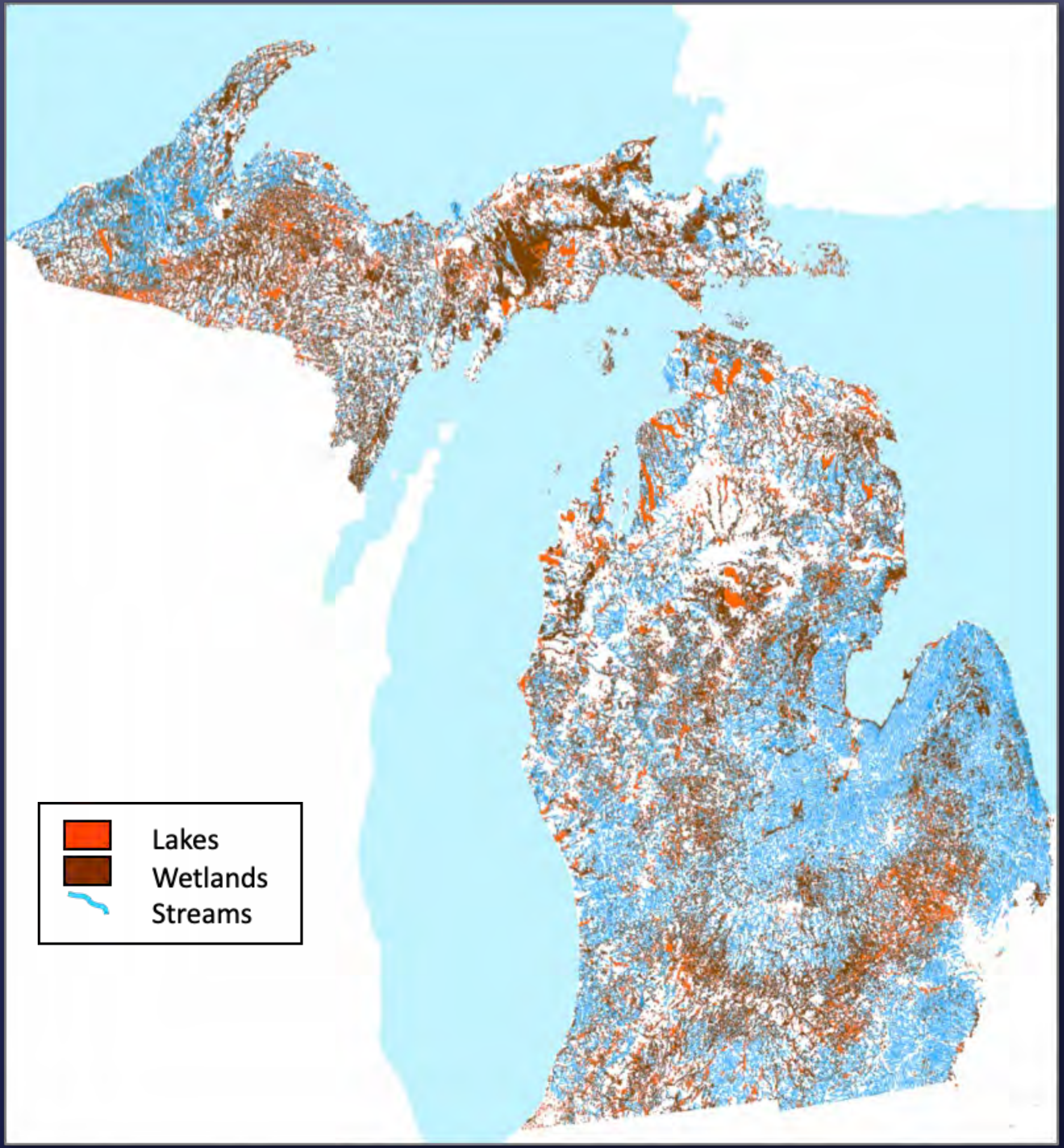
Connectivity: lakes, streams, and their watersheds – and how monitoring helps us understand and protect them

Dr. Katelyn King

Postdoctoral Research Fellow

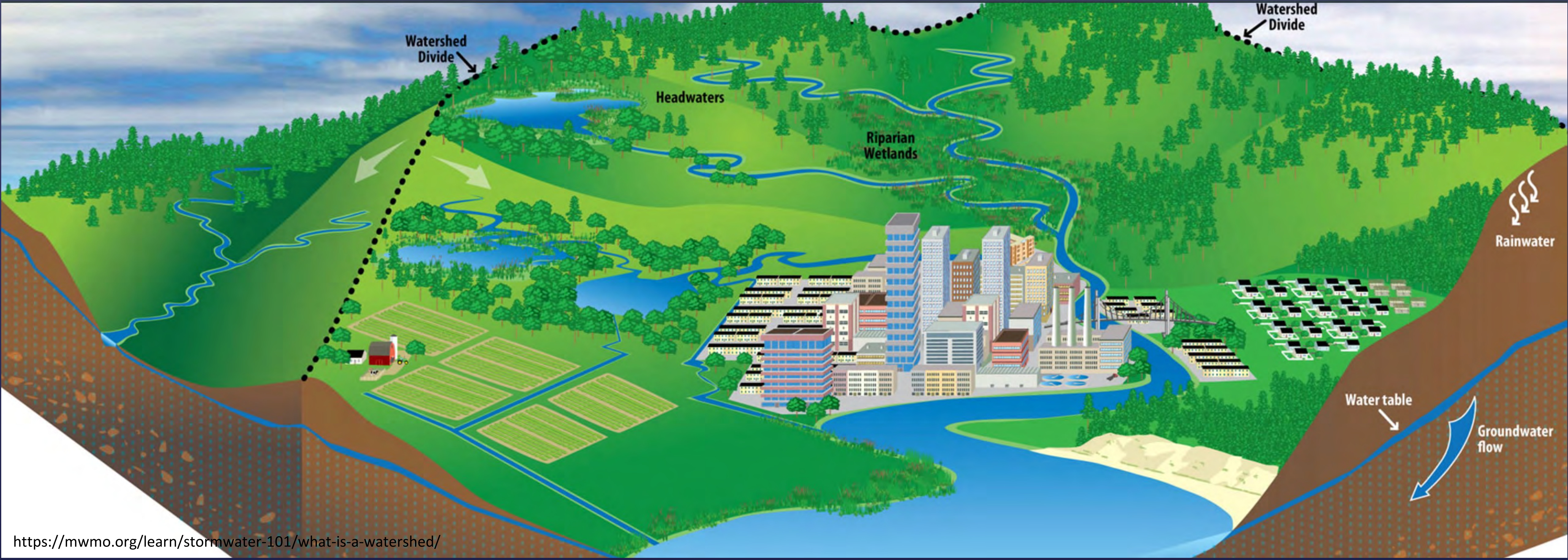
University of Michigan

Landscape perspective



What is a watershed?

Surface water and ground water flow into a receiving water body



https://mwmo.org/learn/stormwater-101/what-is-a-watershed/

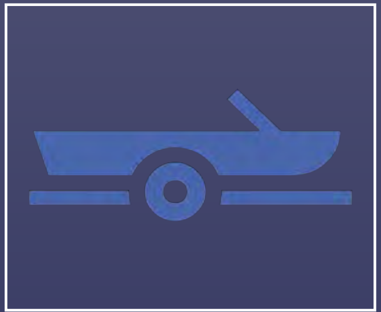
Why is Connectivity Important?

- Nutrients can travel off the land and among waterbodies
- Individuals and materials move between lakes, streams, and wetlands
- Provides food for organisms, spawning habitat for fish, and habitat refuge
- Distributes contaminants and invasive species

Monitoring helps understand connections

allows us to have big datasets to analyze ecosystem health

track trends over space and time



report on water quality, highlight sites or regions for further agency assessment, track invasive species, develop watershed management plans, and set fishing regulations

https://www.eekwi.org/great-lakes/ecosystems

Connectivity provides food

- Food can drift down
- Nutrients between water bodies delivered to aquatic veg
- Some organisms can move within or among a lake or stream to find food

©David H. Funk

Phil Velasquez Chicago Tribune

Fieldandstream.com

Connectivity provides habitat refuge

nsta.org

Ravi Pinisetti

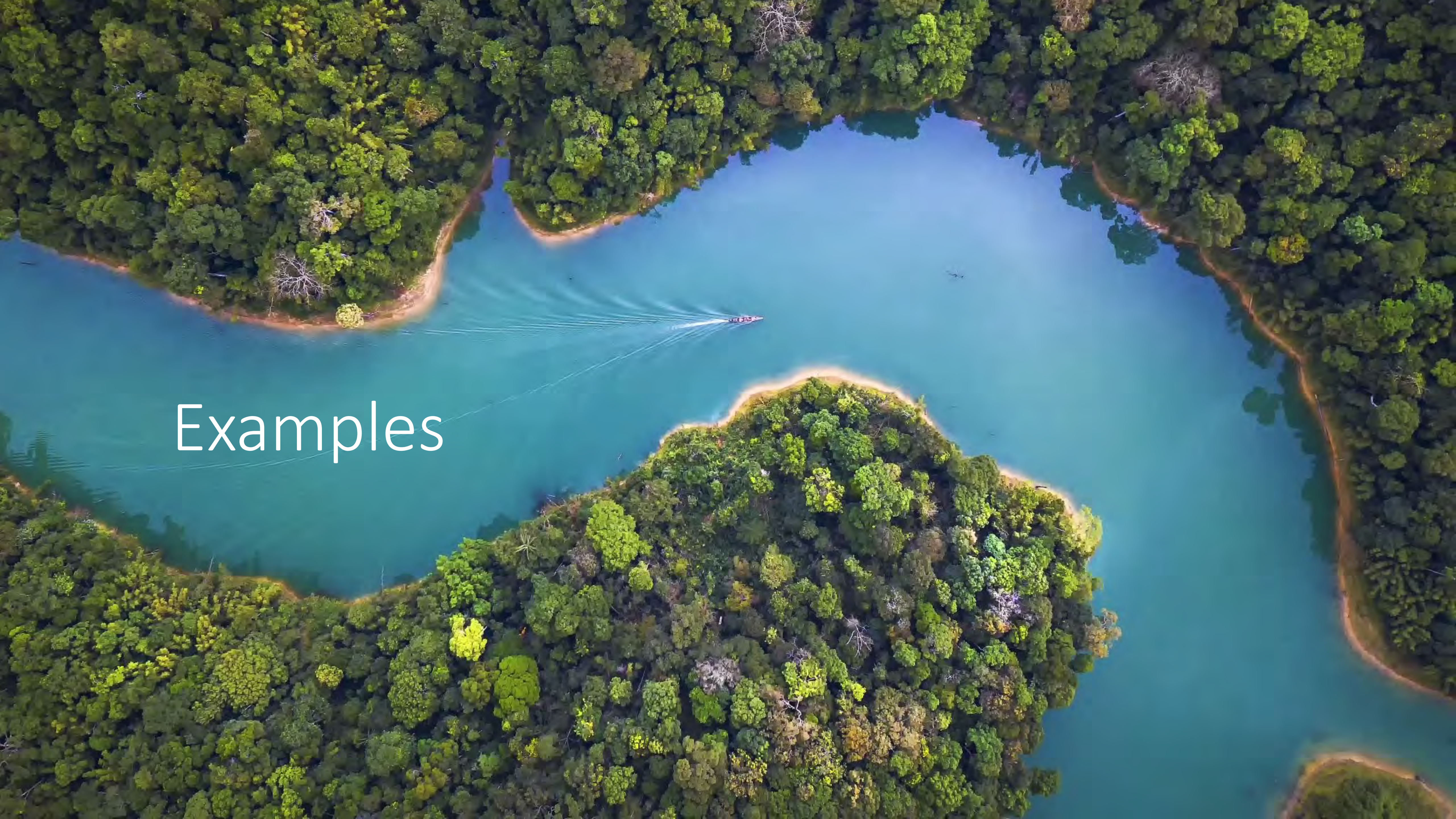
- Temperature
  - Seasonal migration – access to deeper water or cooler water in the summer
  - Long-term shifts in response to warming climate

- Oxygen
  - move into a stream or connecting lake during periods of low oxygen in the winter

Connectivity for spawning

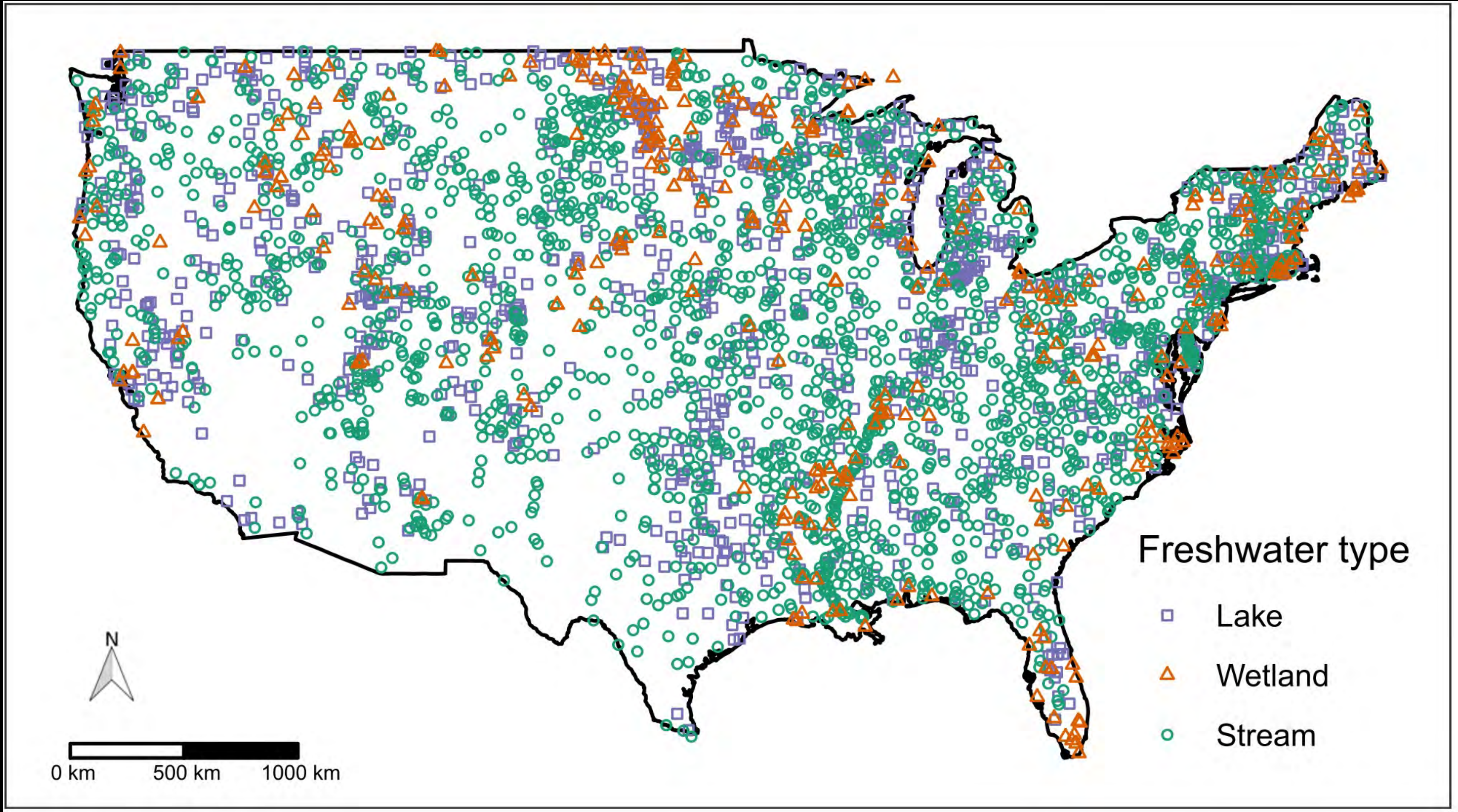
- Shallow portion of a lake, stream, or wetland provides habitat for spawning
- Some species move from lakes into streams to spawn
- Currents are important in transport from spawning habitat to nursery habitats

Examples



How do different factors affect lakes, streams, and wetlands?

EPA assessments

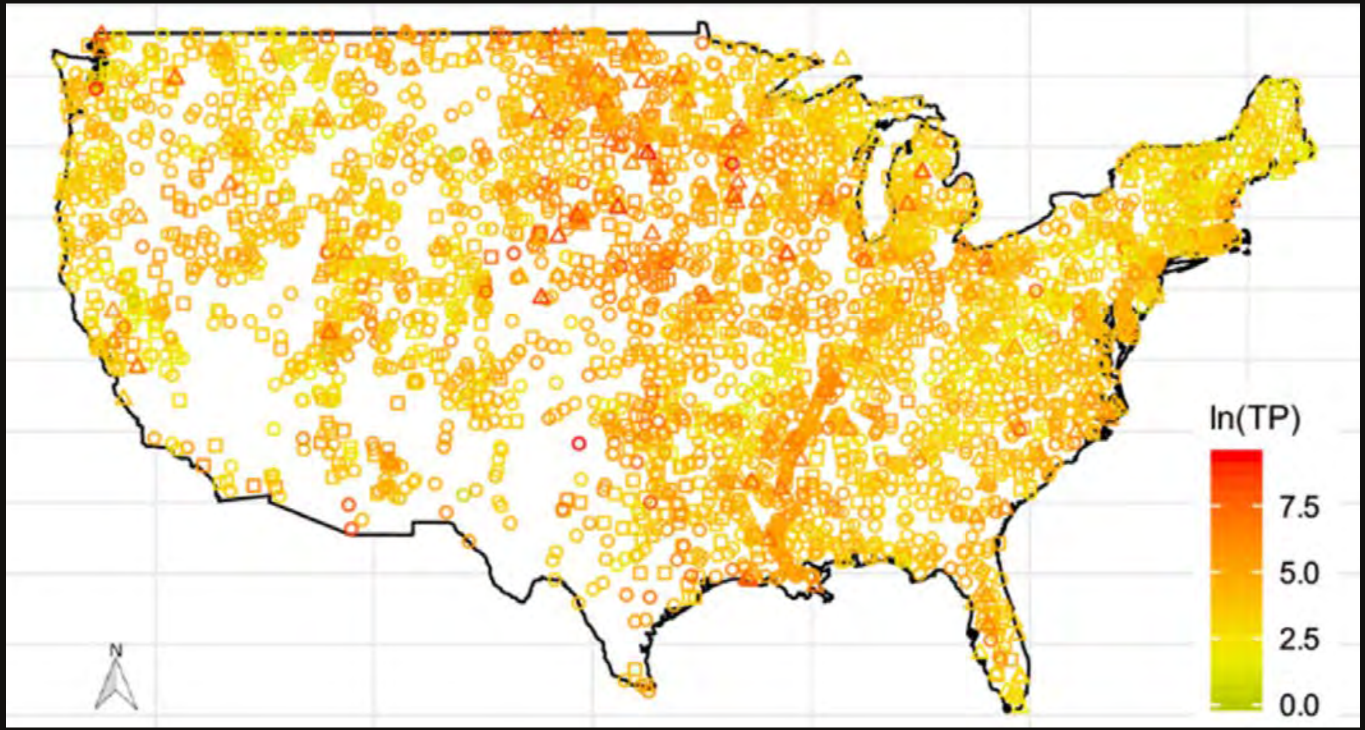


King, Cheruvelil, Pollard. 2019.

Total Phosphorus

Total Nitrogen

Regardless of freshwater type, agricultural and forested land within the watershed were the most influential on TP and TN

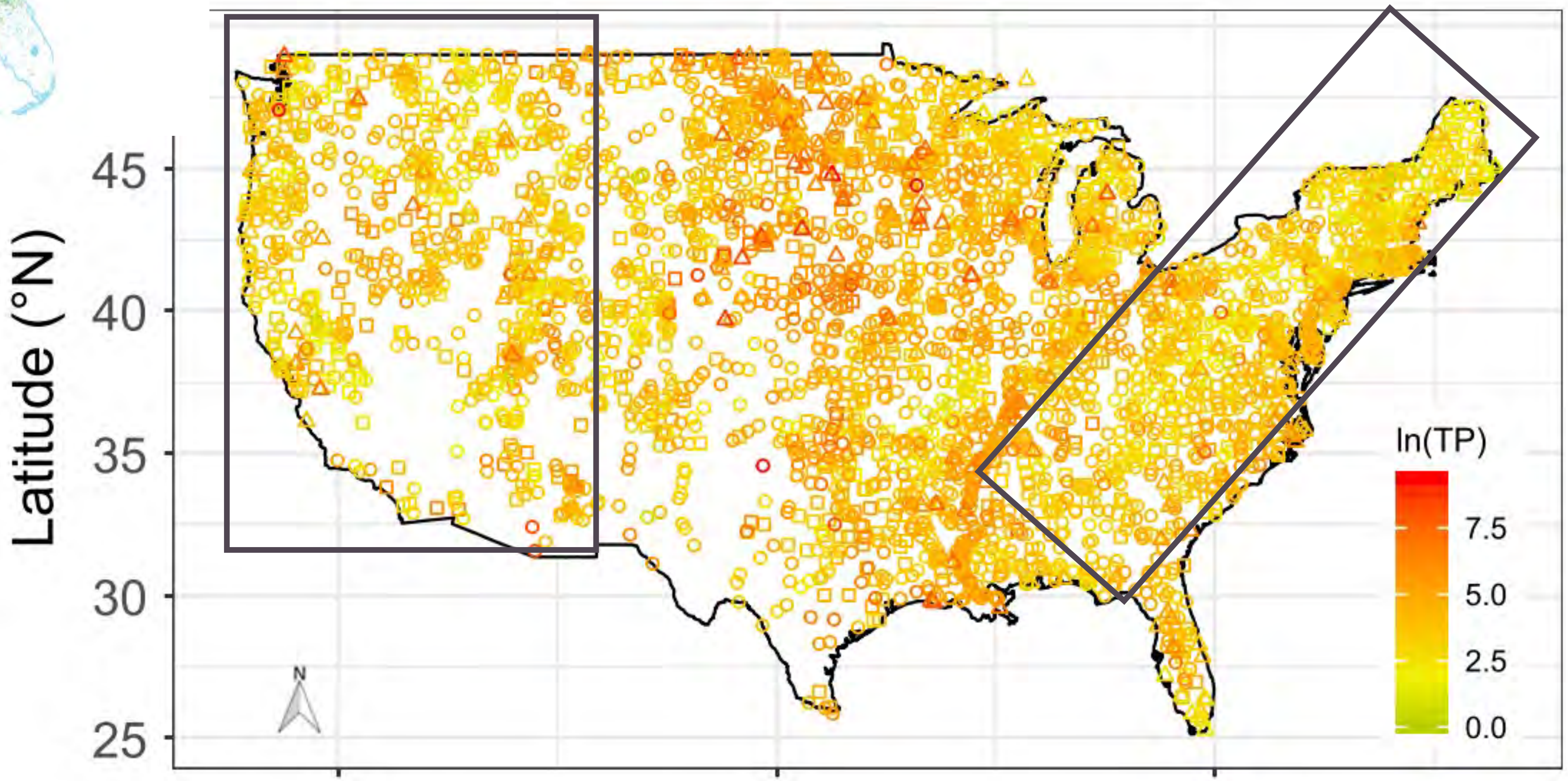


King, Cheruvelil, Pollard. 2019.

King, Cheruvelil, Pollard. 2019.

Forest

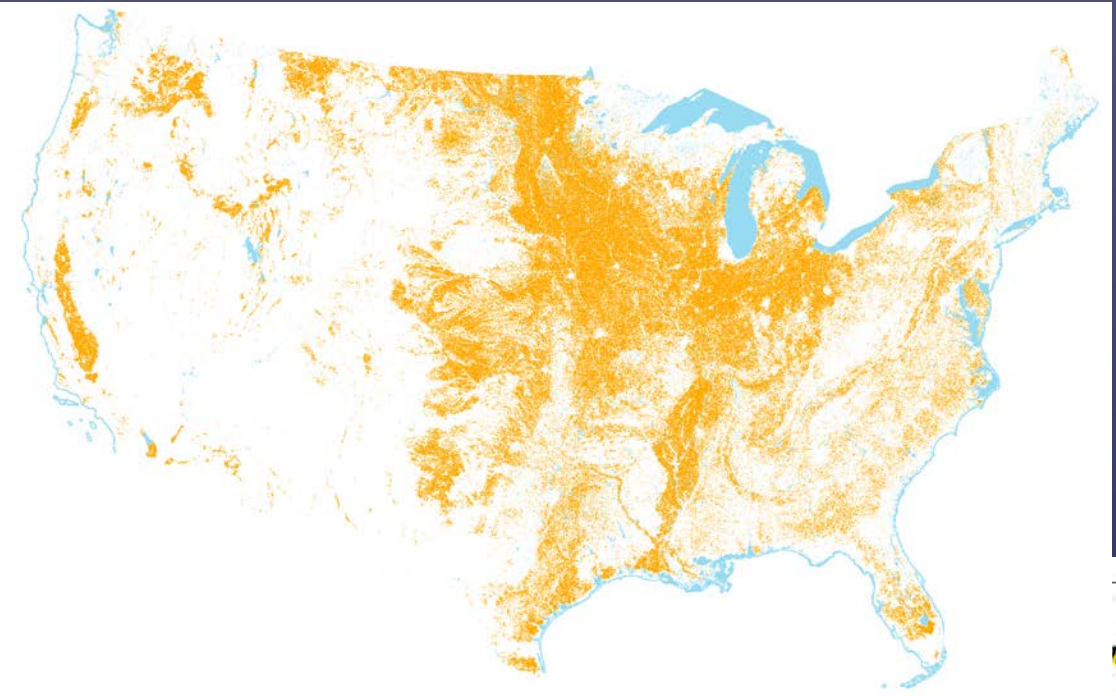
Total Phosphorus



□ lakes

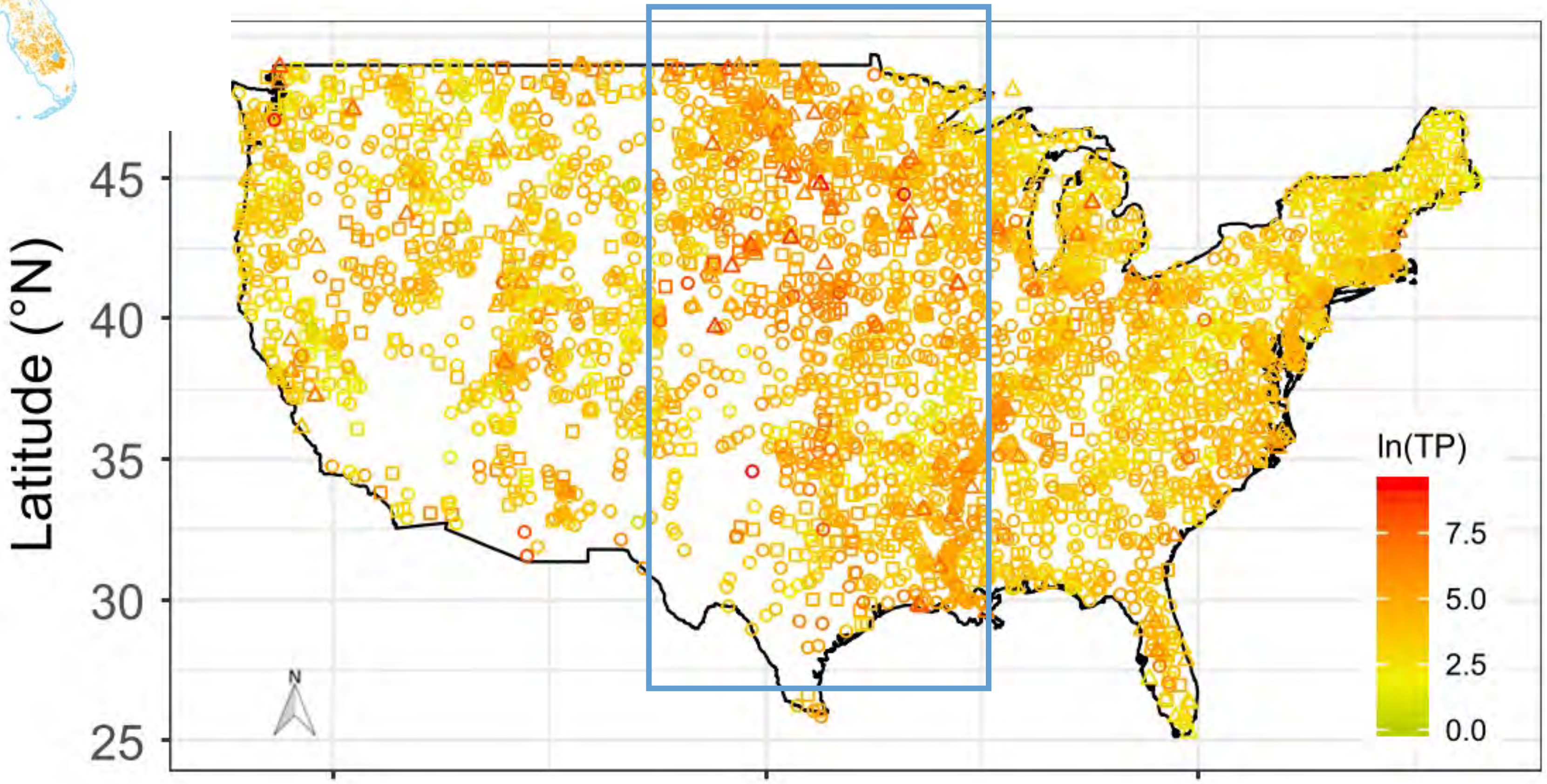
△ wetlands

○ streams



King, Cheruvelil, Pollard. 2019.

Total Phosphorus



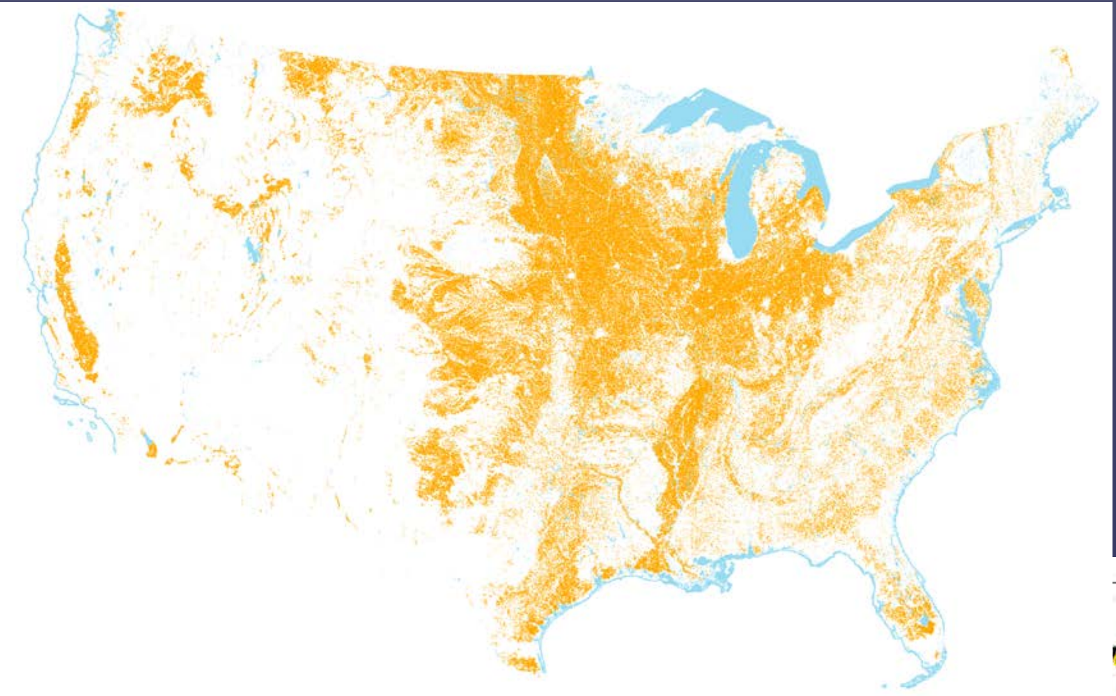
□ lakes

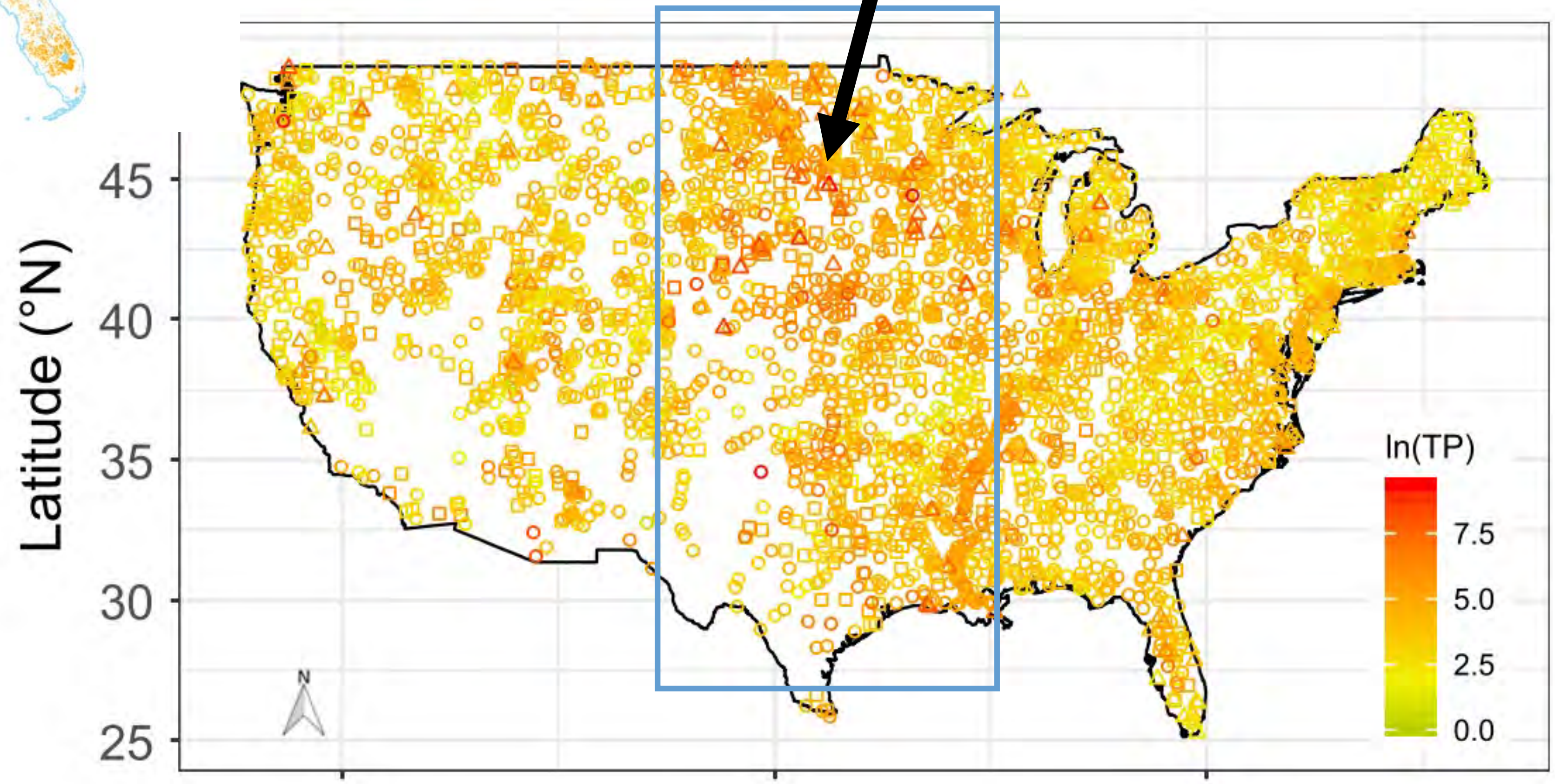
△ wetlands

○ streams

King, Cheruvelil, Pollard. 2019.

Total Phosphorus



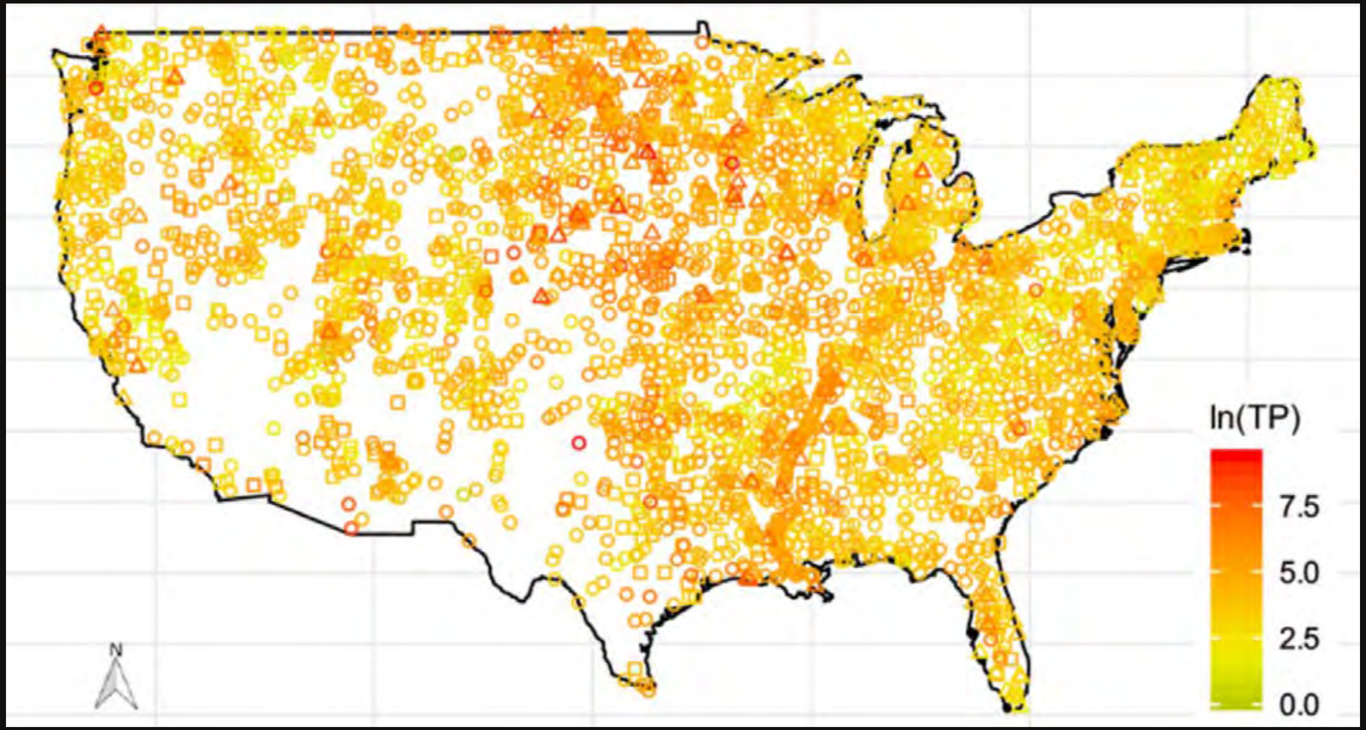


lakes
wetlands
streams

Implications for management

Future land use intensification is likely to similarly negatively impact nutrients in all three freshwater types

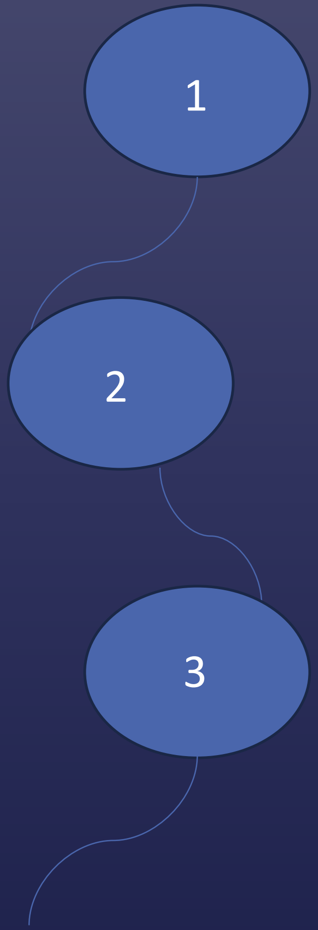
Powerful to integrate across freshwater types at the macroscale

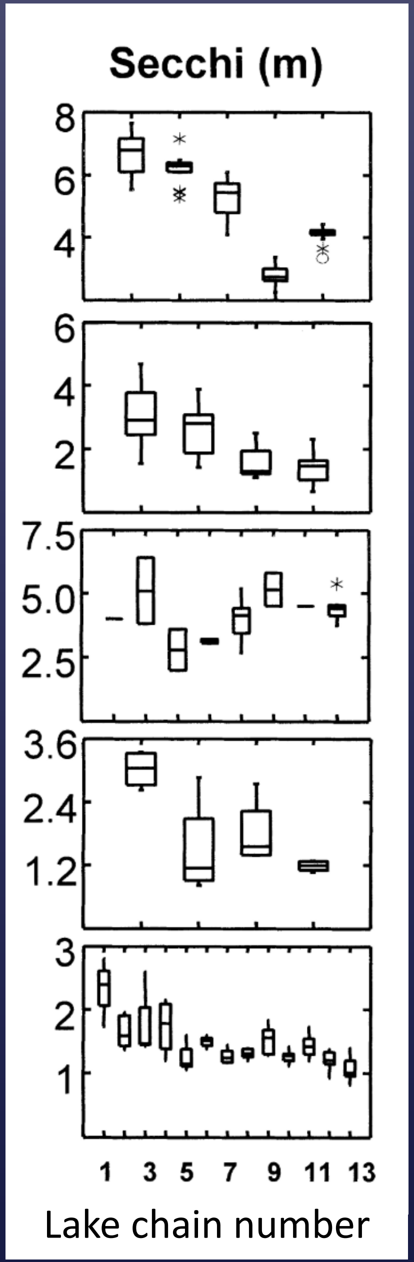


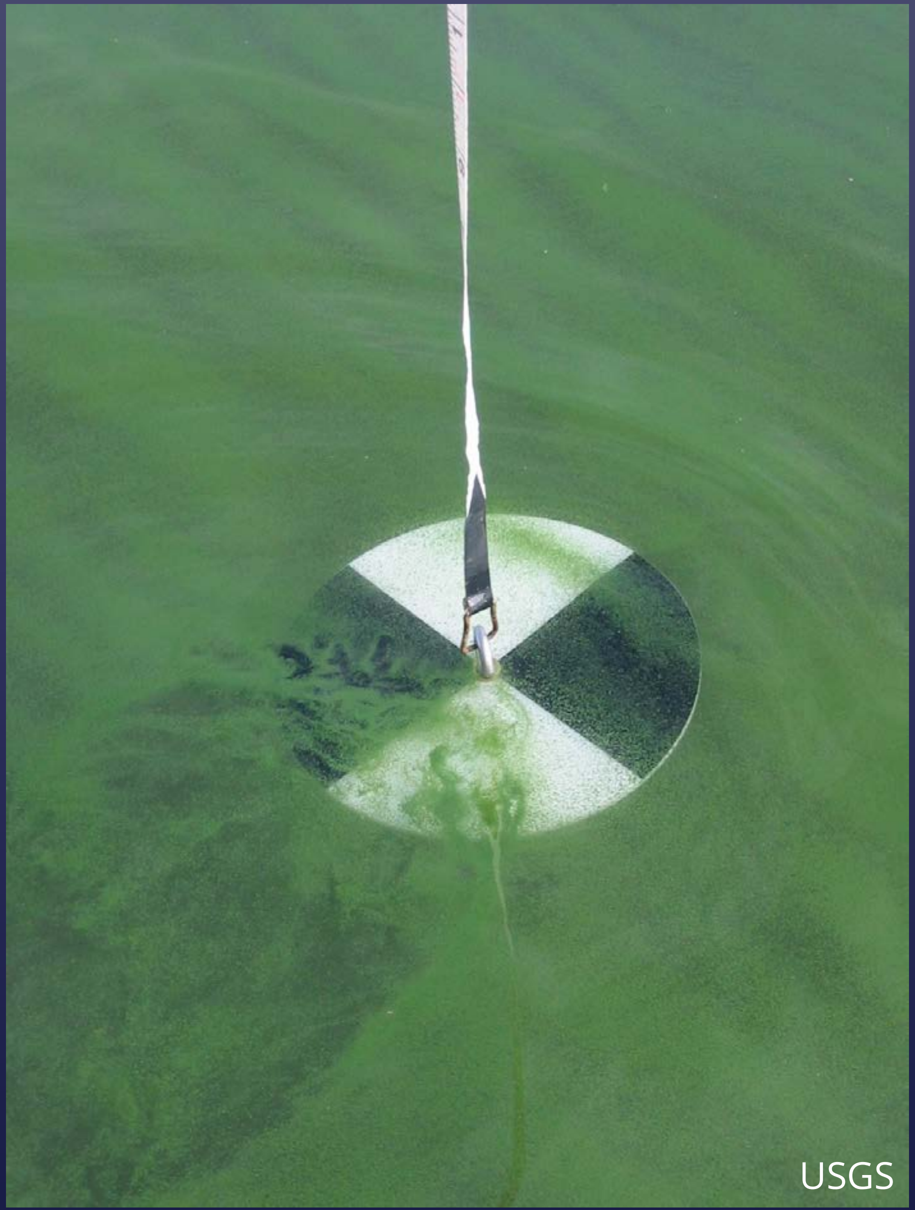
King, Cheruvelil, Pollard. 2019.

How does connectivity affect water quality?

Secchi depth decreased along the lake chain

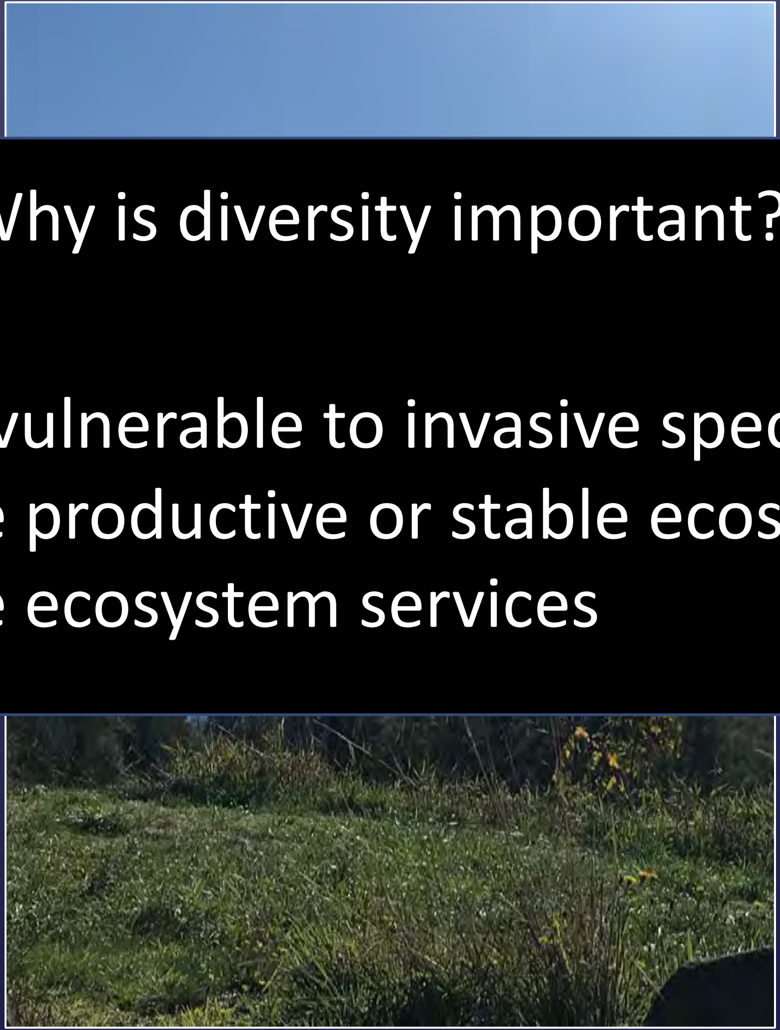
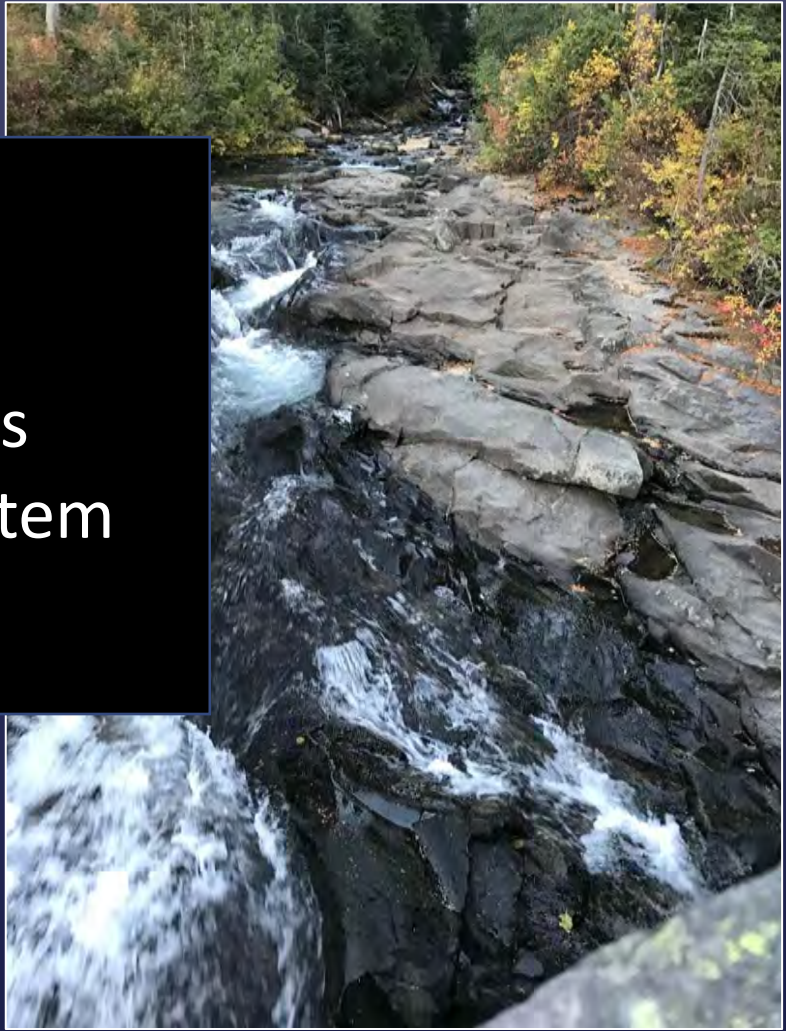






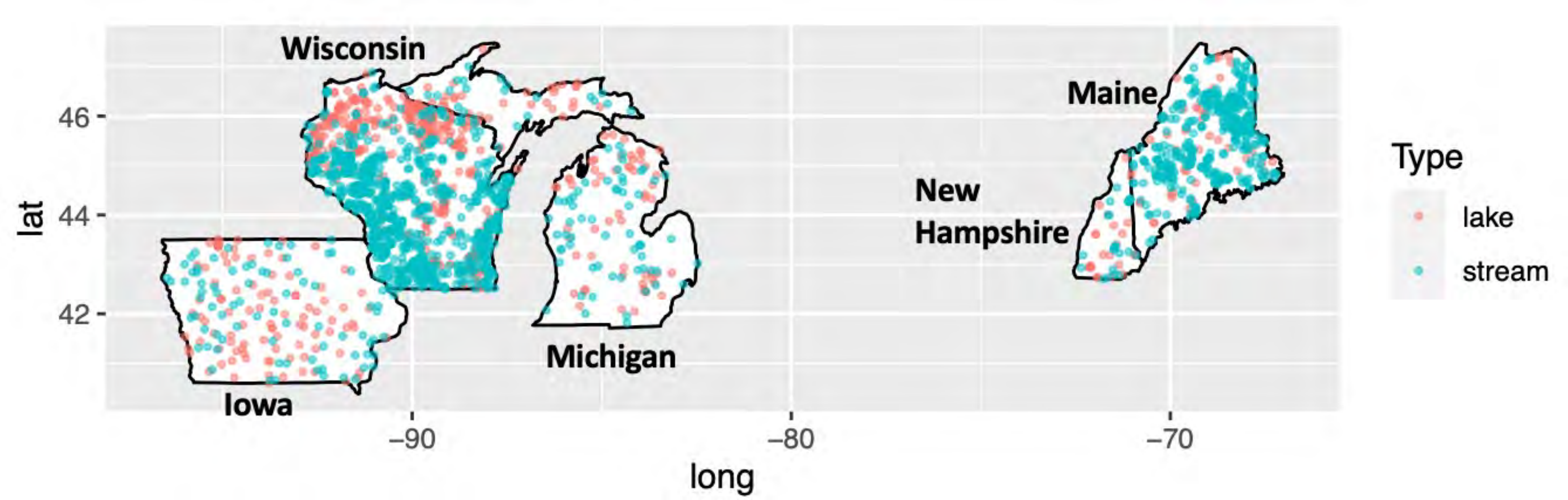
Soranno et al. 1999.

How does connectivity affect fish diversity in lakes and streams?

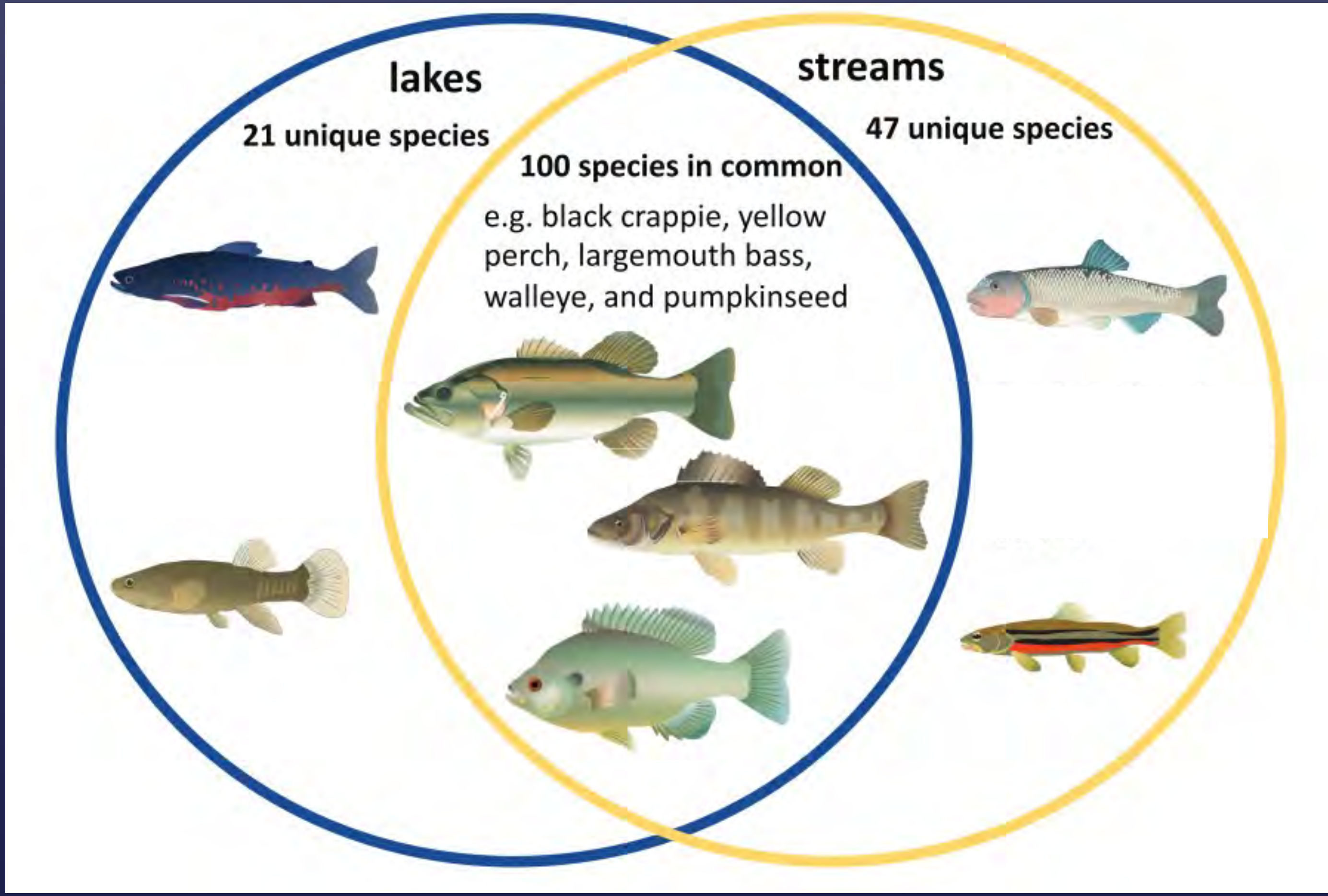




Why is diversity important?

- Less vulnerable to invasive species
- More productive or stable ecosystem
- More ecosystem services

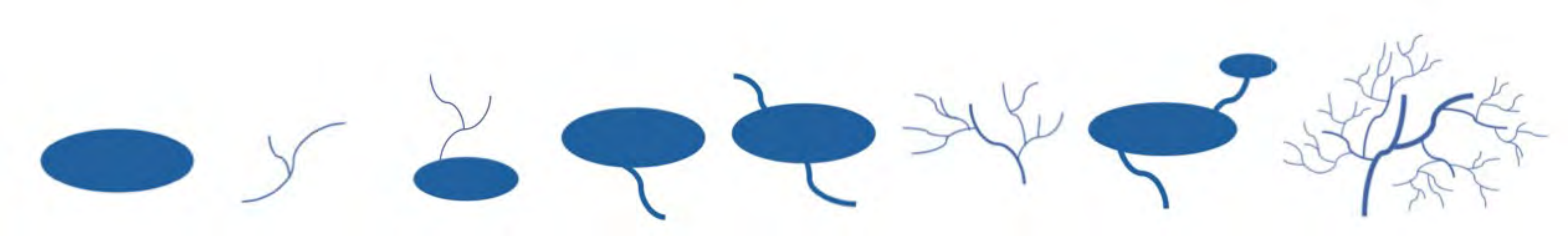

Wisconsin
Maine
New Hampshire
Michigan
Iowa
lat
46
44
42
long
−90
−80
−70
Type
lake
stream

Many fish species are found in both lakes *and* streams/rivers



King, Bremigan, Infante, Cheruvelil. 2021. CJFAS.

Types of connectivity

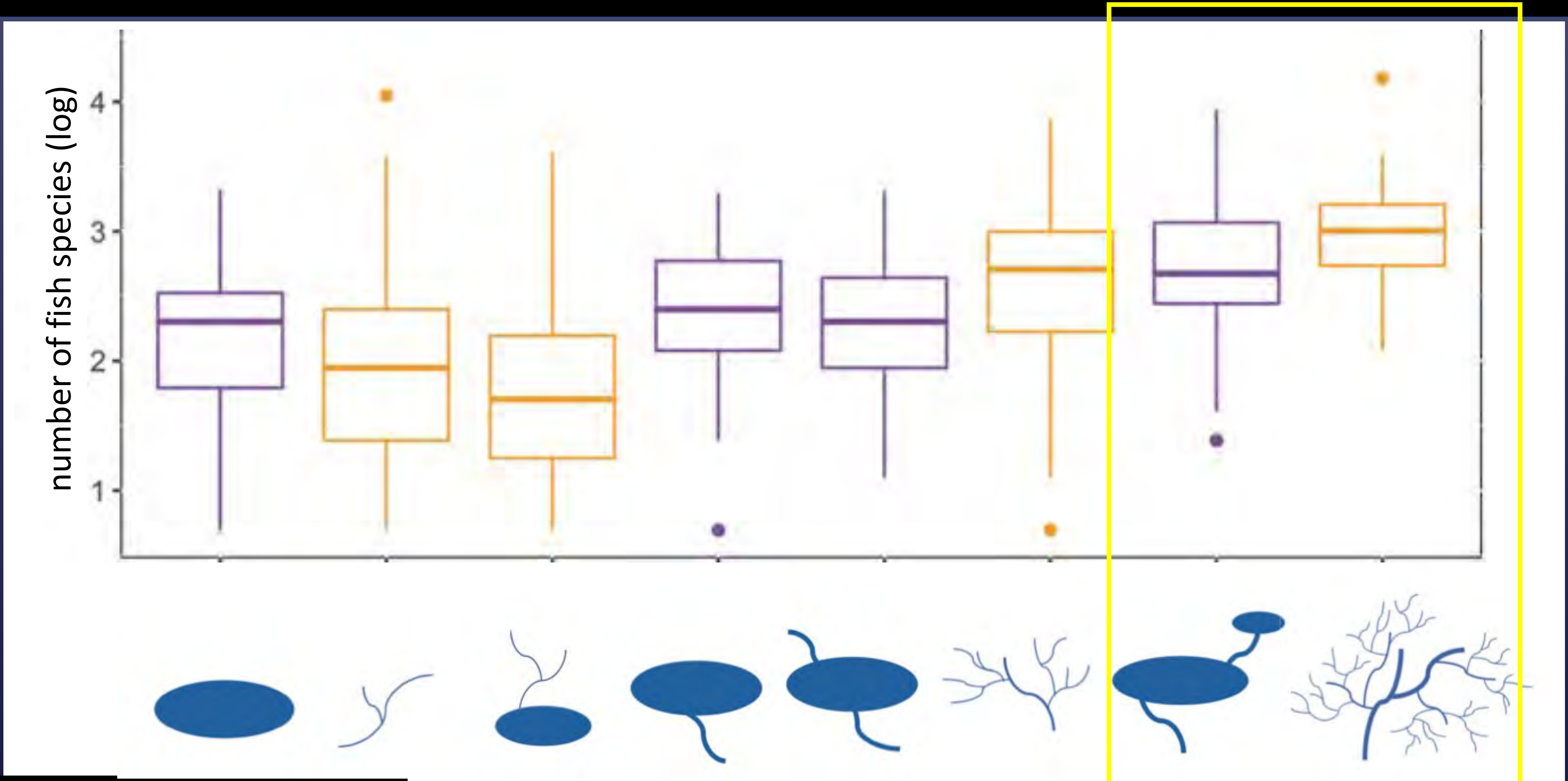


isolated lakes | headwater streams | headwater streams with a downstream lake | headwater lakes | drainage lakes | Mid order streams | lakes with upstream lakes | rivers

less connected → more connected

King, Bremigan, Infante, Cheruvelil. 2021. CJFAS.

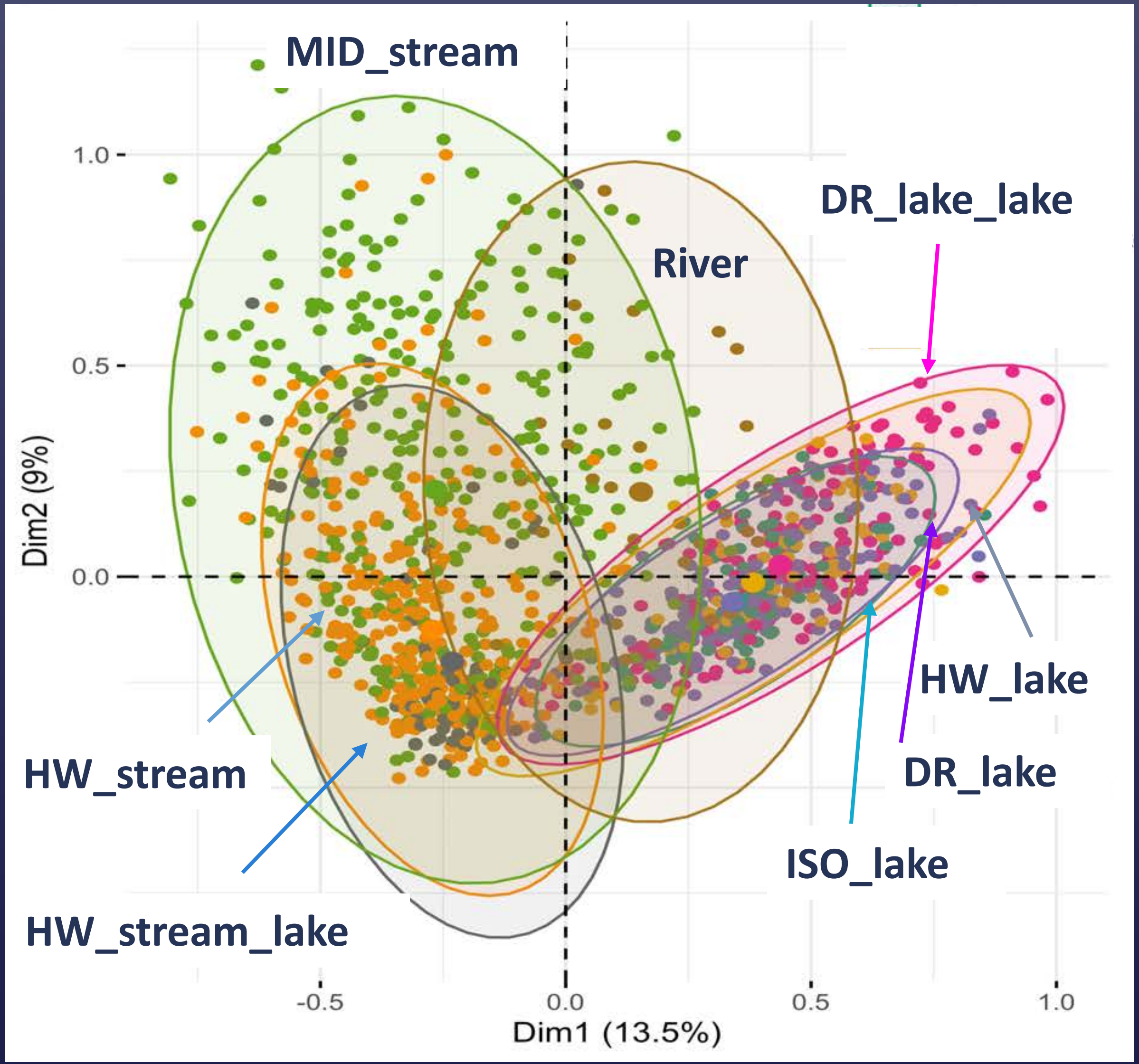
Lakes and streams with high connectivity support many species



King, Bremigan, Infante, Cheruvelil. 2021. CJFAS.

Species composition across LAKE & STREAM connectivity

- connectivity can help explain species composition across lakes, streams, and rivers
- lakes and rivers have similar assemblages
- isolated lake assemblages are a subset of connected lakes
- mid-order streams overlap headwater and river

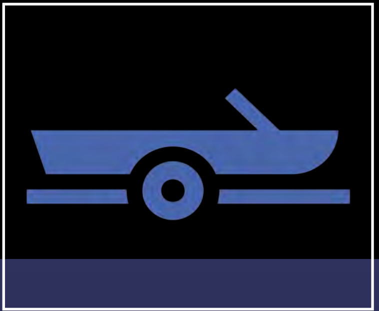


King, Bremigan, Infante, Cheruvelil. 2021. CJFAS.

Implications for conservation

Understanding connectivity & fish biodiversity patterns in lakes & streams can help:

- Include both lakes and streams in management decisions
- Plan protected areas - need a range of connectivity
- Broad-scale management – watershed approach



http://www.divephotoguide.com/user/websidive/gallery/lake-gr-bl/photo/22515/

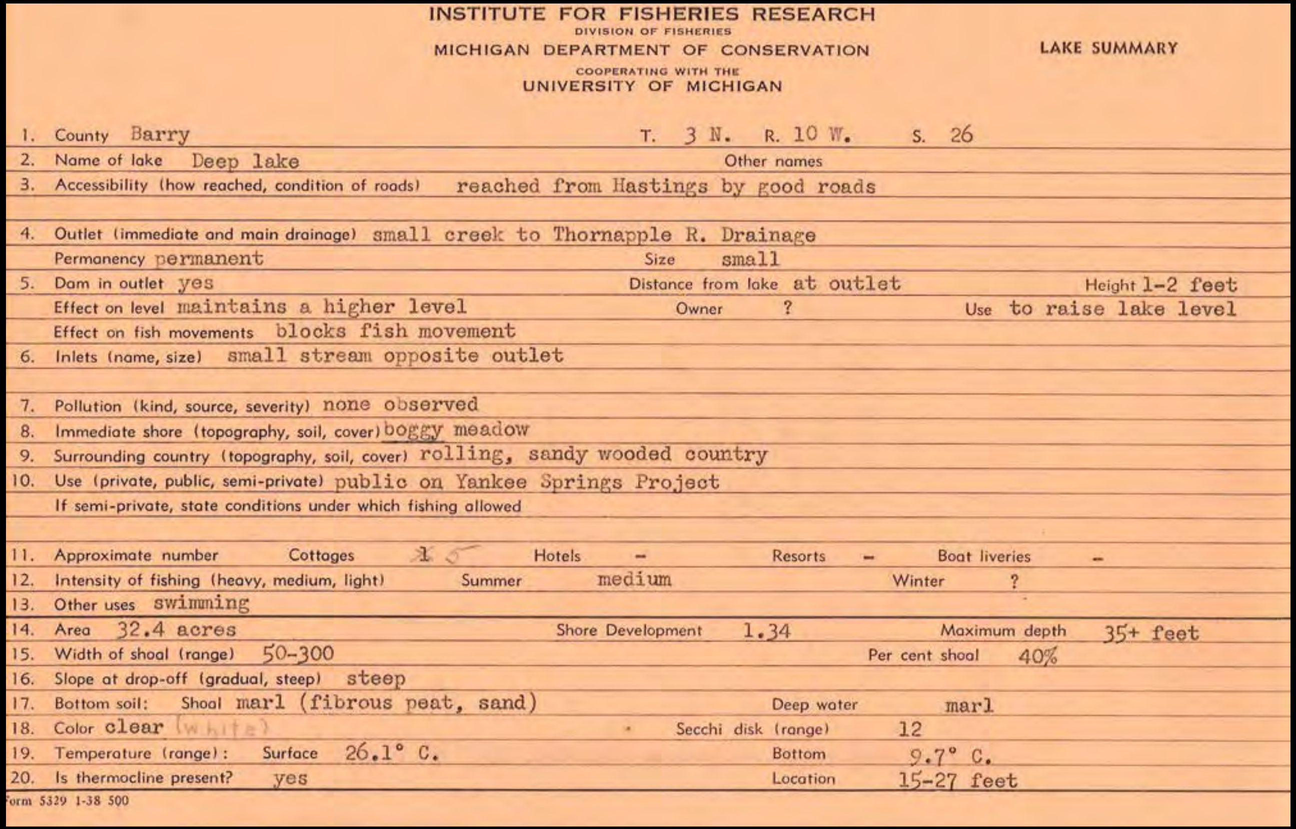
Volunteer Monitoring

allows us to have big datasets to analyze ecosystem health

track trends over space and time

report on water quality, highlight sites or regions for further agency assessment, track invasive species, develop watershed management plans, and set fishing regulations

Volunteers help us have big datasets

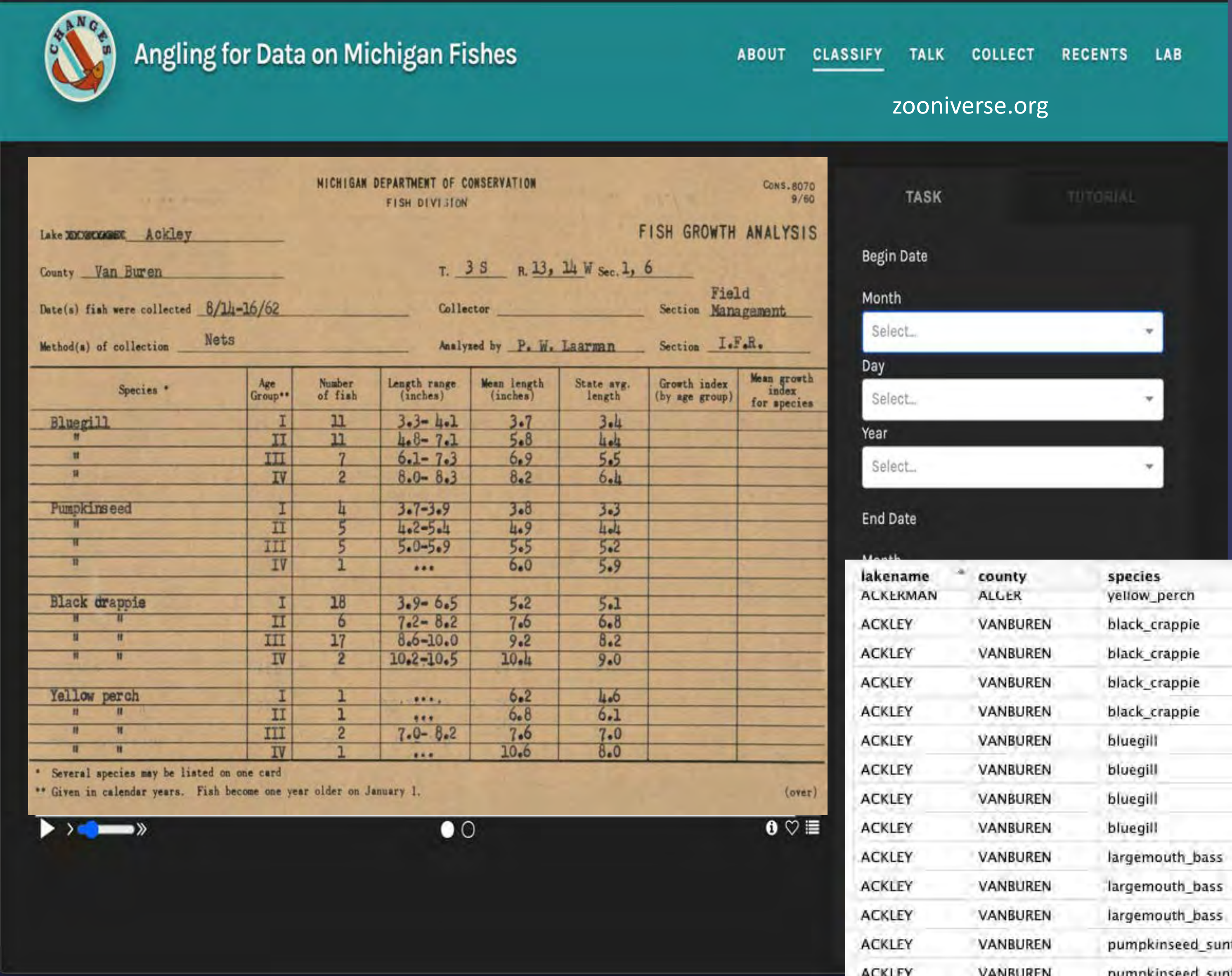


INSTITUTE FOR FISHERIES RESEARCH
DIVISION OF FISHERIES
MICHIGAN DEPARTMENT OF CONSERVATION
COOPERATING WITH THE
UNIVERSITY OF MICHIGAN

LAKE SUMMARY

1. County Barry T. 3 N. R. 10 W. S. 26
2. Name of lake Deep lake Other names
3. Accessibility (how reached, condition of roads) reached from Hastings by good roads
4. Outlet (immediate and main drainage) small creek to Thornapple R. Drainage
   Permanency permanent Size small
5. Dam in outlet yes Distance from lake at outlet Height 1-2 feet
   Effect on level maintains a higher level Owner ? Use to raise lake level
   Effect on fish movements blocks fish movement
6. Inlets (name, size) small stream opposite outlet
7. Pollution (kind, source, severity) none observed
8. Immediate shore (topography, soil, cover) boggy meadow
9. Surrounding country (topography, soil, cover) rolling, sandy wooded country
10. Use (private, public, semi-private) public on Yankee Springs Project
    If semi-private, state conditions under which fishing allowed
11. Approximate number Cottages 15 Hotels – Resorts – Boat liveries –
12. Intensity of fishing (heavy, medium, light) Summer medium Winter ?
13. Other uses swimming
14. Area 32.4 acres Shore Development 1.34 Maximum depth 35+ feet
15. Width of shoal (range) 50-300 Per cent shoal 40%
16. Slope at drop-off (gradual, steep) steep
17. Bottom soil: Shoal marl (fibrous peat, sand) Deep water marl
18. Color clear (white) Secchi disk (range) 12
19. Temperature (range): Surface 26.1° C. Bottom 9.7° C.
20. Is thermocline present? yes Location 15-27 feet

Form 5329 1-38 500



MICHIGAN DEPARTMENT OF CONSERVATION
FISH DIVISION

Cons. 8070 9/60

FISH GROWTH ANALYSIS

Lake Ackley

County Van Buren T. 3 S R. 13, 14 W Sec. 1, 6

Date(s) fish were collected 8/14-16/62 Collector Section Field Management

Method(s) of collection Nets Analyzed by P. W. Laarman Section I.F.R.

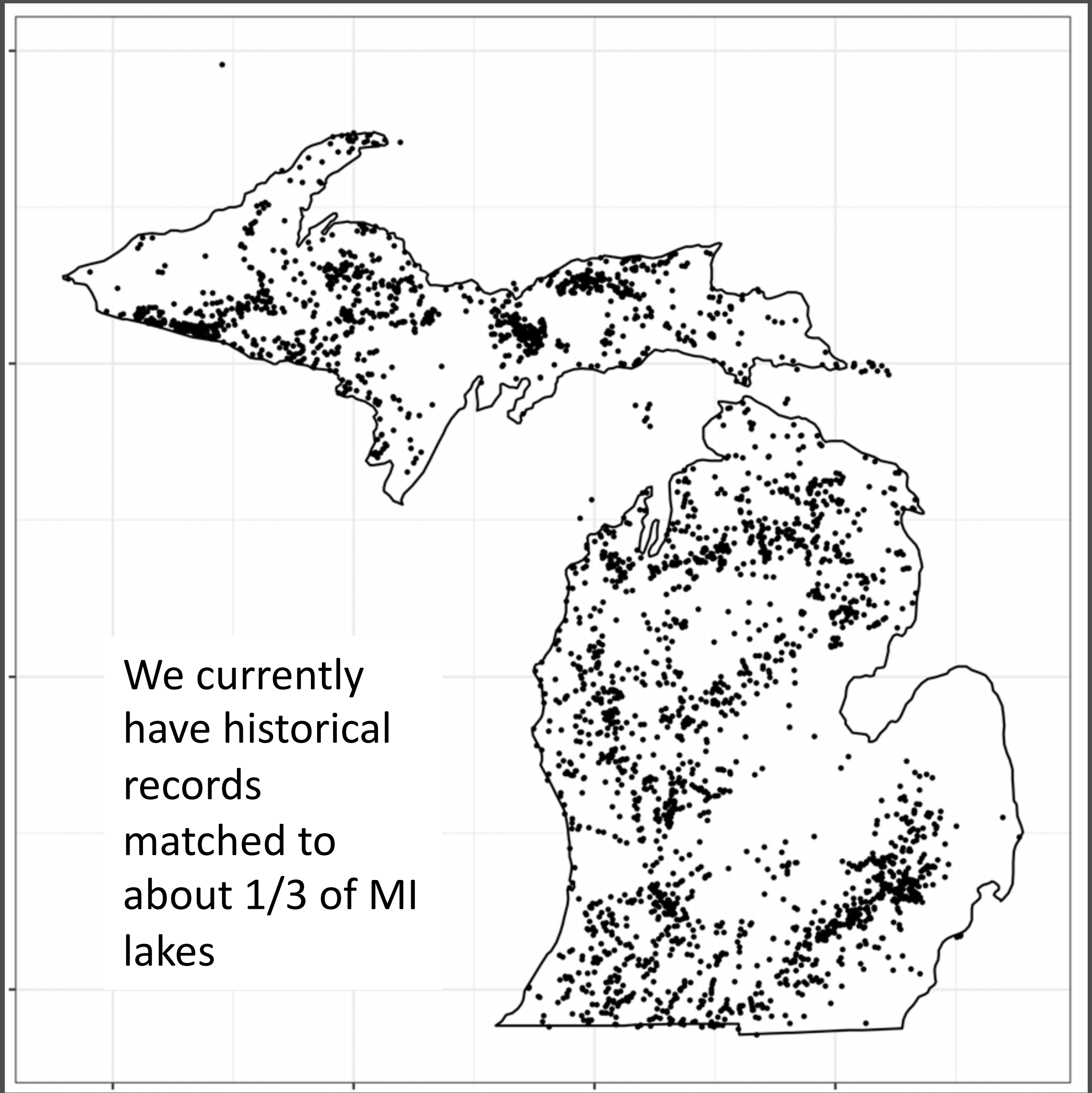
Species *	Age Group**	Number of fish	Length range (inches)	Mean length (inches)	State avg. length	Growth index (by age group)	Mean growth index for species
Bluegill	I	11	3.3- 4.1	3.7	3.4		
"	II	11	4.8- 7.1	5.8	4.4		
"	III	7	6.1- 7.3	6.9	5.5		
"	IV	2	8.0- 8.3	8.2	6.4		
Pumpkinseed	I	4	3.7-3.9	3.8	3.3		
"	II	5	4.2-5.4	4.9	4.4		
"	III	5	5.0-5.9	5.5	5.2		
"	IV	1	...	6.0	5.9		
Black crappie	I	18	3.9- 6.5	5.2	5.1		
" "	II	6	7.2- 8.2	7.6	6.8		
" "	III	17	8.6-10.0	9.2	8.2		
" "	IV	2	10.2-10.5	10.4	9.0		
Yellow perch	I	1	...	6.2	4.6		
" "	II	1	...	6.8	6.1		
" "	III	2	7.0- 8.2	7.6	7.0		
" "	IV	1	...	10.6	8.0		

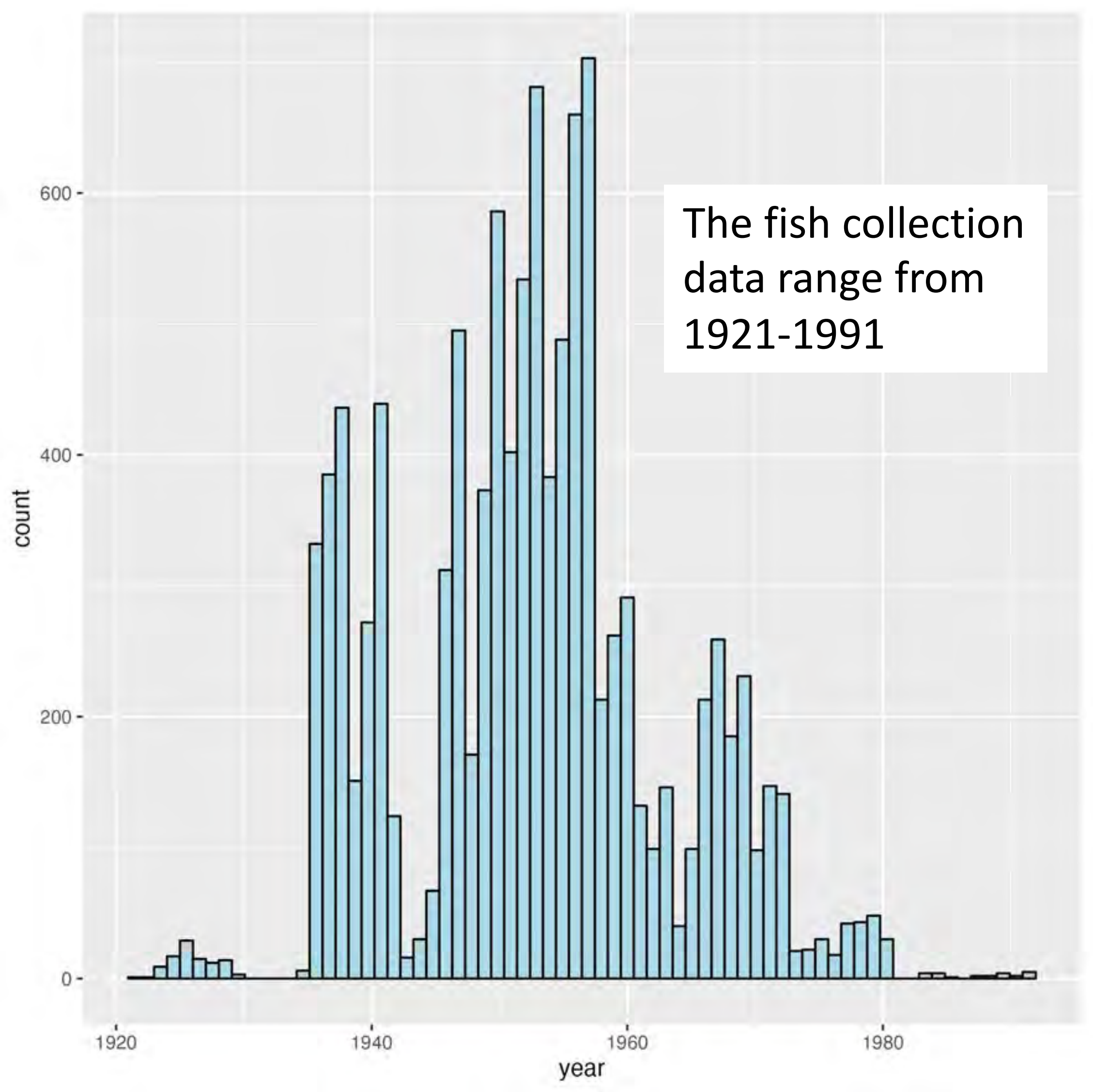
* Several species may be listed on one card

** Given in calendar years. Fish become one year older on January 1.

(over)

lakename	county	species	age_group	fish_count	length_min_mm	length_max_mm	length_mean_mm	begin_date_day
ACKERMAN	ALGER	yellow_perch	2	5	172.72	208.28	193.04	19
ACKLEY	VANBUREN	black_crappie	1	18	99.06	165.10	132.08	14
ACKLEY	VANBUREN	black_crappie	2	6	182.88	208.28	193.04	14
ACKLEY	VANBUREN	black_crappie	3	17	218.44	254.00	233.68	14
ACKLEY	VANBUREN	black_crappie	4	2	259.08	266.70	264.16	14
ACKLEY	VANBUREN	bluegill	1	11	83.82	104.14	93.98	14
ACKLEY	VANBUREN	bluegill	2	11	121.92	180.34	147.32	14
ACKLEY	VANBUREN	bluegill	3	7	154.94	185.42	175.26	14
ACKLEY	VANBUREN	bluegill	4	2	203.20	210.82	208.28	14
ACKLEY	VANBUREN	largemouth_bass	1	12	149.86	238.76	208.28	14
ACKLEY	VANBUREN	largemouth_bass	2	1	NA	NA	266.70	14
ACKLEY	VANBUREN	largemouth_bass	3	4	307.34	327.66	320.04	14
ACKLEY	VANBUREN	pumpkinseed_sunfish	1	4	93.98	99.06	96.52	14
ACKLEY	VANBUREN	pumpkinseed_sunfish	2	5	106.68	137.16	124.46	14
ACKLEY	VANBUREN	pumpkinseed_sunfish	3	5	127.00	149.86	139.70	14
ACKLEY	VANBUREN	pumpkinseed_sunfish	4	1	NA	NA	152.40	14
ACKLEY	VANBUREN	walleye	7	1	632.46	NA	632.46	14
ACKLEY	VANBUREN	yellow_perch	1	1	NA	NA	157.48	14
ACKLEY	VANBUREN	yellow_perch	2	1	NA	NA	172.72	14
ACKLEY	VANBUREN	yellow_perch	3	2	177.80	208.28	193.04	14
ACKLEY	VANBUREN	yellow_perch	4	1	NA	NA	269.24	14

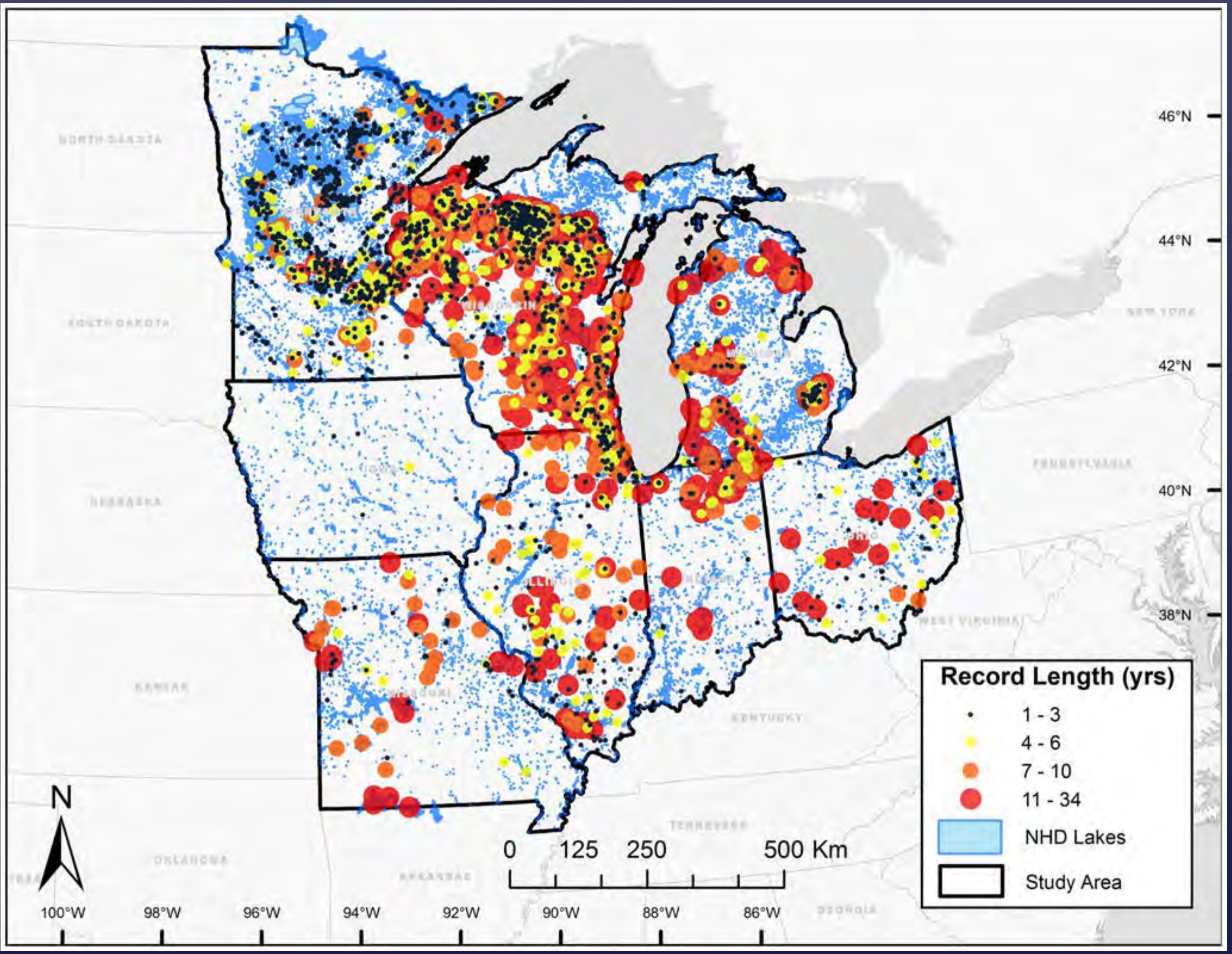

We currently have historical records matched to about 1/3 of MI lakes


The fish collection data range from 1921-1991
count
year
0
200
400
600
1920
1940
1960
1980

Long-Term Citizen-Collected Data Reveal Geographical Patterns and Temporal Trends in Lake Water Clarity

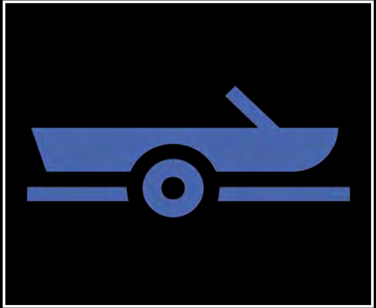
Noah R. Lottig, Tyler Wagner, Emily Norton Henry, Kendra Spence Cheruvelil, Katherine E. Webster, John A. Downing, Craig A. Stow

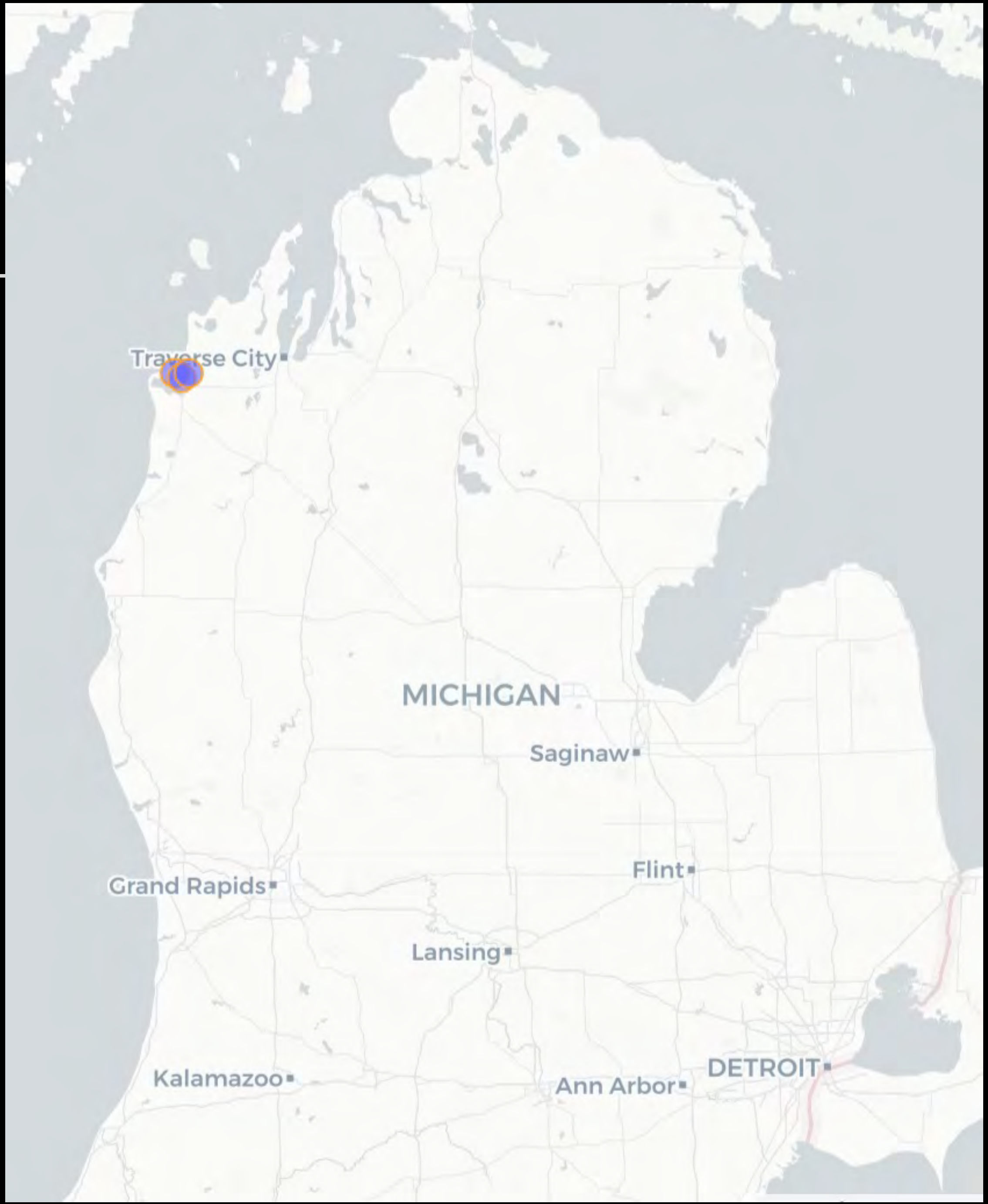
Published: April 30, 2014 • https://doi.org/10.1371/journal.pone.0095769



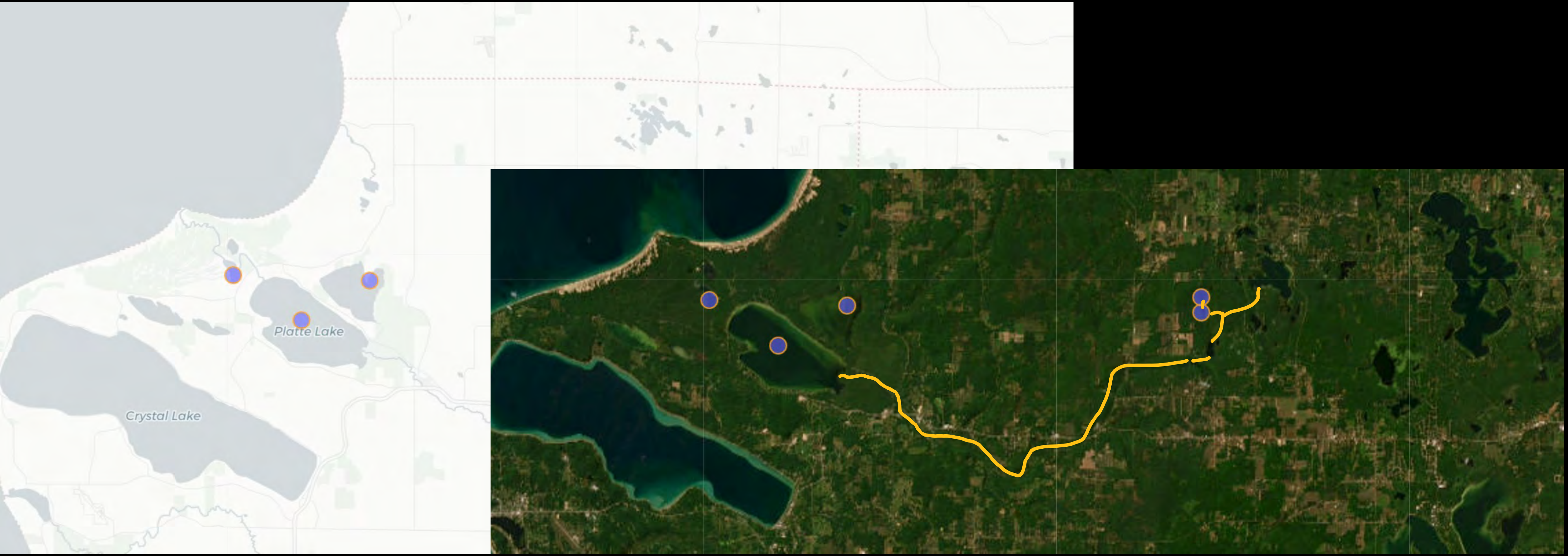
- Most lakes showed relatively stable long-term water clarity
- lakes at more southern latitudes generally had trends of long-term decline in water clarity
- lakes situated at more northern latitudes showed a shift towards long-term increases in water clarity

Connections in MiCorps





Connections in MiCorps



www.iwla.org/

Conclusions

- Lakes and streams are a part of the terrestrial and aquatic landscape
- Not to think of streams and lakes as separate entities
- Future directions for MiCorps- collaboration between programs
- Monitoring helps report on the quality of Michigan waters

Questions?

Dr. Katelyn King

Email: kingkb@umich.edu

@katelyn8king