

# Water Quality Patterns in Cayuga Lake: Looking Backward, Forward, and Upstream

Dave Matthews  
Upstate Freshwater Institute



# Presentation Outline

- Introduction to UFI
- Long-term water quality trends
  - Total phosphorus, chlorophyll-a, harmful algal blooms (HABs)
- Impacts of climate change on lakes
  - Water temperature and stratification patterns
- Tributary monitoring results
  - Spatial and temporal patterns
  - How high is too high? How do we assess progress?
- Conclusions

# Upstate Freshwater Institute



## Background

- established in 1981
  - not-for-profit [501(c)(3)]
  - independent, but close professional ties to Syracuse University and SUNY-ESF
- 
- overseen by a board of directors
  - conducts fundamental and applied interdisciplinary research

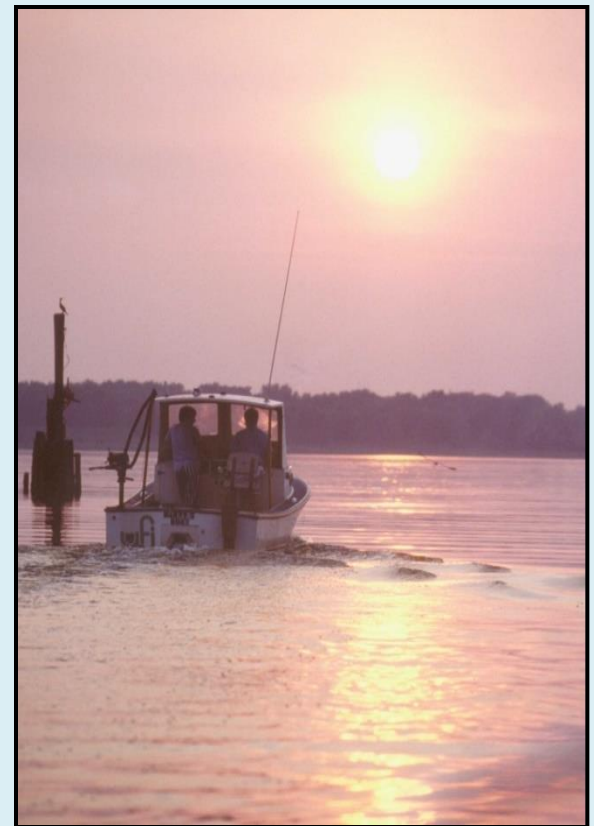


# Upstate Freshwater Institute

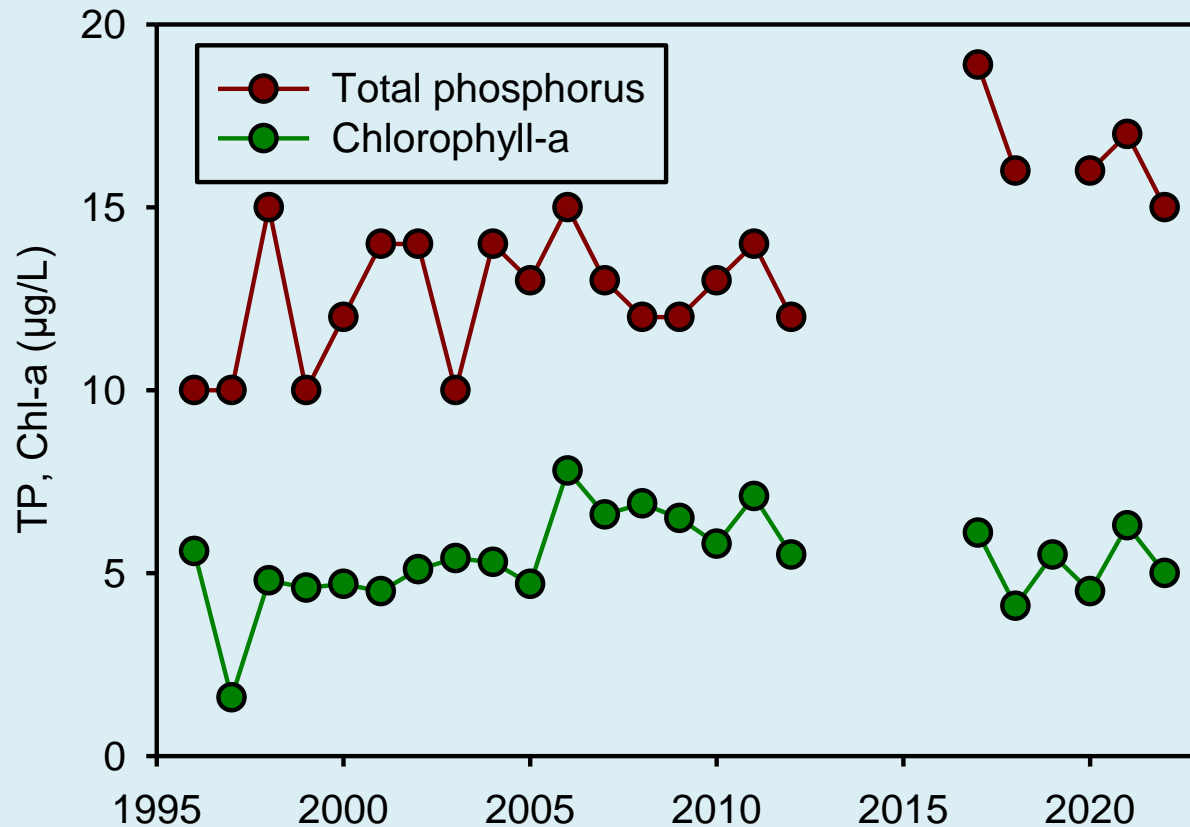


## Mission

- provide the scientific basis for protection of the freshwater resources of New York State
- advance freshwater research and education

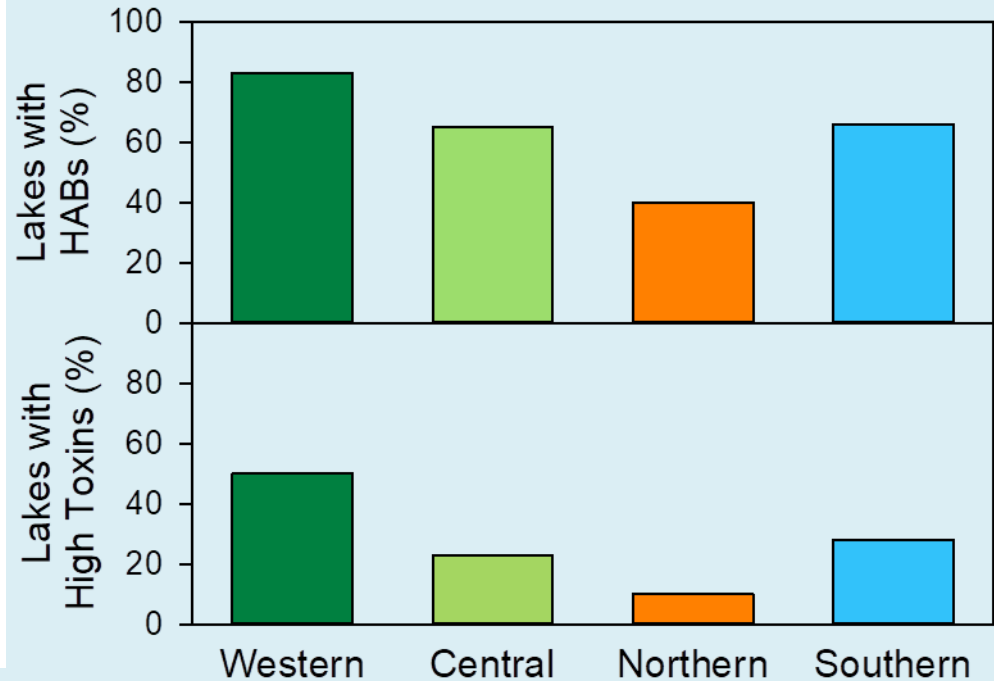
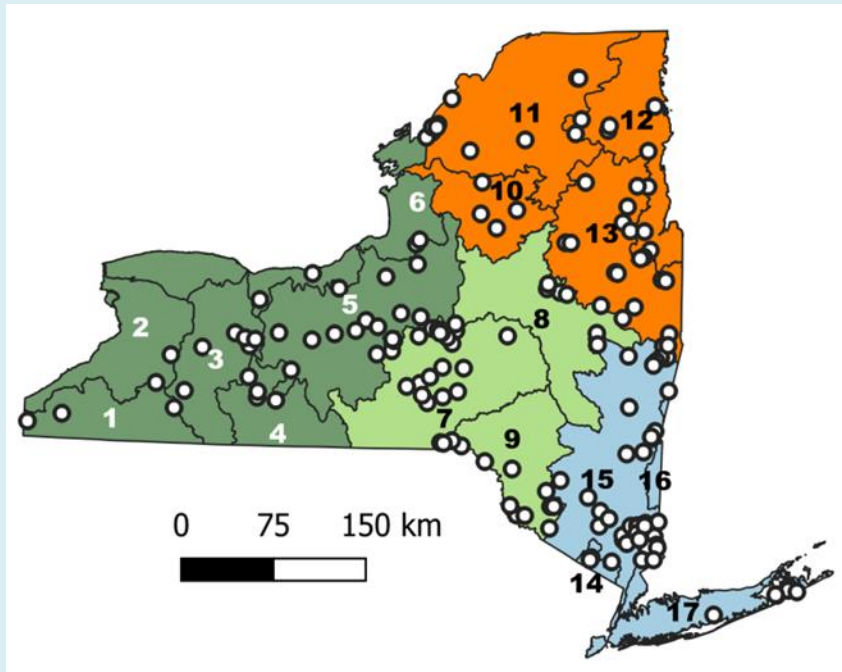


# Long-Term Trends in Total Phosphorus and Chlorophyll-a



# Harmful Algal Blooms by Region

- 168 CSLAP lakes, 2012-2017



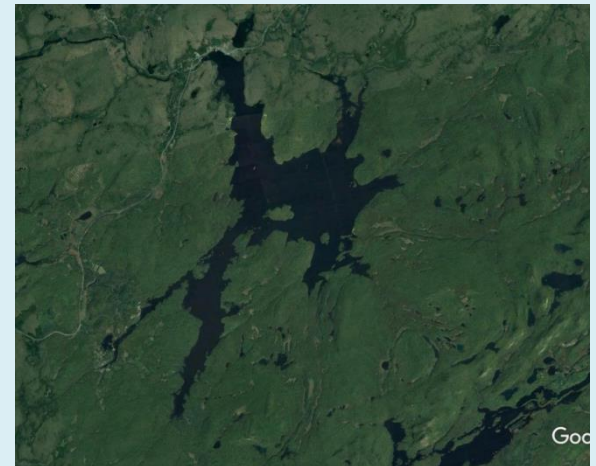
# Factors Associated with HABs in NYS

- High nutrient levels
- Agricultural and developed land uses
- Zebra and quagga mussels

Less than 40% forested

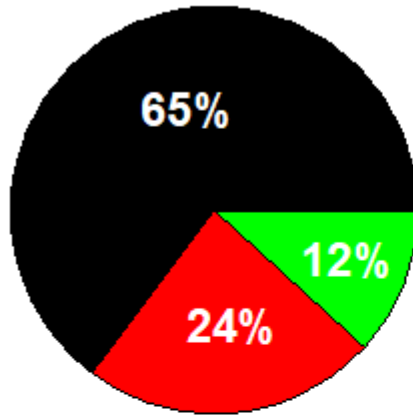


More than 90% forested

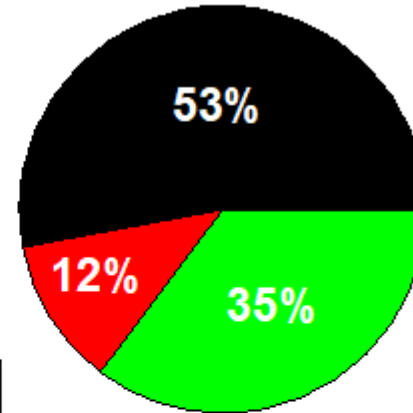


# Water Quality Trends Across NYS Lakes

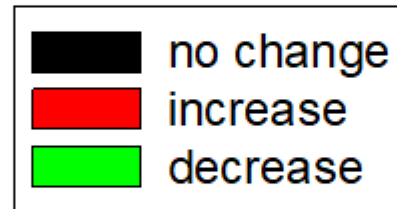
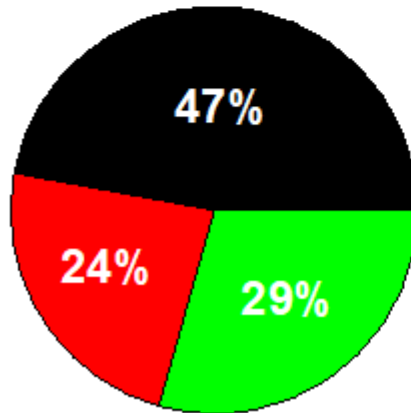
Total phosphorus



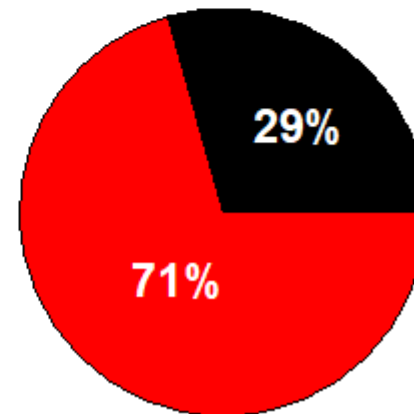
Chlorophyll-a



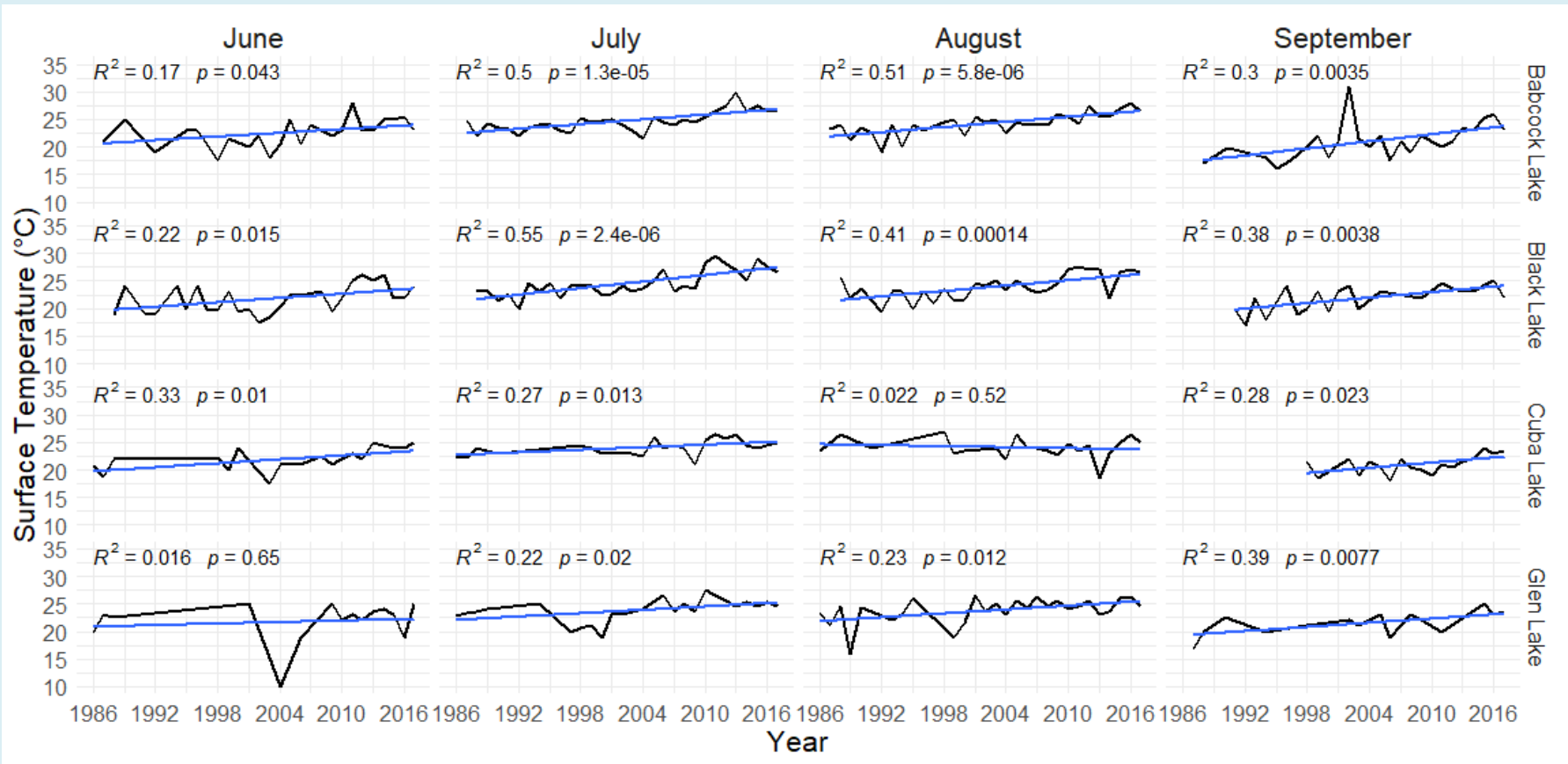
Secchi depth



Temperature



# Monthly Increases in Surface Temperature



**+0.6°C/  
decade**

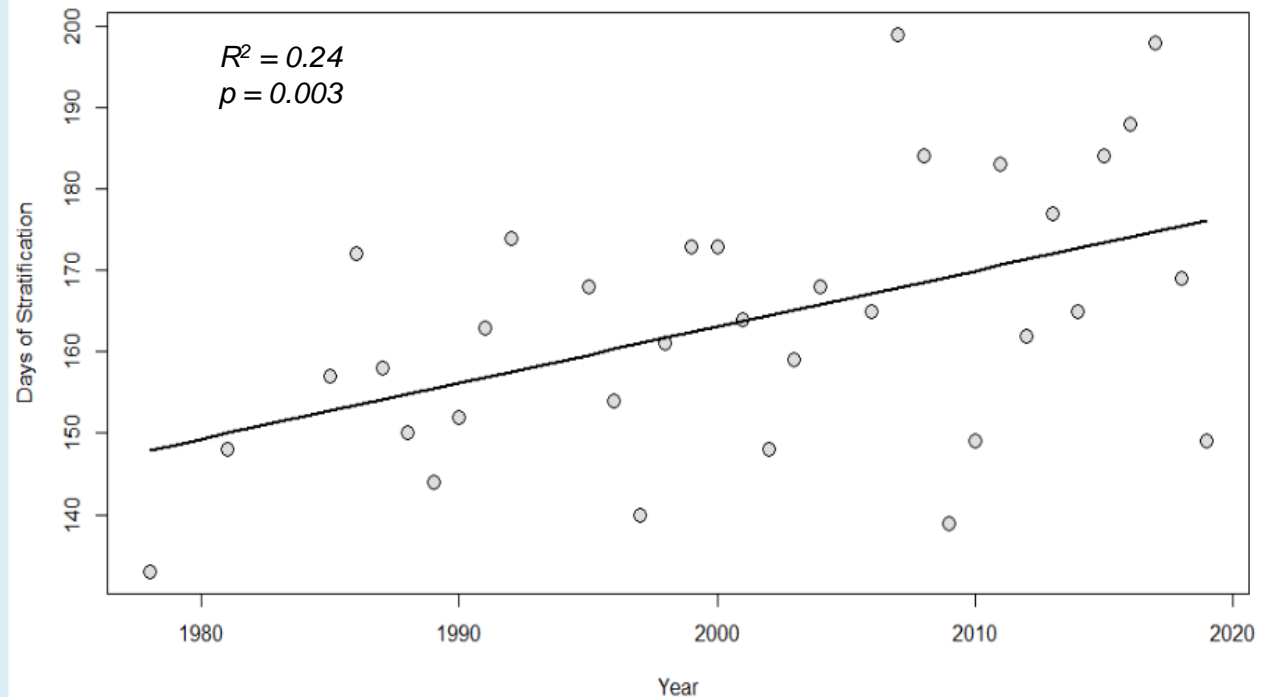
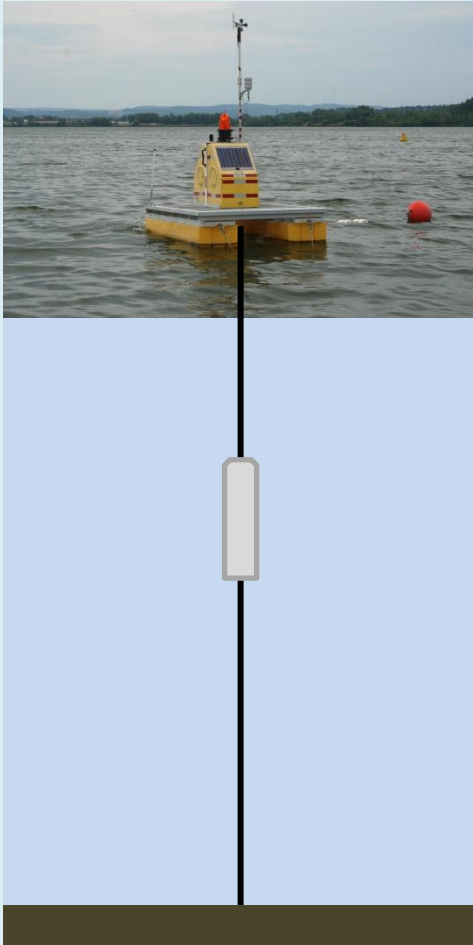
**+0.7°C/  
decade**

**+1.1°C/  
decade**

# Increases in Duration of Stratification

## +1 Week/Decade

*Onondaga Lake*

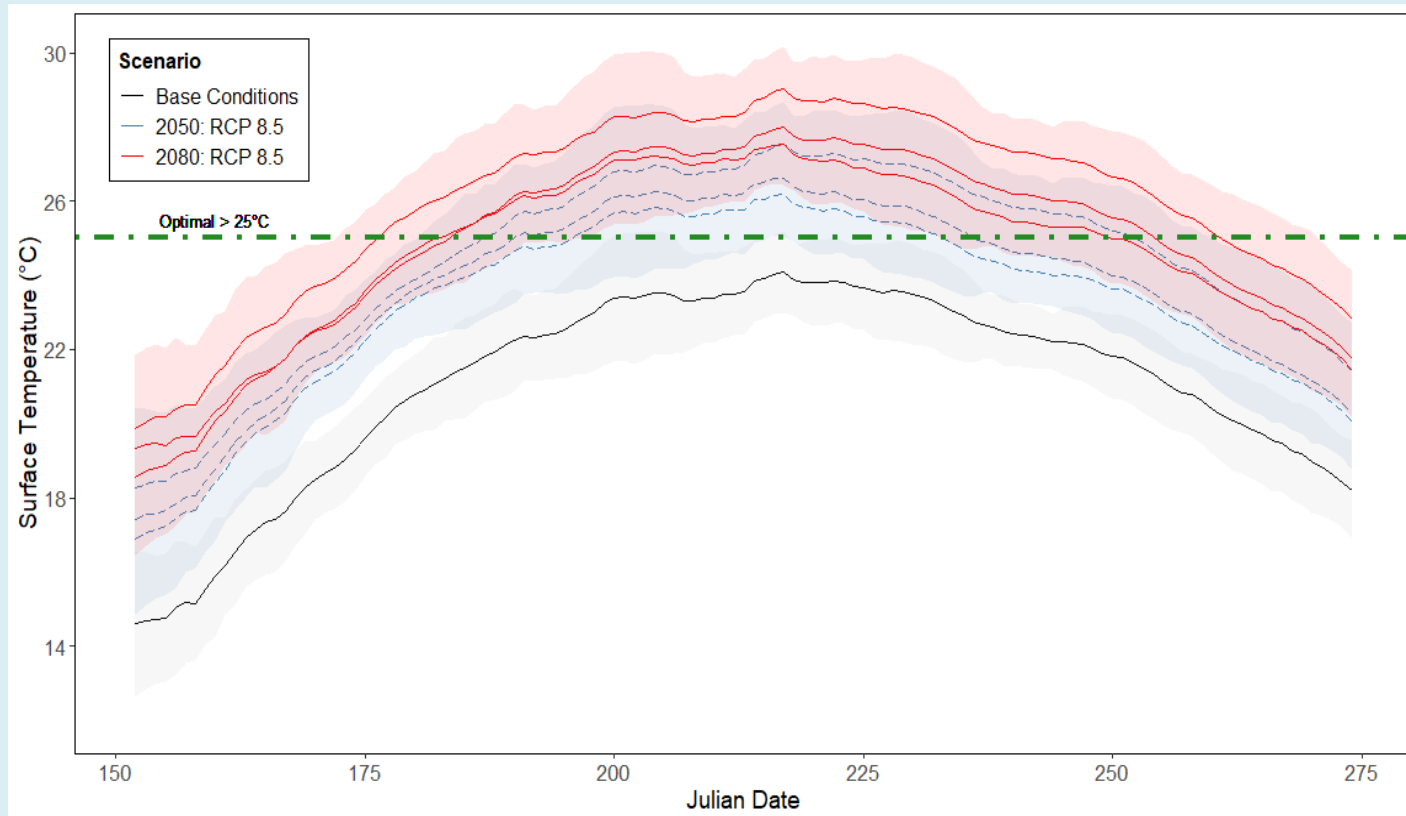


*Temperature profiles every meter, twice a day  
~ April to October each year*

# Model Application - Owasco Lake

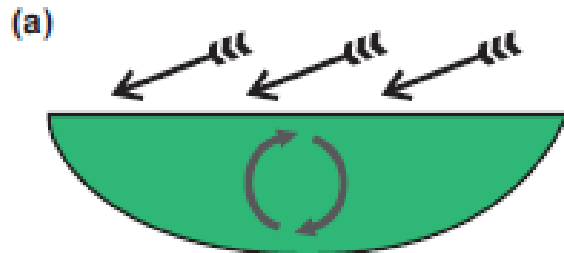
## Climate projections and effects

*Surface temperatures increase and favor cyanobacteria*

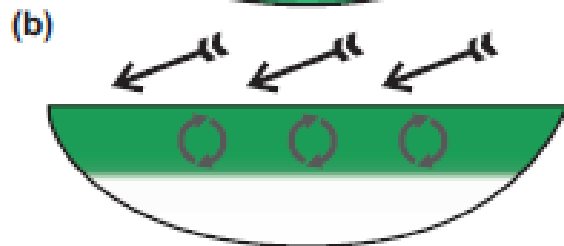


# Theories of Bloom Formation

WHO 2021



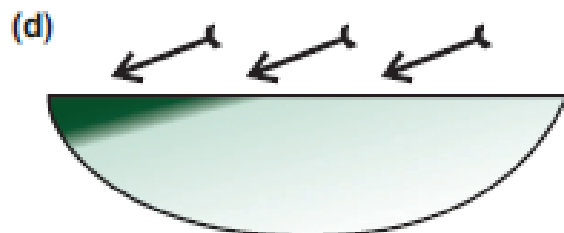
cells/L:	$10^7$
chl-a $\mu\text{g/L}$ :	2
MC $\mu\text{g/L}$ :	1
risk level:	low



max cells/L:	$10^8$
max chl-a $\mu\text{g/L}$ :	20
max MC $\mu\text{g/L}$ :	10
risk level:	moderate



max cells/L:	$10^9$
max chl-a $\mu\text{g/L}$ :	200
max MC $\mu\text{g/L}$ :	100
risk level:	high

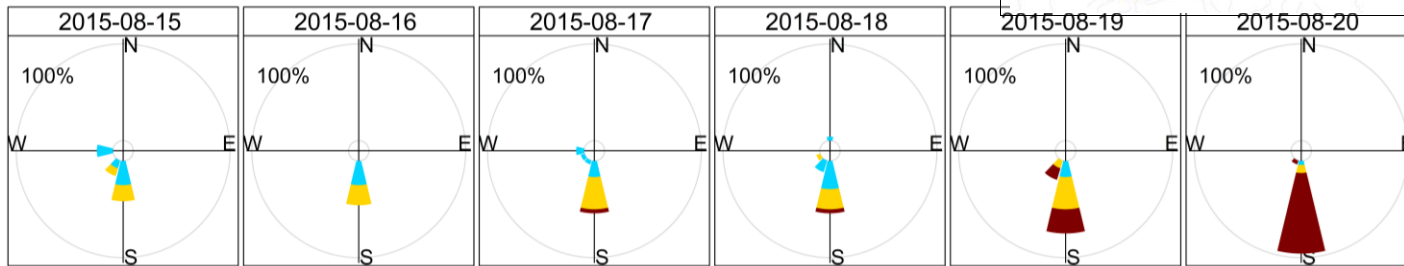
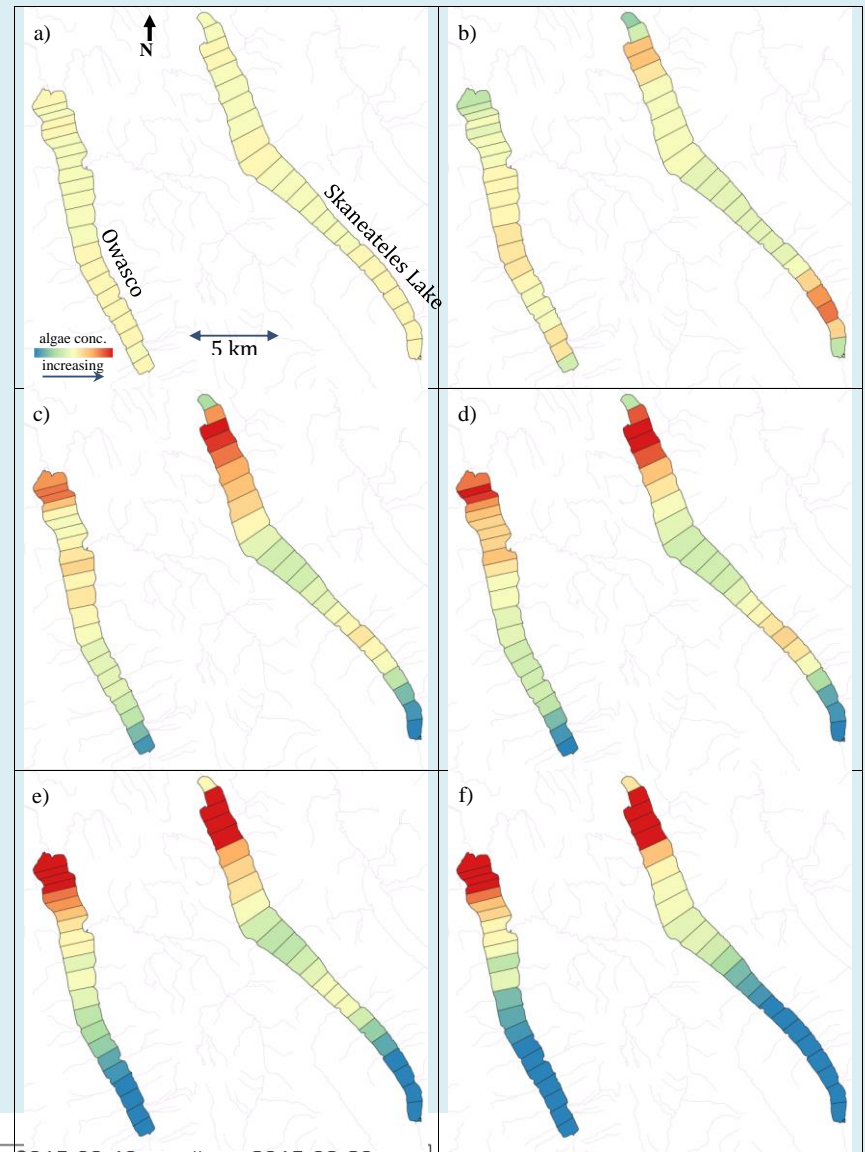


max cells/L:	$10^{12}$
max chl-a $\mu\text{g/L}$ :	200000
max MC $\mu\text{g/L}$ :	100000
risk level:	very high

The shape and orientation of the Finger Lakes makes them especially susceptible to this mechanism of bloom formation

# Wind-driven Transport of Cyanobacteria

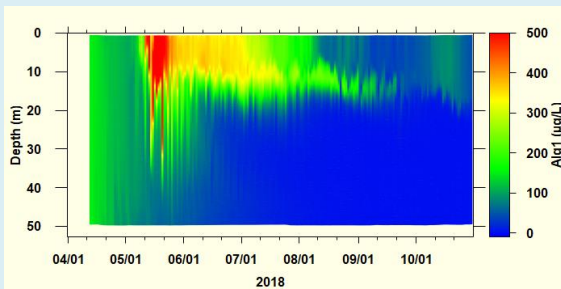
- Simulations of a floating conservative tracer to represent cyanobacteria
- Southerly wind over six consecutive days
- Owasco and Skaneateles Lakes
- NYSERDA project with Hazen&Sawyer



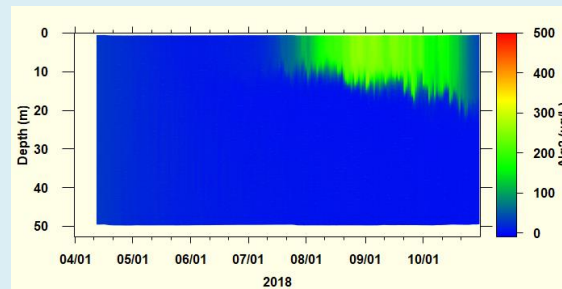
# Modeled Impacts of Dreissenid Mussels on Phytoplankton Community Composition

## Mussels

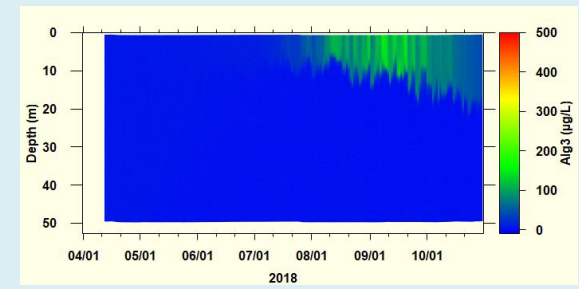
diatoms



greens

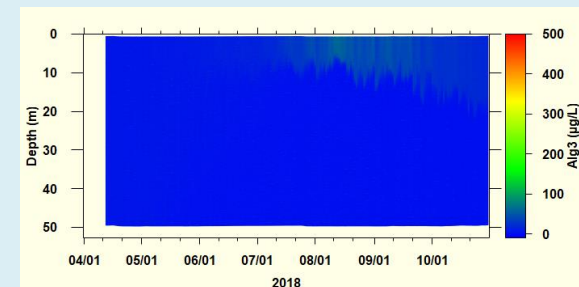
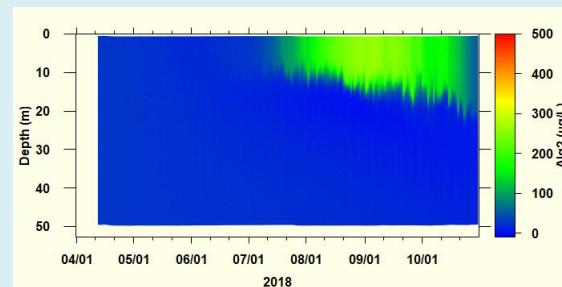
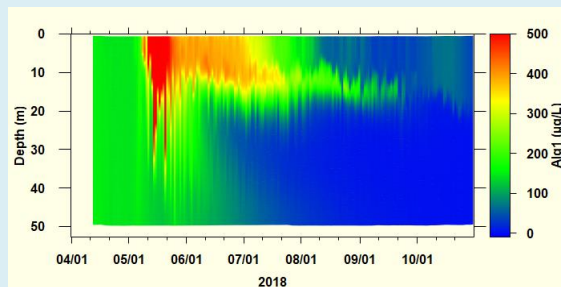


cyanobacteria



time

## No mussels



# Monitoring of Cayuga Lake's Northern Tributaries

- Sampling conducted by CLWN volunteers
- 6 streams, 8 sites, 23 rounds of sampling
- Northern tributaries historically under-studied
- Targeted high flow conditions
- Samples analyzed for nutrients at UFI's lab
  - **Total phosphorus**, total dissolved phosphorus, soluble reactive phosphorus
  - Total nitrogen, nitrate+nitrite, total ammonia
  - Total suspended solids
- Microbial source-tracking conducted at SUNY-ESF (Mike Schummer, Hyatt Green)





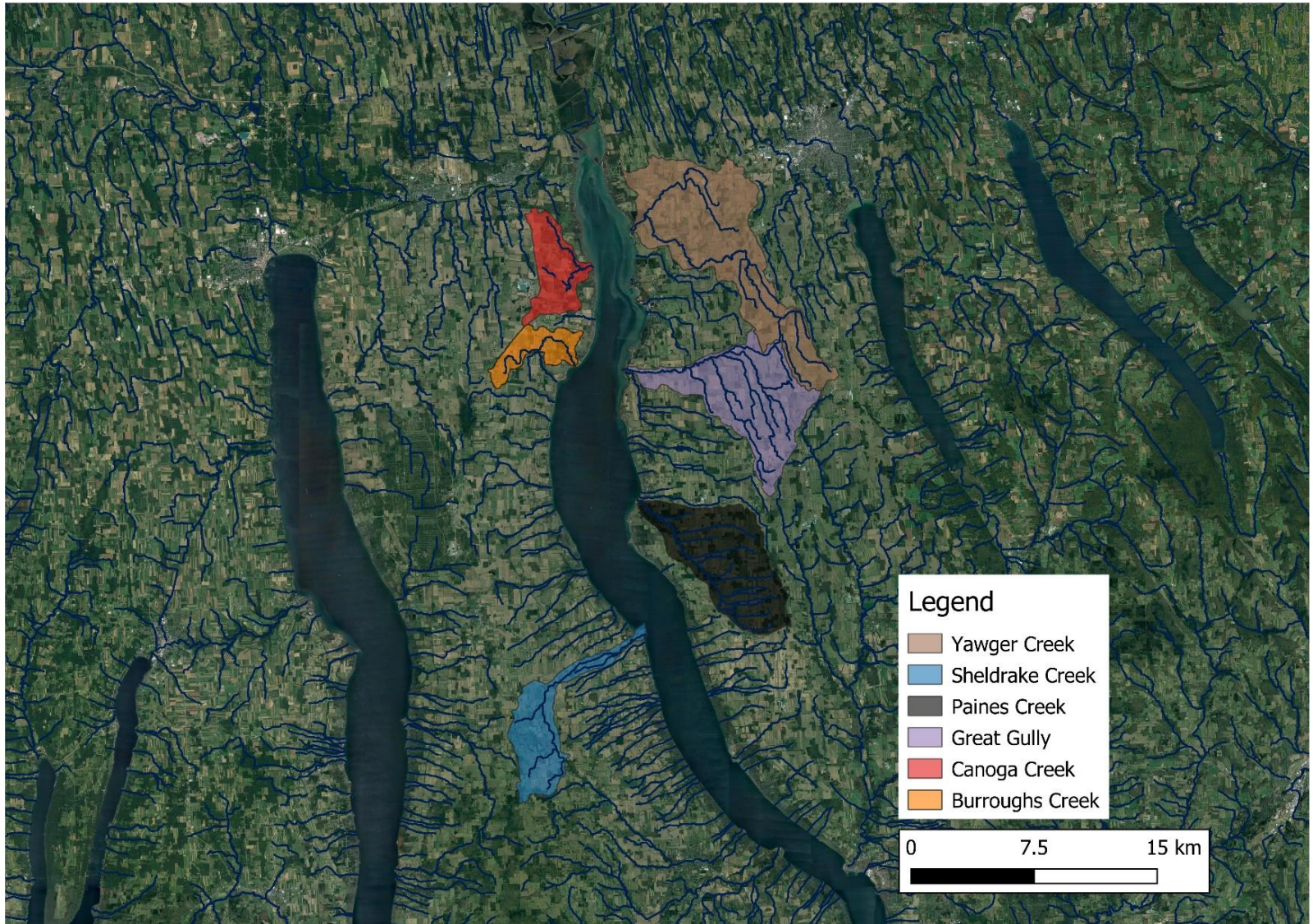
West side tribs:

Canoga Creek-North  
Canoga Creek-South  
Burroughs Creek  
Sheldrake Creek

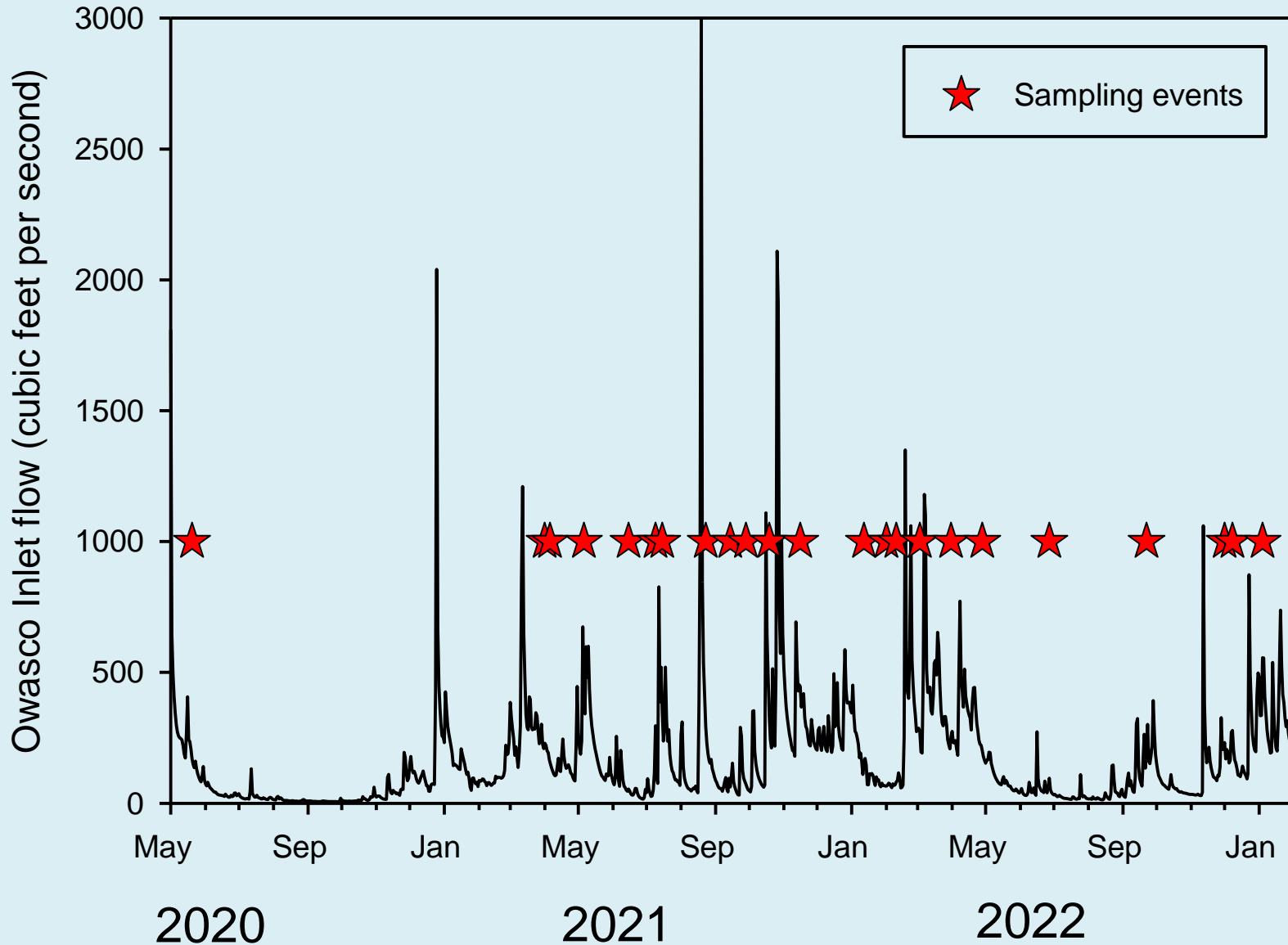
East side tribs:

Yawger Creek-North  
Yawger Creek-South  
Great Gully Brook  
Paines Creek

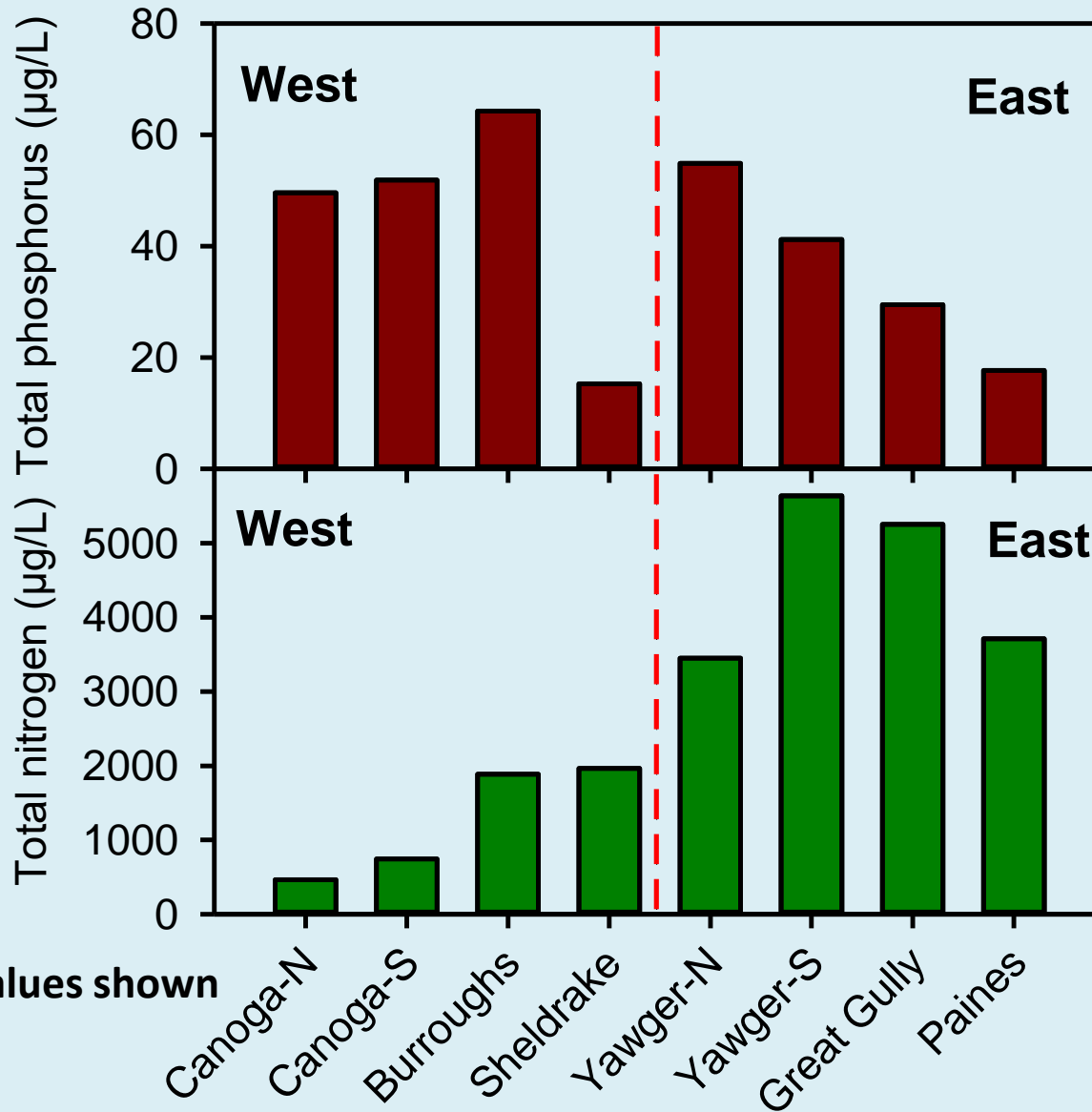
# Monitored Watersheds



# Monitoring Coverage

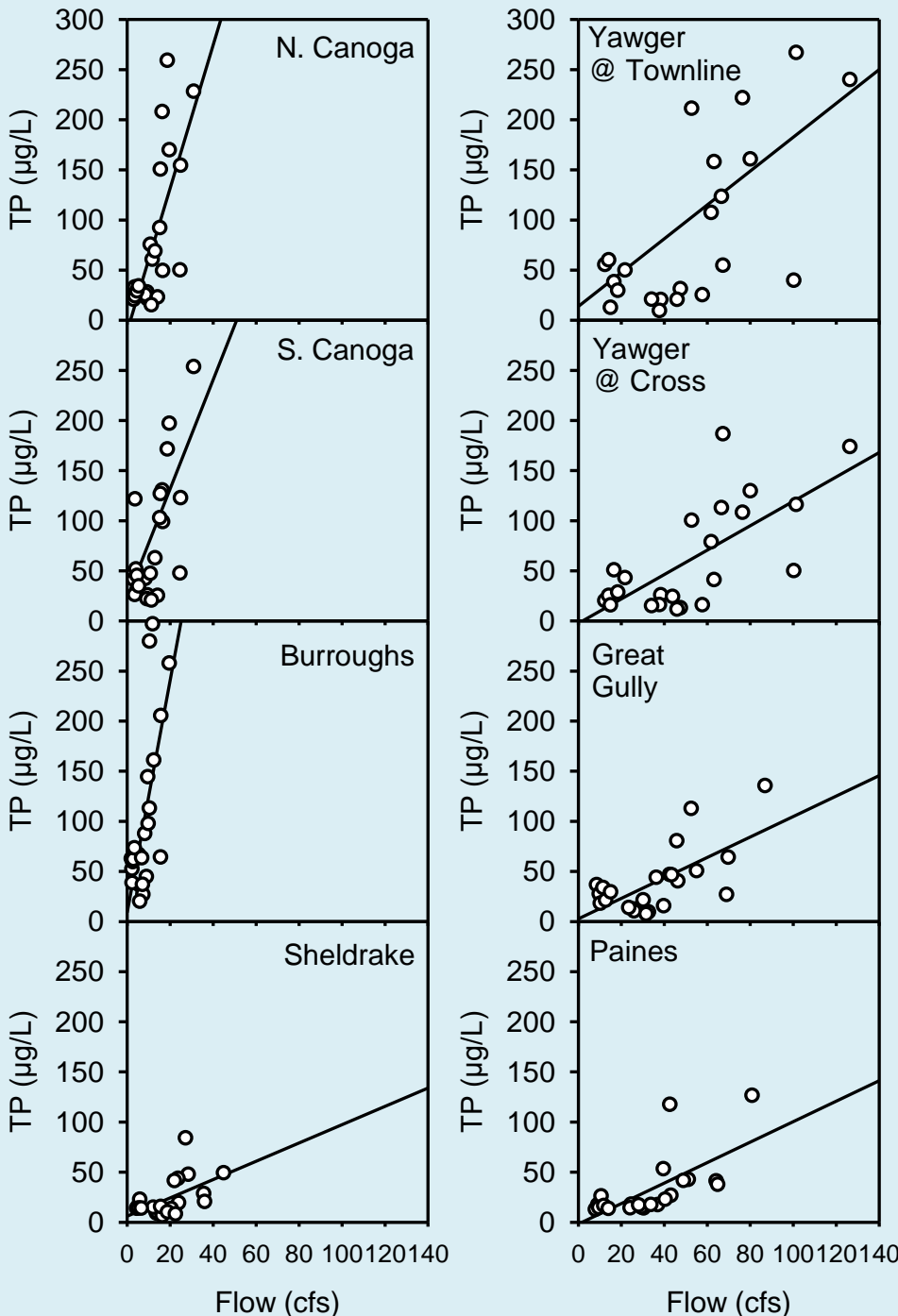


# Spatial Patterns: TP & TN



- animal density higher on west side (59/km<sup>2</sup>) than east side (27/km<sup>2</sup>)
- cultivated crops more prevalent on the east side (67%) than west side (52%)
- use to prioritize and focus BMPs

# Total Phosphorus Versus Flow



- TP ranged from  $<10$  to nearly  $300 \mu\text{g/L}$
- Mostly bioavailable (60-80% dissolved)
- Generally strong concentration-flow relationships
- Relationships provide a means to assess progress
  - Lower slopes and intercepts

# Implications of Streamflow Distribution

- 50% of flow occurs on 18% of days
- 75% of flow occurs on 38% of days
- 90% of flow occurs on 58% of days
  
- Monitoring biased toward high flows is necessary to assess nutrient export and lake impacts
  
- Runoff events can occur during any month but are most common during late fall (Nov-Dec) and spring (Mar-May)



# Conclusions

- Common water quality indicators (TP, Chl-a) suggest stable or slightly worsening conditions
- Climate change will cause continued warming of lakes, favoring cyanobacteria and HABs
- The shape and orientation of the Finger Lakes makes the northern ends especially susceptible to HABs
- Reductions in phosphorus loading are the only proven strategy for addressing lake eutrophication and abating HABs
- Plant nutrients (phosphorus and nitrogen) are escaping from northern watersheds at high rates, particularly during runoff events
- Tributary monitoring by CLWN can be used to prioritize BMPs and assess progress
- Consistent, long-term volunteer monitoring efforts are critically important

# Questions?

