Harmful Algal Blooms
KBS Research Update

Are HABs increasing?

Ted Harris
Kansas Biological Survey

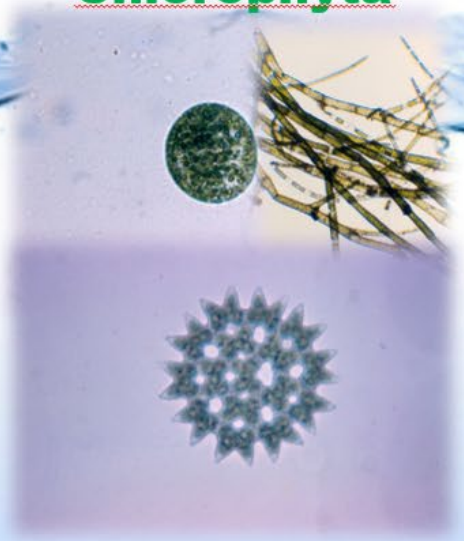
Presentation Roadmap

- HABs: Consequences and Causes
- Are HABs increasing?
  - Focus Milford, Marion, and Sebelius
    - Sediment cores – reconstruct history
    - Long-term WQ data
- Summary/ Future Directions

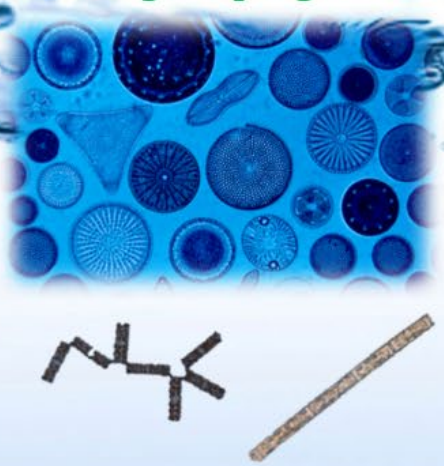
Algal Diversity

Cyanophyta

Chlorophyta



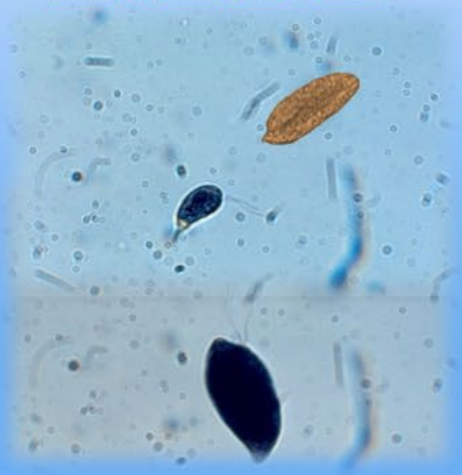
Chrysophyta



Freshwater groups of “tiny plants”

Pyrrophyta

Cryptophyta



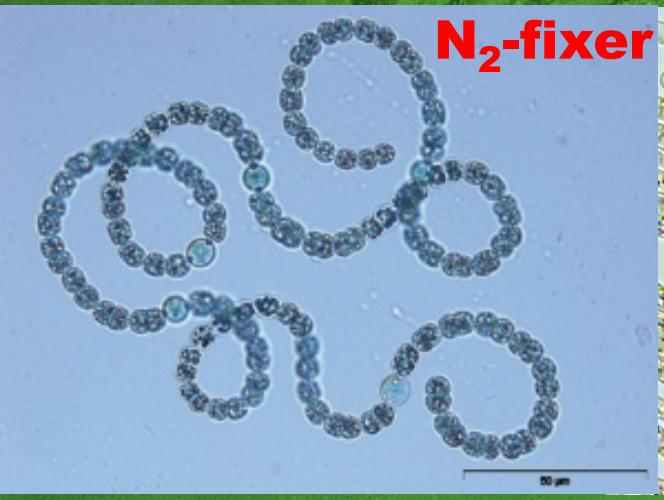
Euglenophyta

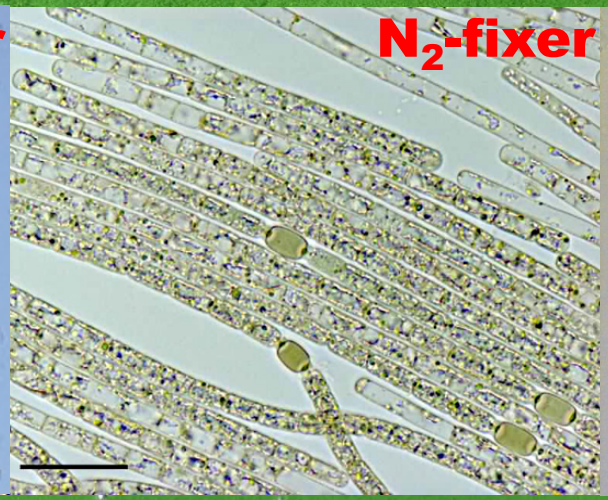
HABs in KS

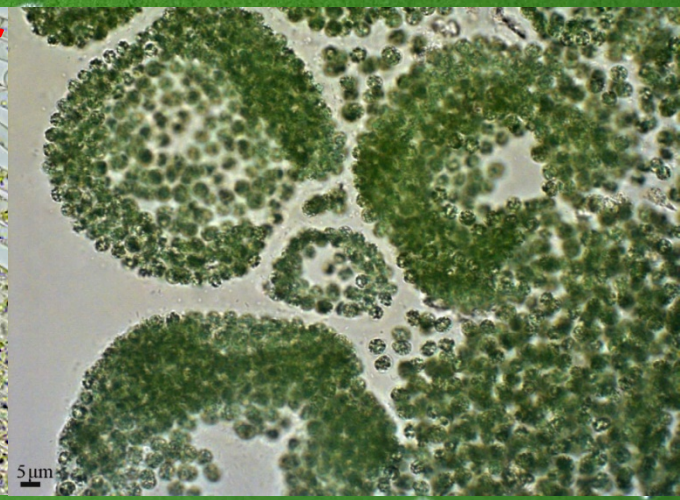
- Made of "blue-green" algae (Cyanobacteria)
- *Can* produce potent toxins (more potent than cobra!)
- *Can* produce taste-and-odor compounds
- <u>But not always</u> (we don't know why)

Cyanobacteria diversity

- 2000 - 8000 cyanobacteria species
- Each species has 100s/1000s of strains
- Only some <u>strains</u> capable of toxin/ T&O
- Strain must have gene(s) to produce toxin



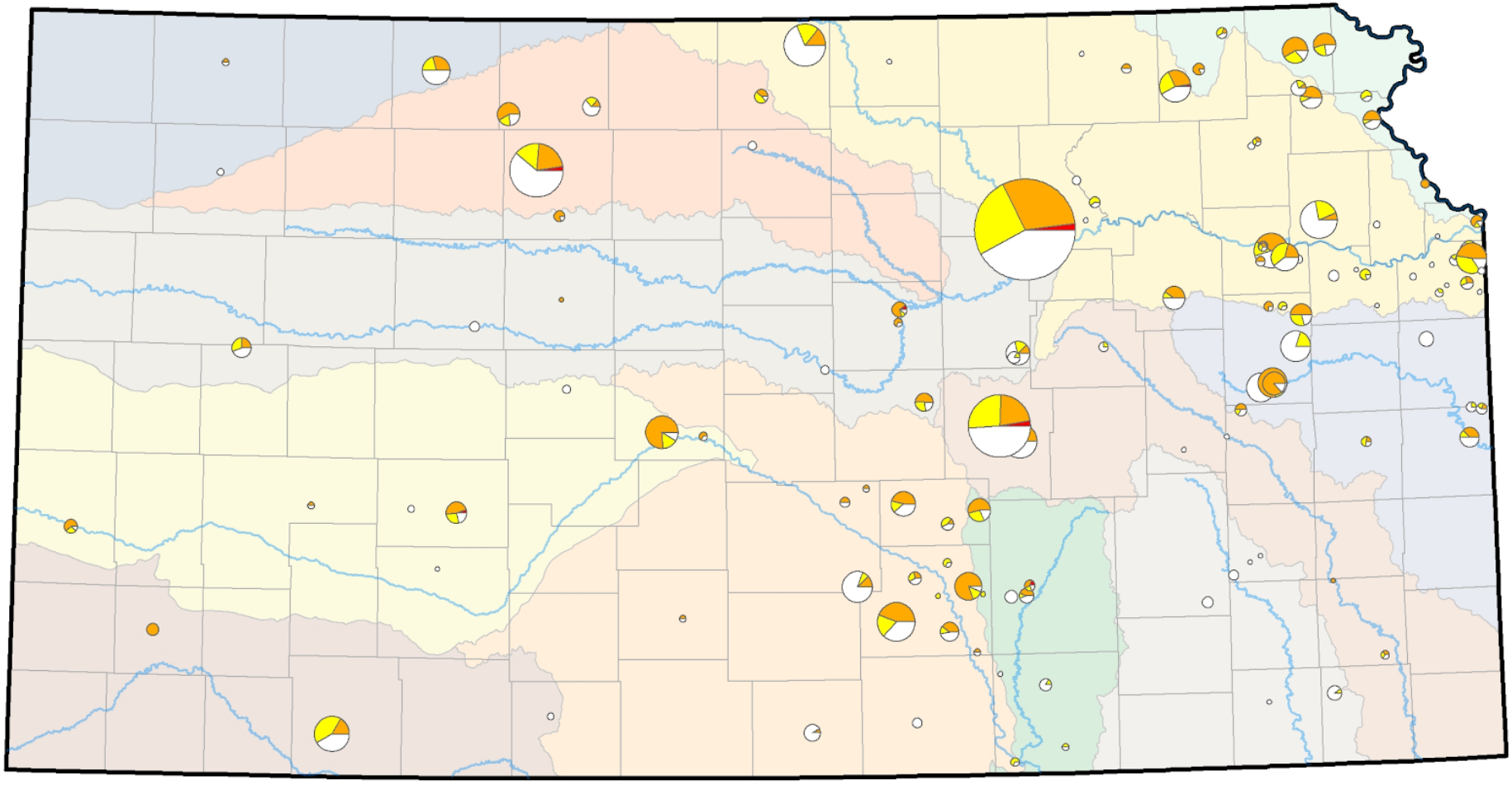




Anabaena
<u>Marion</u>
(now *Dolichospermum*)

Aphanizomenon
<u>Sebelius</u>
(now *Chrysosporum*)

Microcystis
<u>Milford & Marion</u>



CyanoHAB sampling events, KDHE (2010-2019)

Closure (21)
Watch (465)
Warning (703)
No action (1003)

Blooms form under the right conditions

Consequences of Cyano blooms

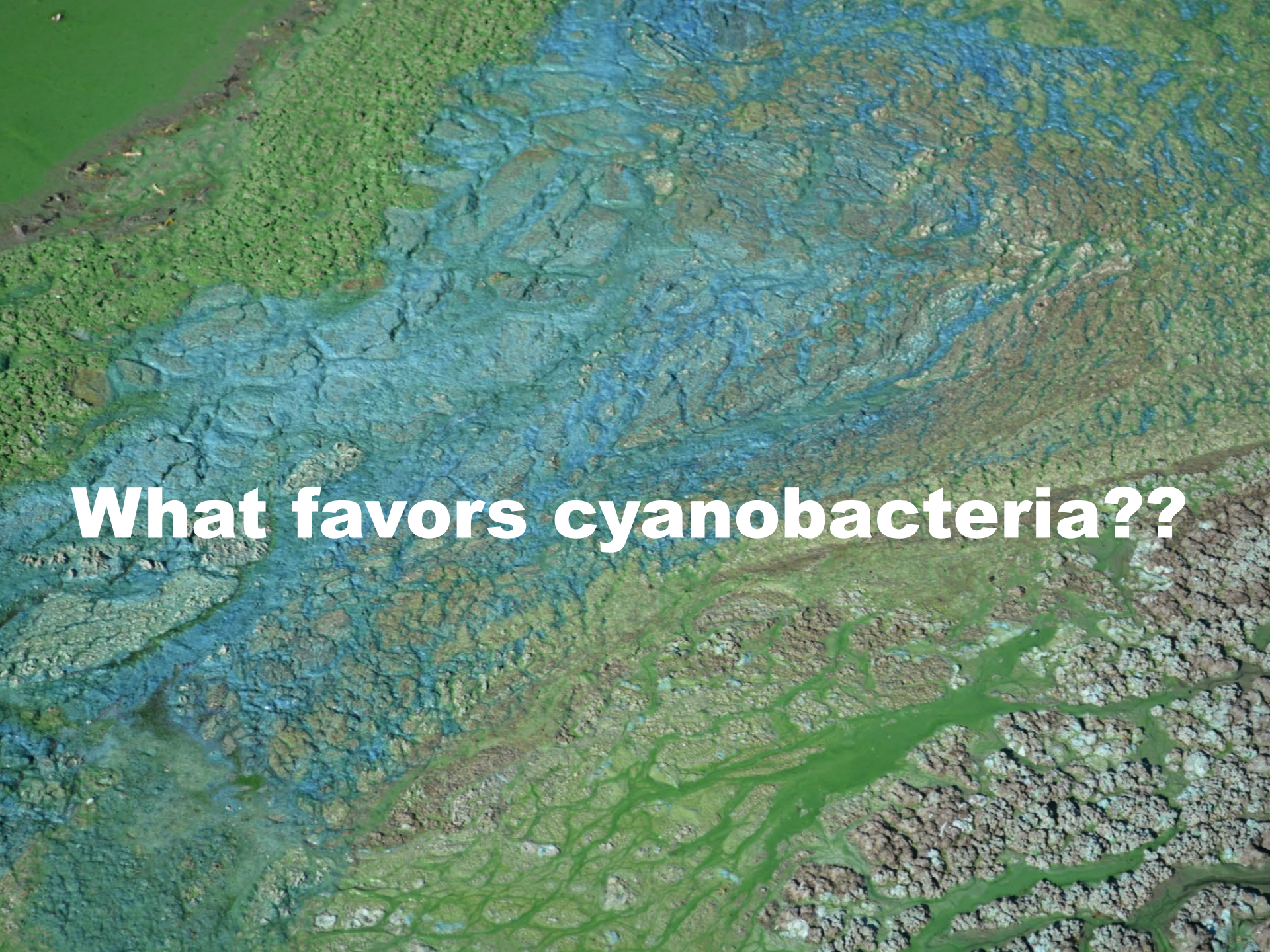
- Economic
  - Aesthetically unpleasing
  - Foul odors
  - Reservoir closure/warnings

- Ecological
  - Disrupts food webs
    - large, un-nutritious → hard to eat for zoops
  - Harmful to animals & humans

Why? Algal bloom causes

- Remember → algae are tiny plants
- Plants need:
  - Light
  - Nutrients
  - Water

- Each group of algae has different adaptations


What favors cyanobacteria??

Why? 2 primary factors

Nitrogen & Phosphorus

ECOLOGY

Controlling Eutrophication: Nitrogen and Phosphorus

Daniel J. Conley,[1*] Hans W. Paerl,[2] Robert W. Howarth,[3] Donald F. Boesch,[4] Sybil P. Seitzinger,[5] Karl E. Havens,[6] Christiane Lancelot,[7] Gene E. Likens[8]

Hot temperatures

CLIMATE

Blooms Like It Hot

A link exists between global warming and the worldwide proliferation of harmful cyanobacterial blooms.

Hans W. Paerl[1] and Jef Huisman[2]

Most Kansas waterbodies:
Have plenty of nutrients
Although nutrient reduction helps!
Get hot in summer

Why Now?

Have there always been algae blooms?

Have blooms always been cyanos?

Are cyano. blooms increasing?

Blooms anomaly or pattern?

Detecting changes over time

2 methods

Sediment cores

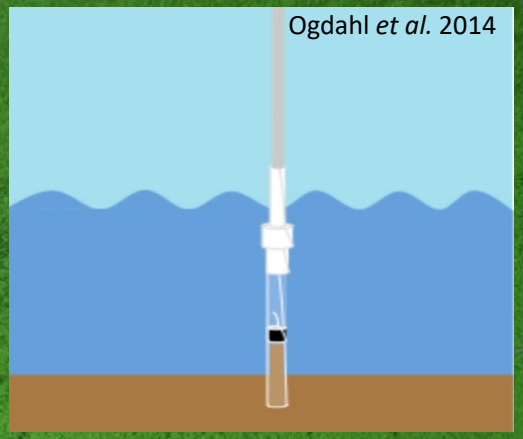
Historical reconstruction using sediments

Compile collected WQ data

Combine data from different agencies

Sediment coring

- Cores – like tree rings
- Integrated historical record of WQ (& HABs!)



Reservoirs for Core + Data

Milford (FY18)

- Large toxic blooms since 2011
- Multiple reservoir closures

Marion (FY19)

- Large toxic blooms since 2003
- Multiple reservoir closures

Sebelius (Norton - FY19)

- Several recent 2-3 week-long blooms
- Blooms recorded since 2014

Kanopolis and Webster cored in 2019 – no data yet

Focus of Results Presented

Each reservoir presented individually

Sediment cores:

- Sediment dating + mixing ($^{239+240}Pu$)
- Sediment nutrients (TN & TP)
- Terrestrial plants or algae? (Isotopes)
- Toxigenic taxa present? (eDNA)
- Algal pigments: Differ by algal groups

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Focus of Results Presented

Combined WQ data to impoundment

-WQ Data from KDHE, USACE, USGS

-Data on Nutrients, Algal Counts,& %Cyano

-Data from multiple sites

-High Freq. data

Land use data from watersheds

-From Cropland Data Layers (USDA NASS)

Focus of Results Presented

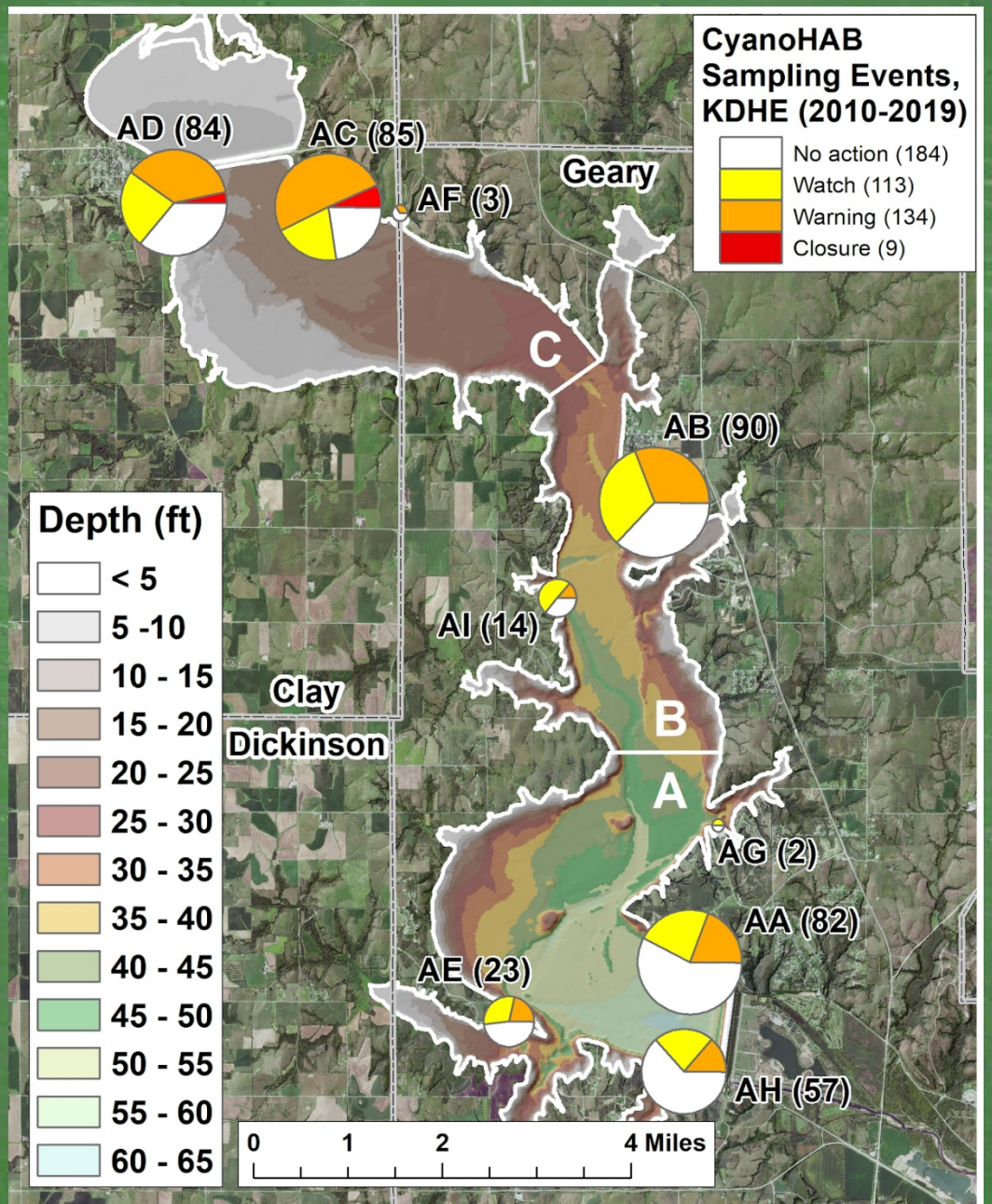
Combined WQ data to impoundment

- WQ Data from KDHE, USACE, USGS
- Near-Dam Nutrients, Algal Counts, & %Cyano
- Data from multiple sites
- High Freq. data

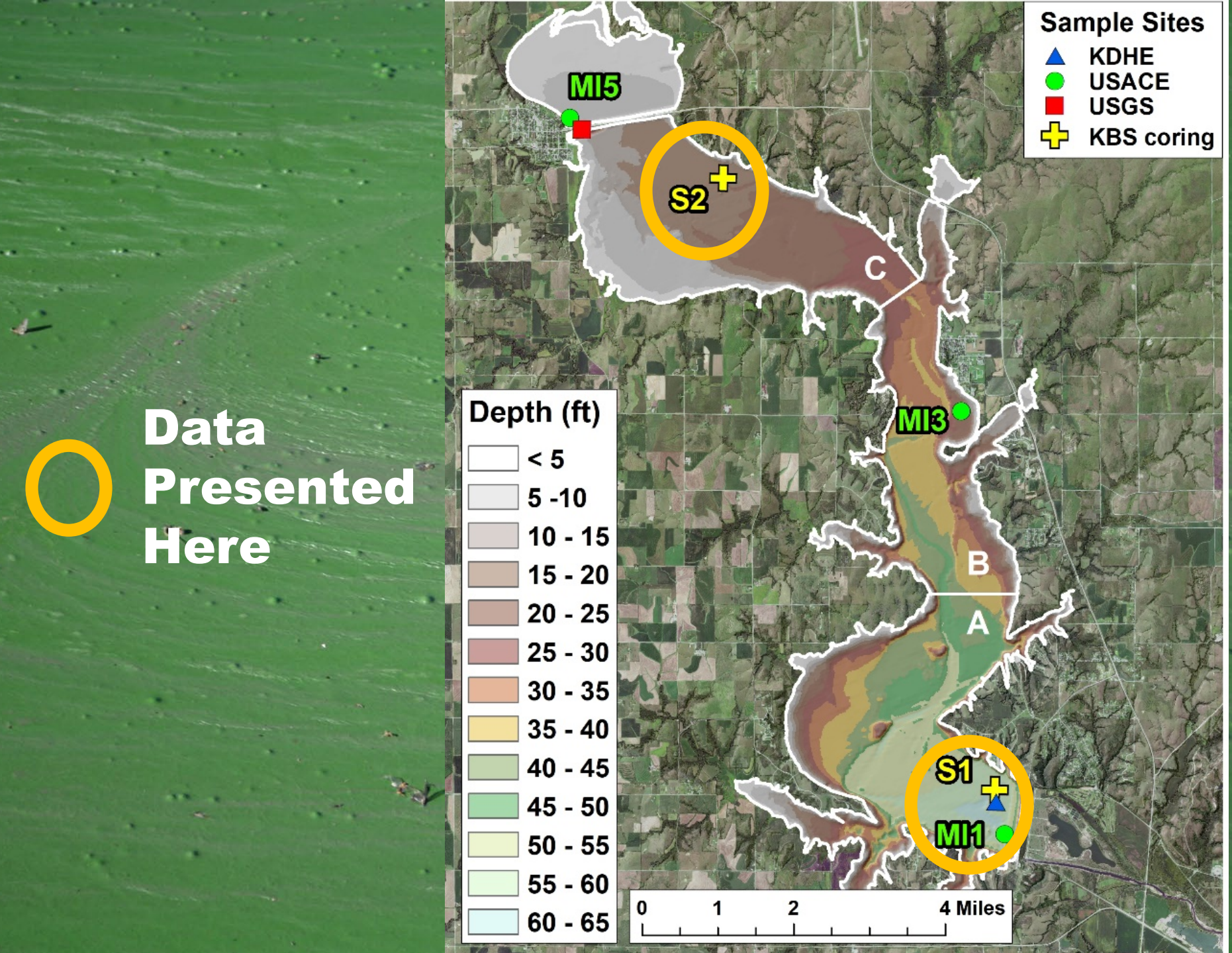
Land use data from watersheds

- From Cropland Data Layers (USDA NASS)

Milford


CyanoHAB Sampling Events, KDHE (2010-2019)
No action (184)
Watch (113)
Warning (134)
Closure (9)
AD (84)
AC (85)
AF (3)
Geary
C
AB (90)
AI (14)
Clay
Dickinson
B
A
AG (2)
AA (82)
AE (23)
AH (57)
Depth (ft)
< 5
5 -10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
55 - 60
60 - 65
0
1
2
4 Miles

Milford: Sediment coring


Data Presented Here
Sample Sites
KDHE
USACE
USGS
KBS coring
MI5
S2
C
MI3
B
A
S1
MI1
Depth (ft)
< 5
5 -10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 55
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1
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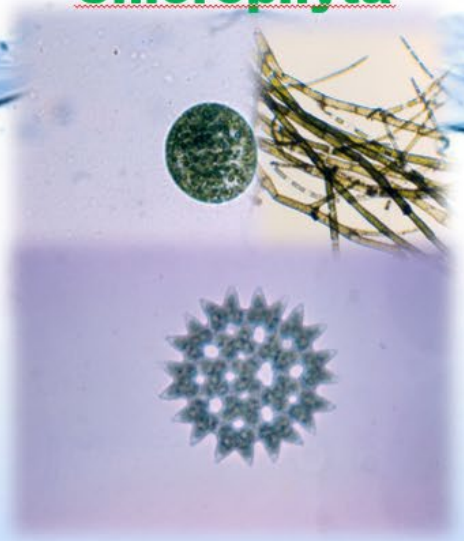
4 Miles

Algal Diversity

Cyanophyta

Chlorophyta



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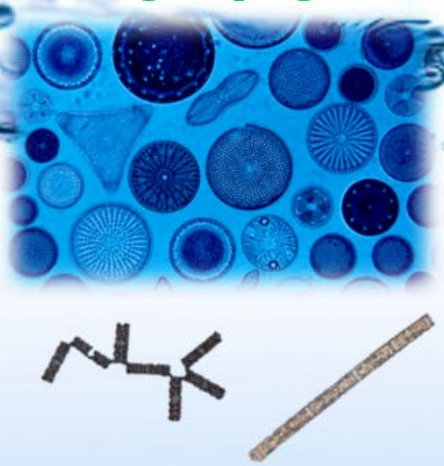
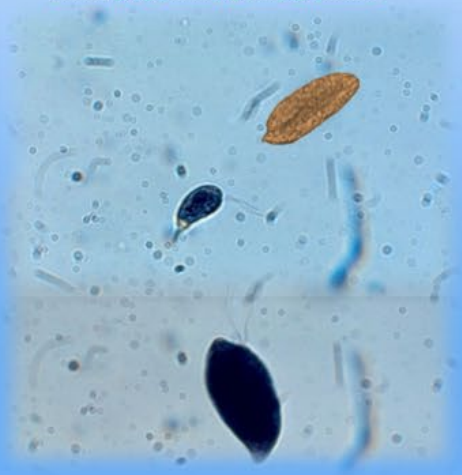


Freshwater groups of “tiny plants”

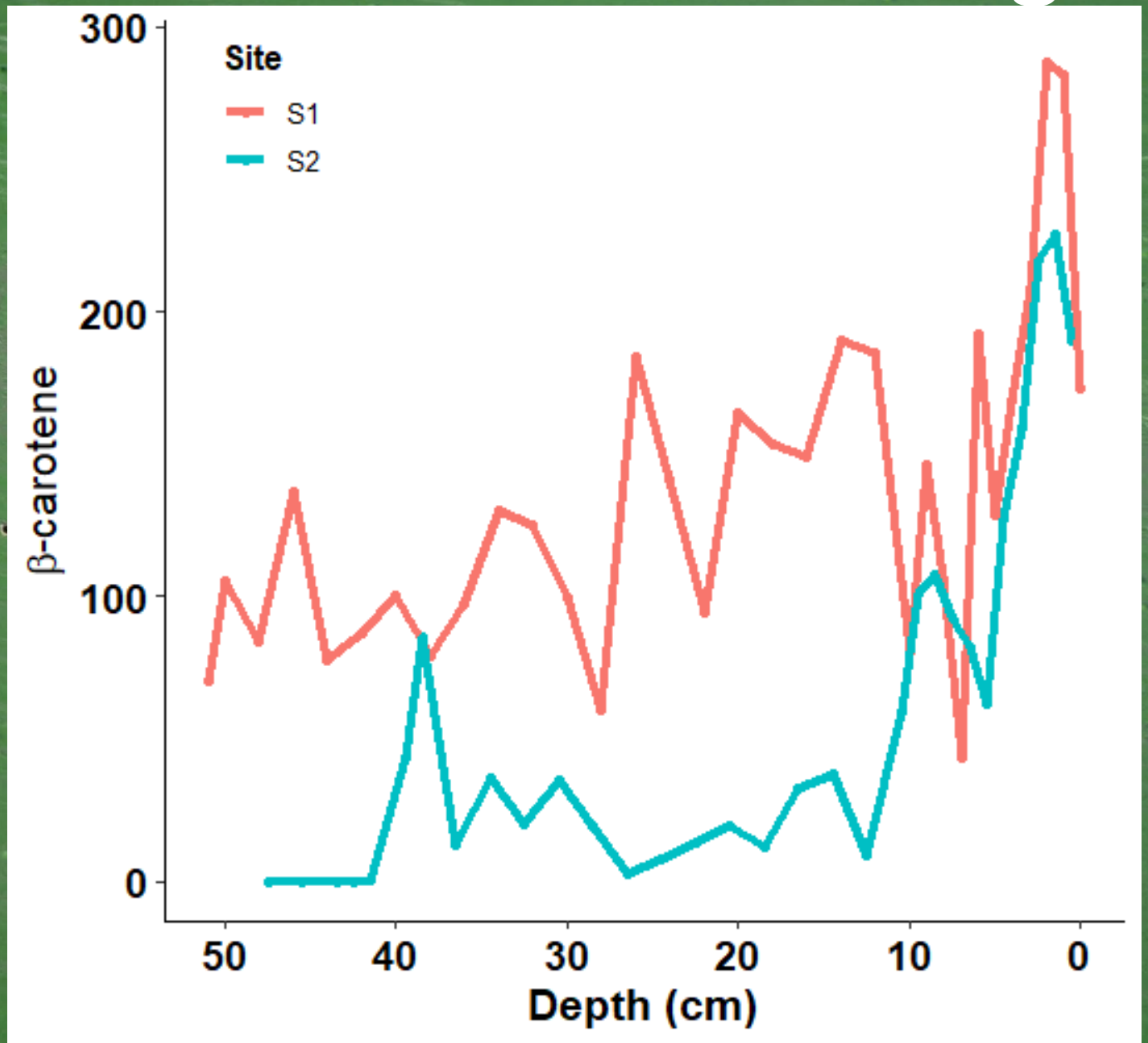
Pyrrophyta

Cryptophyta

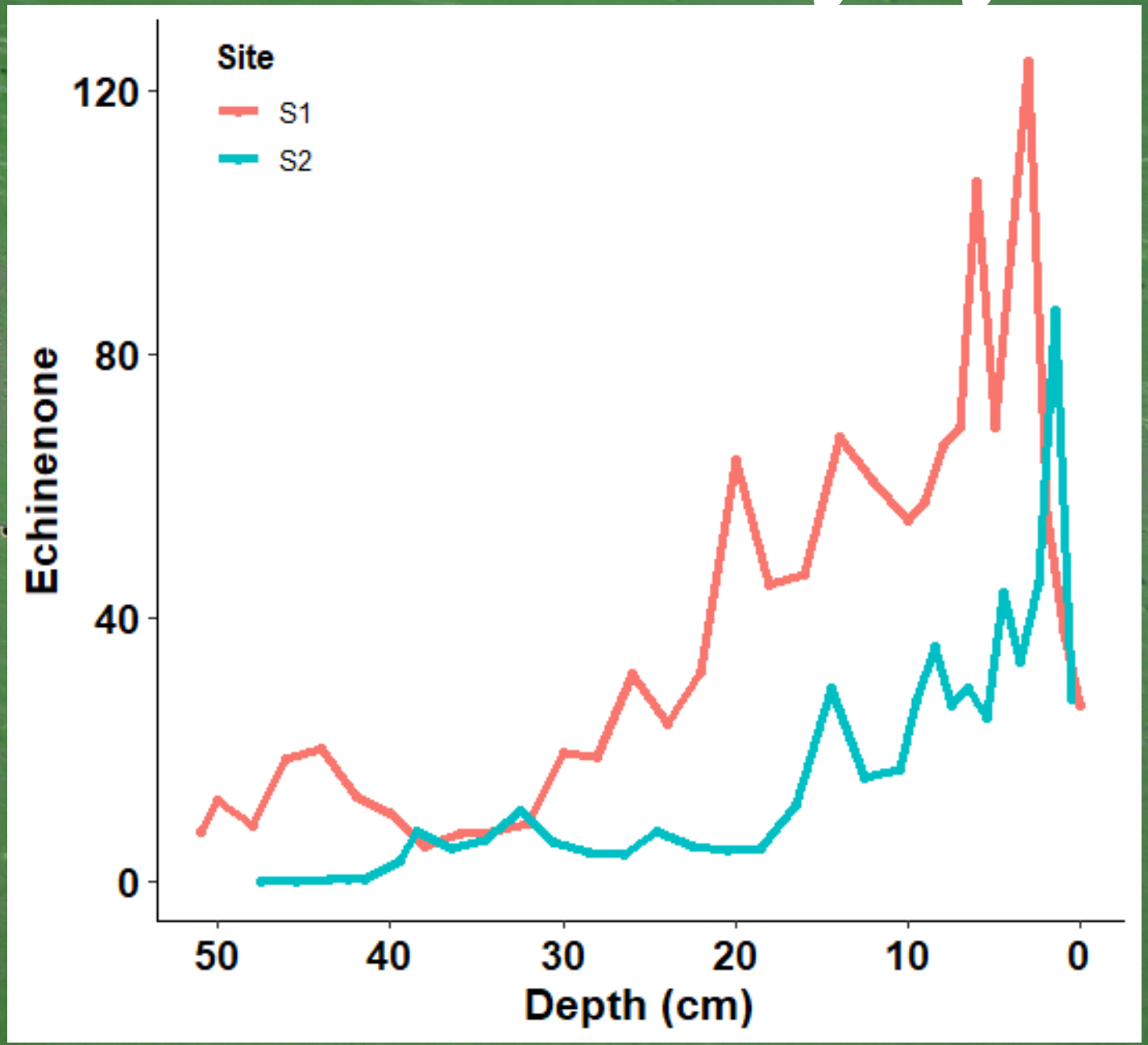


Euglenophyta

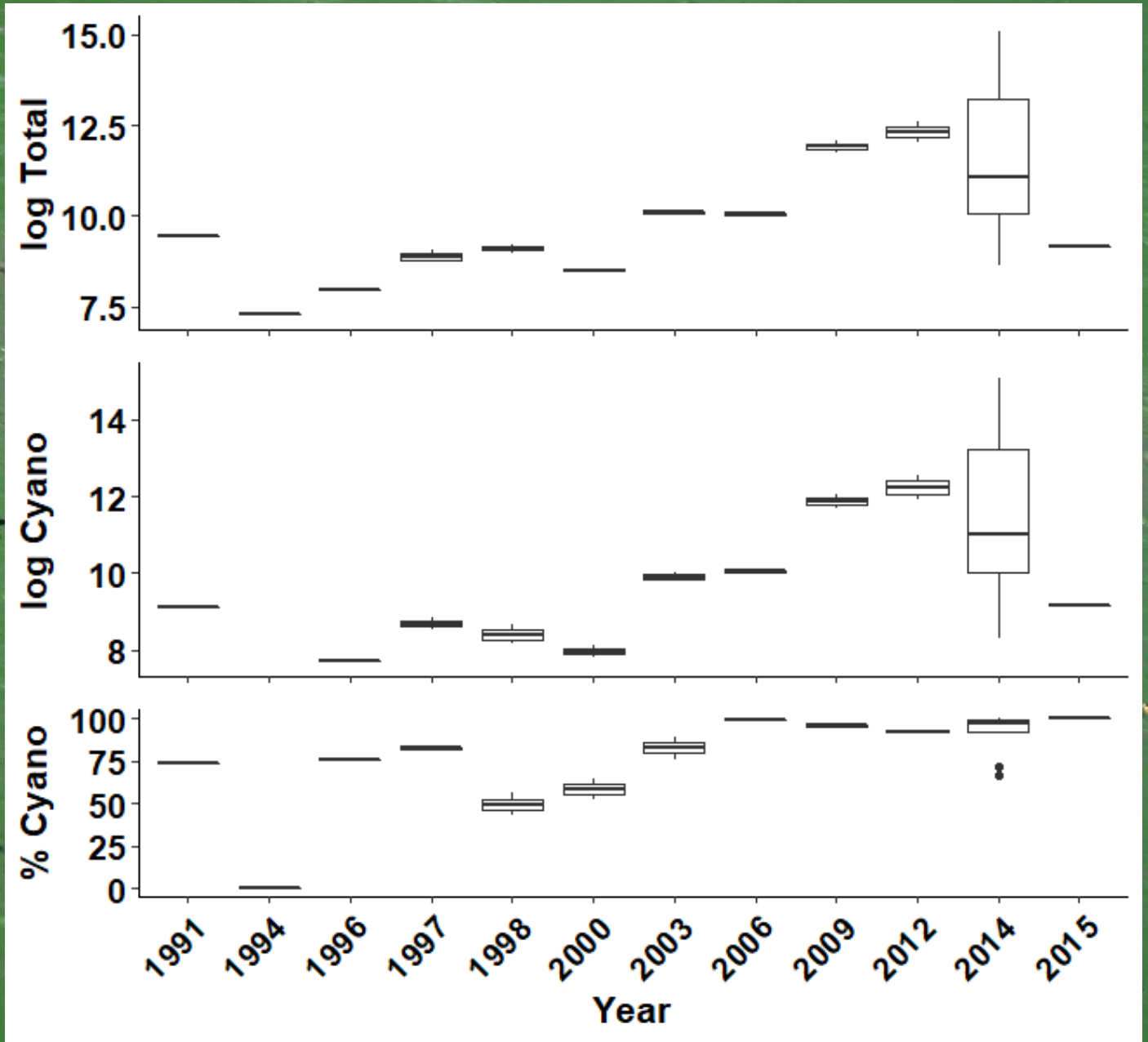
Milford Cores: Total algae



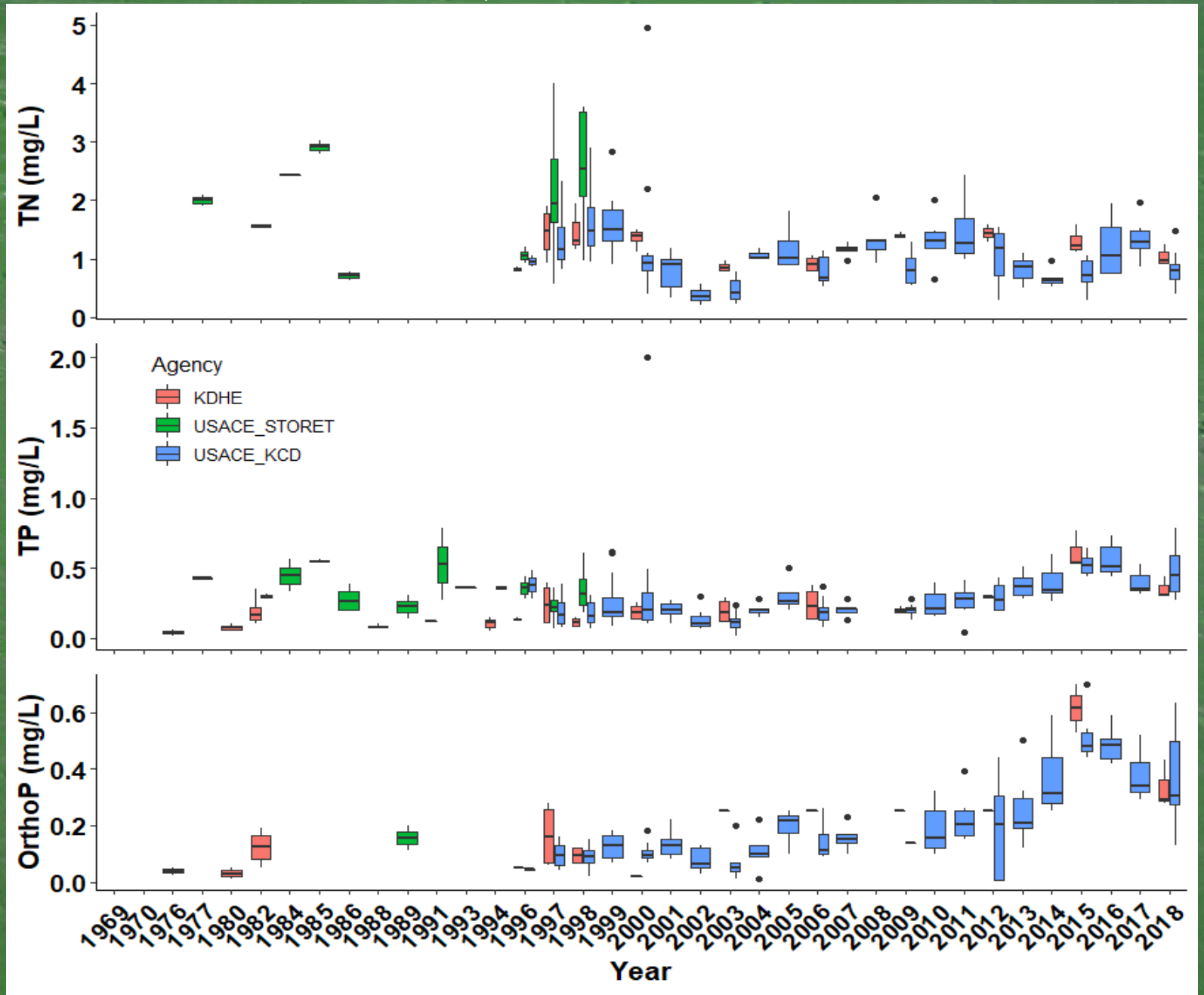
Milford Cores: Only Cyano



Milford KDHE: Algal counts



Milford WQ Data: Nutrients



Milford Cores + Data Summary

Sediment pigments

- Incr. in total algae caused by Cyano

Discrete algal samples (near dam)

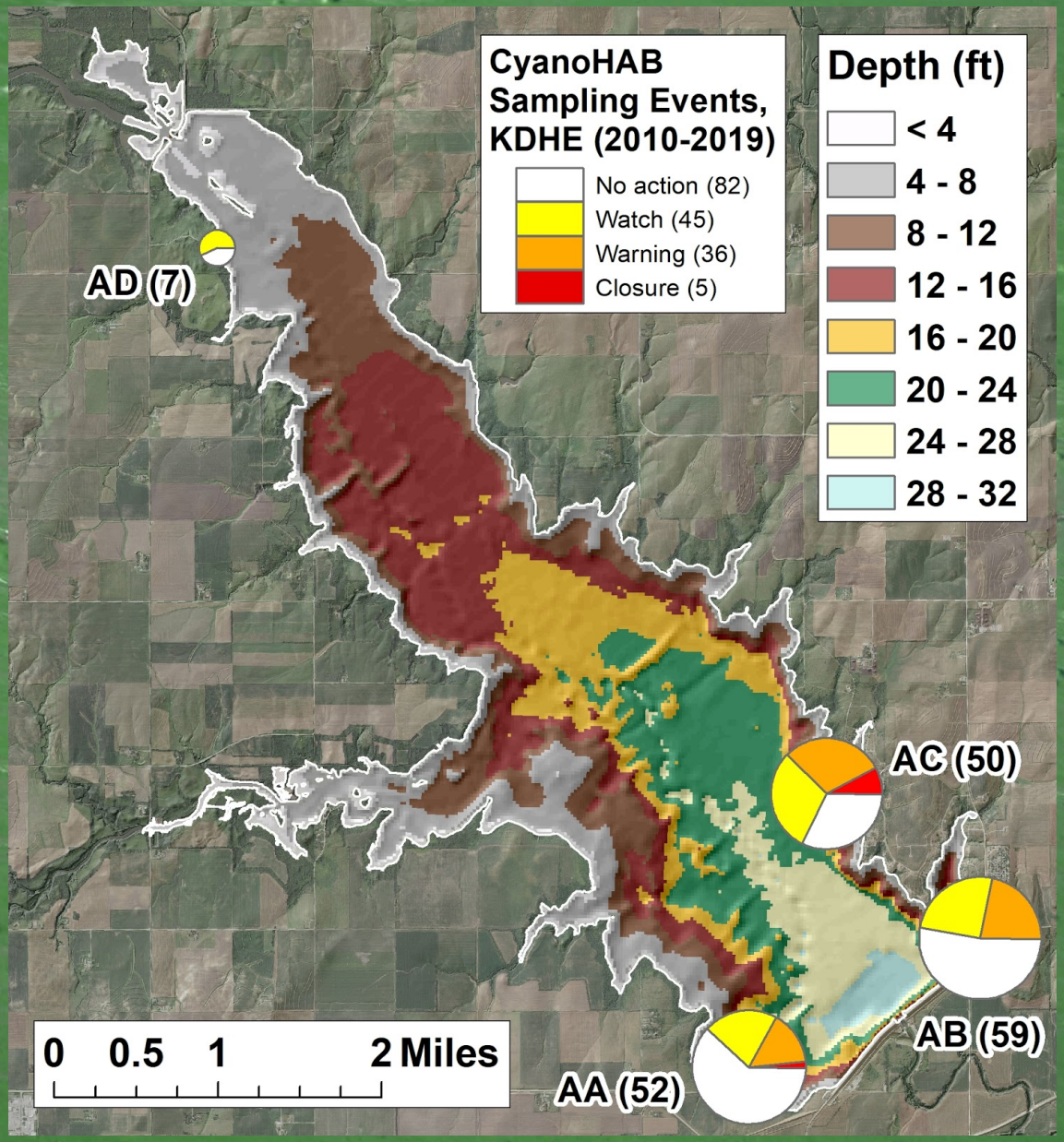
- Incr. in total algae caused by Cyano

Discrete nutrients

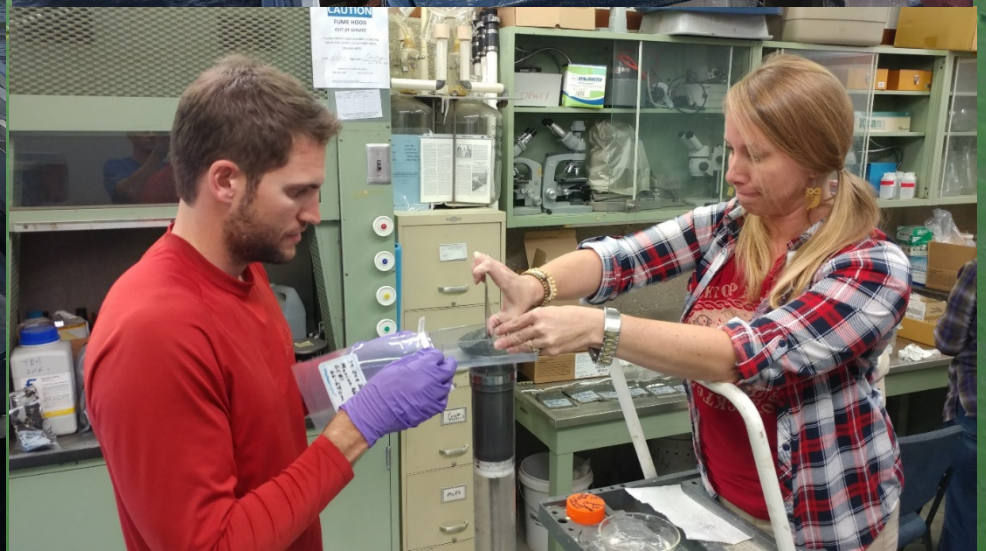
- Little change in N, but P is incr.

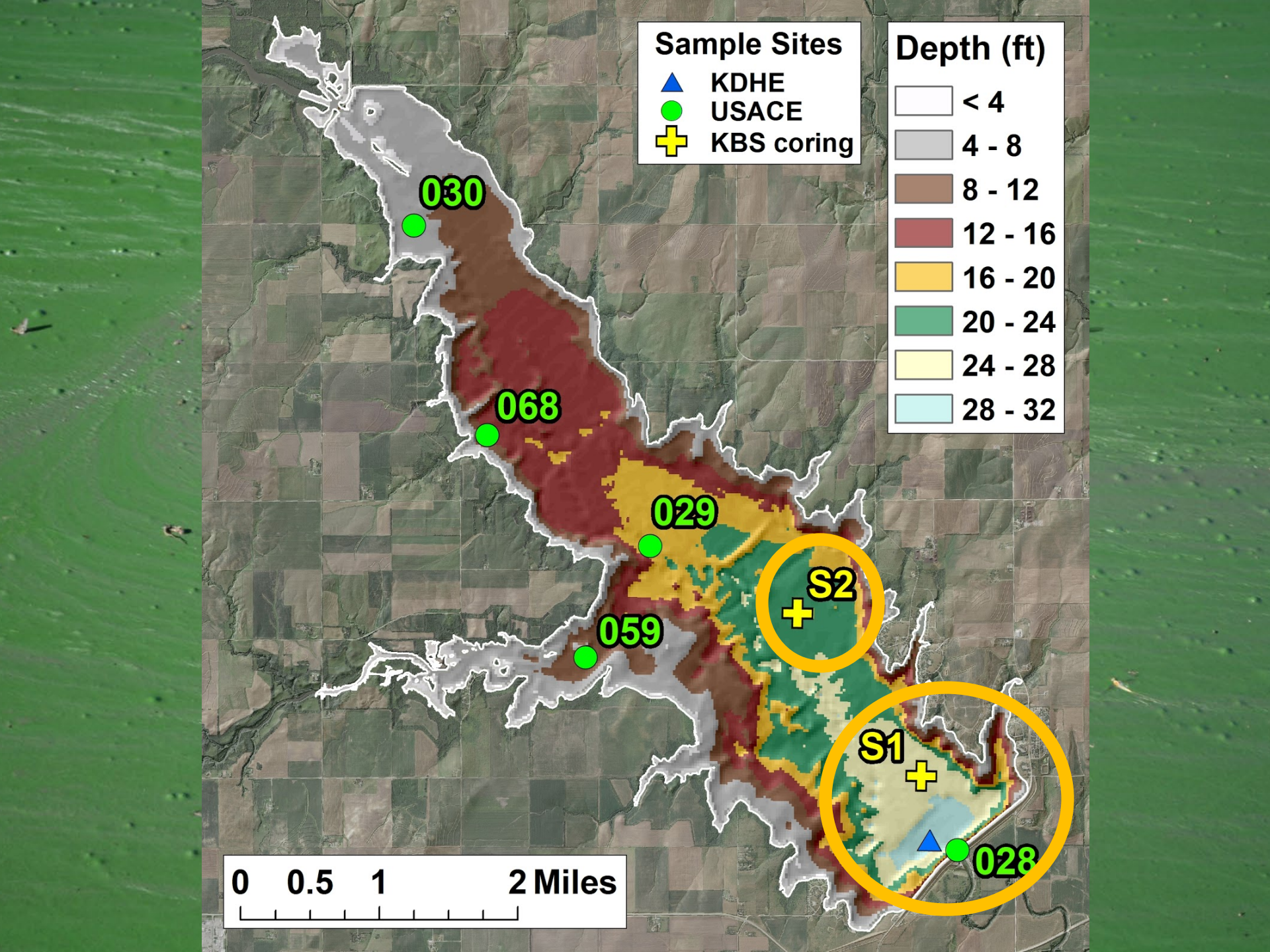
Incr. P seems to drive incr. cyano

Marion

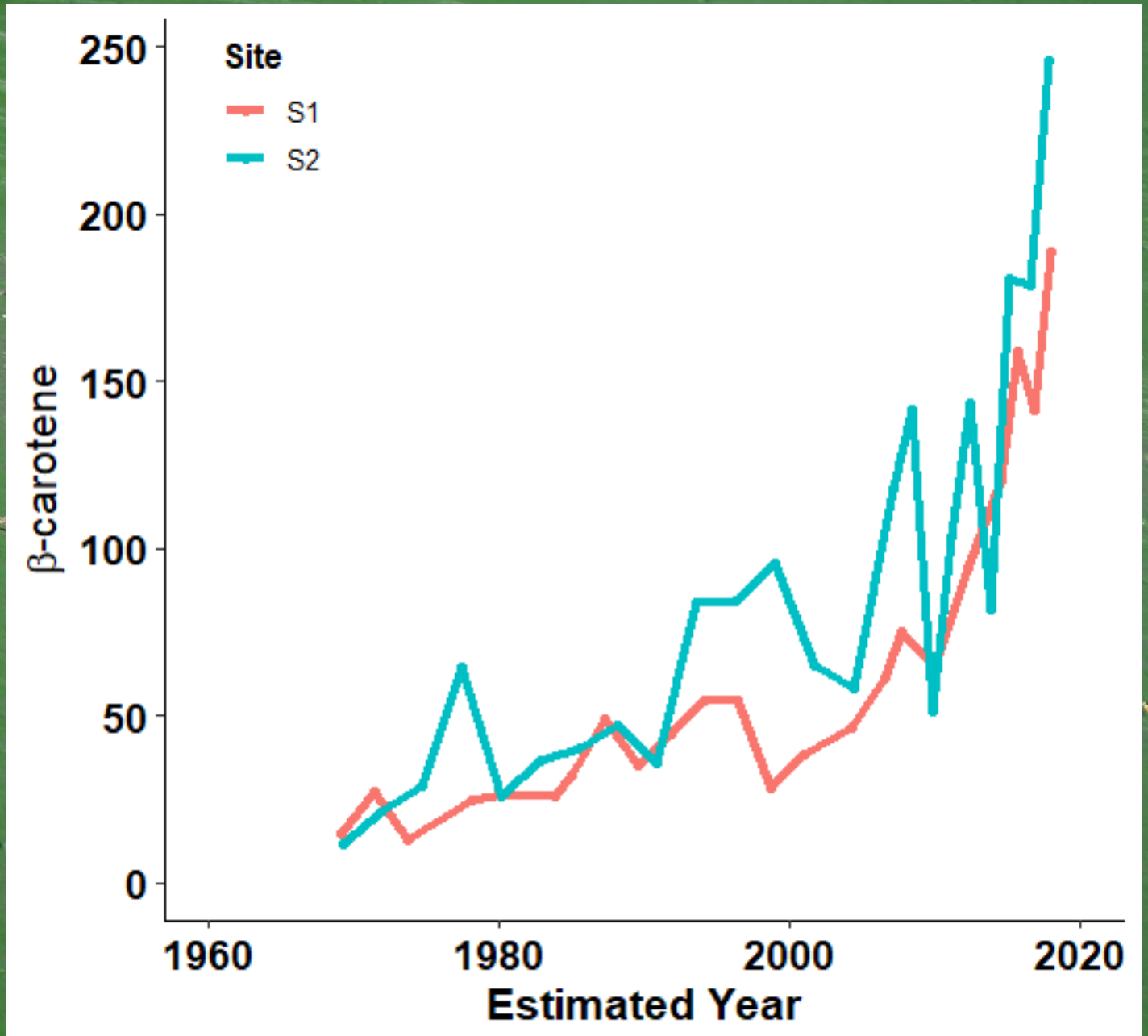

CyanoHAB Sampling Events, KDHE (2010-2019)
No action (82)
Watch (45)
Warning (36)
Closure (5)
Depth (ft)
< 4
4 - 8
8 - 12
12 - 16
16 - 20
20 - 24
24 - 28
28 - 32
AD (7)
AC (50)
AB (59)
AA (52)
0 0.5 1 2 Miles

Marion: Sediment coring

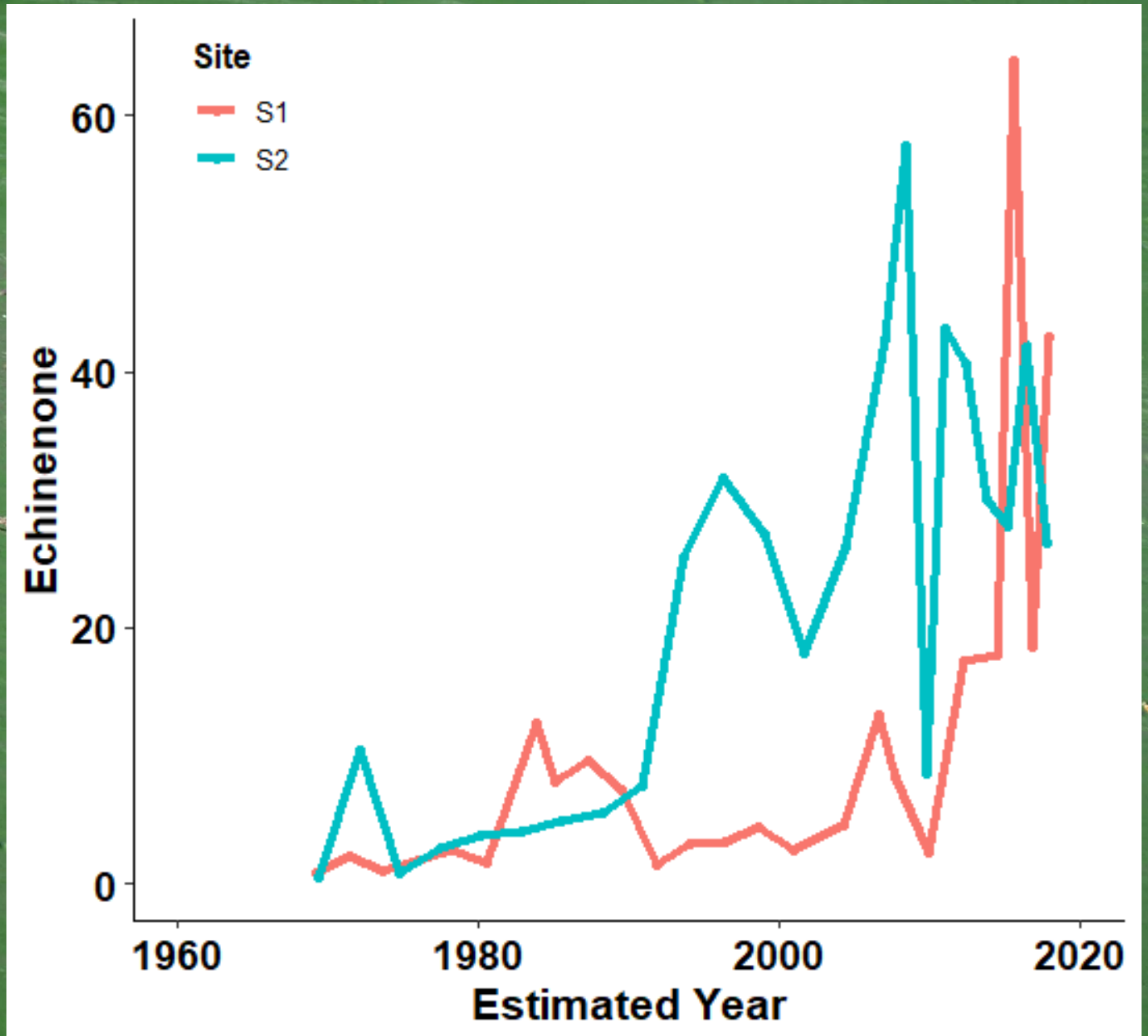



Sample Sites
KDHE
USACE
KBS coring
Depth (ft)
< 4
4 - 8
8 - 12
12 - 16
16 - 20
20 - 24
24 - 28
28 - 32
030
068
029
059
S2
S1
028
0 0.5 1 2 Miles

Marion Cores: Total algae



Marion Cores: Only Cyano



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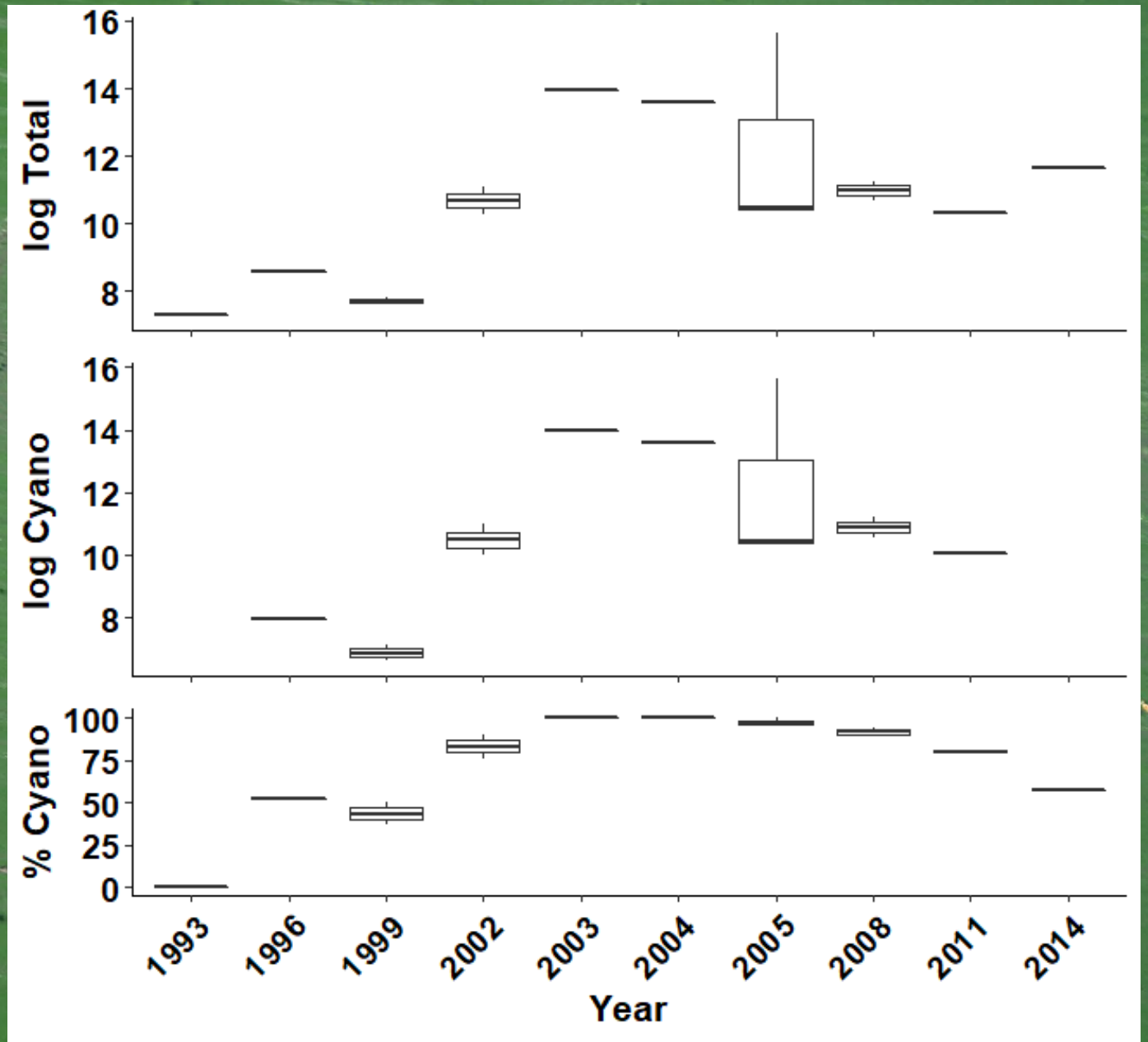
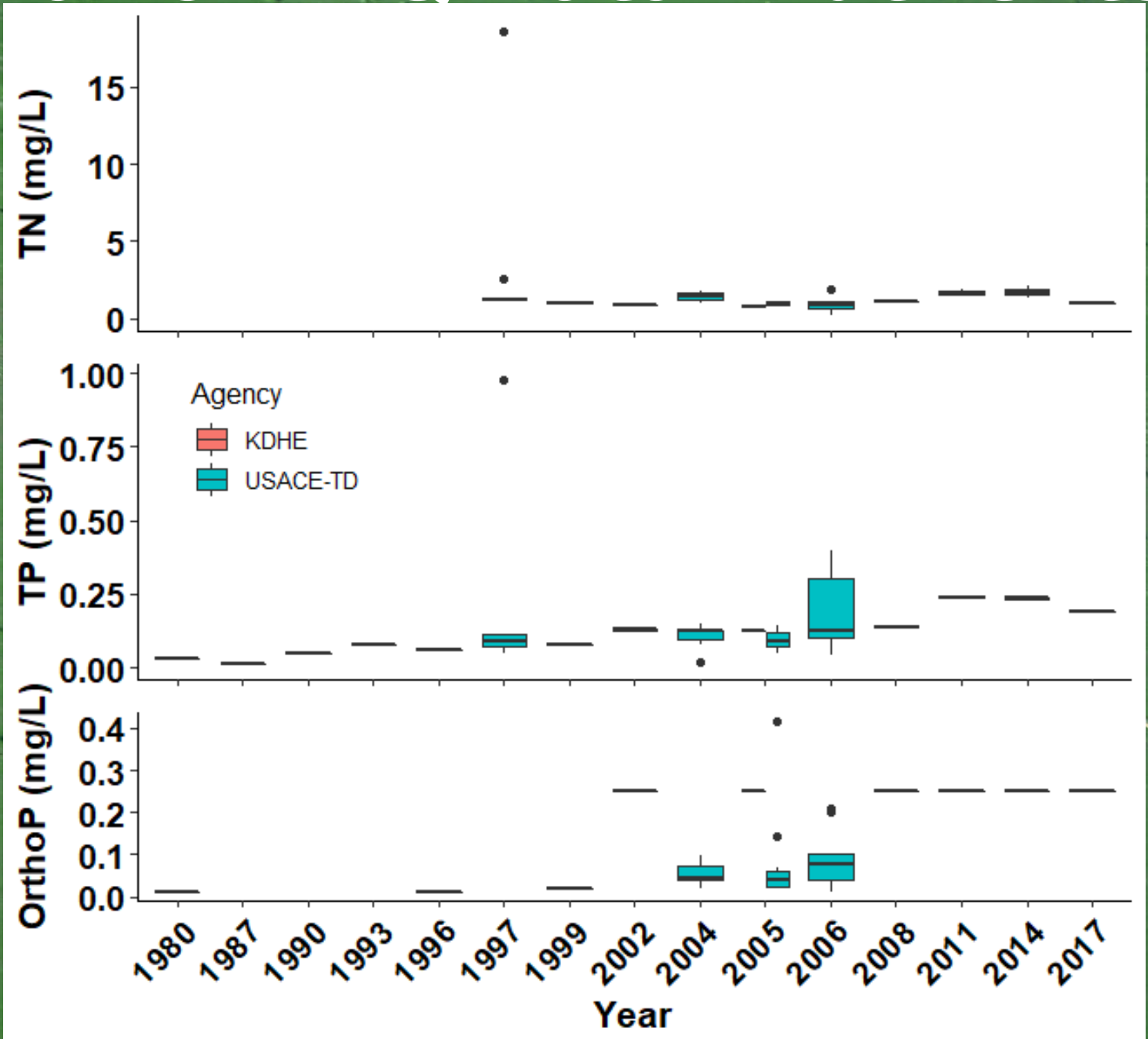
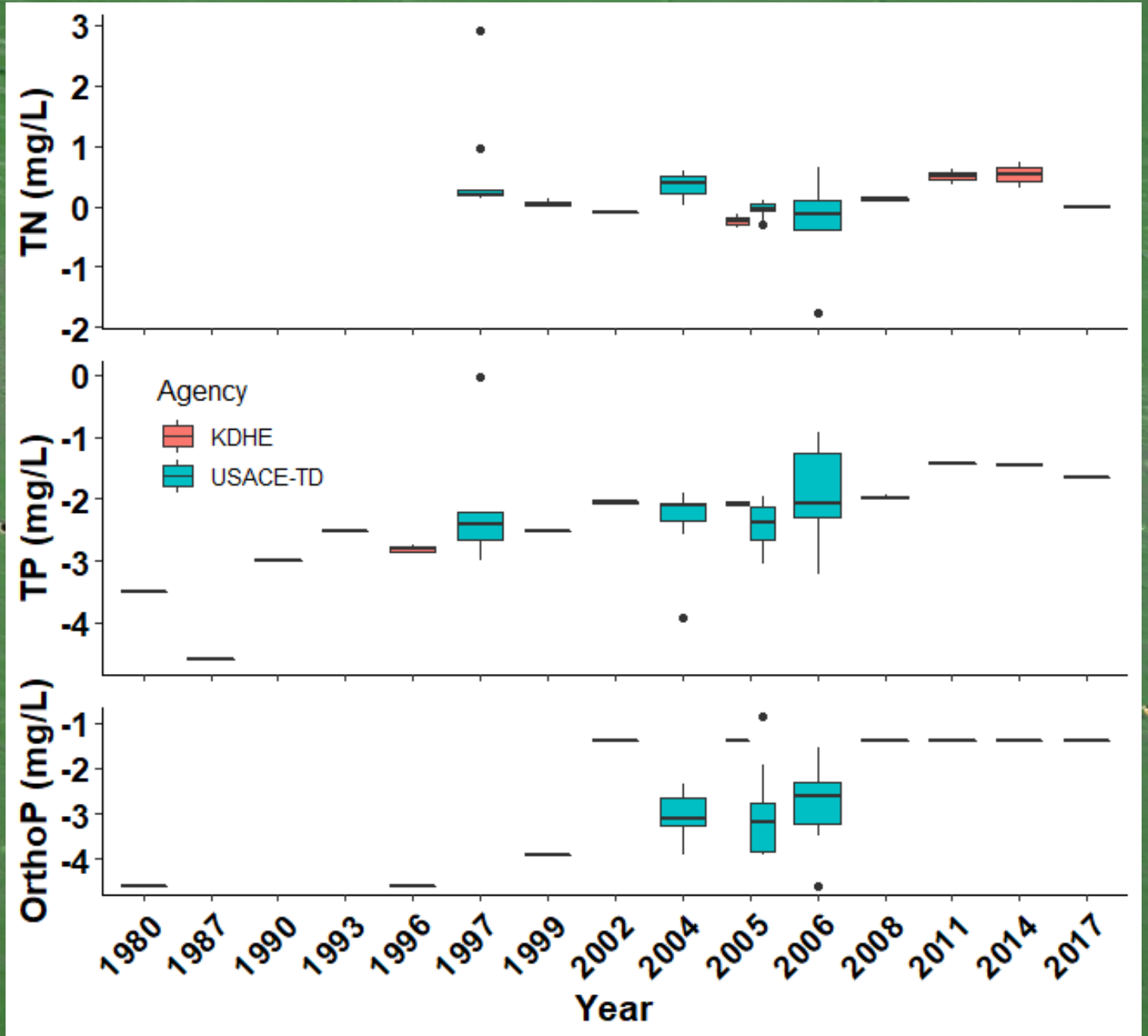


Marion WQ Data: Nutrients



Marion WQ Data: log Nutrients



Marion Cores + Data Summary

Sediment pigments

- Incr. in total algae caused by Cyano

Discrete algal samples (near dam)

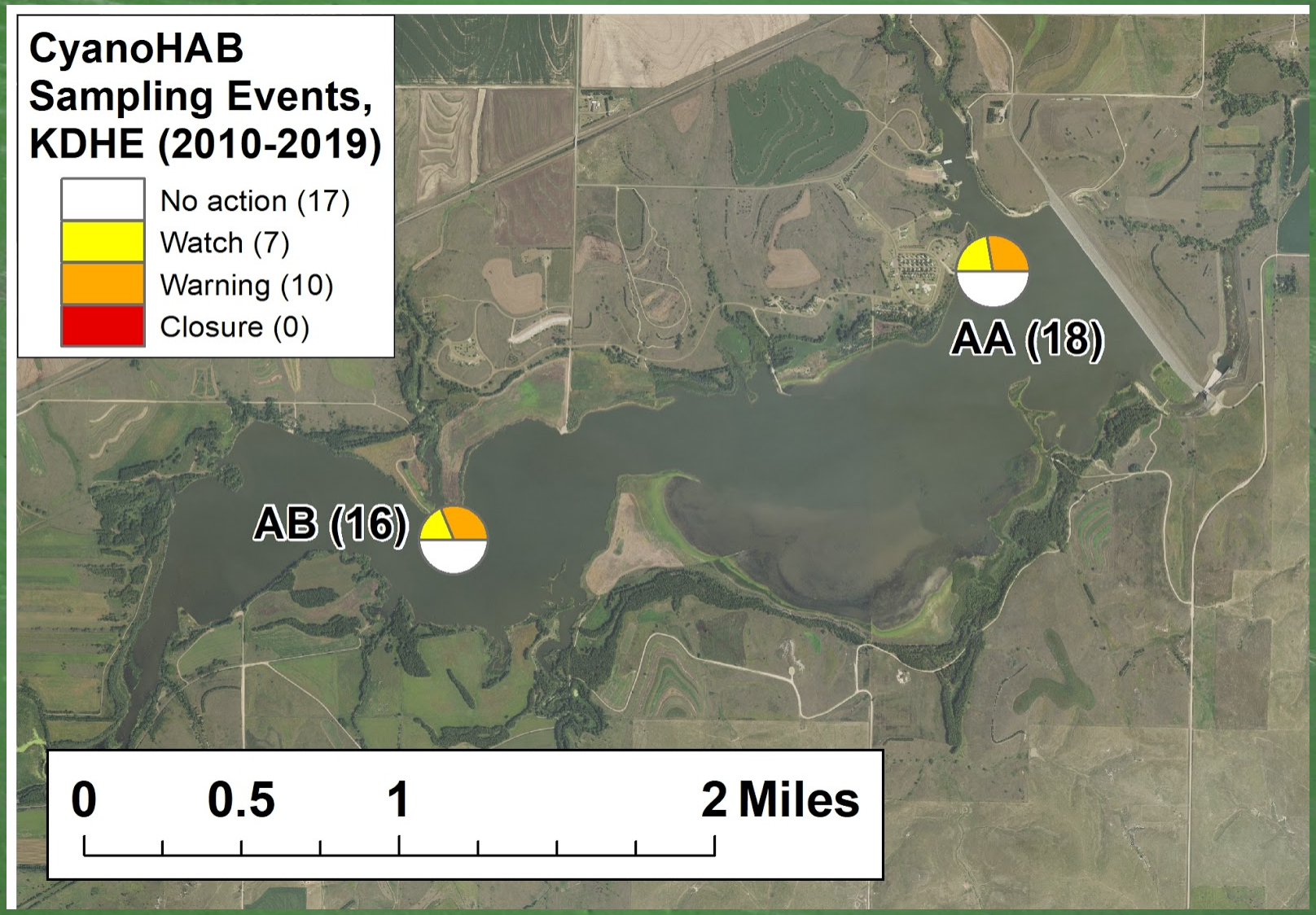
- Incr. in total algae caused by Cyano

Discrete nutrients

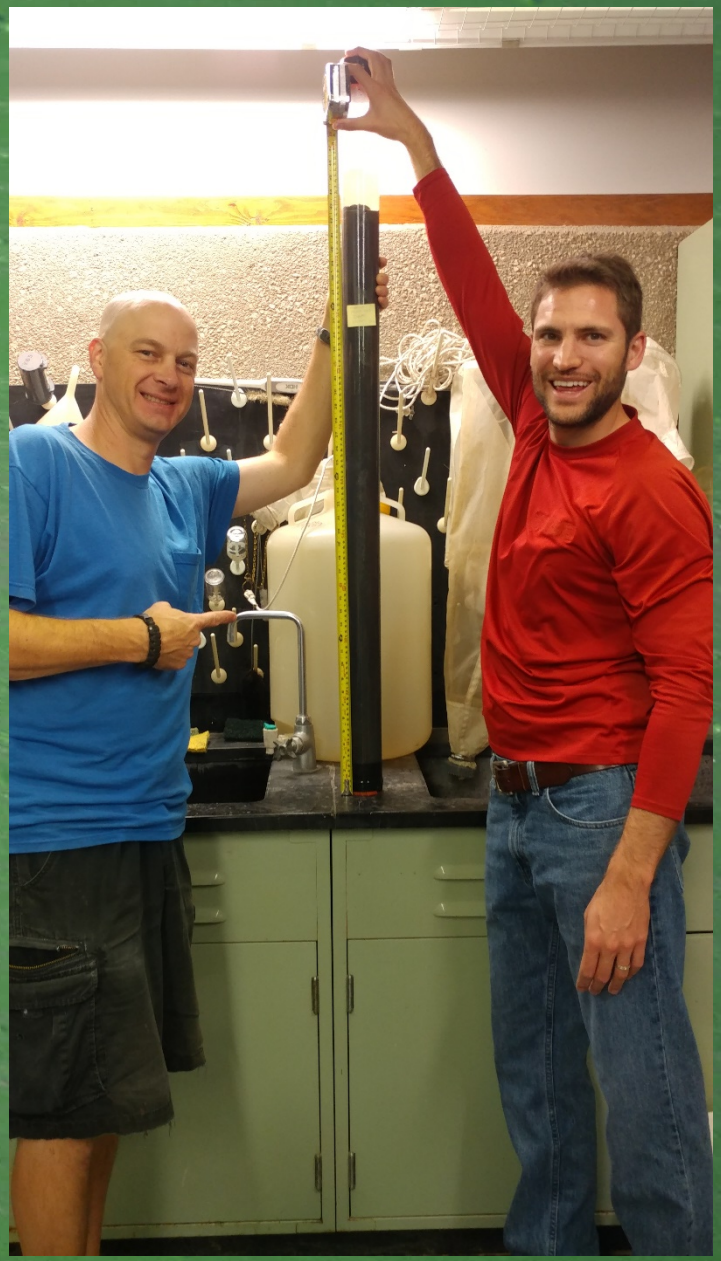
- Little change in N; P is incr. (1990s)

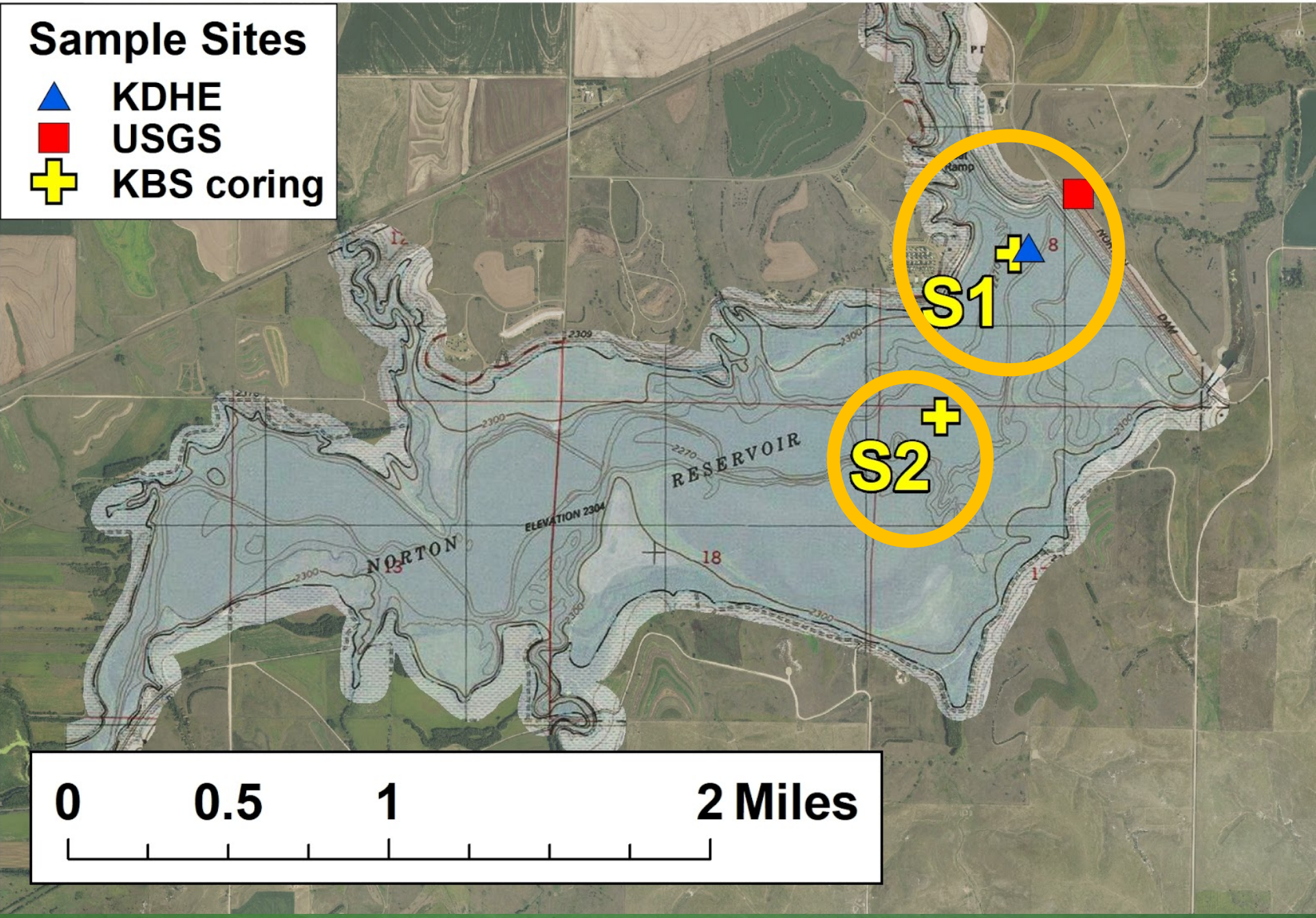
Incr. P seems to drive incr. cyano

Sebelius

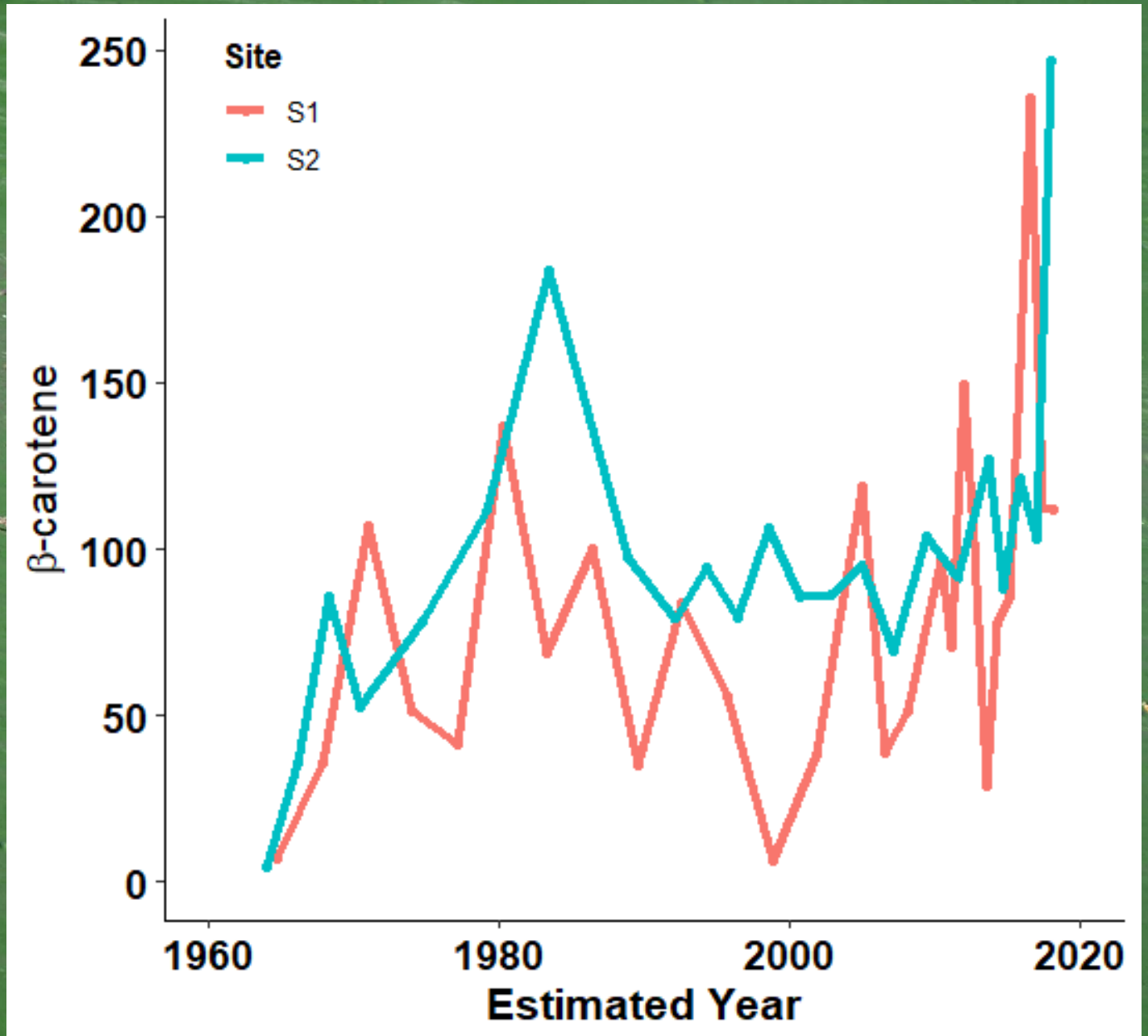

CyanoHAB Sampling Events, KDHE (2010-2019)
No action (17)
Watch (7)
Warning (10)
Closure (0)
AA (18)
AB (16)
0
0.5
1
2 Miles

Sebelius: Sediment coring

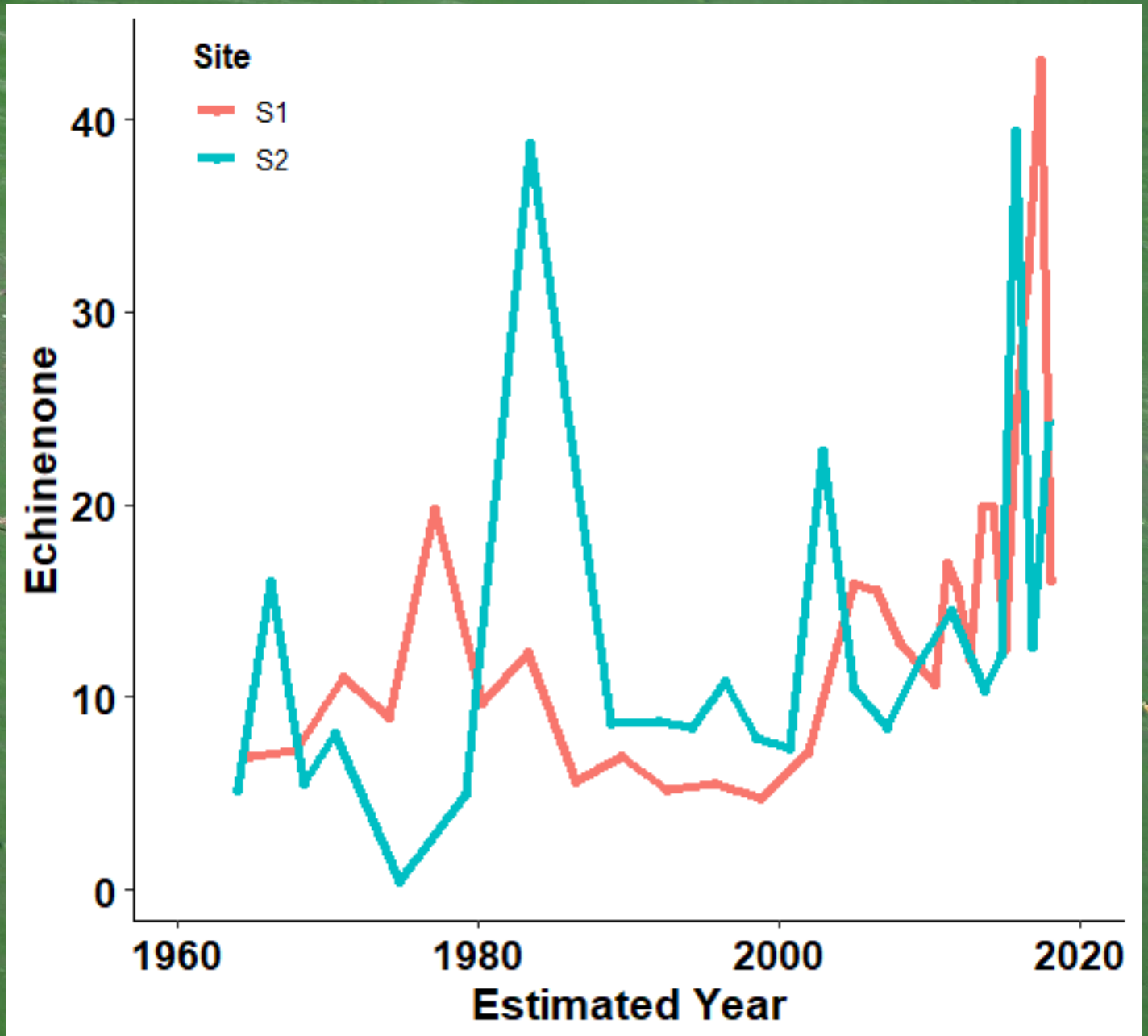



Sample Sites
KDHE
USGS
KBS coring
S1
S2
NORTON
RESERVOIR
ELEVATION 2304
DAM
0
0.5
1
2 Miles

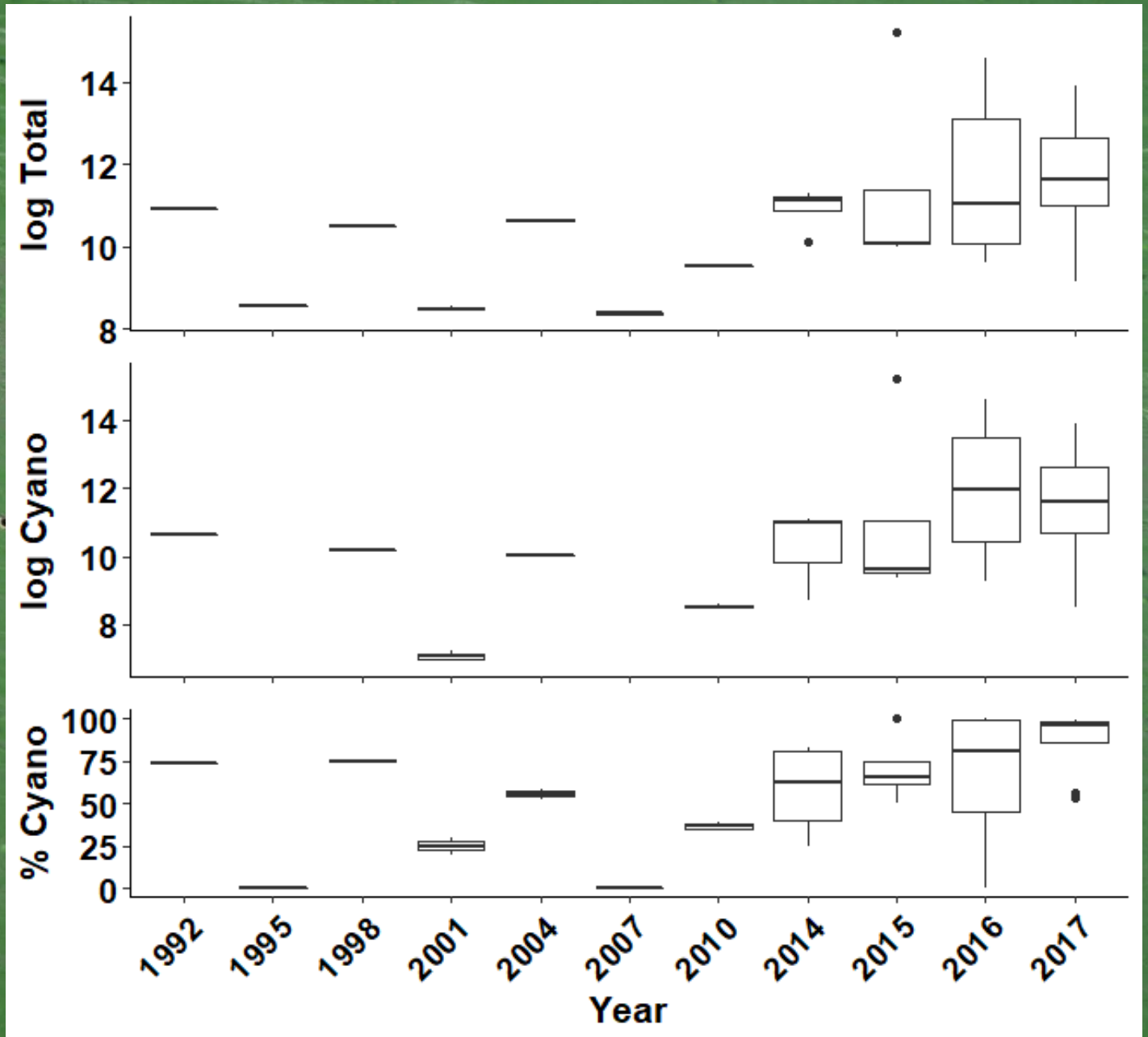
Sebelius Cores: Total algae



Sebelius Cores: Only Cyano



Sebelius KDHE: Algal counts



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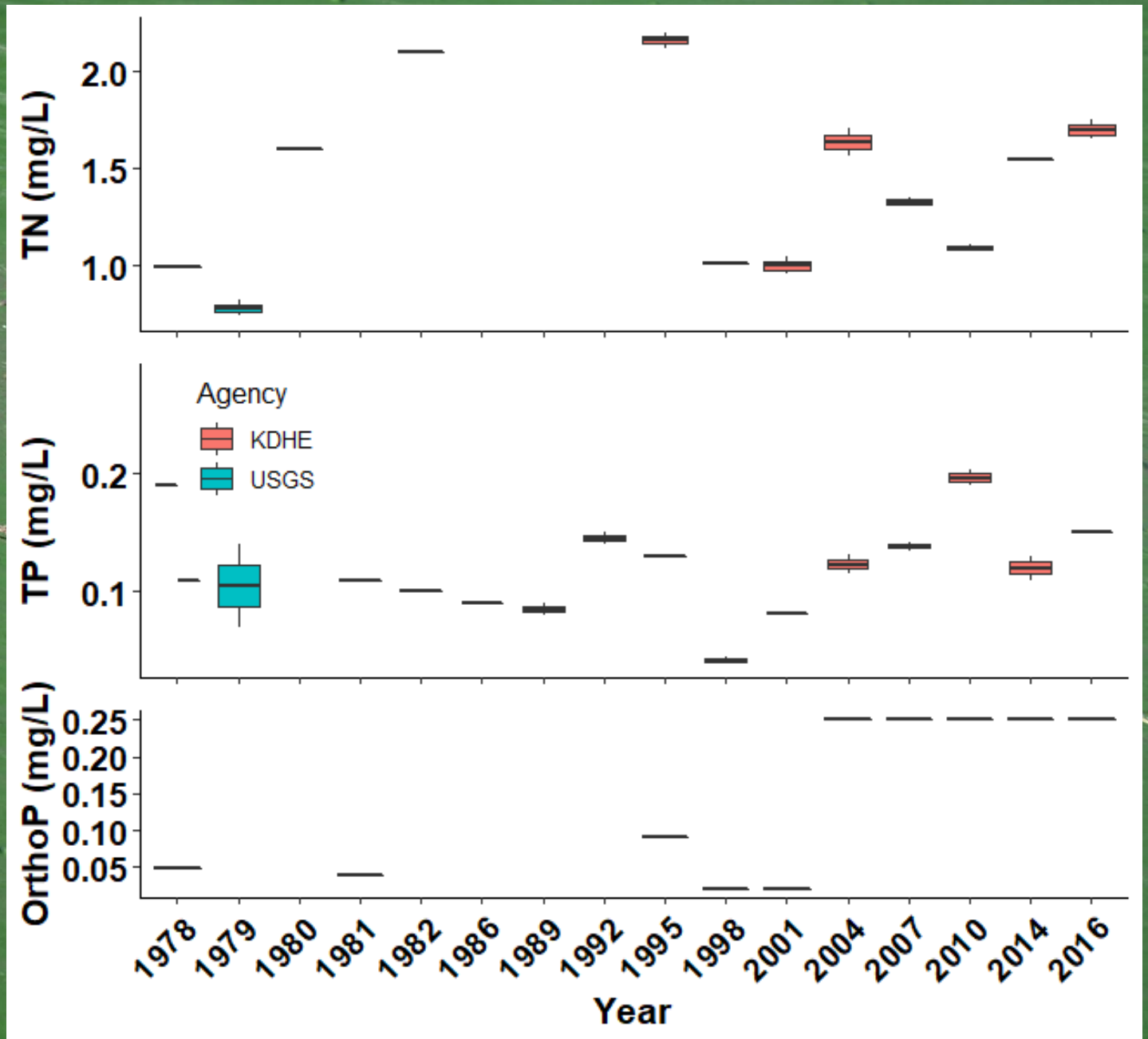
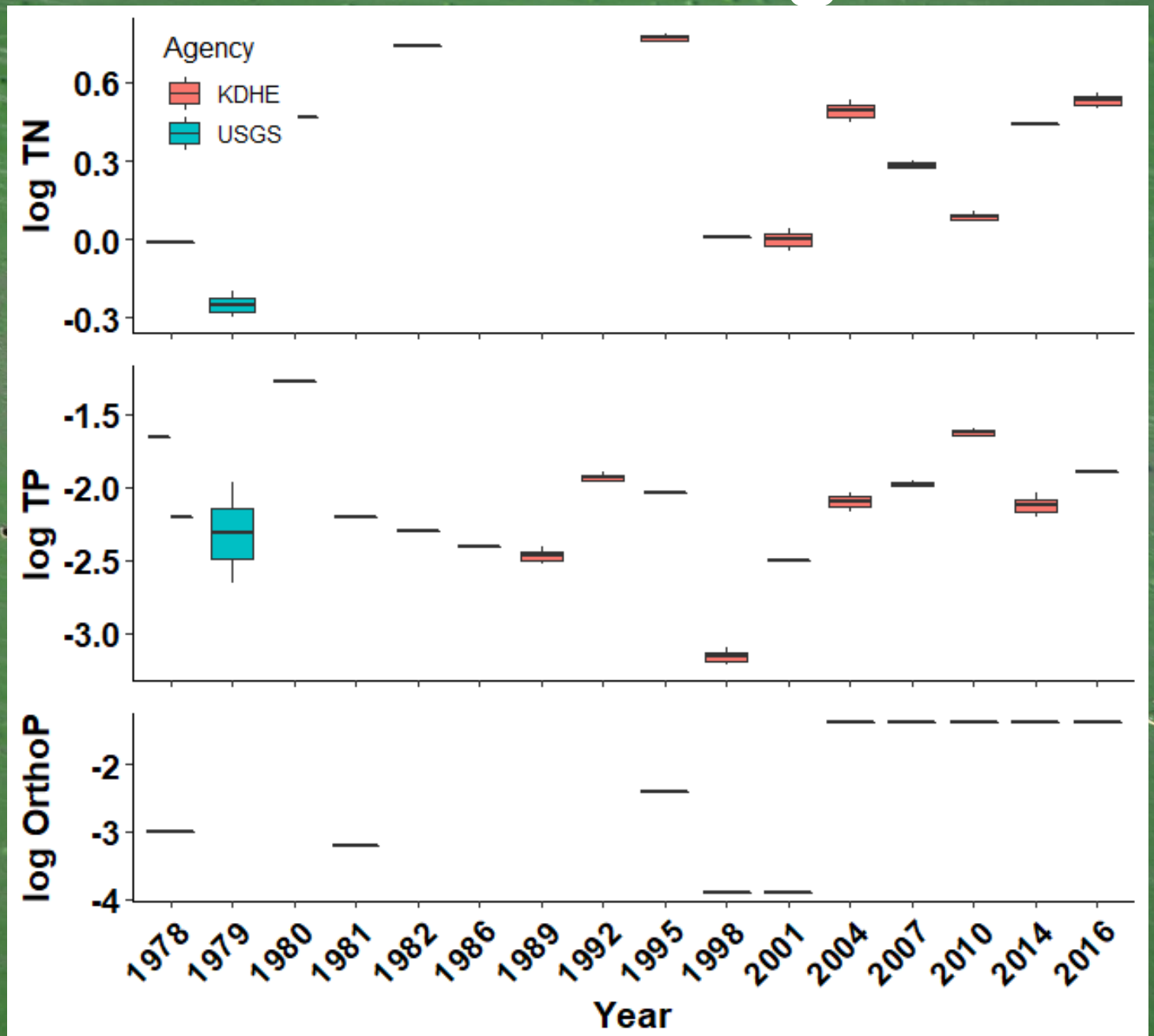


Sebelius WQ Data: log Nutrients



Sebelius Cores + Data Summary

Sediment pigments

- Large mixed blooms in early 1980s

Discrete algal samples (near dam)

- Few trends obs. – slight recent incr.

Discrete nutrients

- Highly variable over time

Dynamic hydro. -> dynamic conditions

Summary

- Milford & Marion are increasing in HABs
  - HAB incr. concurrent with P incr.
  - Incr. started late 90s/early 2000s in both
- Sebelius dynamic but slight HAB incr.
  - Hydrological signal?
  - Short-term conditions?

The lakes with the worst HABs do not seem to be slowing down

Future Directions

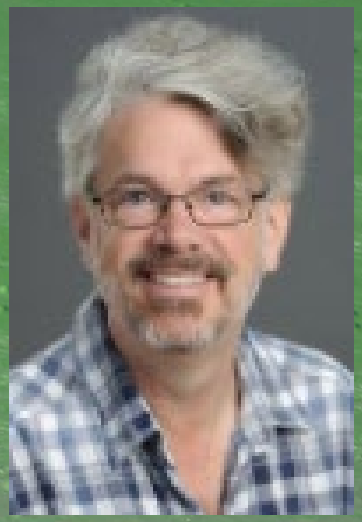
- Are land use trends important to P?
  - Does it matter what crop is planted?
  - Does double cropping matter?
  - Related to tillage practice?
- How much P is internally loaded?
  - Currently finding out in Marion

Dive deeper into the data at 11-Feb webinar @ KWO

Thank you to collaborators!

Debbie Baker

Jude Kastens



Peter Leavitt

Jin-Ho Yun

Belinda Sturm

Michael Ketterer

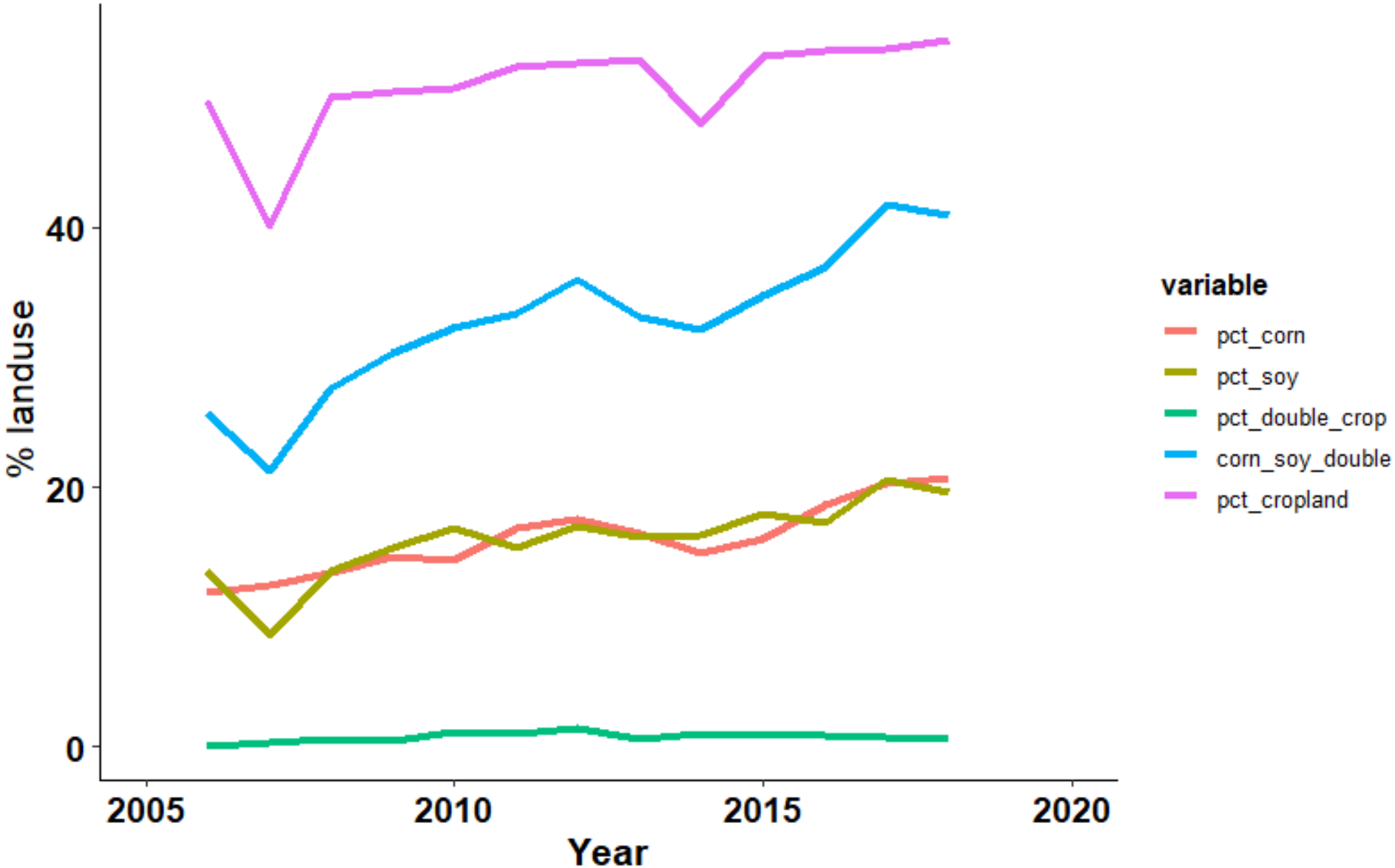
Ann St. Amand

Thank you!

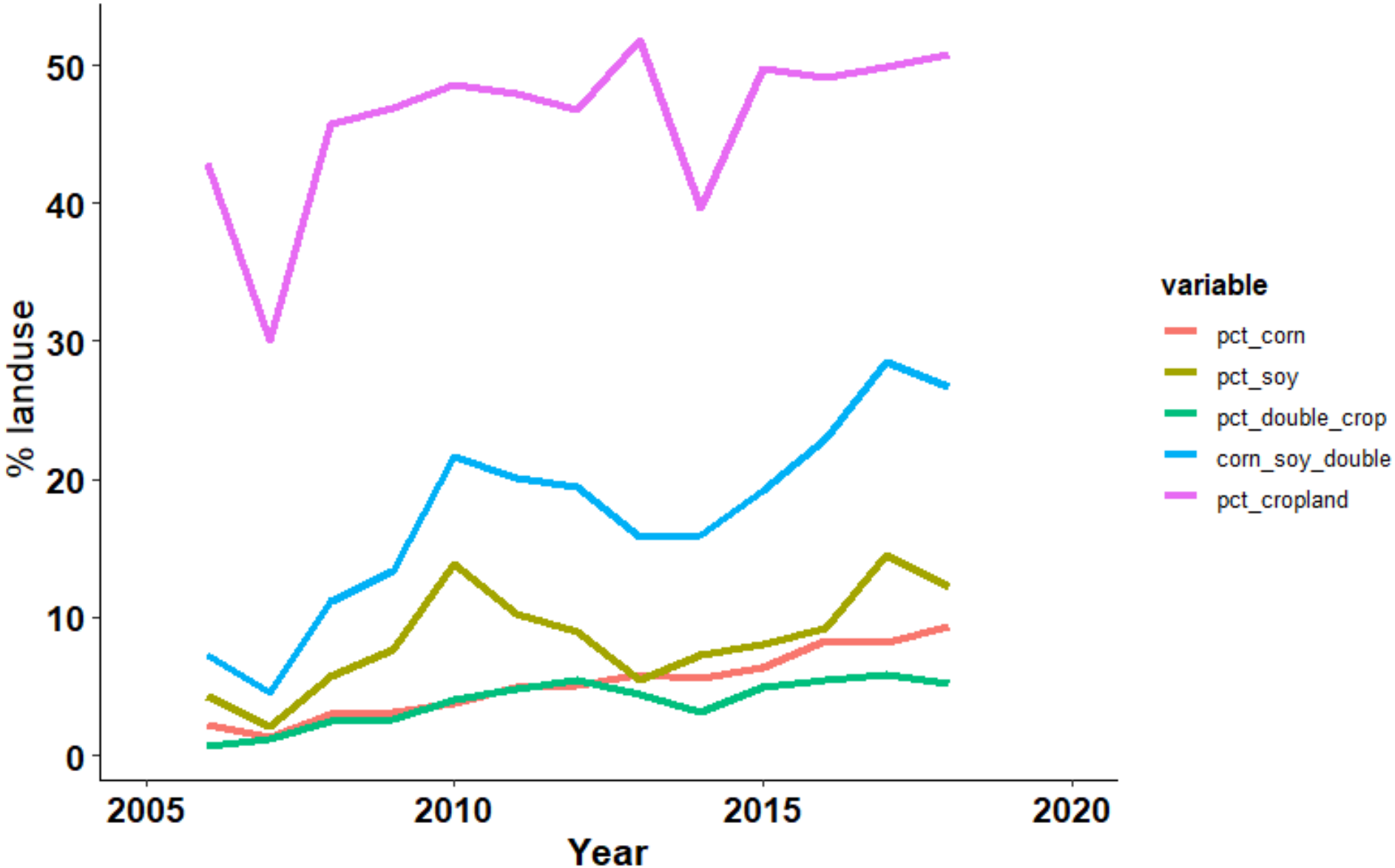
Questions?

T992H557@ku.edu

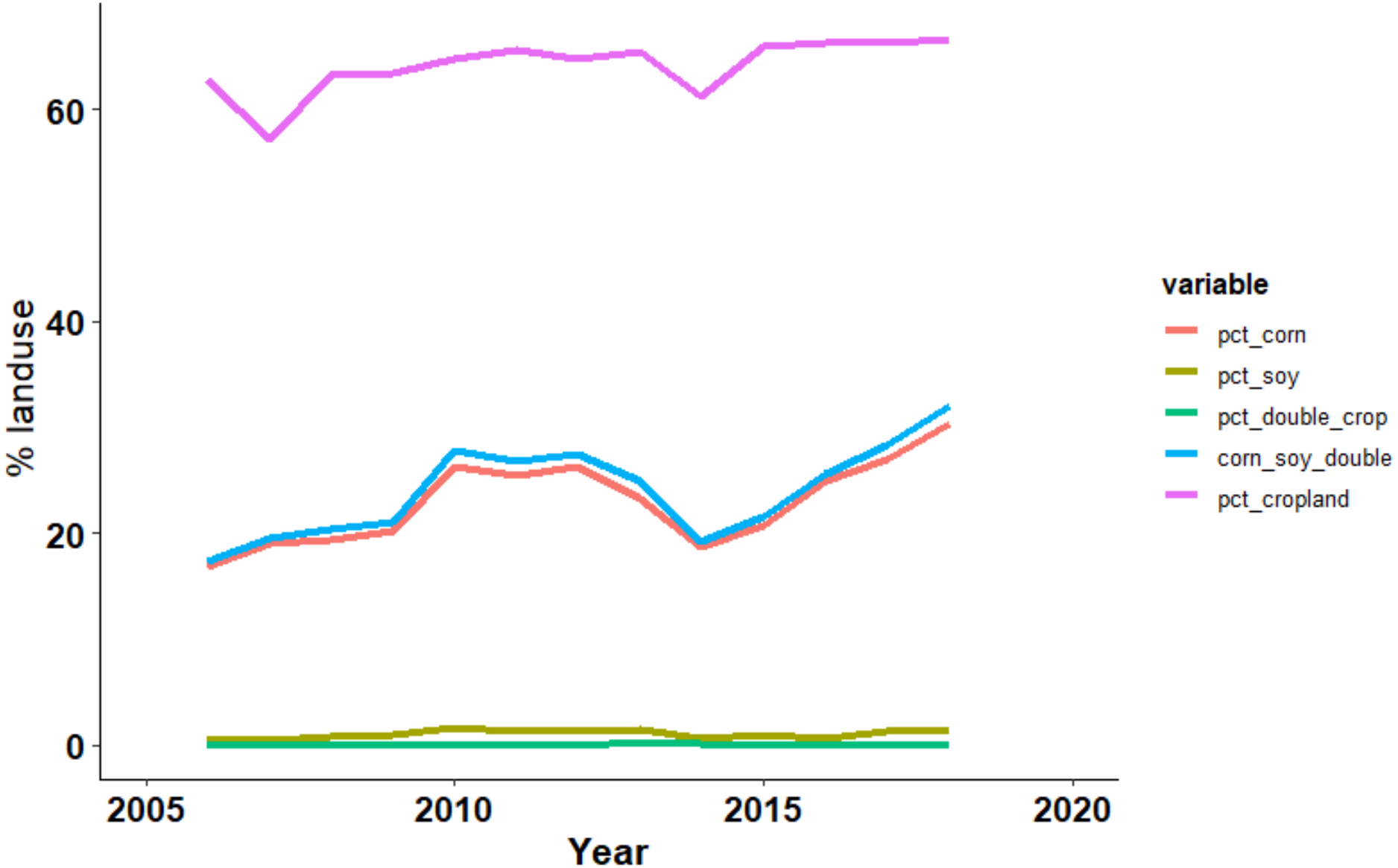
Milford Watershed Land Use



Marion Watershed Land Use



Sebelius Watershed Land Use



Other factors

Low Nitrogen to Phosphorus Ratios Favor Dominance by Blue-Green Algae in Lake Phytoplankton

Val H. Smith

Science, New Series, Vol. 221, No. 4611 (Aug. 12, 1983), 669-671.

N:P

Combined effects of nitrogen to phosphorus and nitrate to ammonia ratios on cyanobacterial metabolite concentrations in eutrophic Midwestern USA reservoirs

Ted D. Harris,[1,2]* Val H. Smith,[1] Jennifer L. Graham,[2] Dedmer B. Van de Waal,[3] Lenore P. Tedesco,[4] Nicolas Clercin[5]

N form

The selective advantage of buoyancy provided by gas vesicles for planktonic cyanobacteria in the Baltic Sea

ANTHONY E. WALSBY, PAUL K. HAYES, ROLF BOJE, LUCAS J. STAL

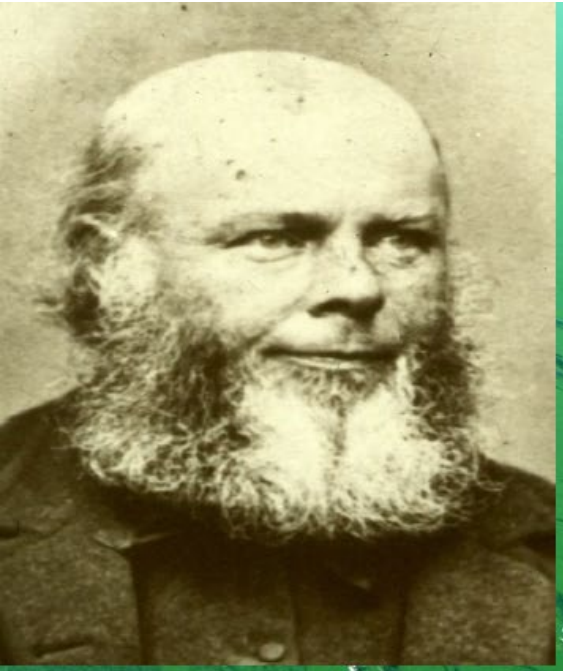
Float

A novel model for cyanobacteria bloom formation: the critical role of anoxia and ferrous iron

L. A. Molot, S. B. Watson, I. F. Creed, C. G. Trick, S. K. McCabe, M. J. Verschoor, R. J. Sorichetti, C. Powe, J. J. Venkiteswaran, S. L. Schiff

Iron?

Others: luxury uptake/ N & P storage, pesticides/herbicides, adapt to hi/lo light…



Poisenous australian lake (Francis, Nature 1878)

«Thick scum like green oil paint, some two inches thick and as thick and pasty as porridge. Unwholesome for cattle and other livestock that drink at the water»

Slide credit: Bas Ibelings

First recorded death in U.S. due to blue-green algal toxins!

Madison, Wisconsin – July 2002

Algae toxin blamed in teen's death

The Capital Times, Sept. 6-7, 2003

Associated Press

The Dane County coroner has concluded that a teenager's death last year was from exposure to a toxin released by algae.

[The local teenager] ... went into shock and suffered a seizure before his heart failed in July 2002 — two days after he swallowed water while splashing and diving in a pond at a golf facility, Coroner John Stanley noted in his report.

Another teen, unnamed in the report, also went in the pond **[...** **...]** and became sick later, complaining of severe diarrhea and abdominal pain, but he survived.

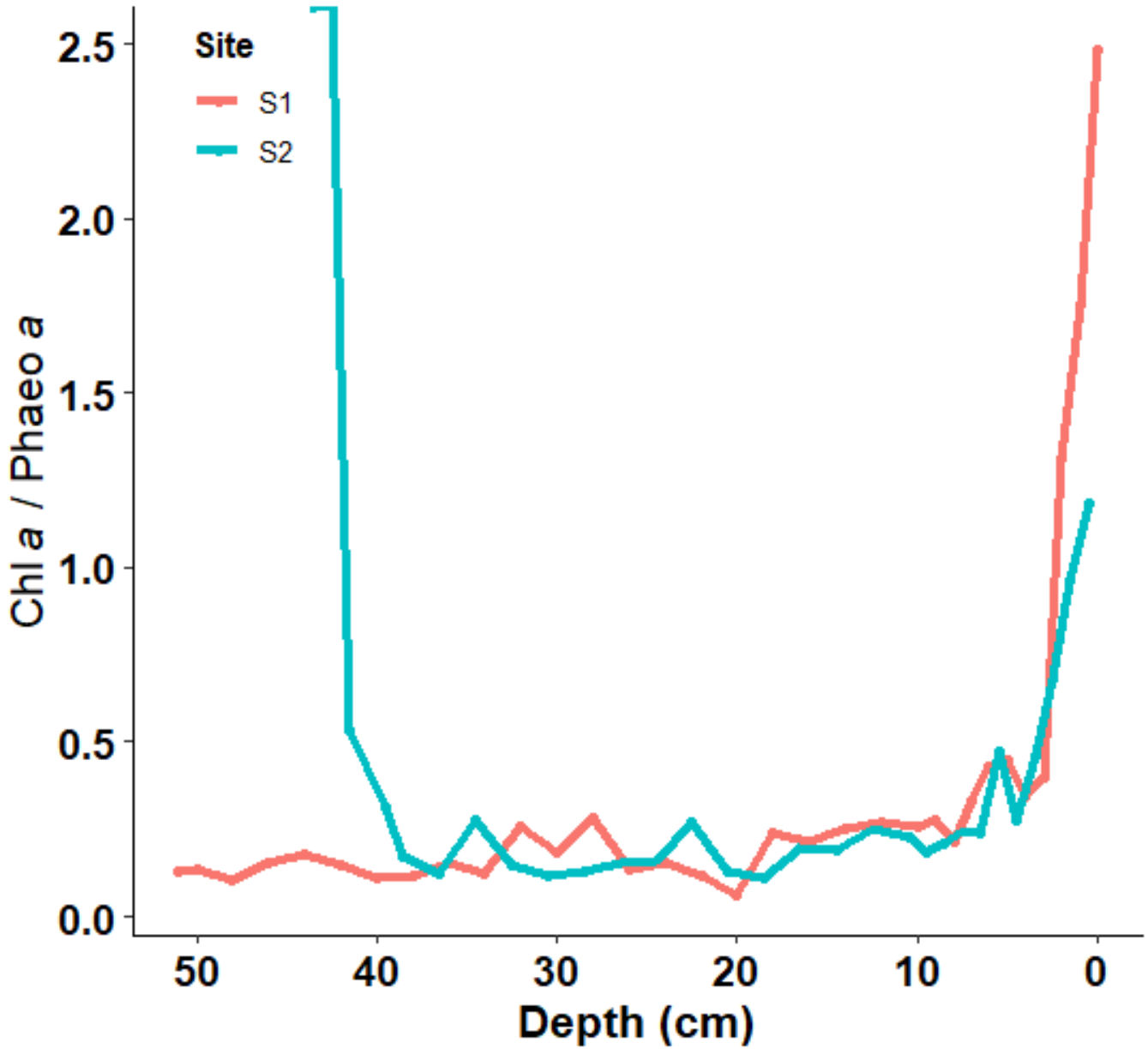
Tests of blood and stool samples from the boys found the common blue-green algae, known as Anabaena flos-aquae, and its toxin, Anatoxin-a.

Stanley said he decided to release the report to make the public aware of the potential dangers of algal toxins in small ponds.

"There are a lot of ponds out there with a lot more algae than was in this one," he said. "We wanted the public to know that you should not go swimming in algae-covered ponds. Parents should even be cautious not to let children collect golf balls from golf course ponds."

But he and other investigators said there is no reason for the public to panic about the presence of the toxins.

While blue-green algae is common in surface water, toxins are released only after thick blooms occur in summer. The toxins are diluted significantly in lakes, rivers and reservoirs and are easily removed by conventional drinking water treatment plants.

Slide credit: Bas Ibelings

Milford Chl:Pheao