Nebraska’s rivers, lakes, and streams: insights from ecology into natural resource management

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Acknowledgements

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…and others!

Collaborators:
Paul Ayayee, UNO
John DeLong, UNL
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Keeley MacNeill, UNL
David Manning, UNO
Steve Thomas, UA

"Every child deserves to grow up with **water that is pure** to drink, lakes that are **safe for swimming**, rivers that are **teeming with fish**. We have to act now to combat these pollution challenges with new protections to give our children the gift of clean, safe water in the 21st century."

-- President Clinton, 23 February 1999, Baltimore

Las Huertas Creek, NM

NEWS • AP-NATIONAL

Swimming closed at Branched Oak & Pawnee Lakes

The state has issued a health alert for toxic blue-green algae at Branched Oak Lake in Lancaster County and an alert continues at Pawnee Lake in Lancaster County.

The New York Times

Behind Toledo's Water Crisis, a Long-Troubled Lake Erie

THE WALL STREET JOURNAL.

Home World U.S. Politics Economy Business Tech Markets Opinion Life & Arts Real Estate WSJ. Magazine

U.S.

As Green Algae Forces Beaches to Close, Ohio Lake Offers Hope

Wetlands created at Grand Lake filter farm runoff; despite warning signs, boaters are back

Heartbroken dog owners mourn the loss of their pets from deadly algae

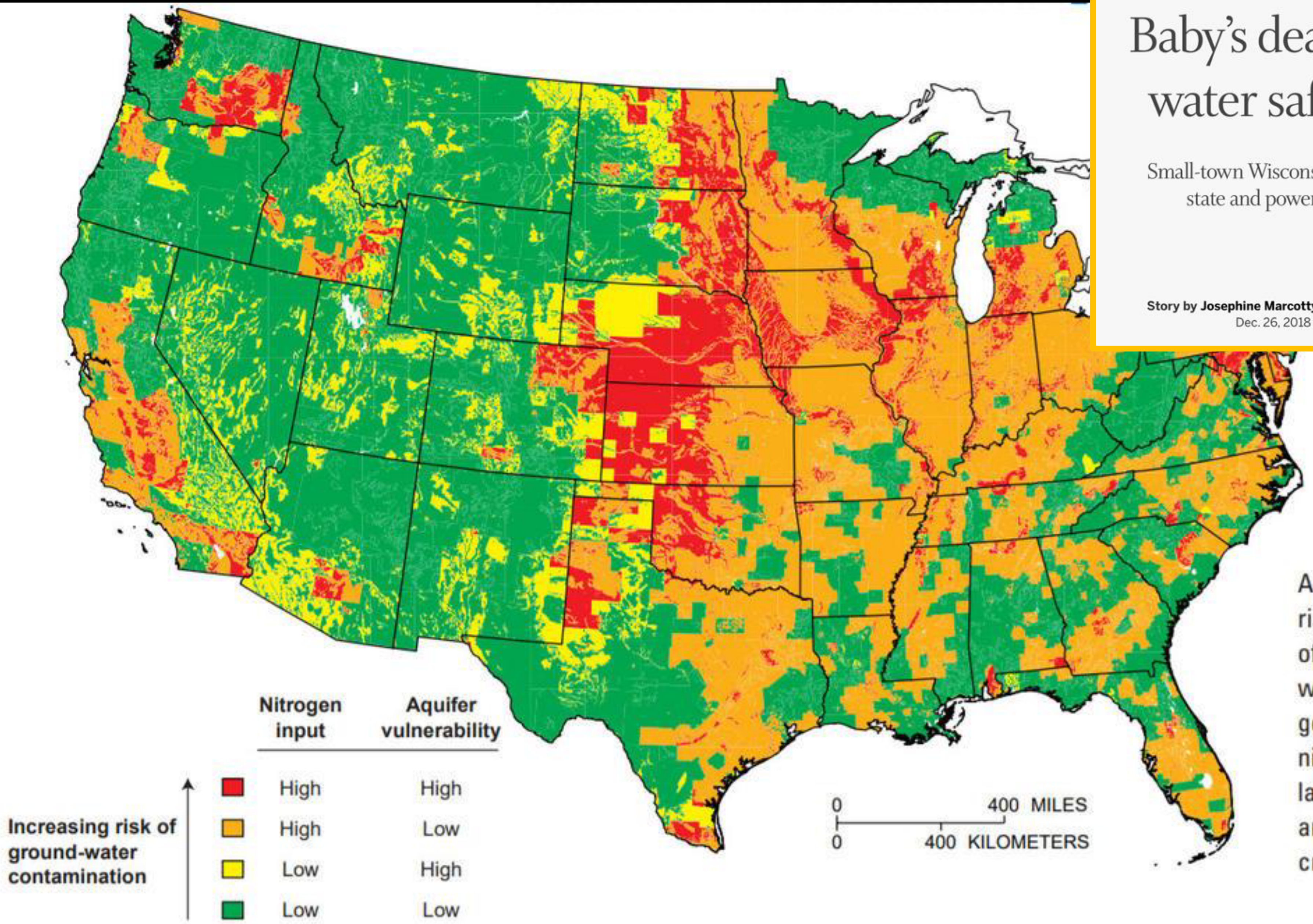
Blooms of blue-green algae, which can produce toxins fatal to animals, have been connected to dog deaths in Texas, Georgia and North Carolina.

Cyanobacterial bloom, aka "blue-green algae" or "harmful algal blooms" or "cyanoHAB"

Eutrophication is a problem for livestock and animals, too

Photos: Cow (cdc.gov), green fish (thepondguy.com), pelican (Papadimitriou et al. 2018), brown fish (extension.mmstate.edu)

Nitrate groundwater contamination risk



Areas with the highest risk for contamination of shallow ground water by nitrate generally have high nitrogen inputs to the land, well-drained soils, and a high ratio of cropland to woodland.

USGS, 1998

The cost of nutrient pollution in waters

- Water treatment costs have increased in 1/3rd of all large cities due to watershed degradation → $5.4 billion per year (McDonald et al. 2019).

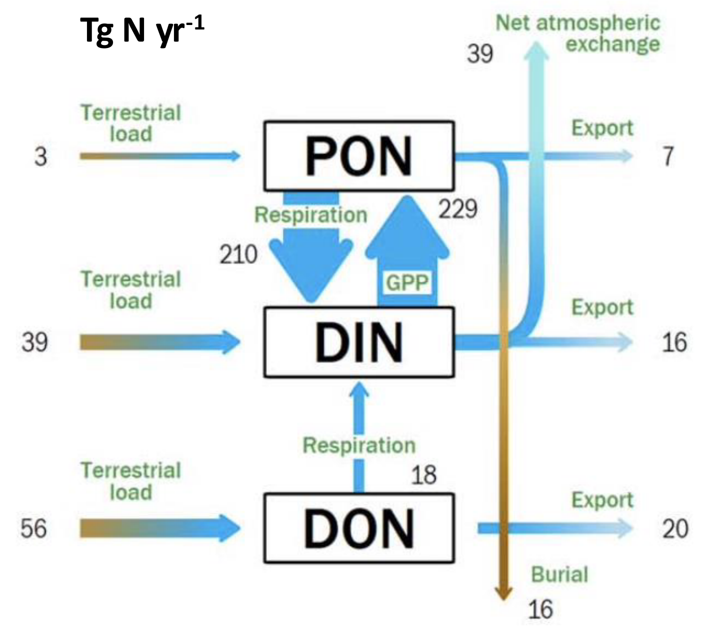
- Since 1972, US has spent $5 trillion to meet water quality standards (Keiser & Shapiro 2019).

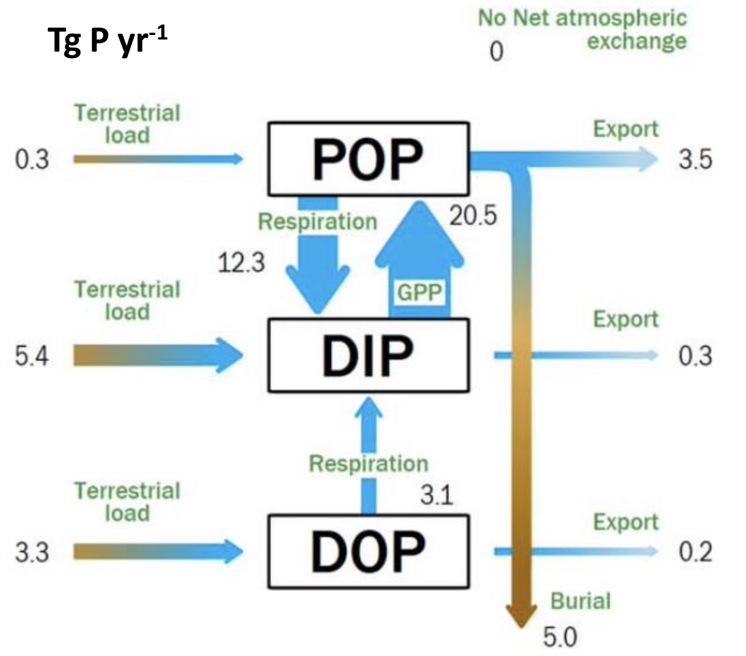
Photos: Ashokan Reservoir (NPR, Getty Images), Croton Reservoir (Getty Images)

Want N and P here

Don’t want N and P here

Lakes, rivers, and streams are not pipes!





56% of N!

55% of P!

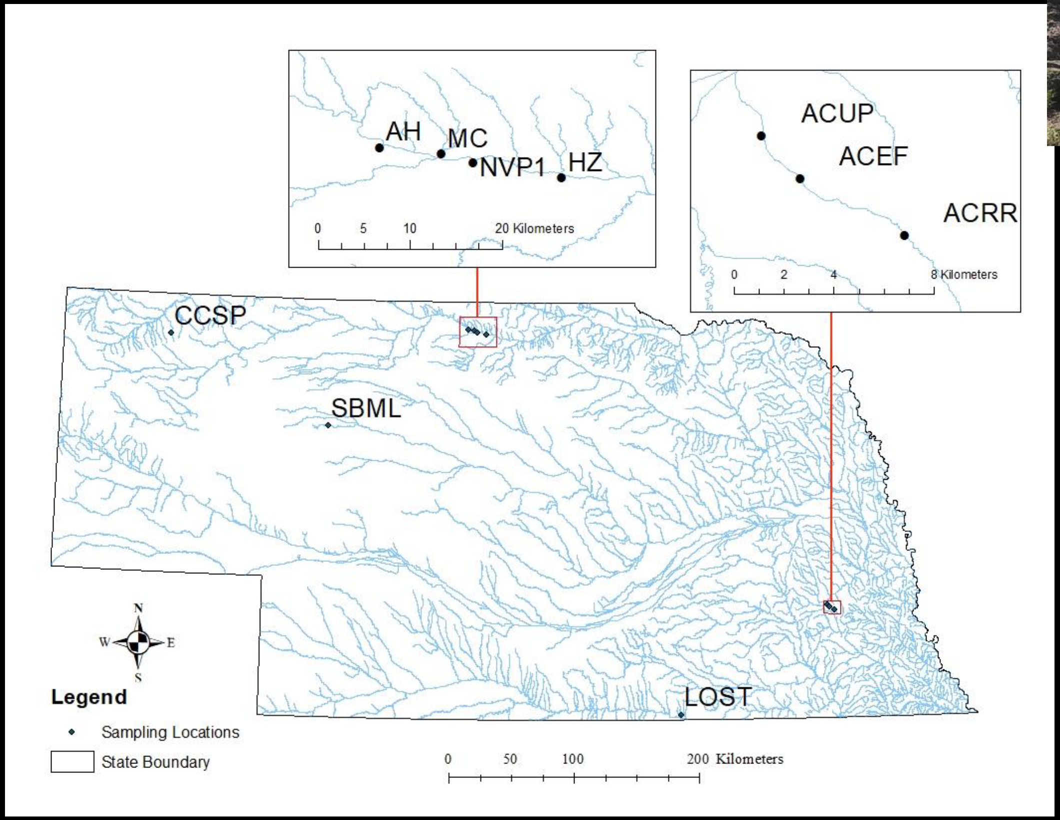
Maranger et al 2018, *L&O Letters*

How are Nebraska aquatic ecosystems impacted by N & P?

How do lakes, rivers, and streams move or sequester N & P?

If we know how nutrients (N & P) are cycling,
we can better manage our aquatic resources.

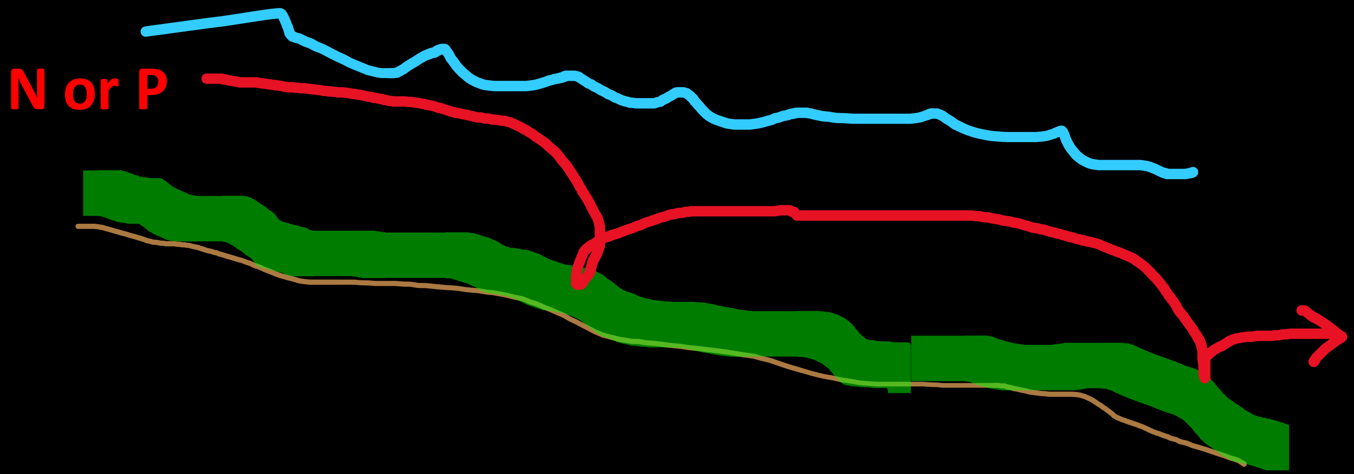
How do N & P cycle in Nebraska's small streams?

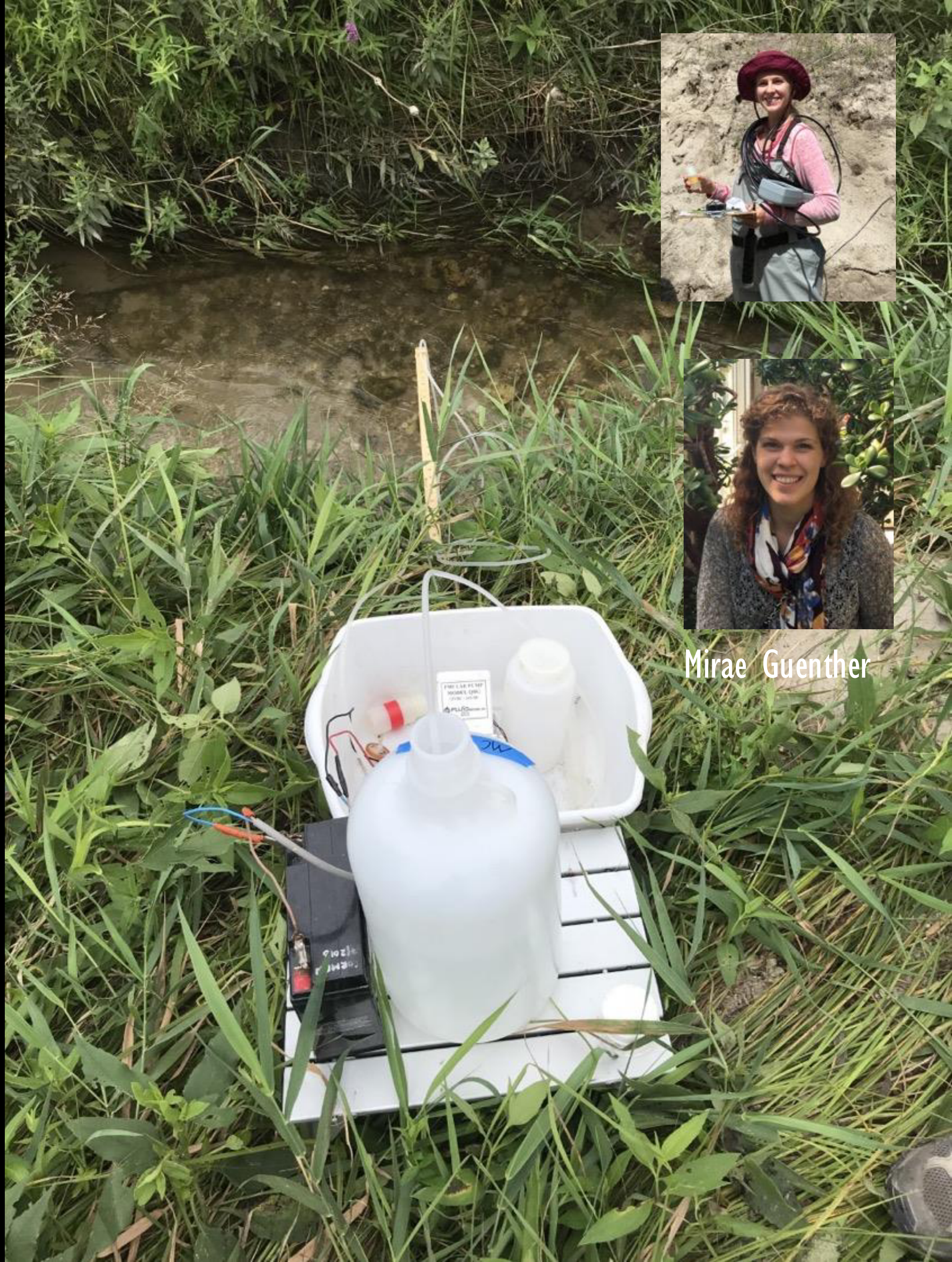


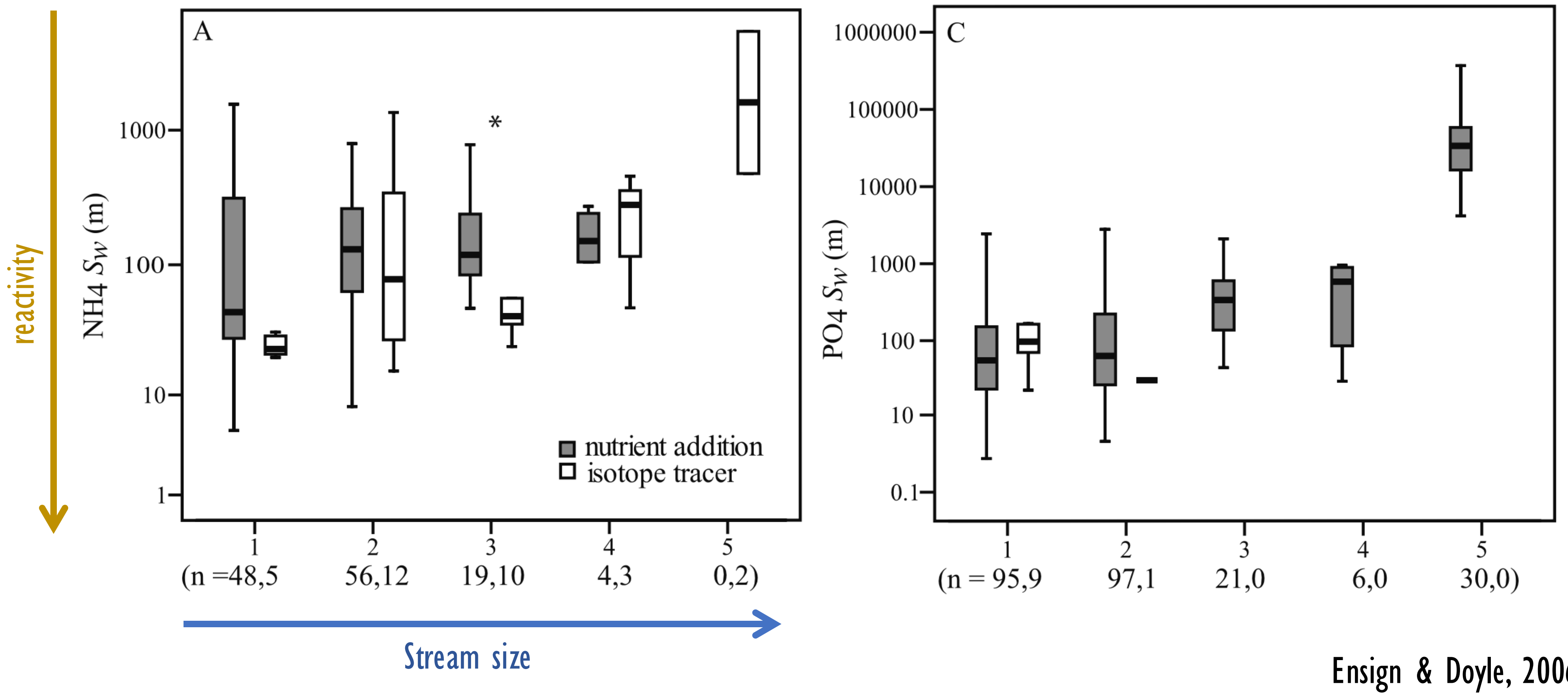
Alexa Davis, MS '19

Mirae Guenther

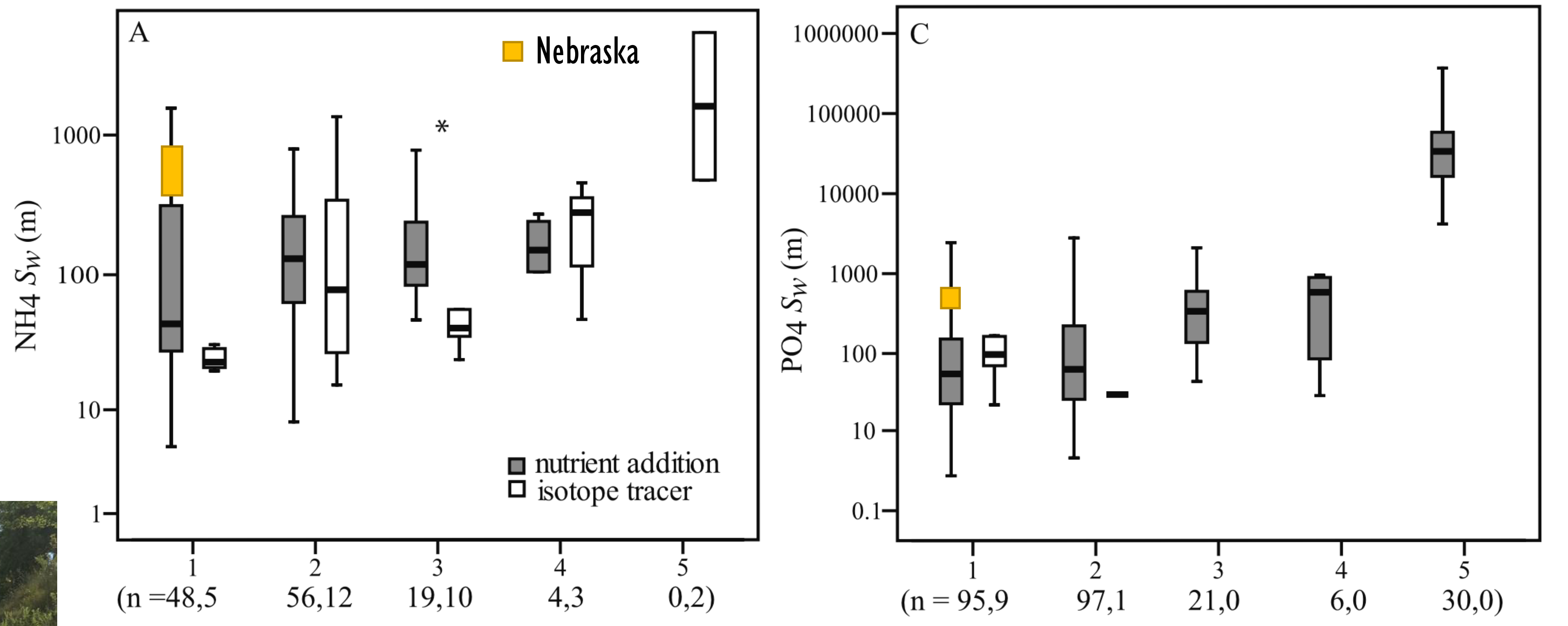
Nutrient spiraling technique







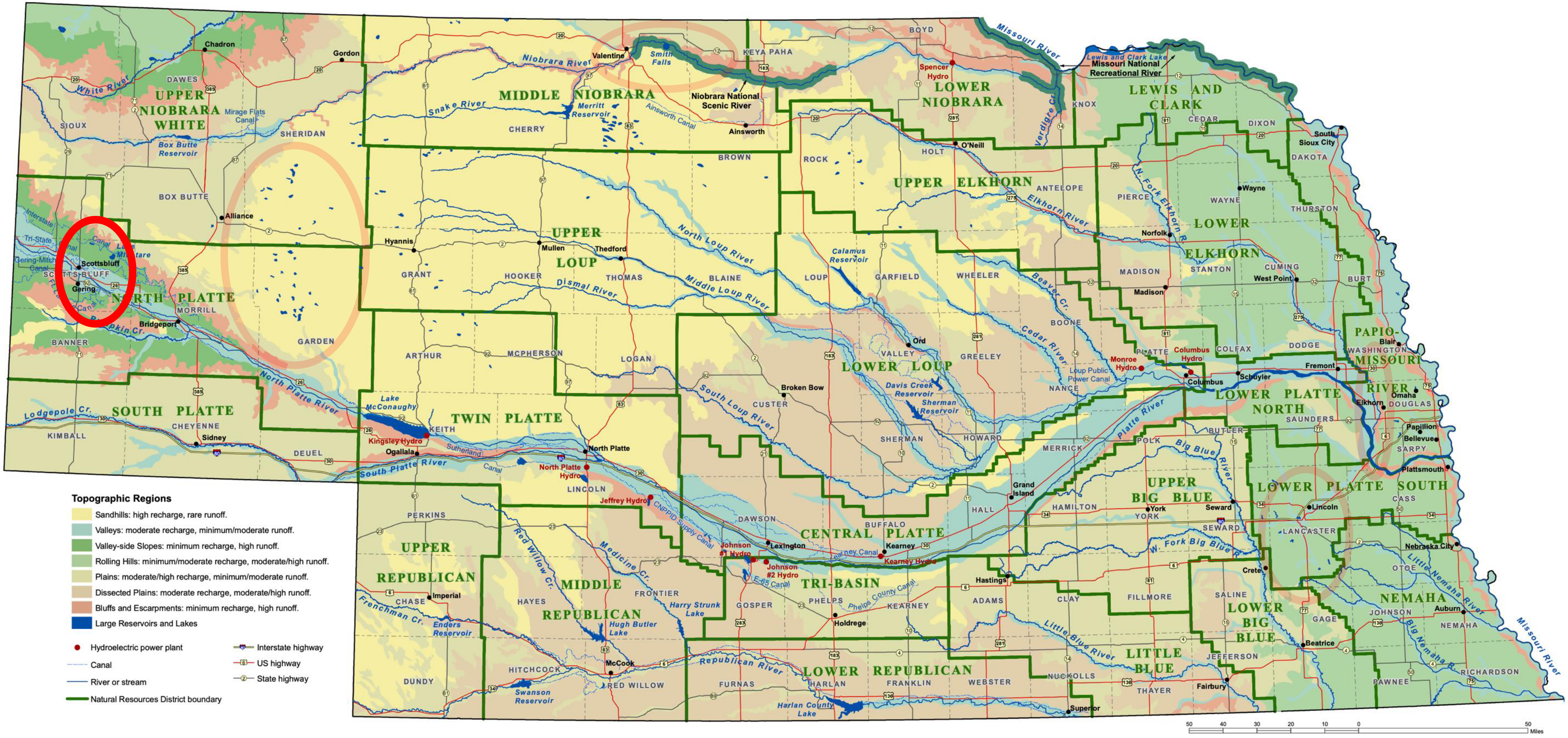
Ensign & Doyle, 2006



Ensign & Doyle, 2006

Mirae Guenther

Not a lot of nutrient uptake in small, prairie streams! What’s going on??



Topographic Regions
Sandhills: high recharge, rare runoff.
Valleys: moderate recharge, minimum/moderate runoff.
Valley-side Slopes: minimum recharge, high runoff.
Rolling Hills: minimum/moderate recharge, moderate/high runoff.
Plains: moderate/high recharge, minimum/moderate runoff.
Dissected Plains: moderate recharge, moderate/high runoff.
Bluffs and Escarpments: minimum recharge, high runoff.
Large Reservoirs and Lakes
Hydroelectric power plant
Canal
River or stream
Natural Resources District boundary
Interstate highway
US highway
State highway
UPPER NIOBRARA WHITE
MIDDLE NIOBRARA
LOWER NIOBRARA
LEWIS AND CLARK
UPPER ELKHORN
LOWER ELKHORN
UPPER LOUP
LOWER LOUP
NORTH PLATTE
SOUTH PLATTE
TWIN PLATTE
CENTRAL PLATTE
PAPIO-MISSOURI RIVER
LOWER PLATTE NORTH
LOWER PLATTE SOUTH
UPPER BIG BLUE
LOWER BIG BLUE
LITTLE BLUE
NEMAHA
TRI-BASIN
UPPER REPUBLICAN
MIDDLE REPUBLICAN
LOWER REPUBLICAN
Missouri River
Niobrara River
Missouri National Recreational River
Niobrara National Scenic River
Lewis and Clark Lake
White River
Snake River
Merritt Reservoir
Smith Falls
Box Butte Reservoir
Mirage Flats Canal
North Loup River
Middle Loup River
Dismal River
South Loup River
Calamus Reservoir
Davis Creek Reservoir
Sherman Reservoir
Elkhorn River
N. Fork Elkhorn R.
Beaver Cr.
Cedar River
Loup Public Power Canal
North Platte River
South Platte River
Platte River
Lodgepole Cr.
Pumpkin Cr.
Lake McConaughy
Sutherland Canal
CNPPID Supply Canal
Kearney Canal
E-65 Canal
Phelps County Canal
Big Blue River
W. Fork Big Blue R.
Little Blue River
Little Nemaha River
Big Nemaha R.
Republican River
Red Willow Cr.
Medicine Cr.
Frenchman Cr.
Enders Reservoir
Swanson Reservoir
Hugh Butler Lake
Harry Strunk Lake
Harlan County Lake
Spencer Hydro
Kingsley Hydro
North Platte Hydro
Jeffrey Hydro
Johnson #1 Hydro
Johnson #2 Hydro
Kearney Hydro
Monroe Hydro
Columbus Hydro
Chadron
Gordon
Valentine
Ainsworth
O'Neill
Norfolk
Wayne
South Sioux City
Alliance
Scottsbluff
Gering
Bridgeport
Hyannis
Mullen
Thedford
Ord
Broken Bow
Madison
West Point
Columbus
Schuyler
Fremont
Blair
Elkhorn
Omaha
Papillion
Bellevue
Plattsmouth
Keith
Ogallala
North Platte
Sidney
Lexington
Kearney
Grand Island
Hastings
Holdrege
York
Seward
Lincoln
Crete
Nebraska City
Auburn
Beatrice
Fairbury
Superior
McCook
Imperial
DAWES
SIOUX
SHERIDAN
BOX BUTTE
SCOTTS BLUFF
MORRILL
BANNER
GARDEN
KIMBALL
CHEYENNE
DEUEL
CHERRY
KEYA PAHA
BOYD
BROWN
ROCK
HOLT
KNOX
CEDAR
DIXON
DAKOTA
ANTELOPE
PIERCE
WAYNE
THURSTON
GRANT
HOOKER
THOMAS
BLAINE
LOUP
GARFIELD
WHEELER
MADISON
STANTON
CUMING
BURT
ARTHUR
MCPHERSON
LOGAN
CUSTER
VALLEY
GREELEY
BOONE
PLATTE
COLFAX
DODGE
WASHINGTON
DOUGLAS
SARPY
SAUNDERS
BUTLER
POLK
MERRICK
NANCE
HOWARD
SHERMAN
LINCOLN
PERKINS
DAWSON
BUFFALO
HALL
HAMILTON
YORK
SEWARD
LANCASTER
CASS
OTOE
CHASE
HAYES
FRONTIER
GOSPER
PHELPS
KEARNEY
ADAMS
CLAY
FILLMORE
SALINE
GAGE
JOHNSON
NEMAHA
DUNDY
HITCHCOCK
RED WILLOW
FURNAS
HARLAN
FRANKLIN
WEBSTER
NUCKOLLS
THAYER
JEFFERSON
PAWNEE
RICHARDSON
50 40 30 20 10 0 50 Miles

STREAM NET

Jessica Corman

Steve Thomas

Chris Chizinski

School of Natural Resources

University of Nebraska-Lincoln

Nebraska Environmental Trust

North Platte NATURAL RESOURCES DISTRICT

Installation around Scottsbluff/Gering/Terrytown

sub-hourly data generation

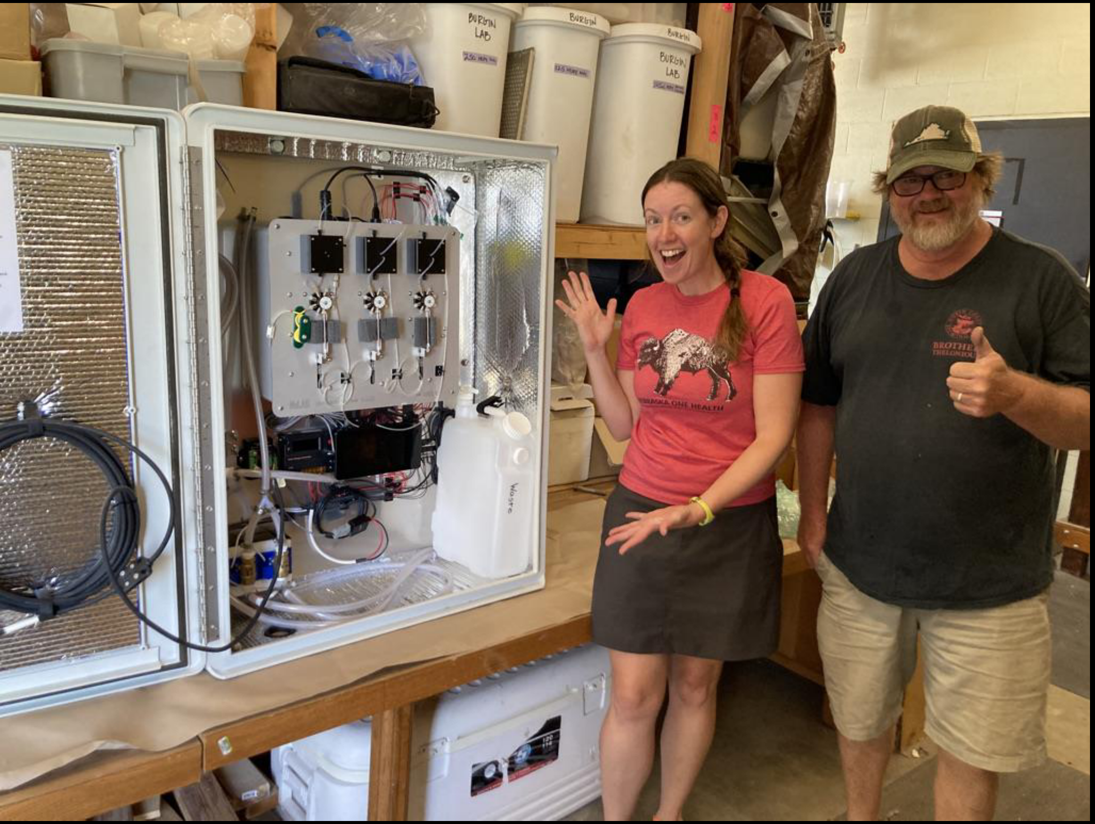
Real-time data transmission to FTP server

Data pipeline

Relational database system (RDS)

Data portal & web-based data application

STREAM NET



Corman and Thomas w/ NULab

2021 monthly sampling (June – October):

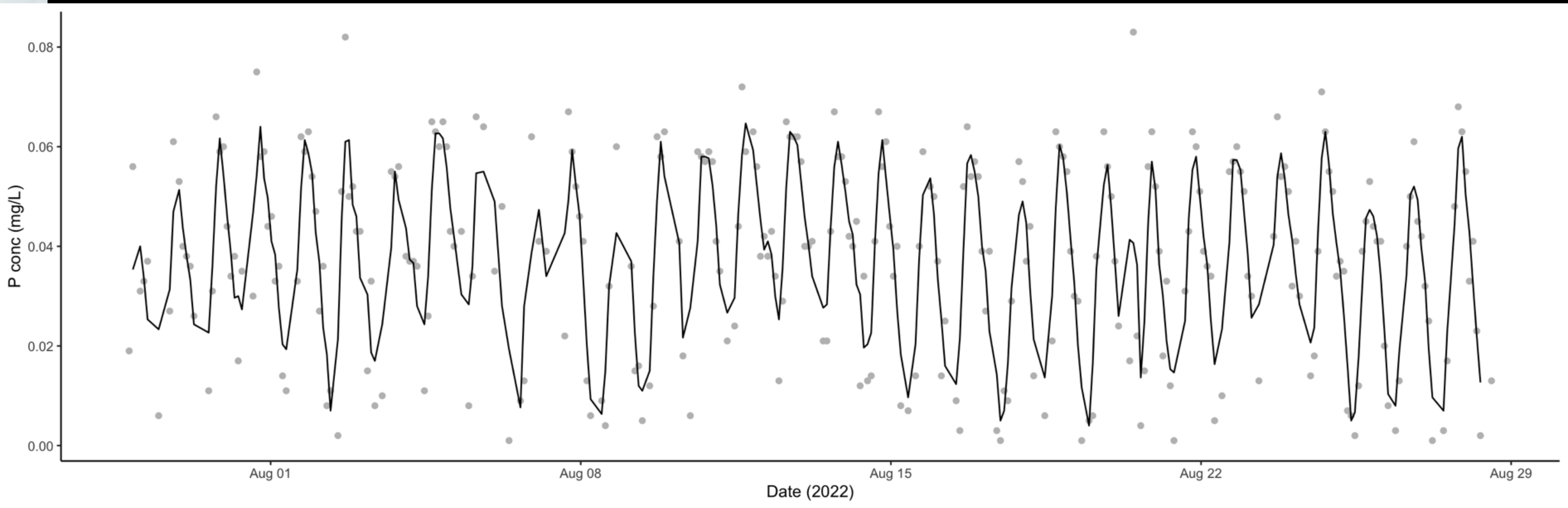
Basic Parameters	**Temp. (°C)**	**Sp Cond (uS/cm)**	**pH**
Site 1 (Winter's Creek)	19.8 (1.6)	831 (11)	8.26 (0.14)
Site 2 (Gering Valley)	20.2 (3.2)	906 (280)	8.08 (0.14)
Dissolved Nutrients	**NH_4^+-N (ug/L)**	**PO_4^{3-}-P (mg/L)**	**NO_3^-N (mg/L)**
Site 1 (Winter's Creek)	6.5 (3.1)	0.11 (0.06)	4.2 (1.1)
Site 2 (Gering Valley)	5.9 (5.5)	0.07 (0.02)	5.0 (4.2)

Installing sensor at Winter's Creek, Scottsbluff:

Water parameters monitored:

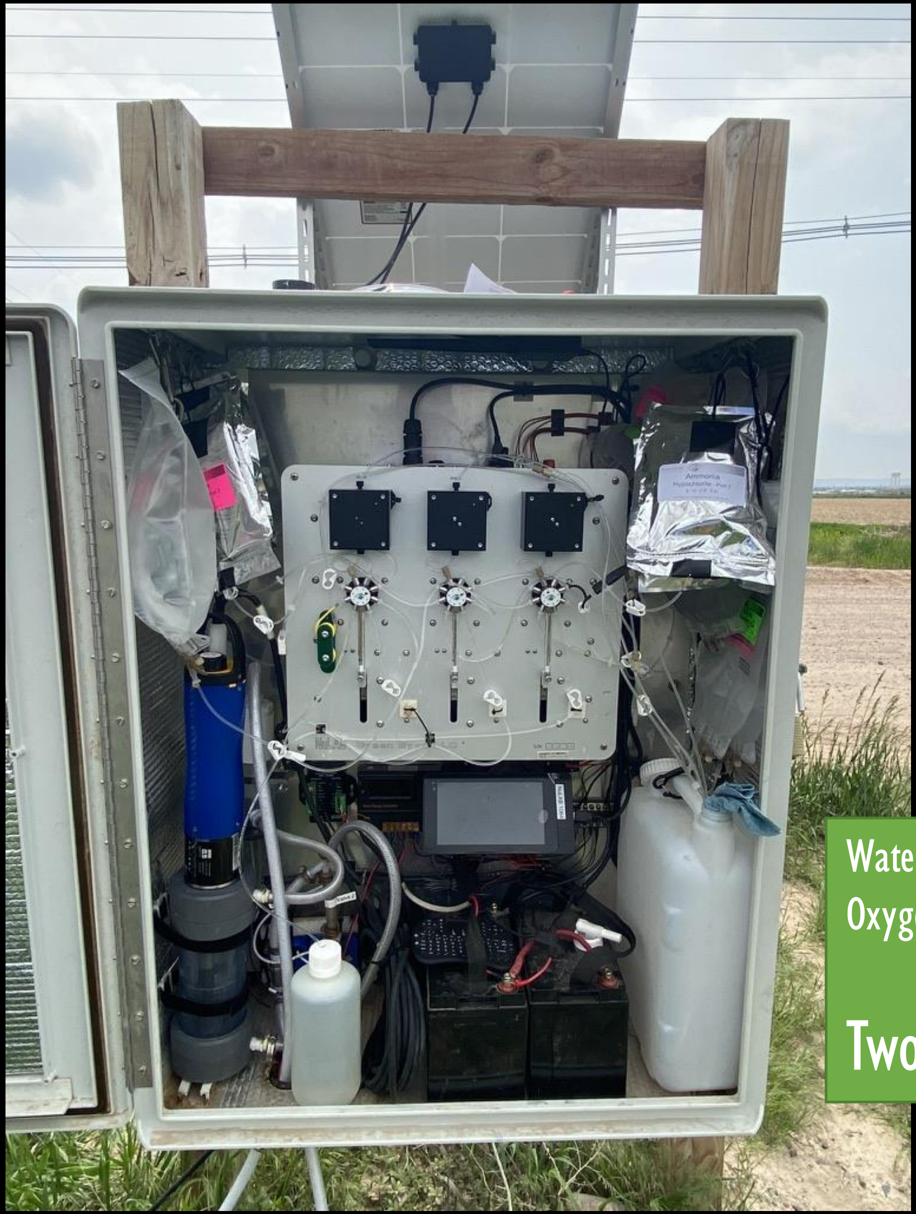
Oxygen, Temperature, Conductivity, Nitrate, Ammonium, Phosphate

2021


P conc (mg/L)
0.00
0.02
0.04
0.06
0.08
Aug 01
Aug 08
Aug 15
Aug 22
Aug 29
Date (2022)

2022

STREAM NET

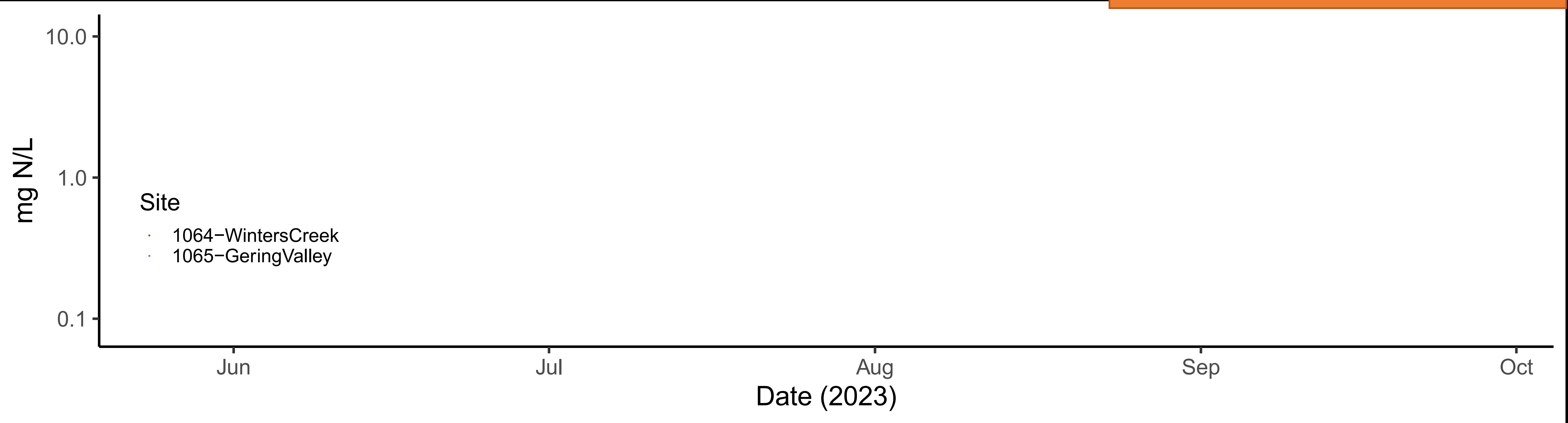


Water parameters monitored:
Oxygen, Temperature, Conductivity, Nitrate, Ammonium, Phosphate

Two units successfully running most of the summer!

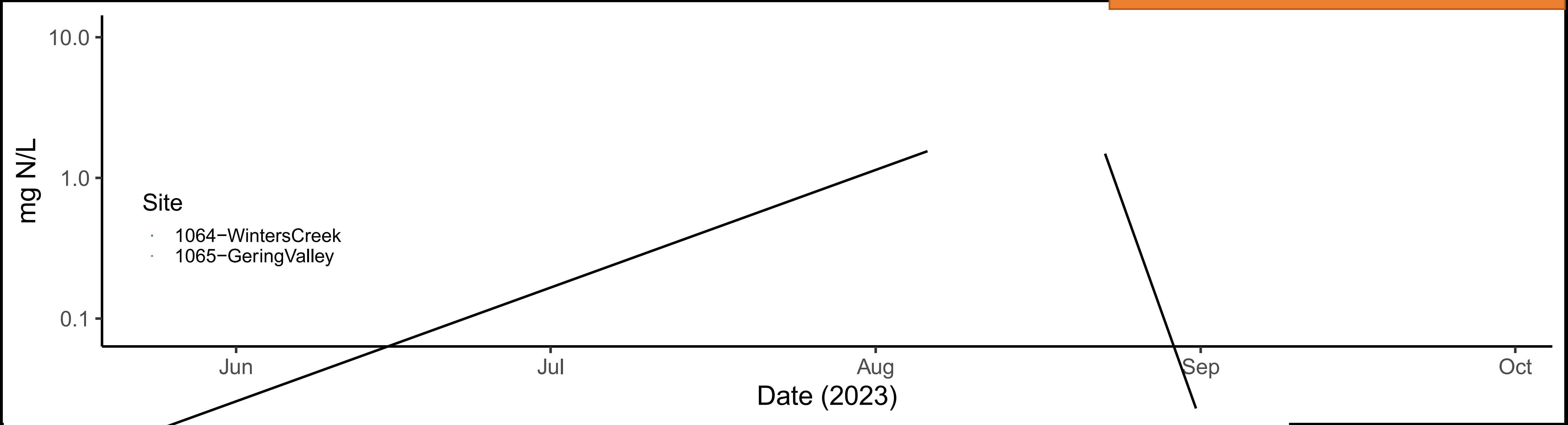
2023

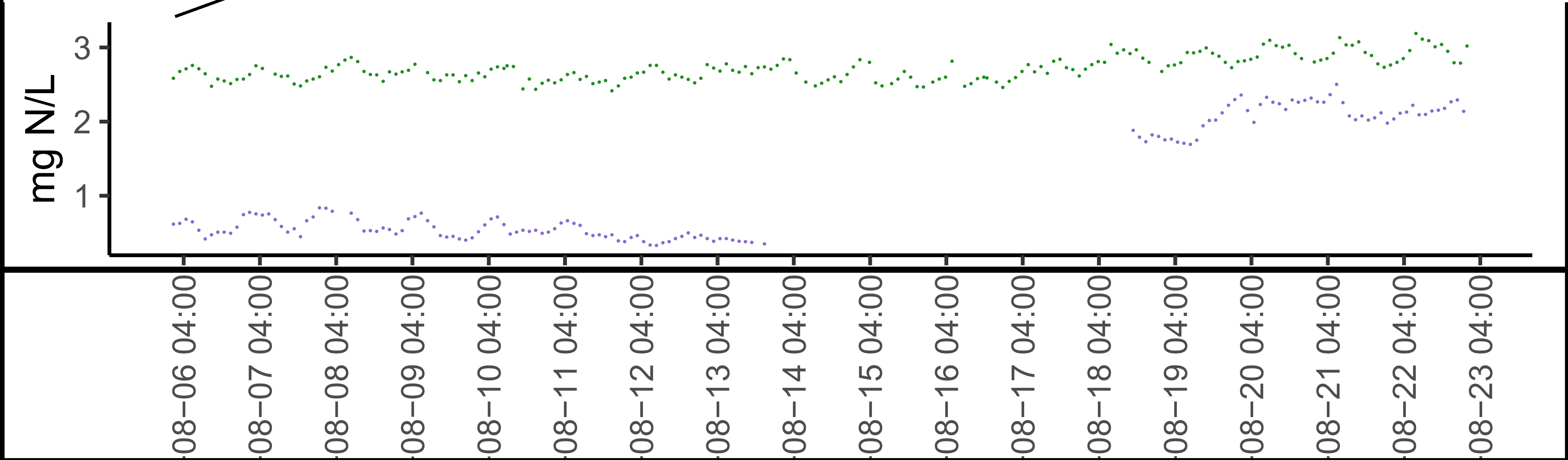
Nitrate-N Concentrations



STREAM NET

Nitrate-N Concentrations

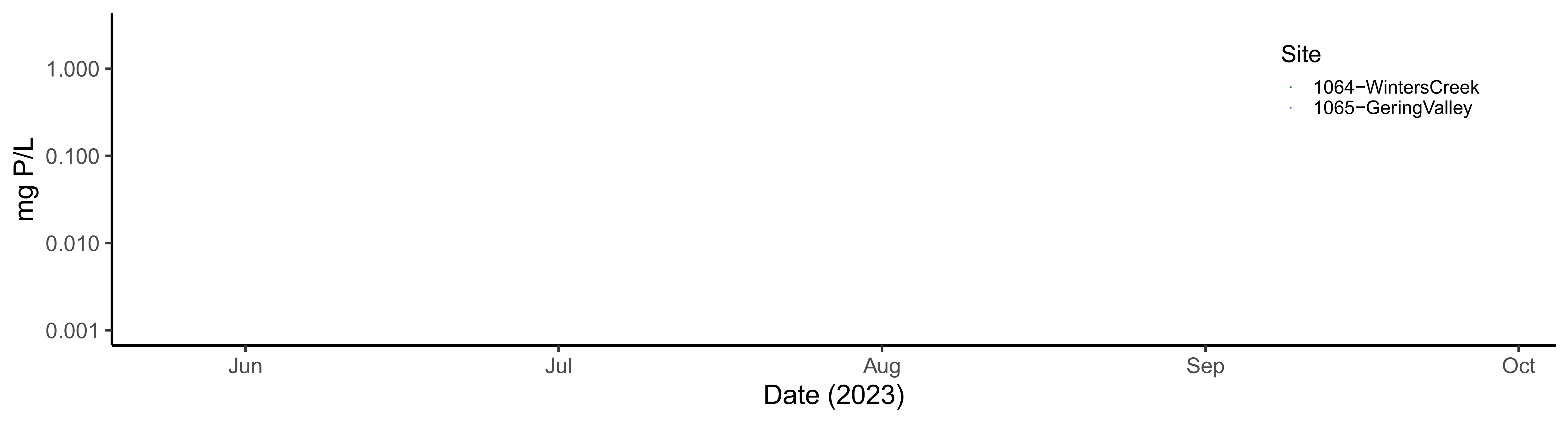




Zoom in of time series to highlight daily nitrate cycles

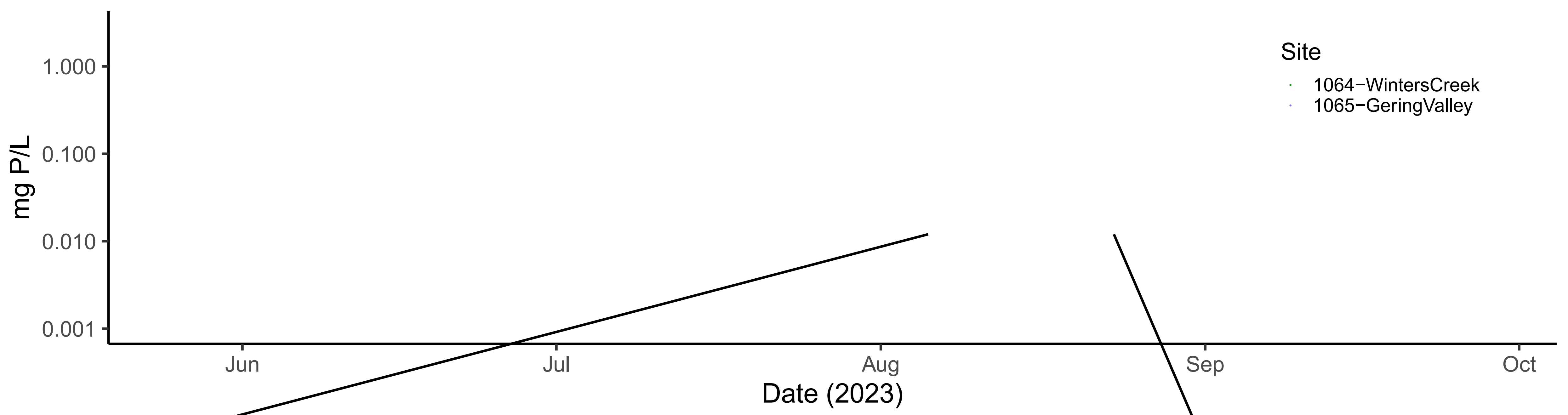
STREAM NET

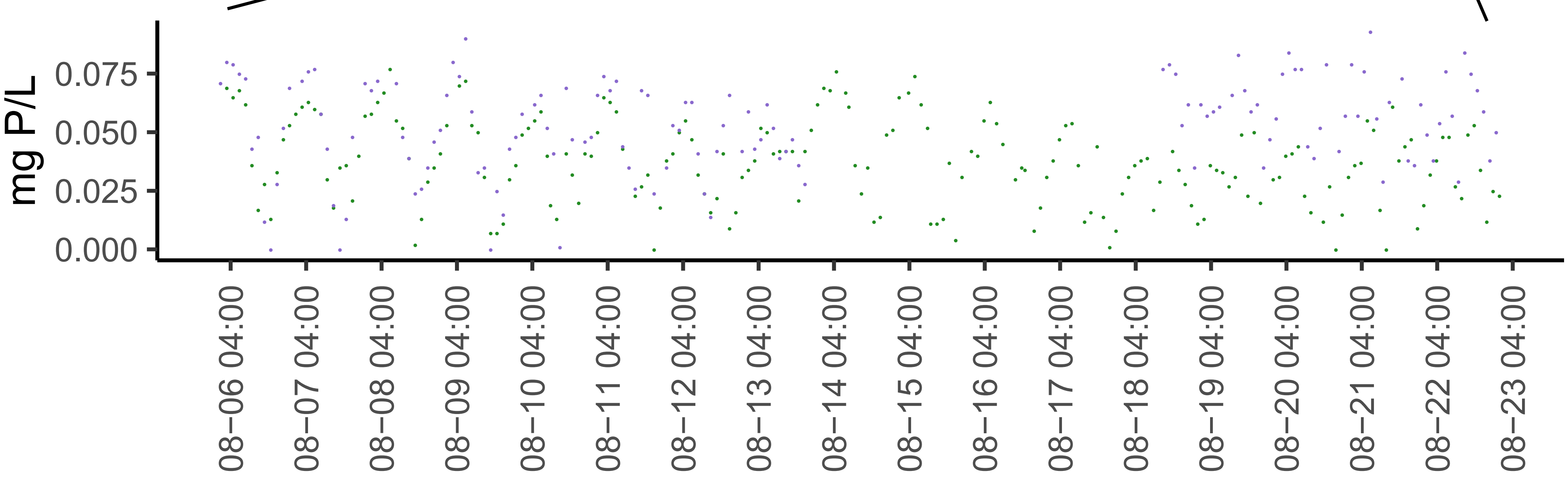
Phosphate Concentrations



STREAM NET

Phosphate Concentrations

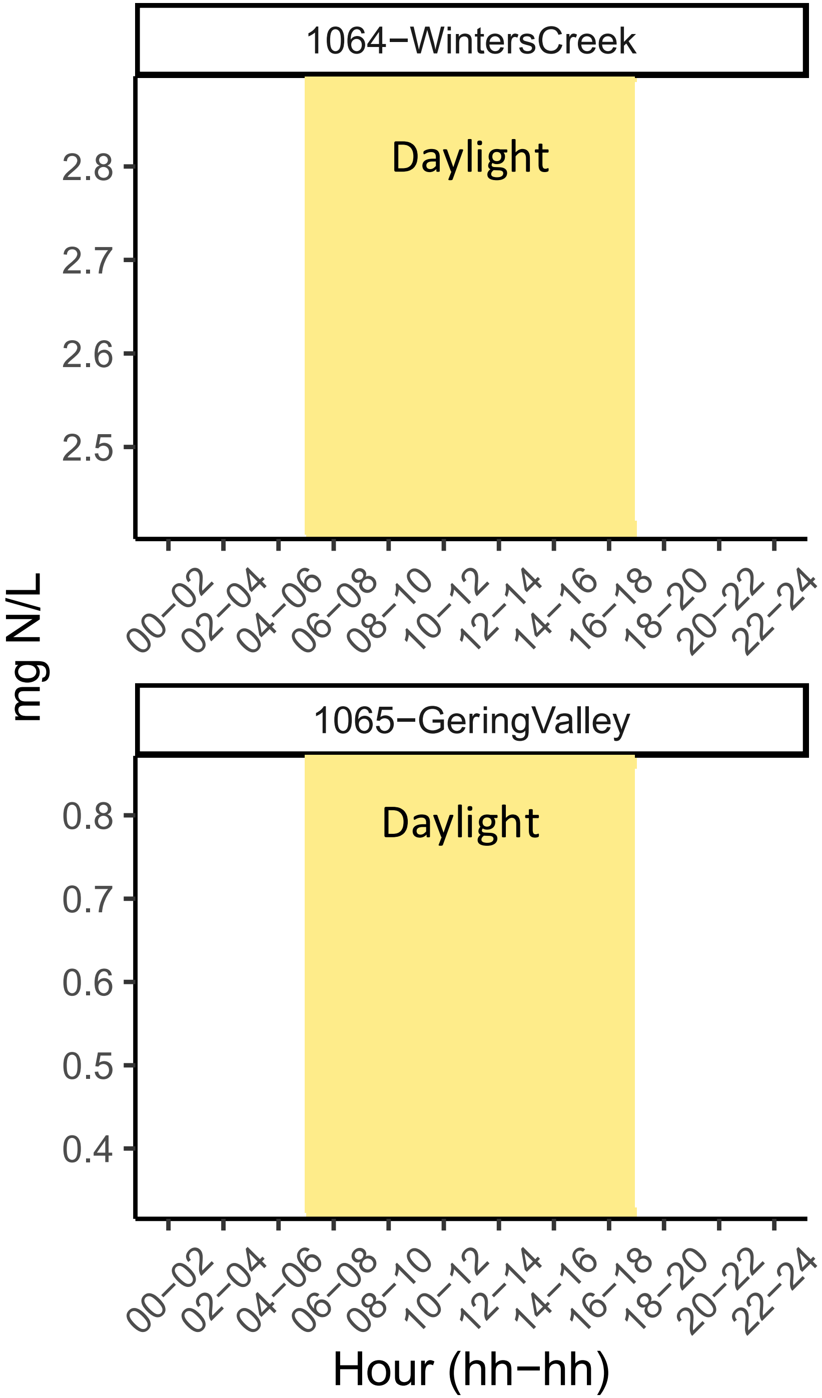




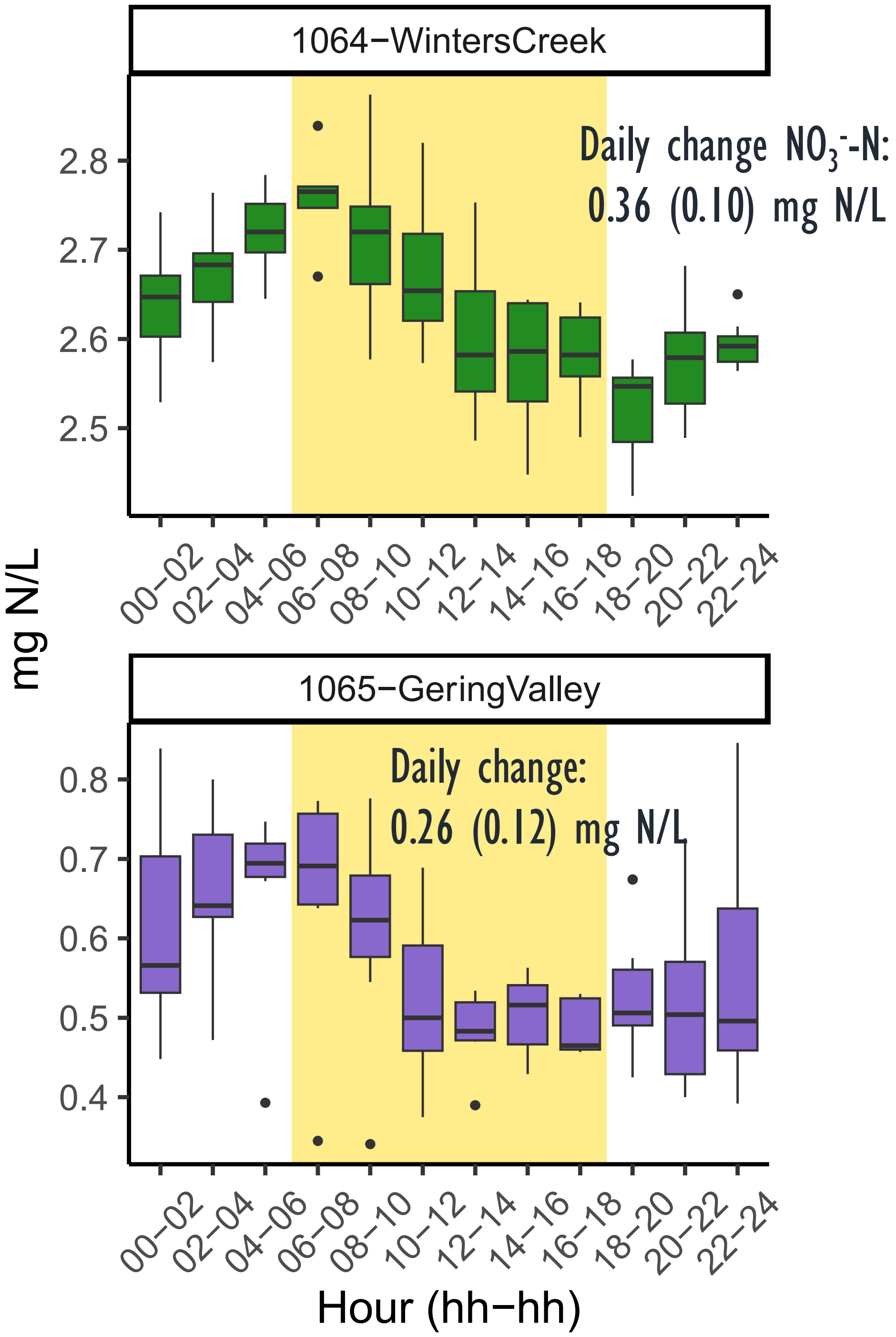
Zoom in of time series to highlight daily phosphate cycles

STREAM NET

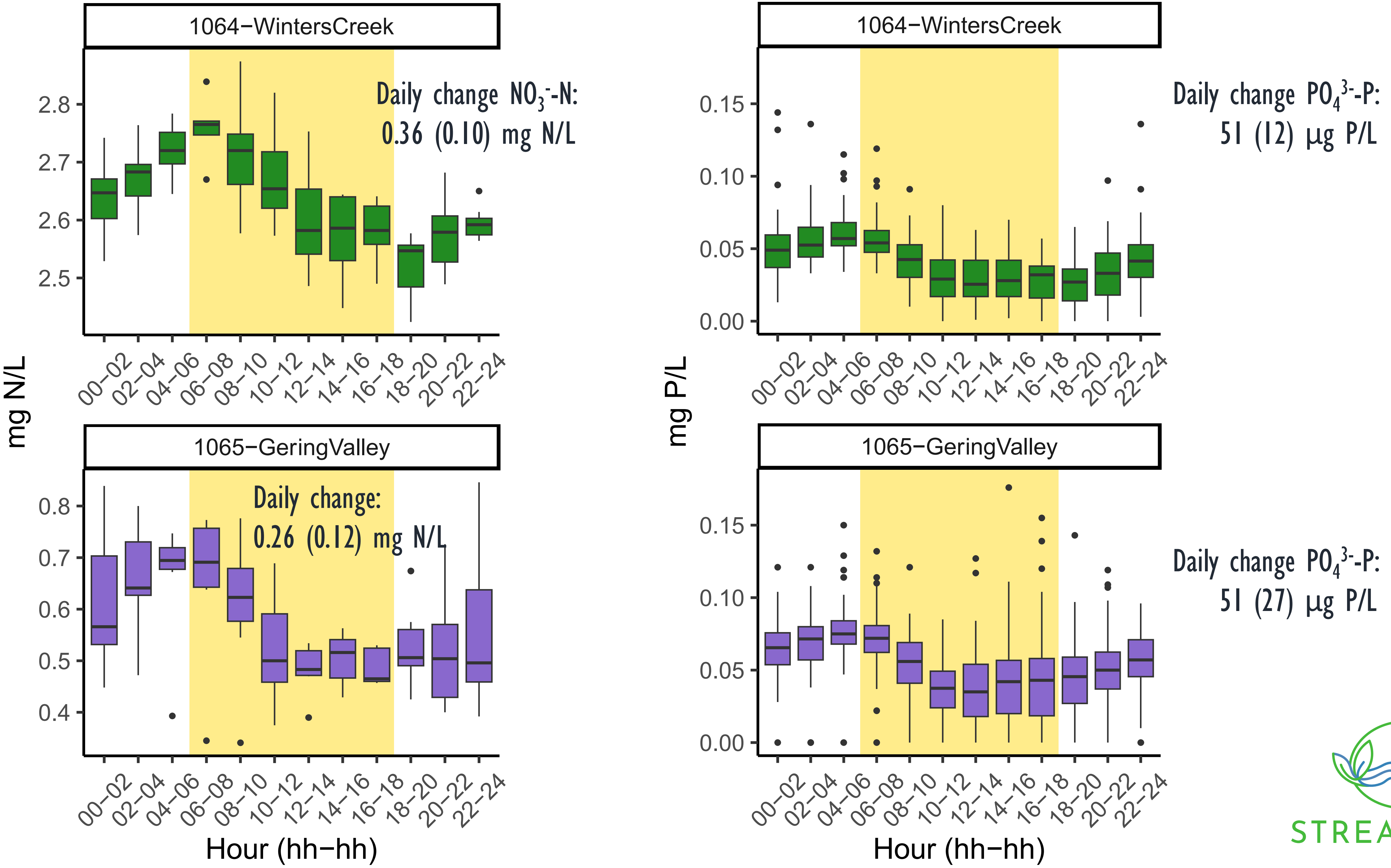
Daily Cycles (August)



STREAM NET


1064−WintersCreek
Daily change NO_3^--N:
0.36 (0.10) mg N/L
2.8
2.7
2.6
2.5
00−02
02−04
04−06
06−08
08−10
10−12
12−14
14−16
16−18
18−20
20−22
22−24
mg N/L
1065−GeringValley
Daily change:
0.26 (0.12) mg N/L
0.8
0.7
0.6
0.5
0.4
Hour (hh−hh)

STREAM NET



1064−WintersCreek
Daily change NO_3^--N:
0.36 (0.10) mg N/L
1064−WintersCreek
Daily change PO_4^{3-}-P:
51 (12) µg P/L
mg N/L
mg P/L
1065−GeringValley
Daily change:
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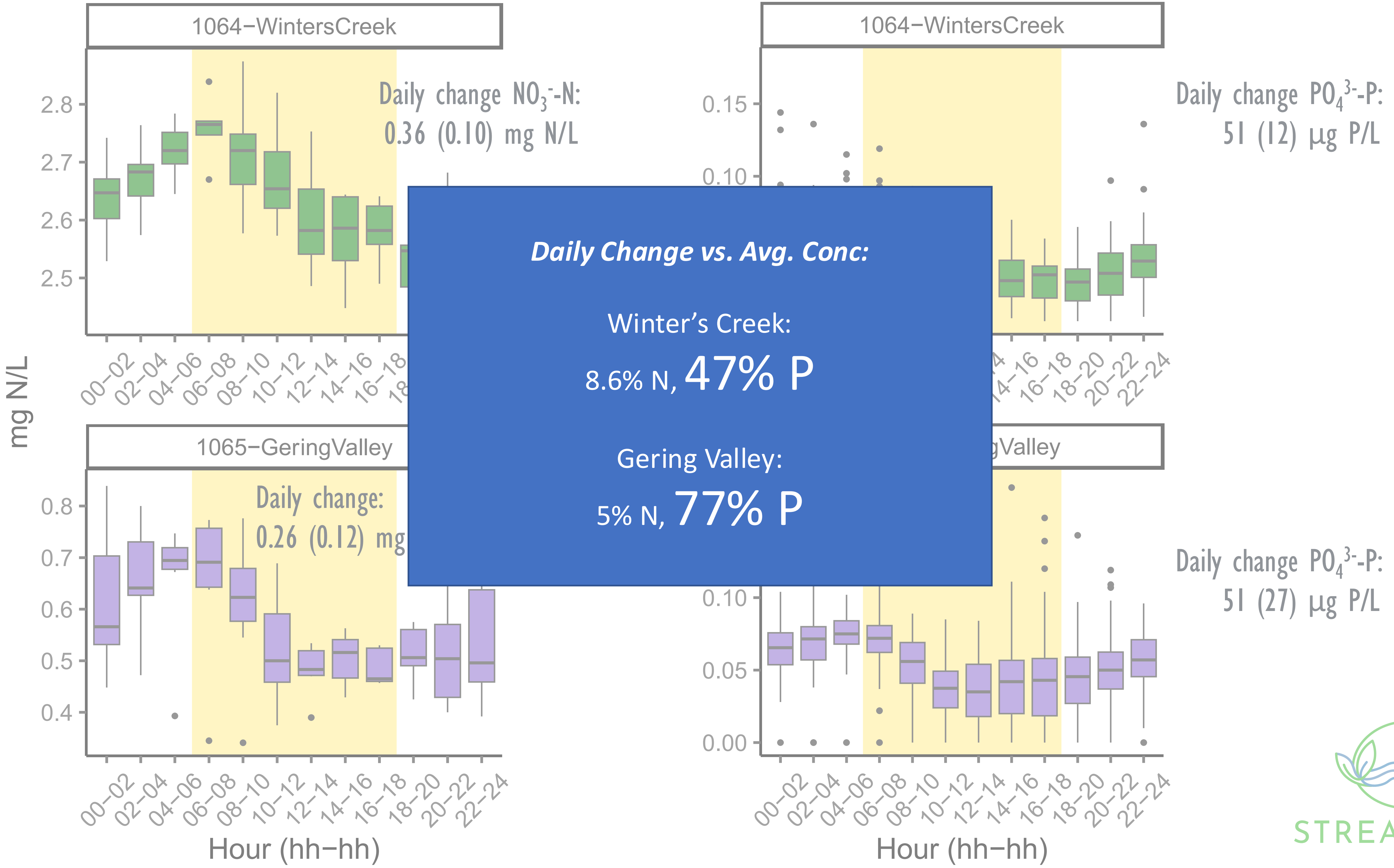
1065−GeringValley
Daily change PO_4^{3-}-P:
51 (27) µg P/L
2.8
2.7
2.6
2.5
0.8
0.7
0.6
0.5
0.4
0.15
0.10
0.05
0.00
00−02
02−04
04−06
06−08
08−10
10−12
12−14
14−16
16−18
18−20
20−22
22−24
Hour (hh−hh)
Hour (hh−hh)

STREAM NET



Daily Change vs. Avg. Conc:

Winter's Creek:

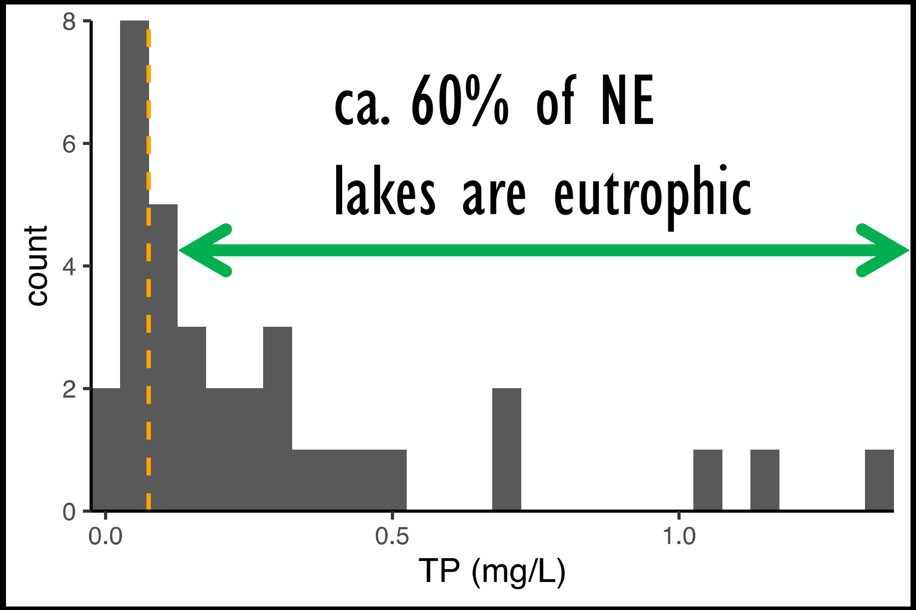
8.6% N, **47% P**

Gering Valley:

5% N, **77% P**

STREAM NET

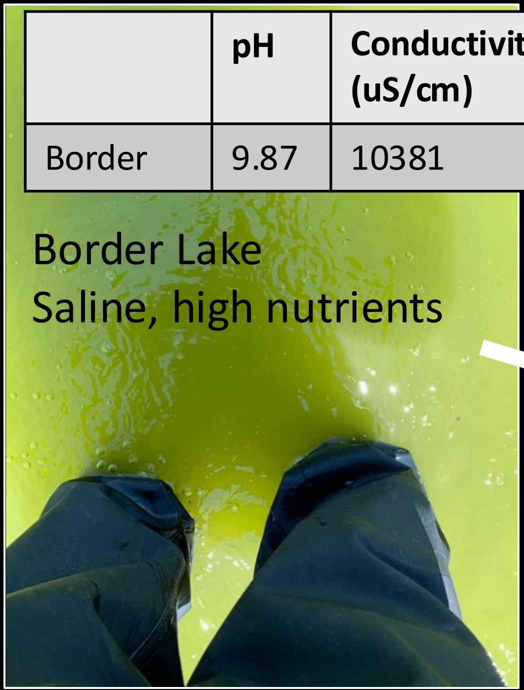
If a lake has a lot of nutrients, does it matter if it gets more?



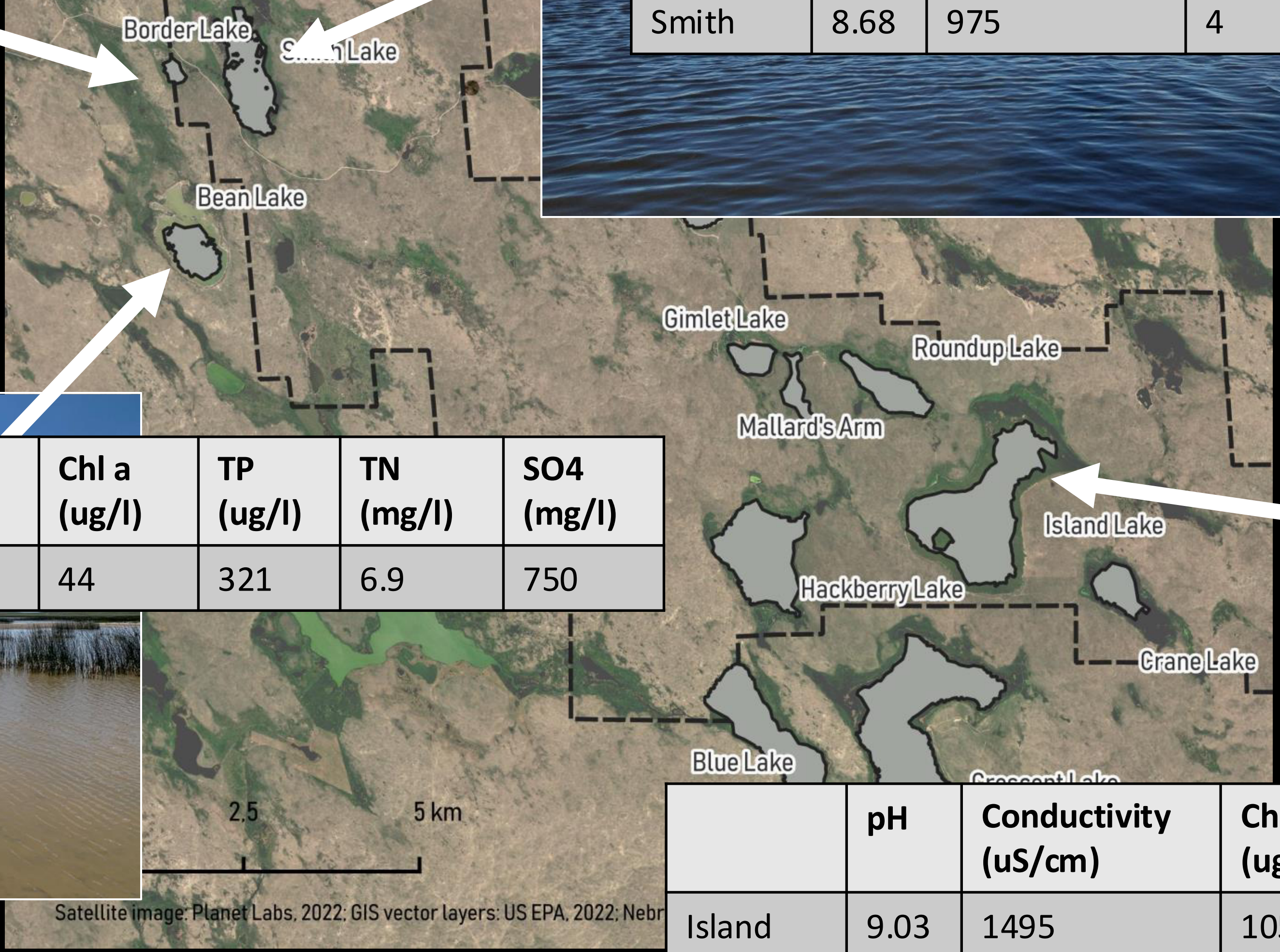
Data from EPA National Lakes Assessment, 2017

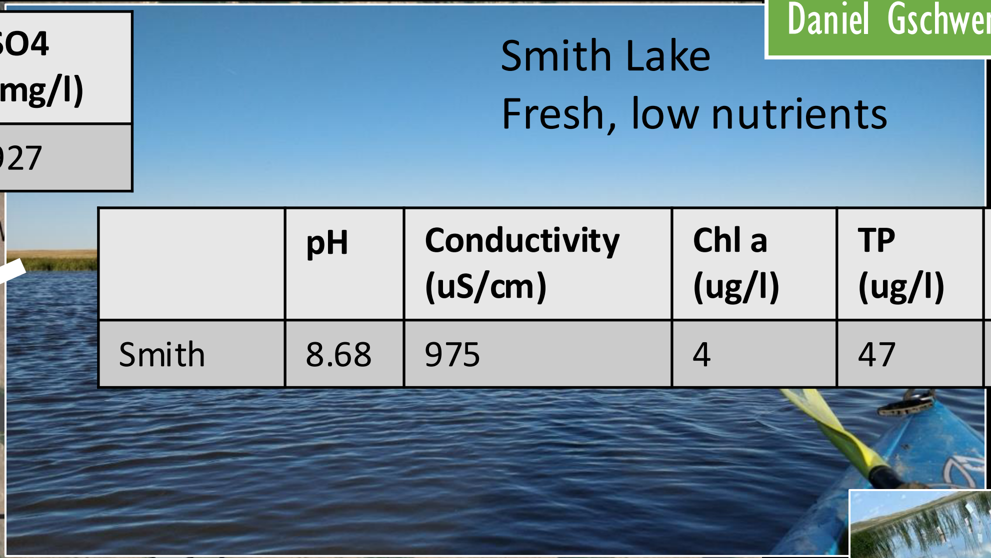
Daniel Gschwentner, PhD Candidate

	pH	Conductivity (uS/cm)	Chl a (ug/l)	TP (ug/l)	TN (mg/l)	SO4 (mg/l)
Border	9.87	10381	920	1330	5.7	927



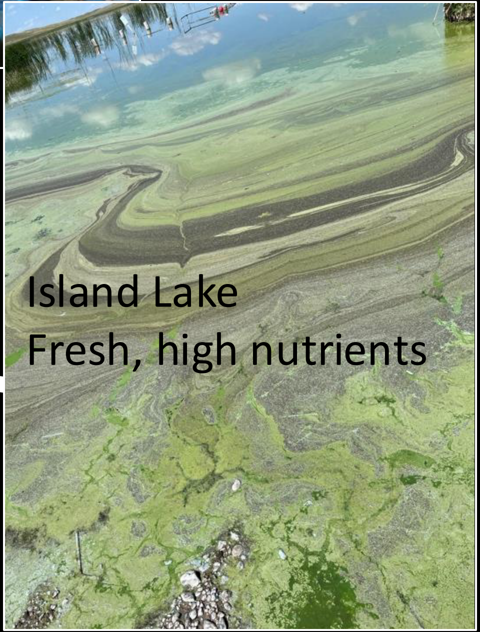
Border Lake
Saline, high nutrients





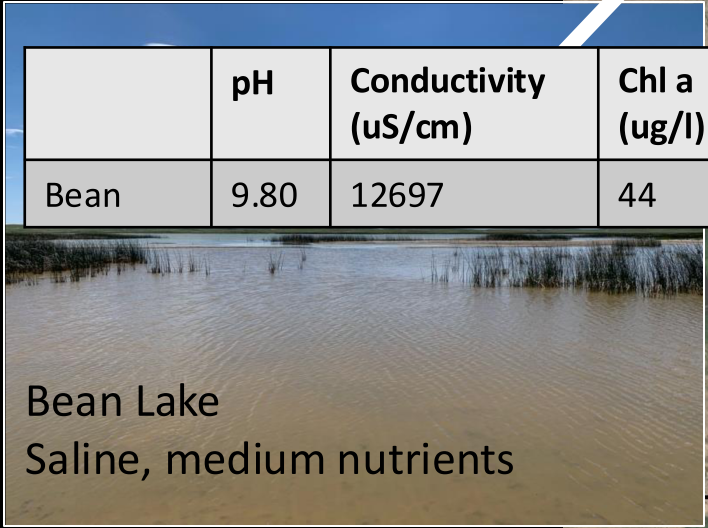
Smith Lake
Fresh, low nutrients

	pH	Conductivity (uS/cm)	Chl a (ug/l)	TP (ug/l)	TN (mg/l)	SO4 (mg/l)
Smith	8.68	975	4	47	1.5	102



Island Lake
Fresh, high nutrients

	pH	Conductivity (uS/cm)	Chl a (ug/l)	TP (ug/l)	TN (mg/l)	SO4 (mg/l)
Bean	9.80	12697	44	321	6.9	750



Bean Lake
Saline, medium nutrients

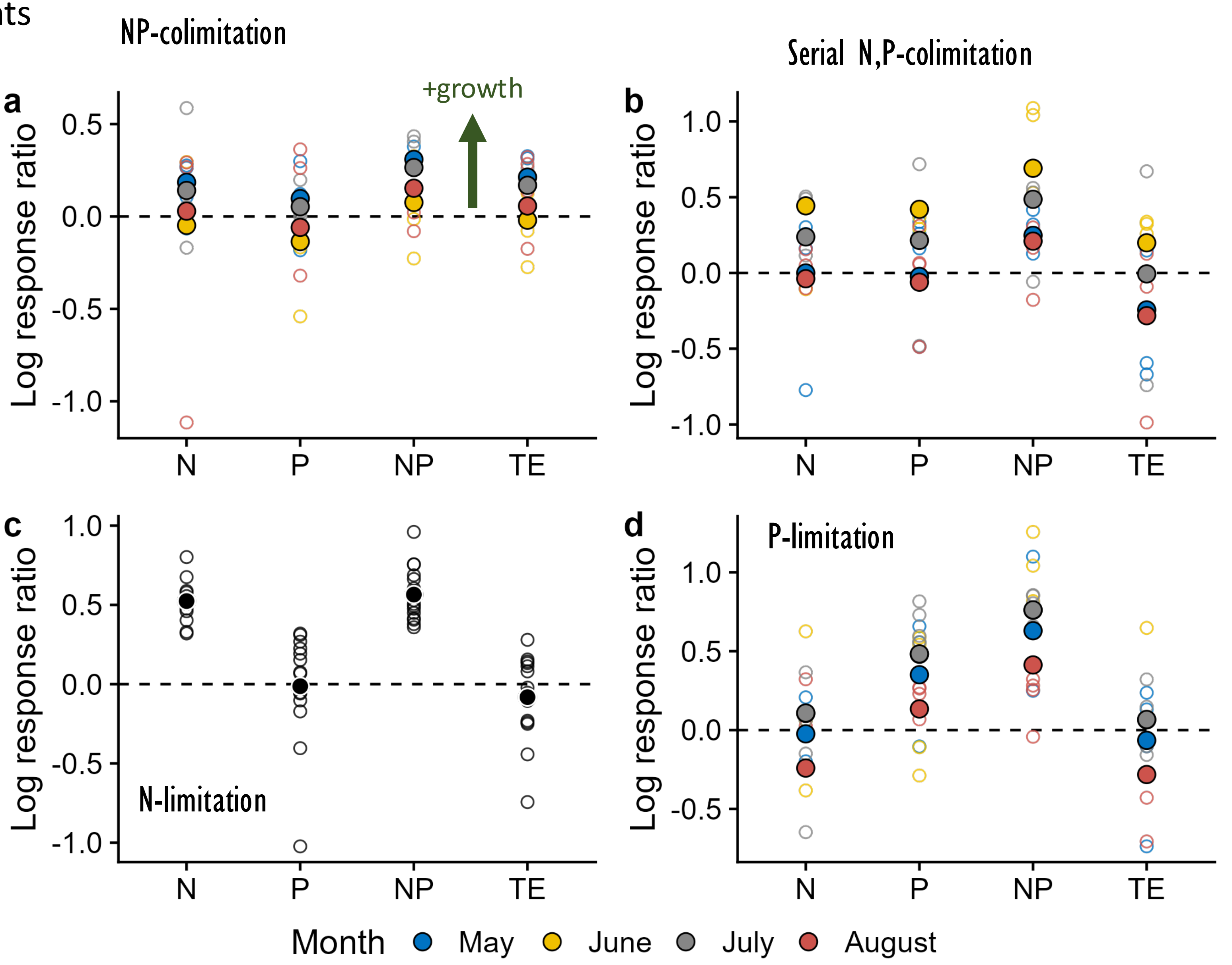
	pH	Conductivity (uS/cm)	Chl a (ug/l)	TP (ug/l)	TN (mg/l)	SO4 (mg/l)
Island	9.03	1495	105	414	2.9	9

NSF OIA-2019596

Daniel Gschwentner, PhD Candidate

NSF OIA-2019596

Border Lake
Saline, high nutrients



Bean Lake
Saline, medium nutrients

Island Lake
Fresh, high nutrients

Smith Lake
Fresh, low nutrients

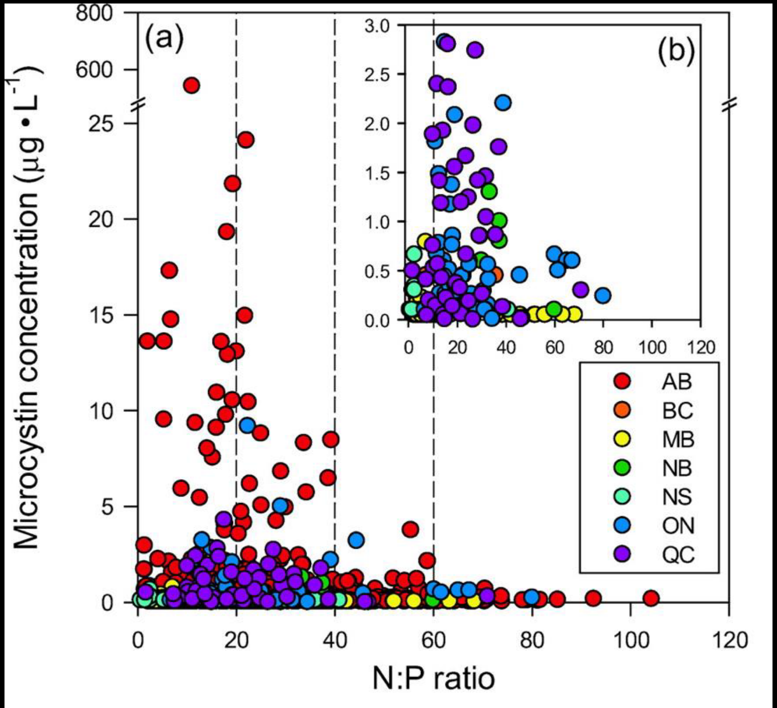
NSF OIA-2019596

Daniel Gschwentner, PhD Candidate

Yes. This lake can get greener.

Yes. You need to manage for N and P.

Digging a little deeper into N and P…



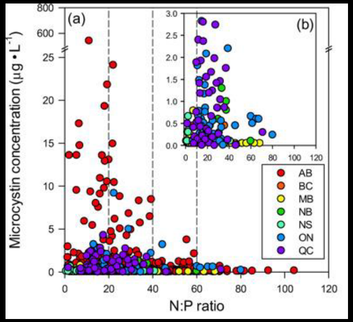
Orihel et al. 2012

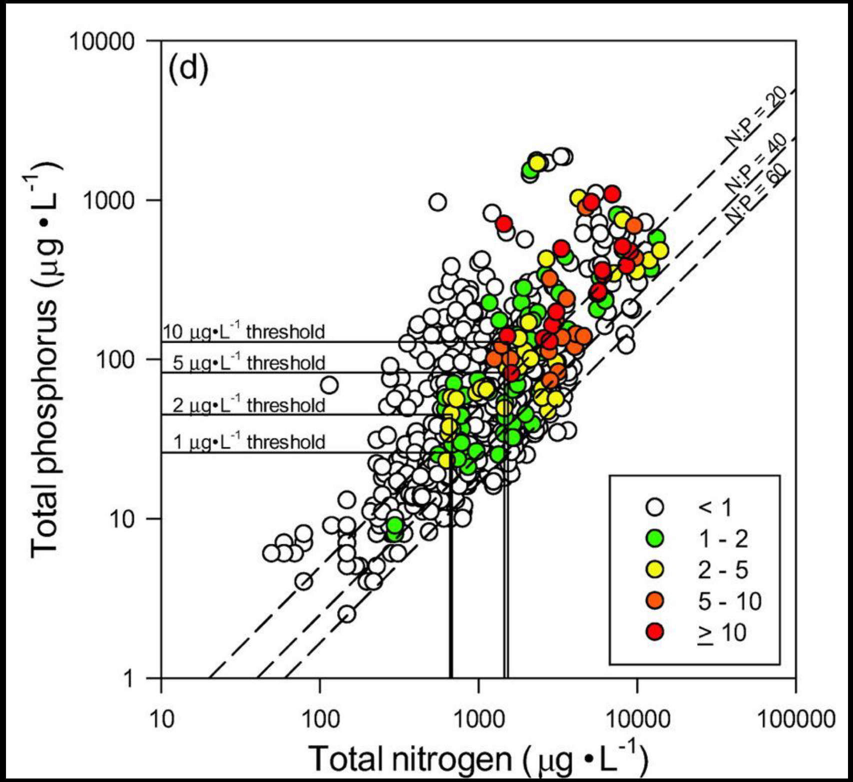
Long-term study of lakes in Canada:

- Relative amount of N and P is related to cyanotoxins.

Microcystis aeruginosa, Central Park Lake, KS, Source: Elizabeth Fabri Smith

Digging a little deeper into N and P…

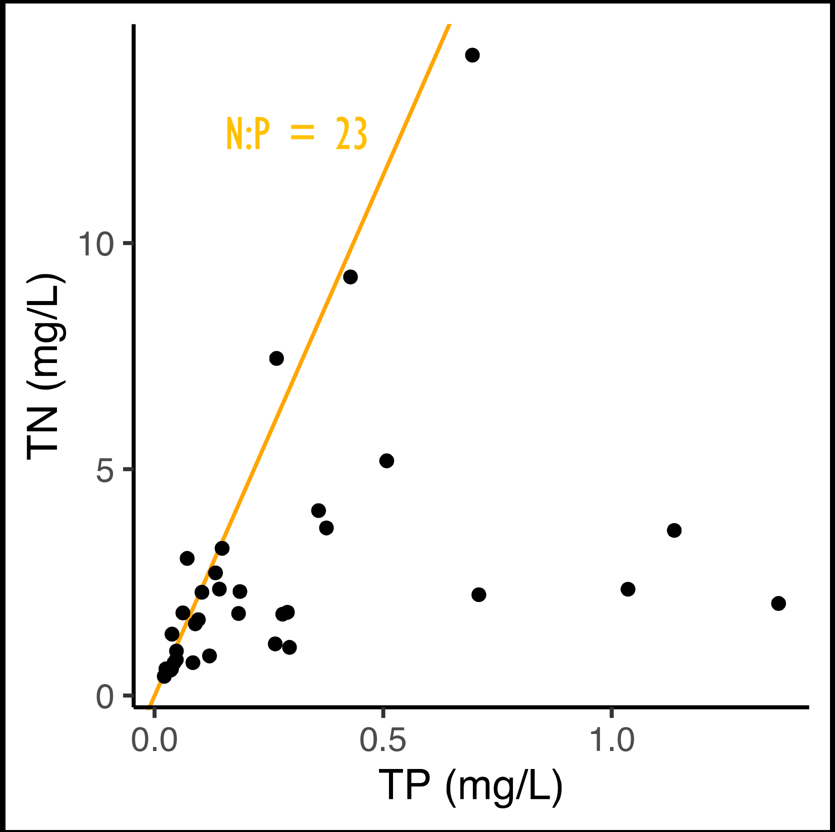




Orihel et al. 2012

"Maximum concentrations of microcystins occurred in hypereutrophic lakes at mass ratios of N:P below 23."

Digging a little deeper into N and P…



38% of Nebraska lakes have $N:P_{mass} < 23$

Low N:P → More P than N

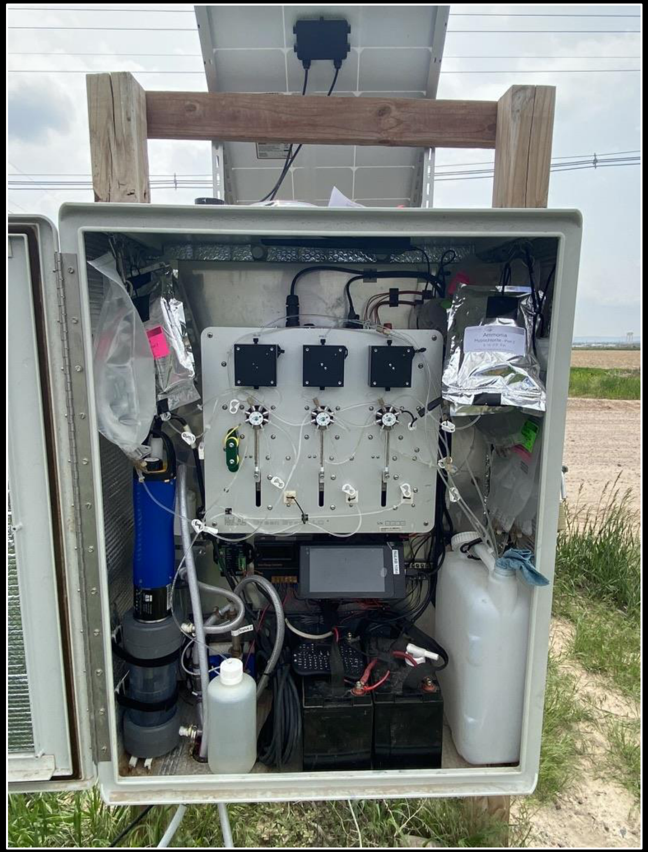
Are we doing enough to manage P in Nebraska?

STOICH 106~16~1

NSF OIA-2019596, Corman et al. *in prep*

Ecological Insights:

- New methods may be needed to understand biogeochemical processes in nutrient-rich streams.
- Primary production in eutrophic lakes has not reached its limit.
- Opportunities for better management:
  - Unlike their temperate counterparts, prairie streams are not strongly sequestering nutrients. But, they are processing them.
  - Are we sampling our waterways at the right times?



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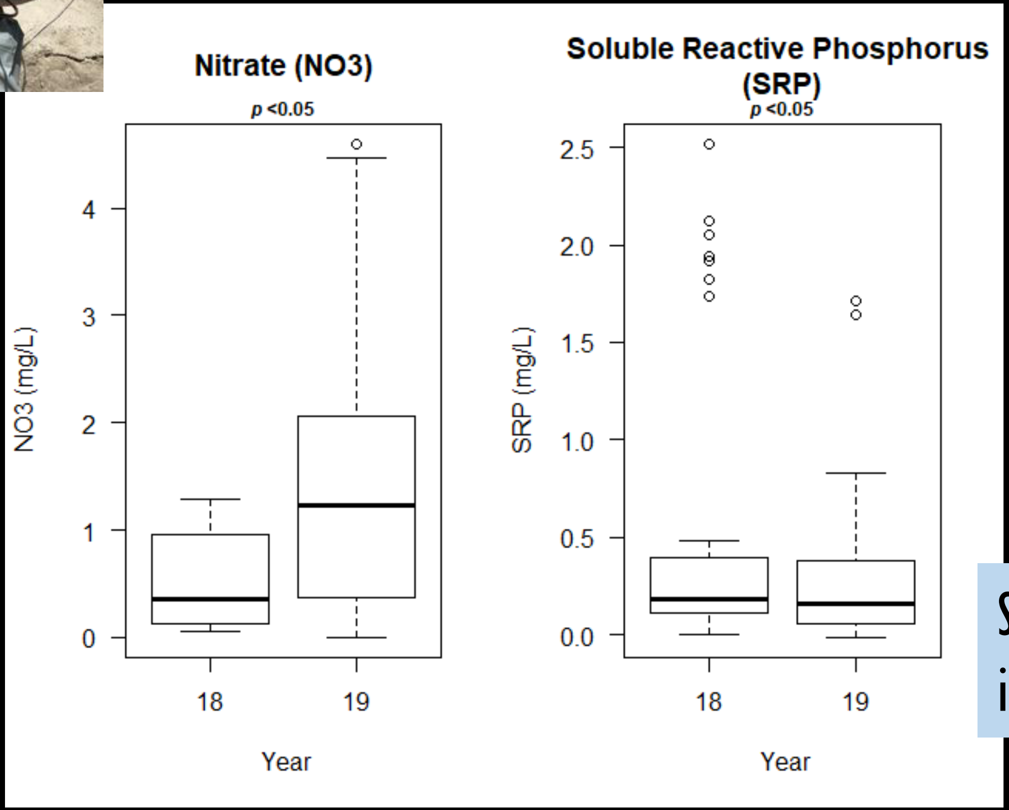
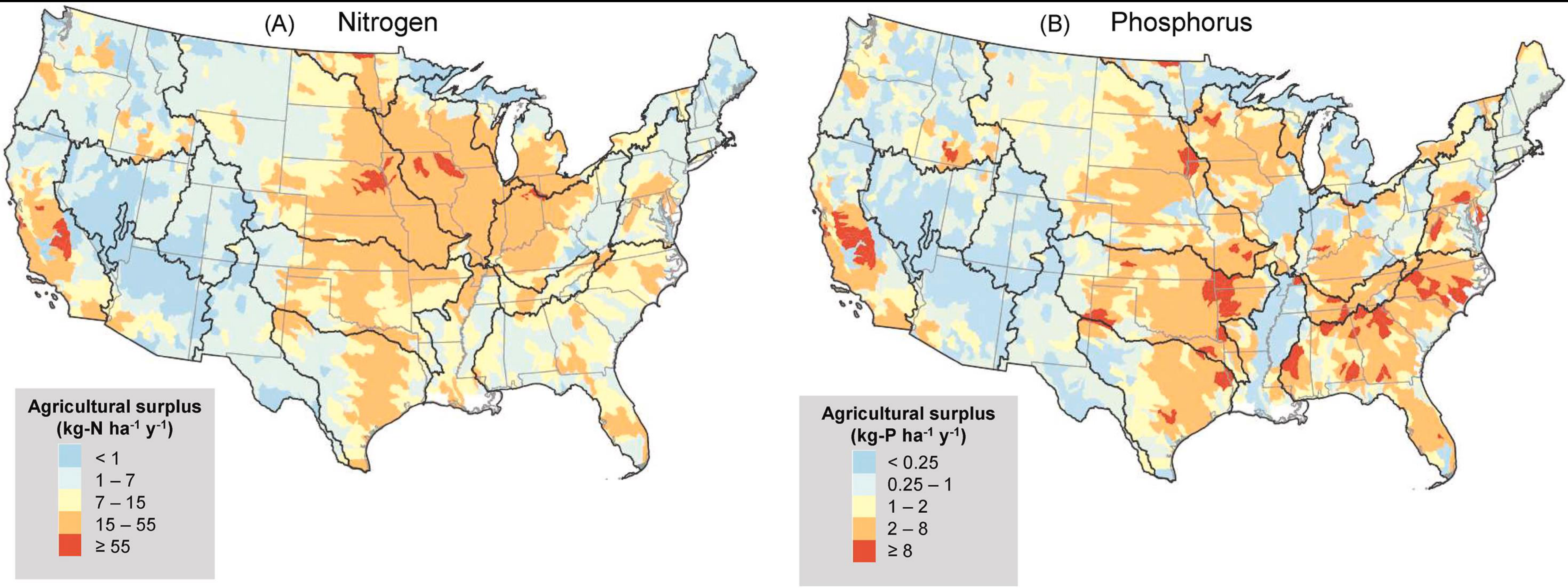
  - Are we sampling our waterways at the right times?

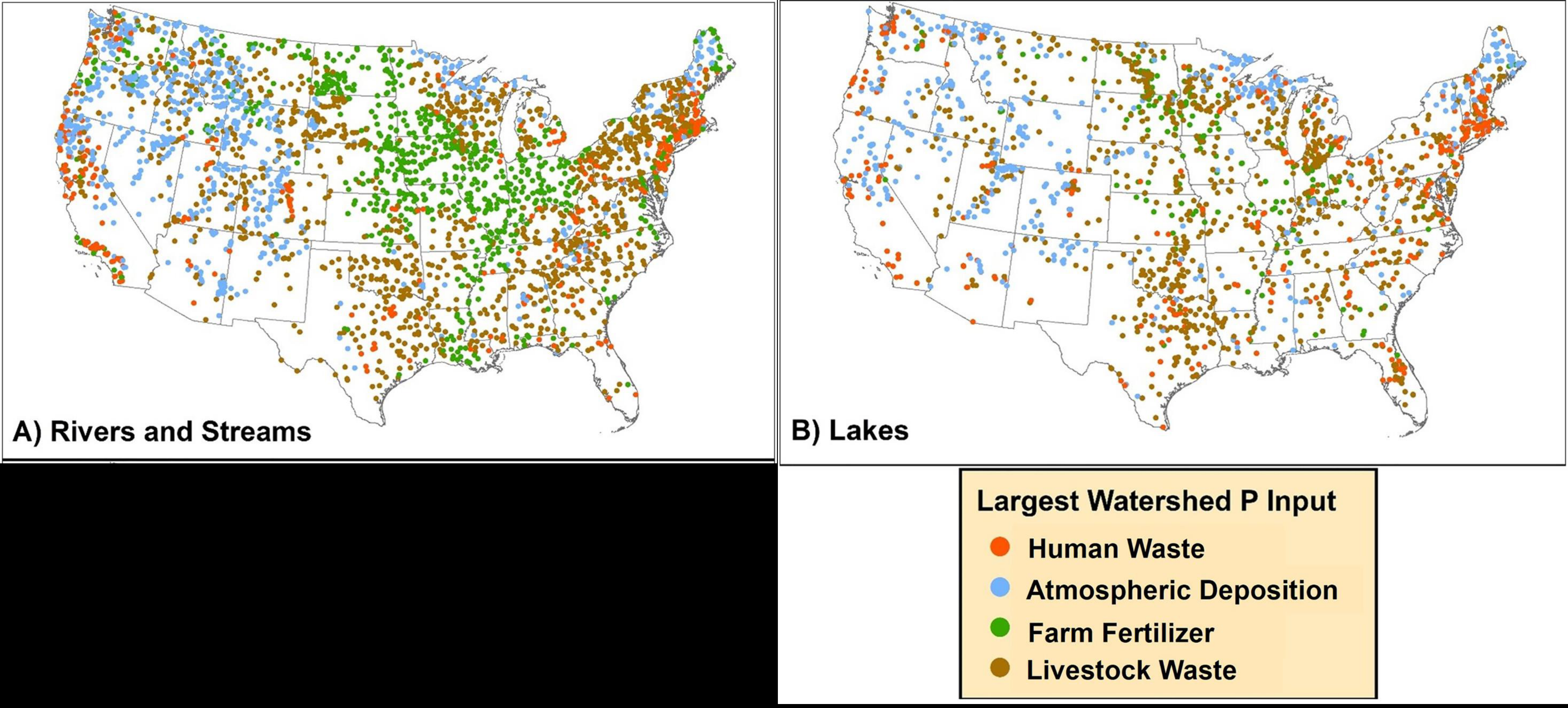
A clear water stream in Nebraska



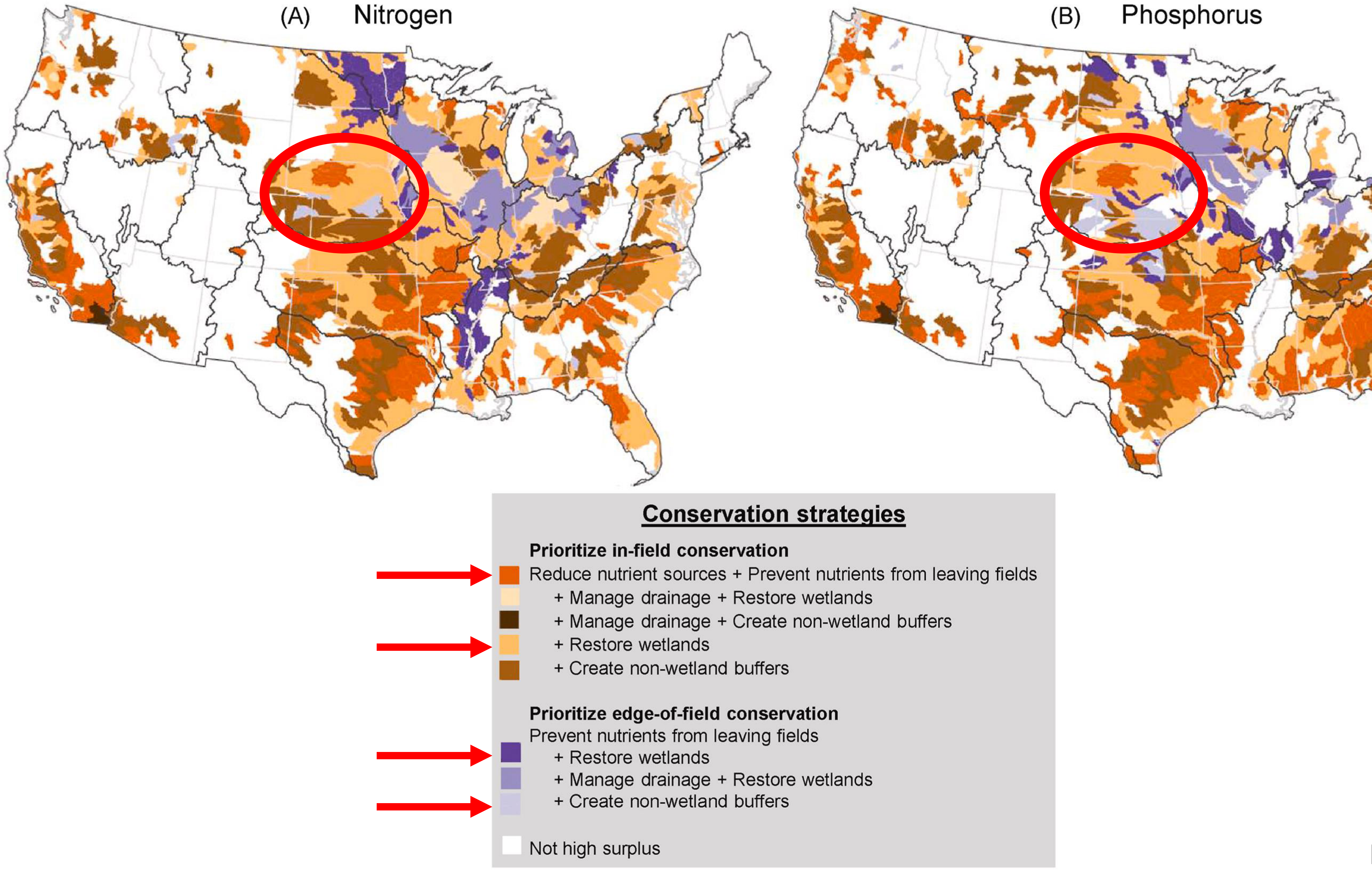
Standard methods may not be detecting uptake in high nutrient streams (Covino et al. 2018).



Kirk et al 2024, JEM



Sabo et al 2024, JGR-Biogeosciences



Kirk et al 2024, JEM