Citizen Scientists Help Identify Long-term Trends in Water Clarity Across the United States

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What are the long-term patterns of water clarity

Pietro Angelo Secchi

Ecoinformatics




FW science
















GIS science

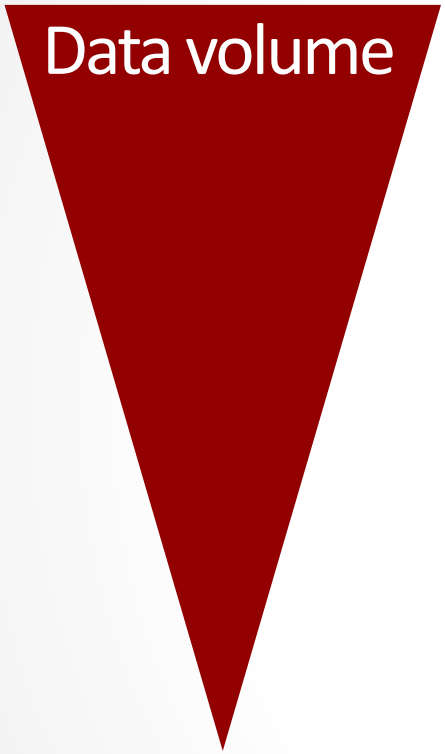




Statistics & machine learning




LAke GeOSpatial temporal database



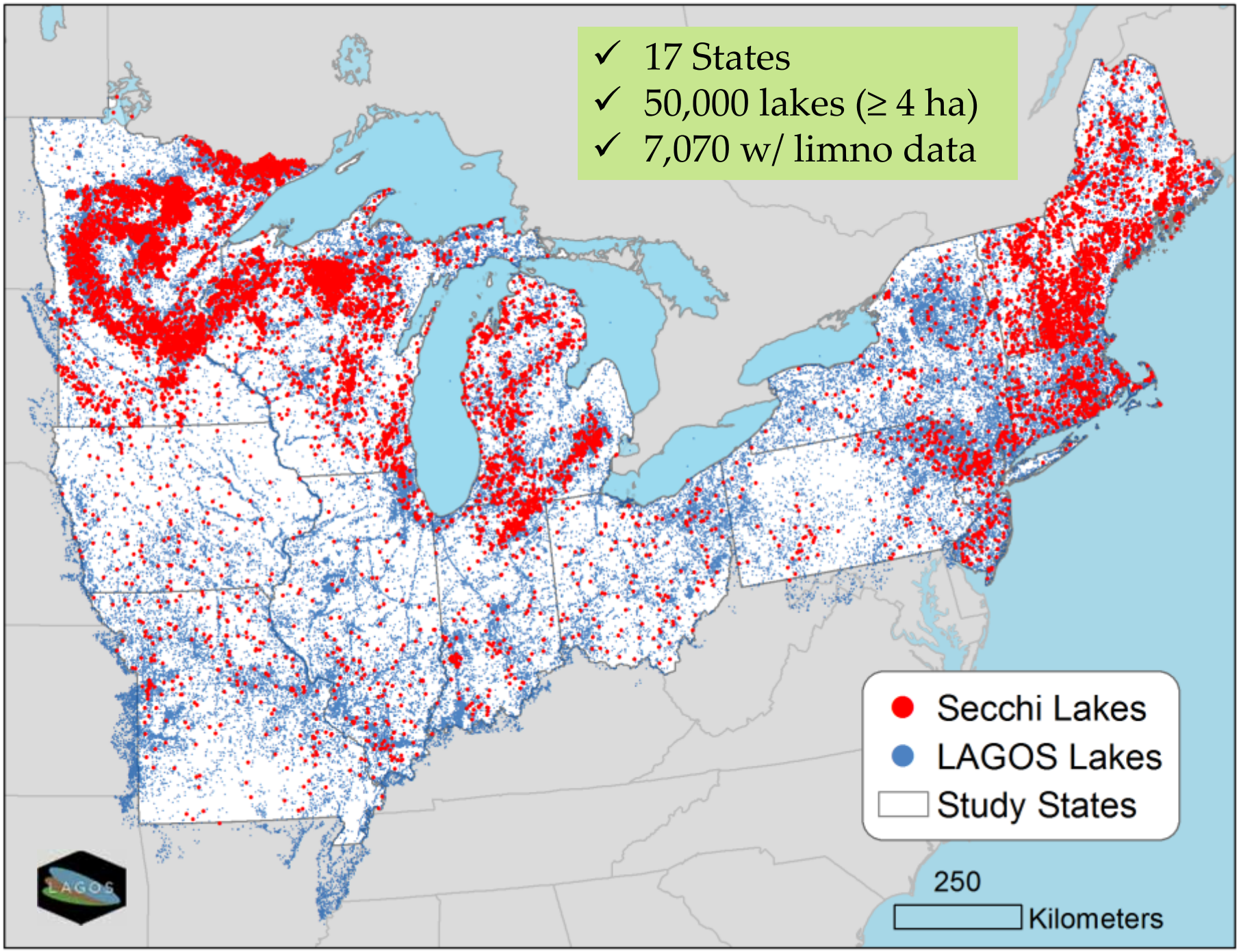
State & tribal agencies

Citizen monitoring programs

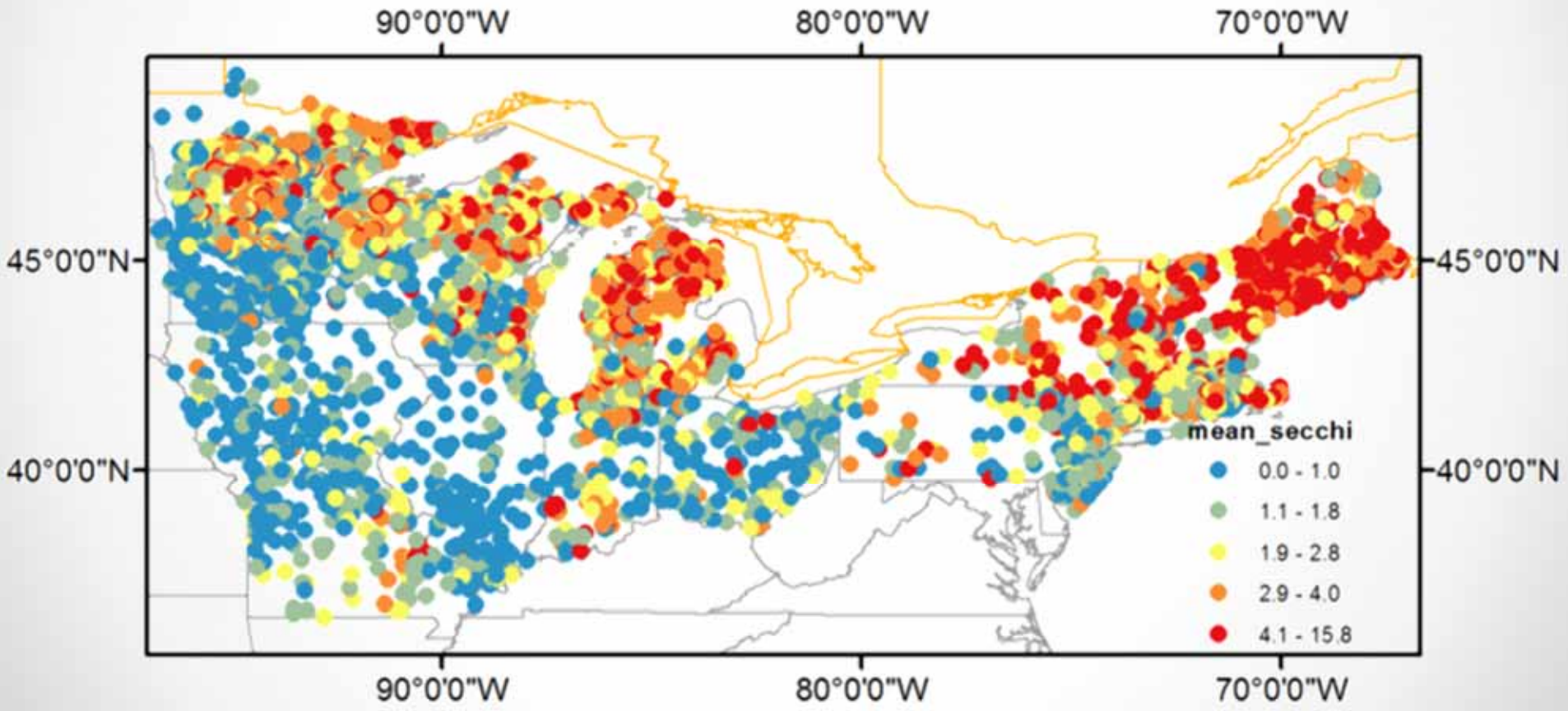
Federal agencies

University researchers

Limnological data sources *(~90 total)*


✓ 17 States
✓ 50,000 lakes (≥ 4 ha)
✓ 7,070 w/ limno data
Secchi Lakes
LAGOS Lakes
Study States
250
Kilometers

Average Secchi

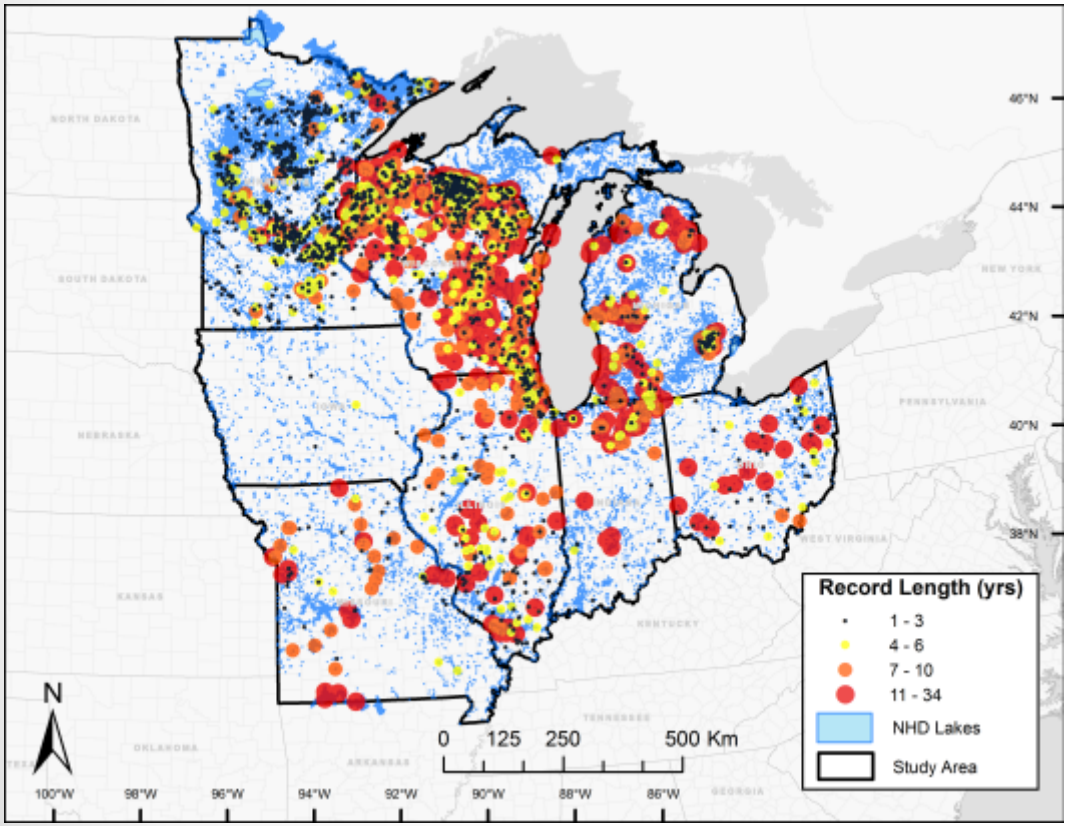


Research Questions

- What are the long-term trends in water clarity across a broad spatial extent
- How does spatial location, size, and monitoring time period influence long-term trends

Lottig et al. PLoS ONE (2014)

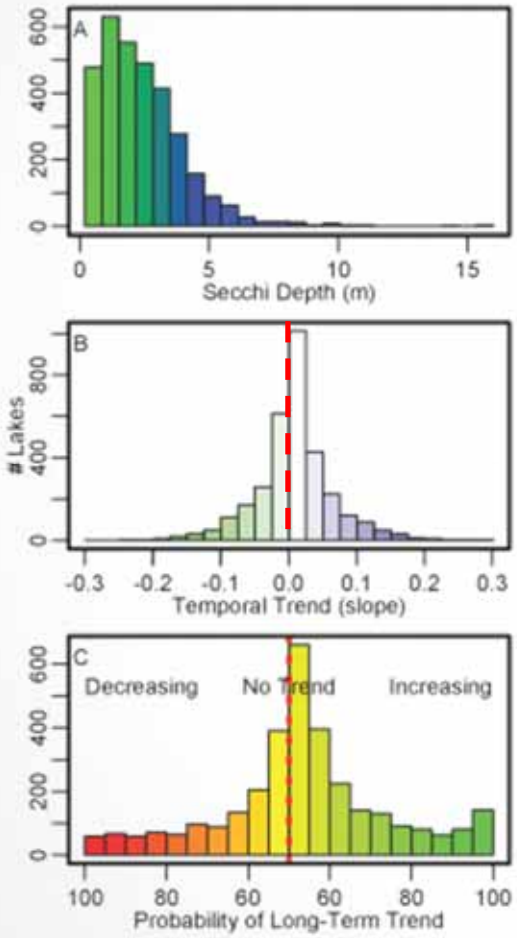
Long-term lake clarity trends



- Citizen Data!
- 8 States
- 239,741 observations
- Summer Observations
- 21,020 annual values
- 3,251 different lakes

Lottig et al. PLoS ONE (2014)

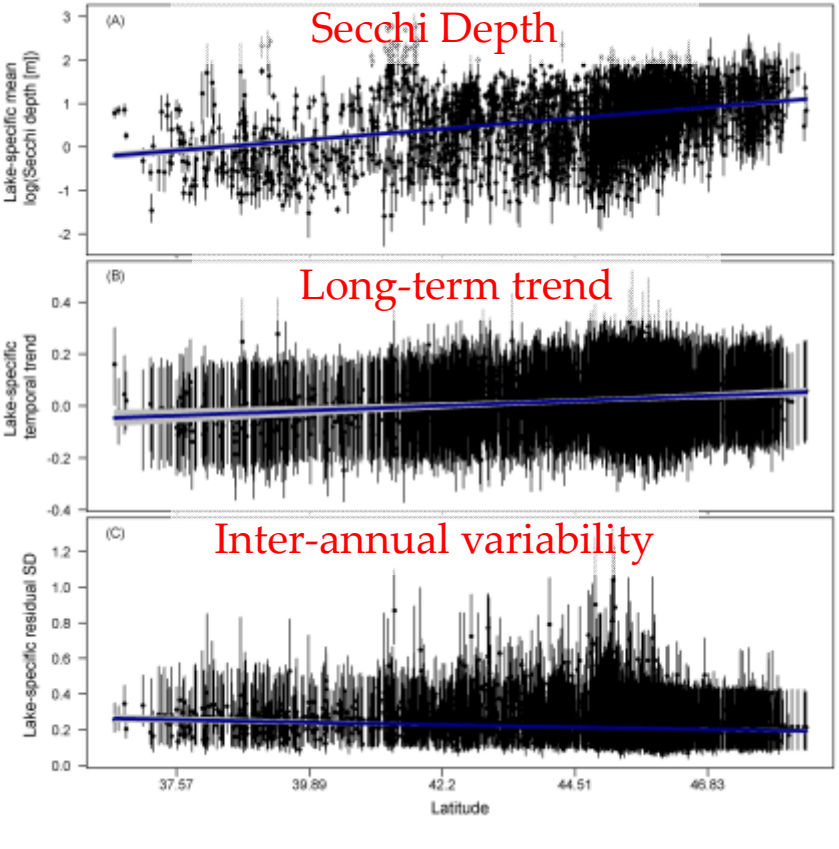
Long-term lake clarity trends



- Average Secchi (2.4m)
- Low inter-annual variability (30%)
- 1% yr^{-1} increase in Secchi depth
- Few lakes with significant long-term trends
  - 7% increasing
  - 4% decreasing

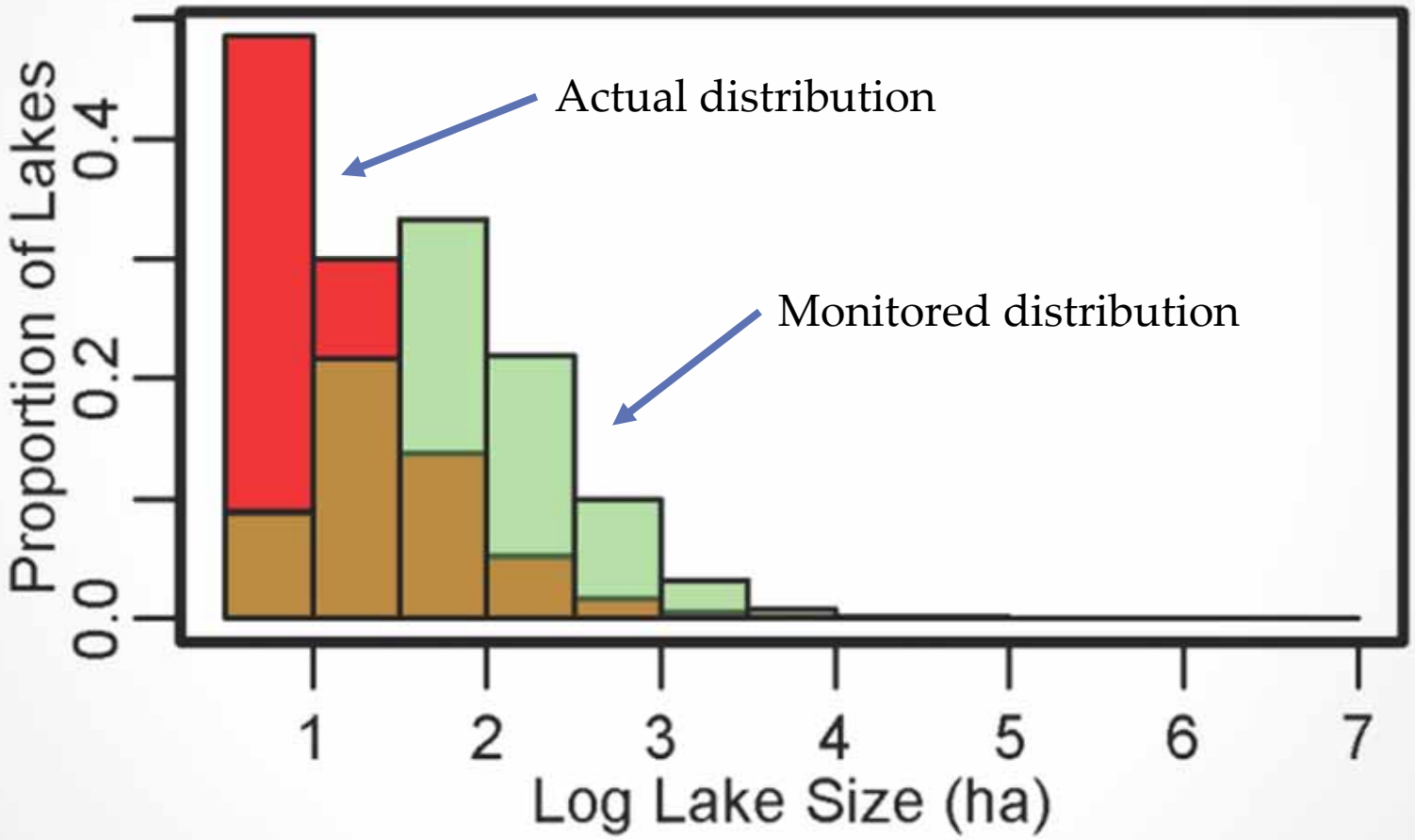
Lottig et al. PLoS ONE (2014)

Long-term lake clarity trends – Spatial Location



1. Latitudinal gradients in Secchi depth
2. Latitudinal gradients in long-term trends
3. Latitudinal gradients in inter-annual variability

Not monitoring small lakes!



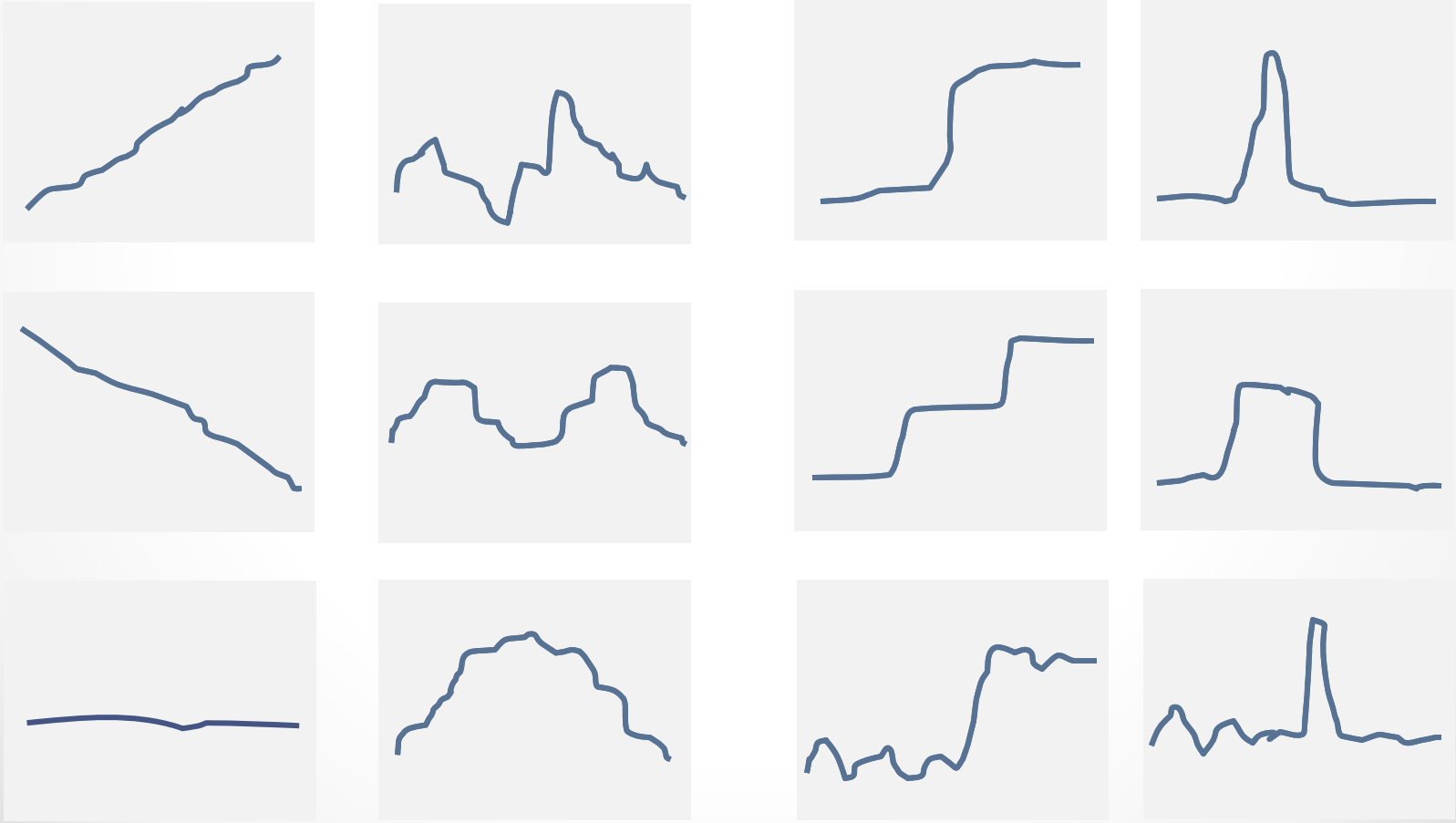
What are the long-term secchi patterns?

Linear-trend

Non-linear

Threshold

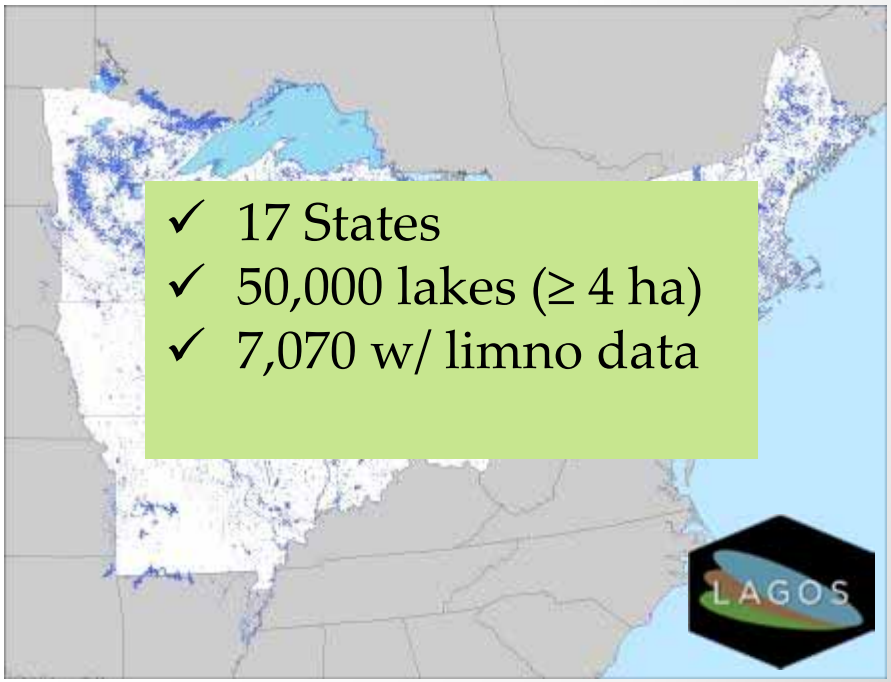
Anomalous event



Research Questions:

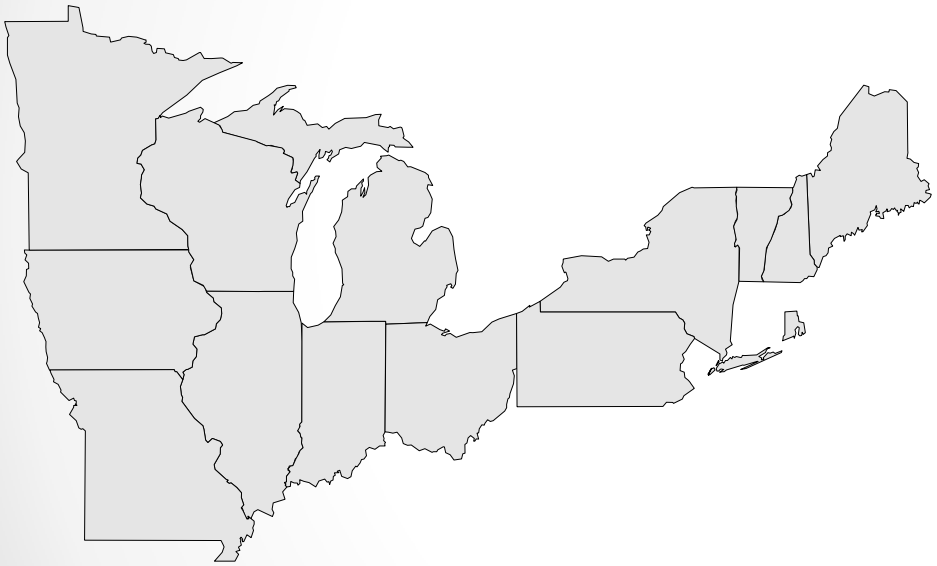
1. What are secchi patterns across large spatial scales?
2. Do lakes exhibit similar patterns?
3. Can we identify factors influencing patterns
   - Spatial
   - Local
   - Regional

LAke **GeOS**patial temporal database



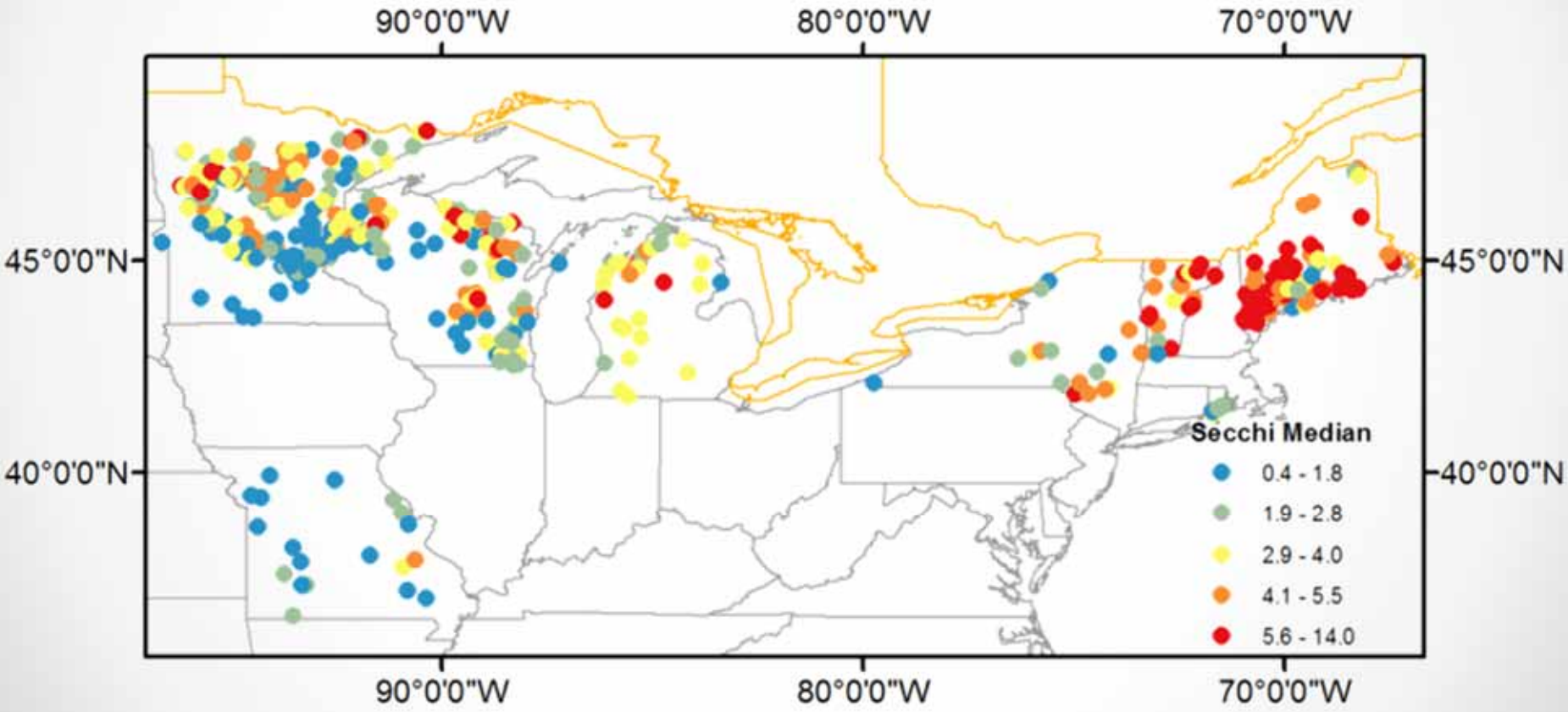
ver 1.054.1

Long-term Secchi data



- 22+ years of data
- 1987 – 2012
  - ≥ 88% overlap among time-series
- Annual median value
  - 15 June – 15 September
- 601 lakes / 8 states

Average Secchi



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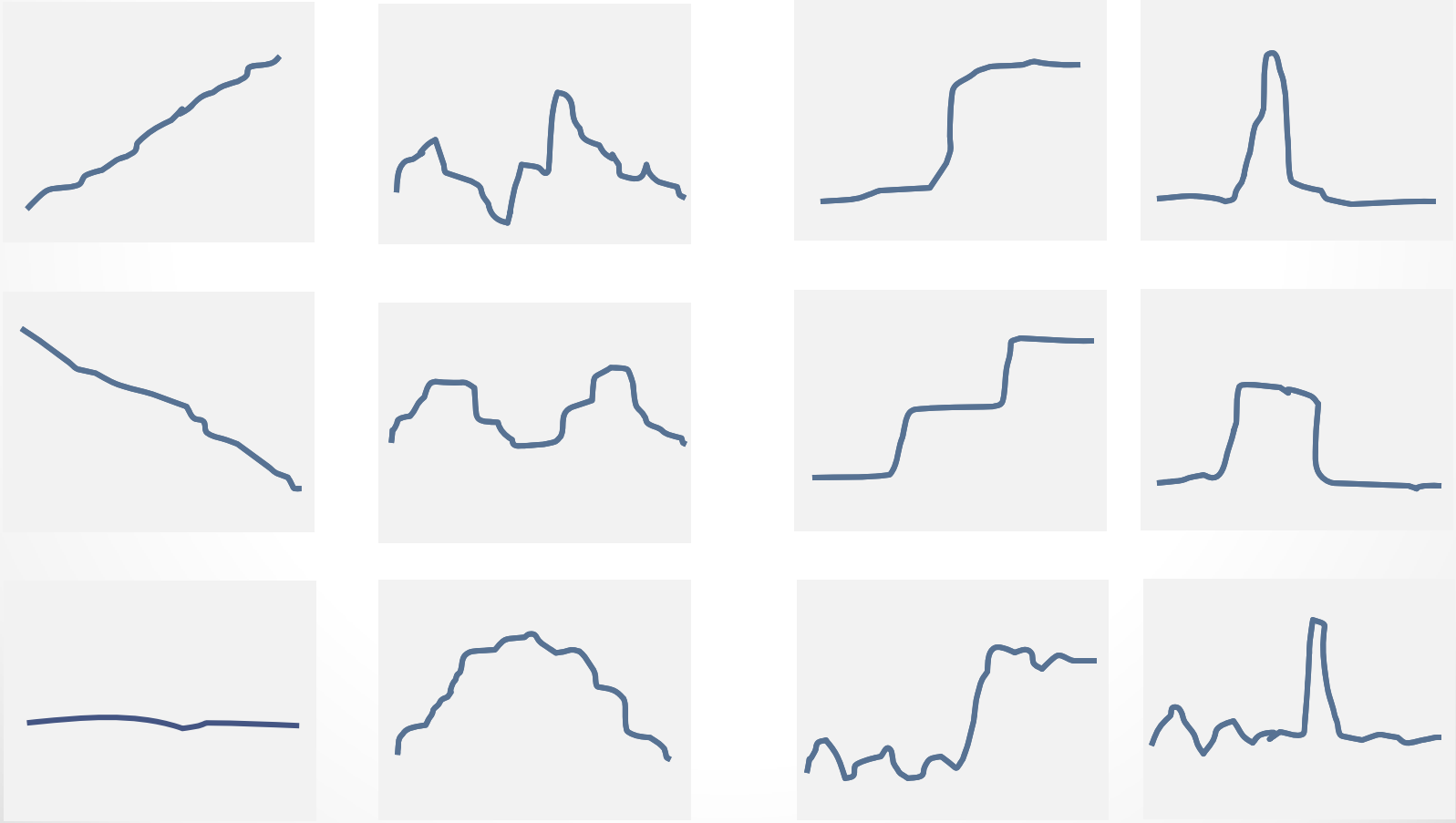
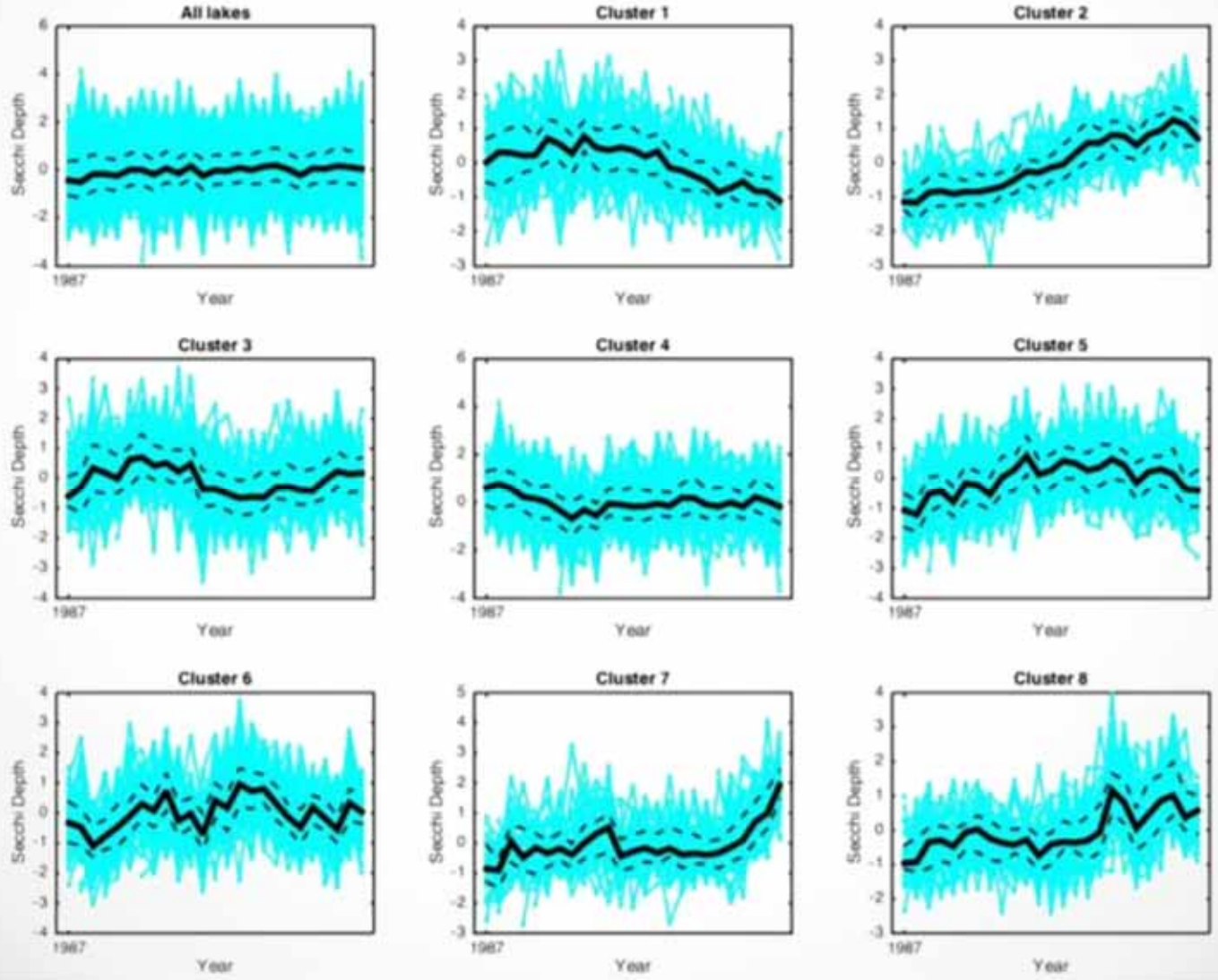
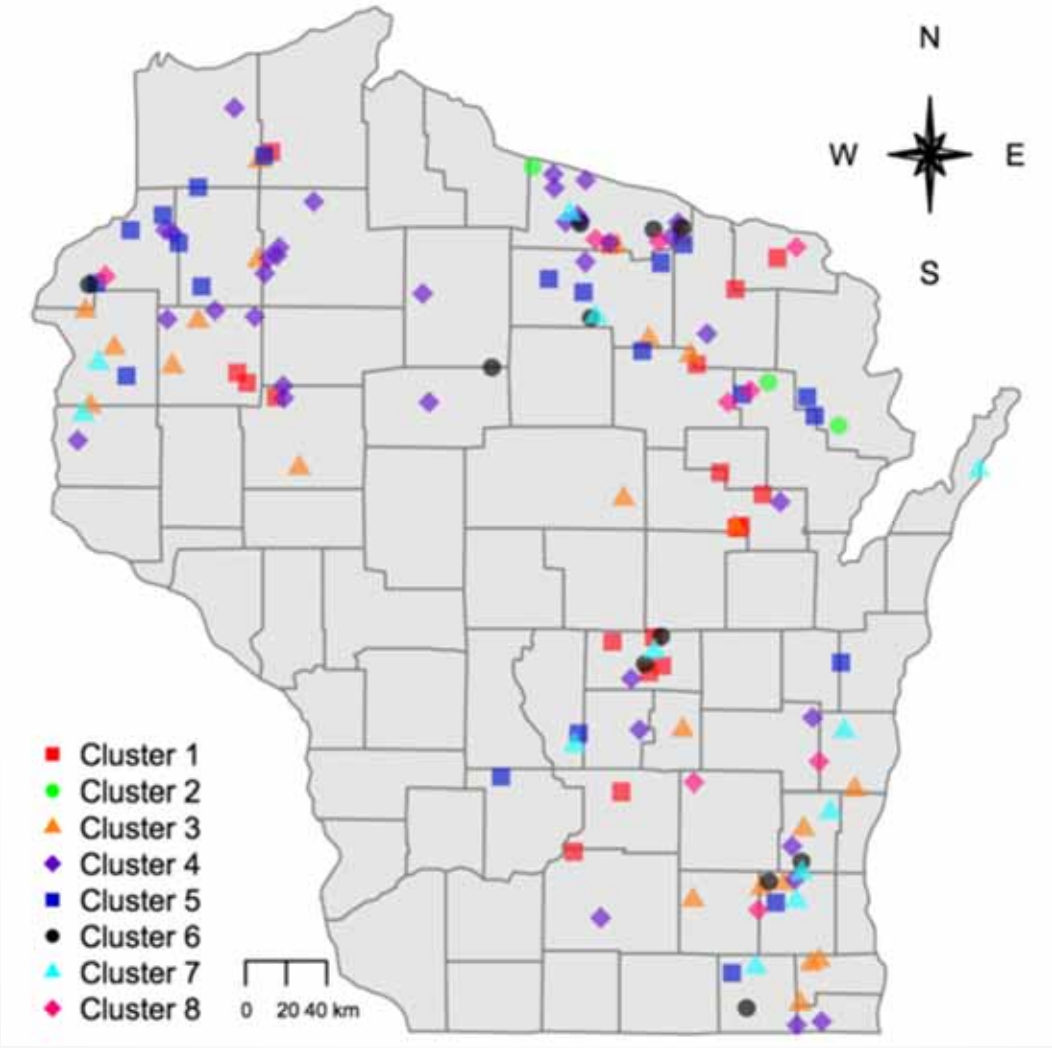


Finding Patterns in a Noisy Environment

Long-Term Secchi Trends

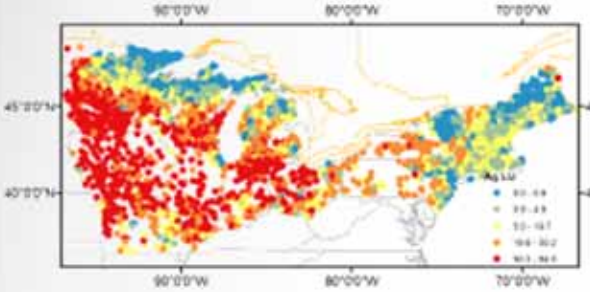


Cluster Locations

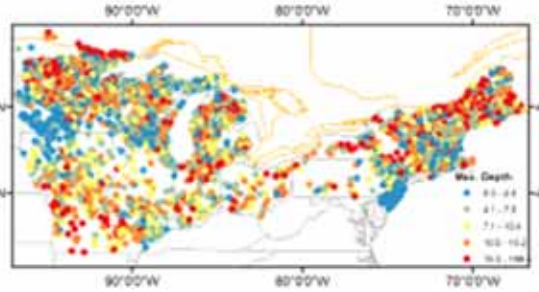


Drivers of Long-Term Change

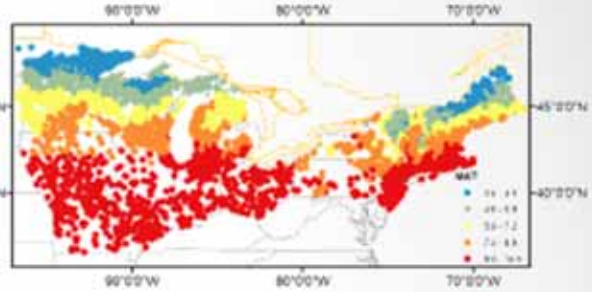
Ag



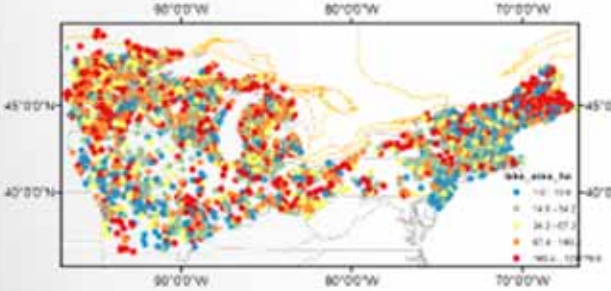
Max Lake Depth



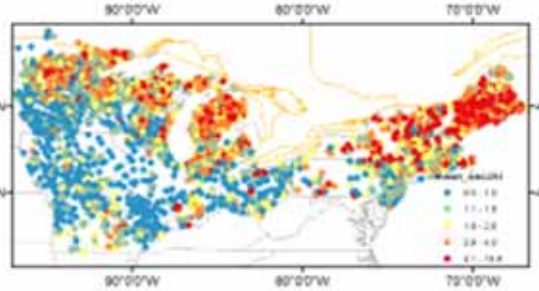
Mean Annual Temp



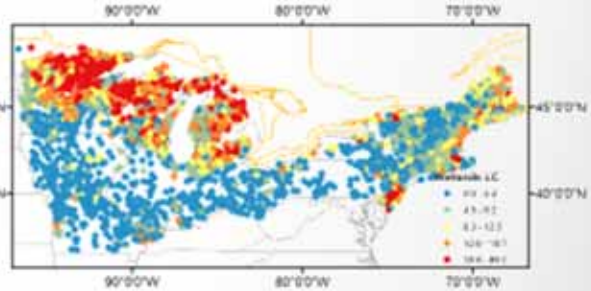
Lake Size



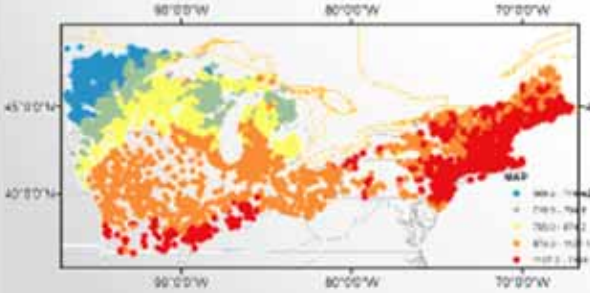
Mean Secchi



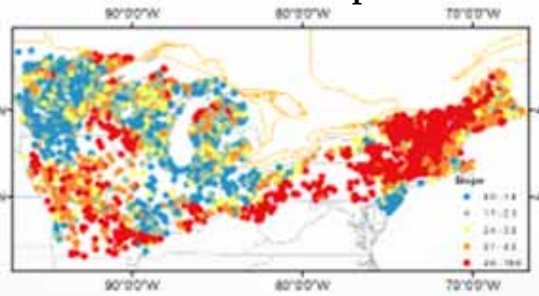
Wetlands



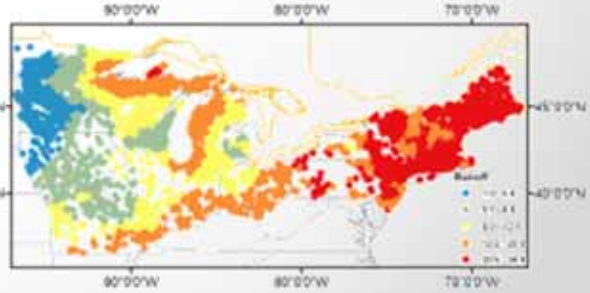
Mean Annual Precip



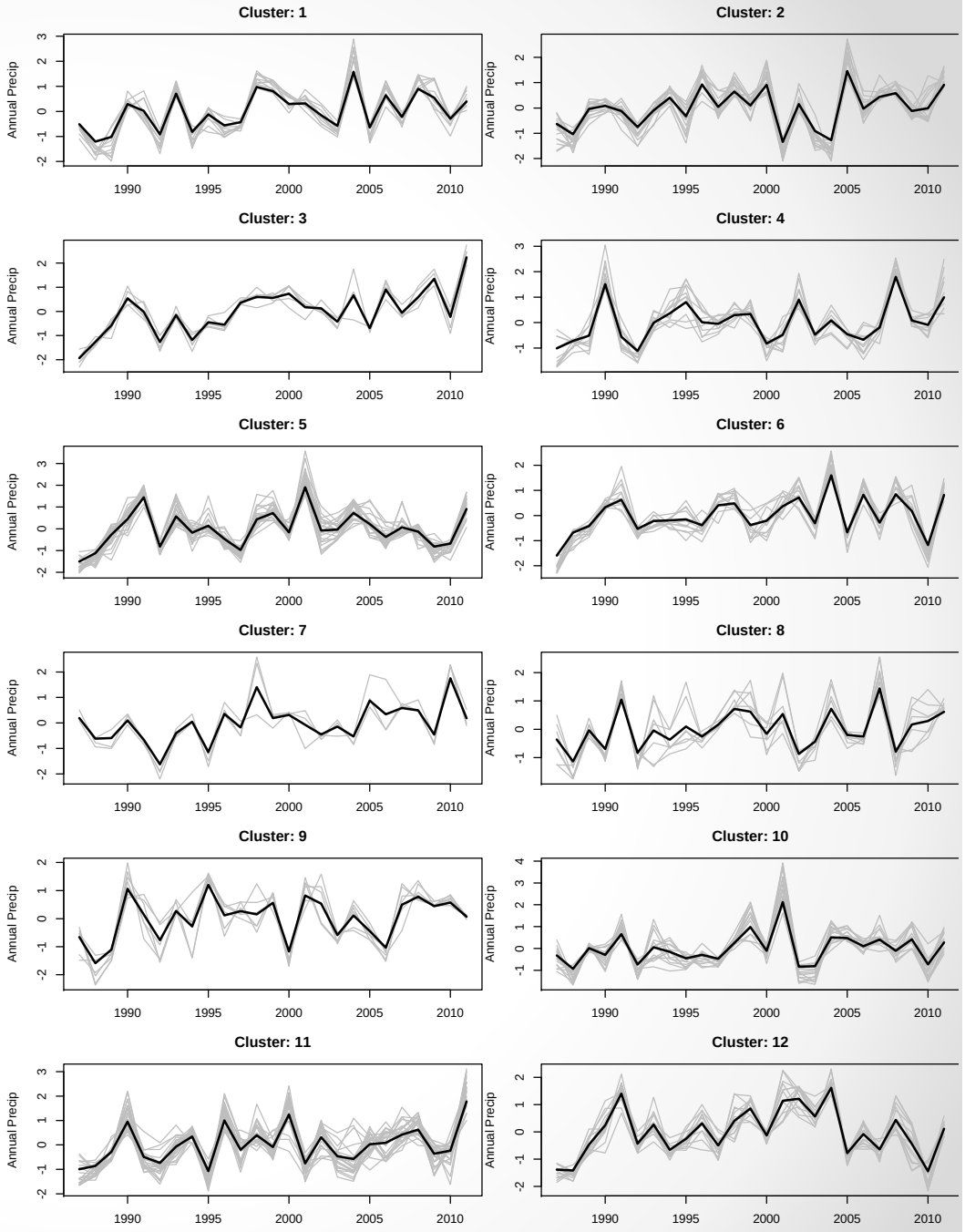
Shoreline Slope



Runoff



Long-Term Precip Patterns



Drivers of Long-Term Change

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Confusion Matrix and Statistics

          Reference
Prediction  1  2  3  4  5  6  7  8
         1  8  1  4  8  4  4  3  5
         2  1  7 12 15  9  3  6 12
         3 10  1 21 13 12  6 15  3
         4 14  7 11 45 17  9  7  7
         5 10  7 15 21 21  5 11 16
         6 17  9 13 25 10 49  2  5
         7  4  4 11  6  5  2  1  3
         8  1  8  5  5  6  1  1  2

Overall Statistics

               Accuracy : 0.2562
                 95% CI : (0.2218, 0.2931)
    No Information Rate : 0.2296
    P-Value [Acc > NIR] : 0.0677162

                  Kappa : 0.1333
 Mcnemar's Test P-Value : 0.0005477

Statistics by Class:

                     Class: 1 Class: 2 Class: 3 Class: 4 Class: 5 Class: 6 Class: 7 Class: 8
Sensitivity           0.12308  0.15909  0.22826  0.32609  0.25000  0.62025 0.021739 0.037736
Specificity           0.94590  0.89587  0.88212  0.84449  0.83559  0.84483 0.936937 0.950730
Pos Pred Value        0.21622  0.10769  0.25926  0.38462  0.19811  0.37692 0.027778 0.068966
Neg Pred Value        0.89894  0.93097  0.86346  0.80785  0.87273  0.93631 0.920354 0.910839
Prevalence            0.10815  0.07321  0.15308  0.22962  0.13977  0.13145 0.076539 0.088186
Detection Rate        0.01331  0.01165  0.03494  0.07488  0.03494  0.08153 0.001664 0.003328
Detection Prevalence  0.06156  0.10815  0.13478  0.19468  0.17637  0.21631 0.059900 0.048253
Balanced Accuracy     0.53449  0.52748  0.55519  0.58529  0.54279  0.73254 0.479338 0.494233
```

Existing data does a poor job explaining long-term patterns

Conclusions

1. Citizen monitoring is critical!
2. Lakes are dynamic…
3. Small changes in overall long-term trends
4. Lack data to describe long-term patterns