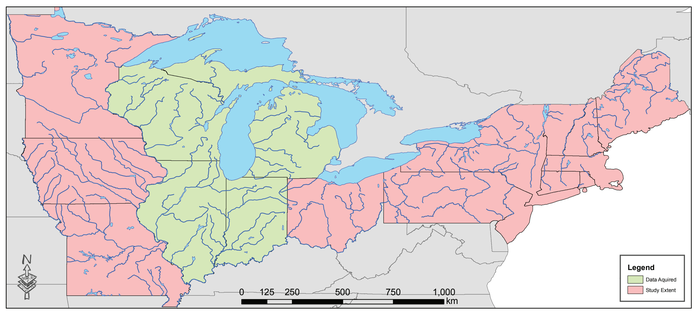


Figure 1. Map of entire study extent (17 NE U.S. states; pink) and focal area depicted for this poster (green)

- Data sources:
  - WI: Wisconsin Citizen Lake Monitoring Program (CLMP)
  - IL: Illinois Volunteer Lake Monitoring Program (VLMP)
  - IN: Indiana Clean Lakes Program (CLP)
  - MI: Michigan Clean Water Corps (MiCorps)
- Data were aggregated to obtain an annual average for individual lakes
- Long-term trends identified with Bayesian Hierarchical Models
- Future work will include:
  - QA/QC remainder of the 17 states
  - Merge Secchi data with basic and readily-available landscape data
  - Conduct analyses that include both space and time

The Data

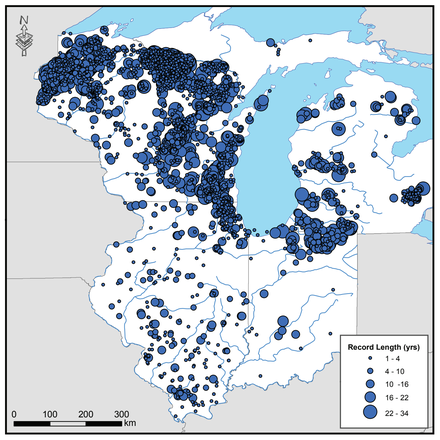


Figure 2. Map depicting locations of citizen-collected Secchi disk depth data. The lake locations are indicated by a circle, with the length of data record depicted by the relative size of circles. Information about the number of lakes sampled are in the bottom left inset. There are ~230,000 citizen-collected Secchi disk depth observations from ~2500 lakes in 4 U.S. Great Lakes states.

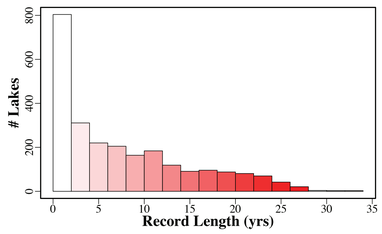


Figure 3. Histogram of annual monitoring records for all lakes. 50% of lakes have 6+ years of data (longest record is 34 yrs).

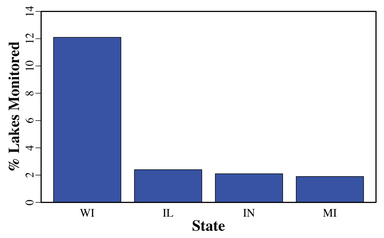


Figure 4. Percent of lakes within a state monitored by citizens. Highest percent of citizen Secchi disk depth monitoring occurs in Wisconsin (~12%).

Results: Spatial Trends

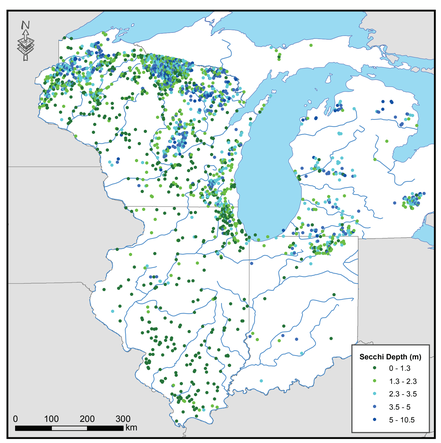


Figure 5. Map of Secchi disk depths. Secchi disk depths are depicted along a color gradient from shallow (dark green) to deep (dark blue). Frequency distribution showing the number of lakes with each Secchi depth are in the bottom left inset. Majority of secchi measurements are < 4 meters and Secchi measurements > 6 meters rare.

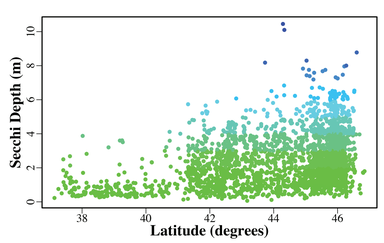


Figure 6. Secchi disk depths versus latitude. There appears to be an increasing latitudinal gradient in Secchi depths. However, it is unclear what is driving this pattern (e.g., spatial location, # monitored lakes).

Results: Temporal Trends

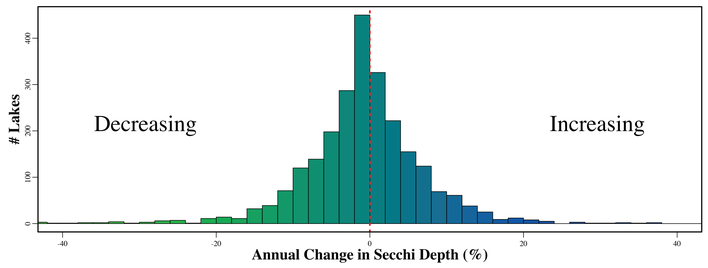


Figure 7. Frequency distribution of the number of lakes experiencing decreasing (left) to increasing (right) annual changes in Secchi disk depth. Long-term trends indicate secchi depths are generally declining over the 4-state region (97% probability average secchi depth decreasing). Average annual change is ~1% decrease in Secchi depth.

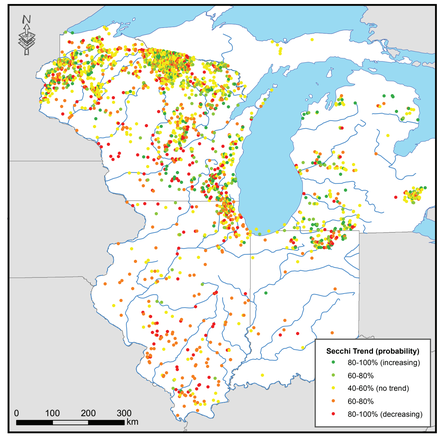
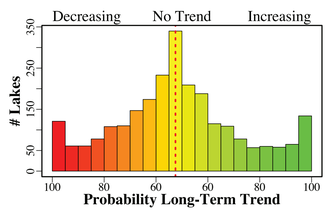


Figure 8. Map of the probability of Secchi disk trends across 4-state study area. Probability of Secchi disk declines are depicted along a color gradient from not likely (likely increasing Secchi, green) to very likely(red). Frequency distribution showing the number of lakes with each probability of Secchi depth trend below.



Future Research questions

1. How do weather trends such as drought and warming influence water clarity?
2. How do monitoring strategies and timing influence the probability of detecting trends?
3. How much temporal and regional synchrony is there in transparency trends?
4. Are trends more likely in lakes that are perturbed by anthropogenic factors?
5. What is the spatial component of transparency trends?
6. How long do transparency records need to be in order to detect significant trends?
7. Are regional synchrony and trends influenced by the season or seasons in which monitoring occurs?