

Analysis of 500 lake catchments reveals the relationship between crop type, fertilizer and manure inputs and lake nutrient concentrations

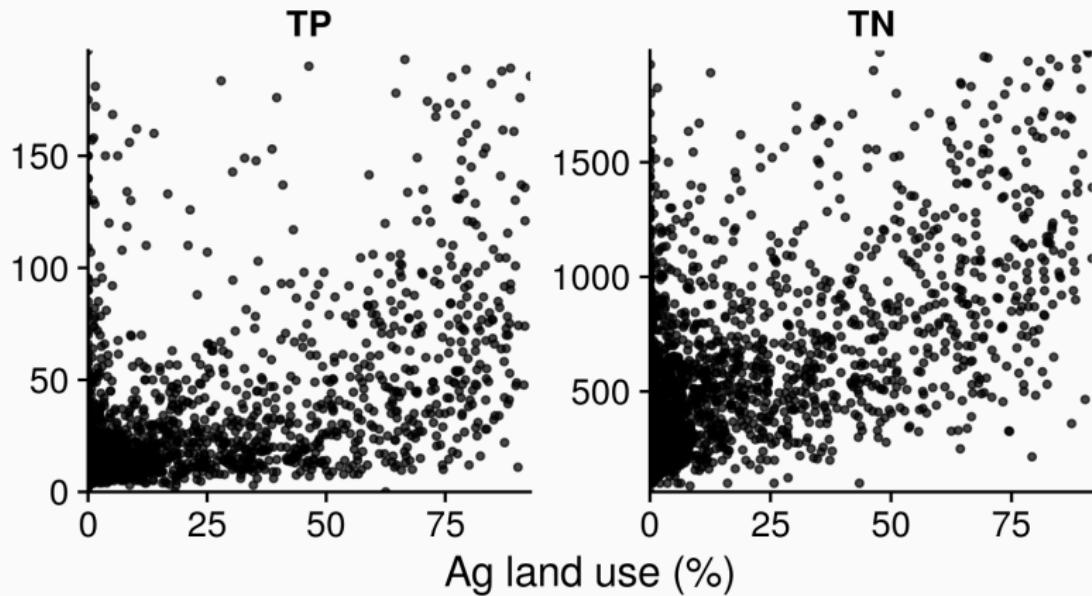
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Introduction

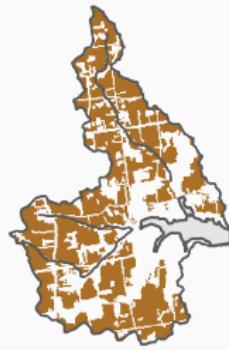
Ag land-use is associated with increased nutrient loading to lakes and higher nutrient concentrations.



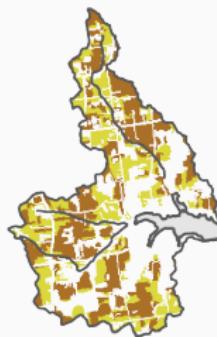
Background

Ag land-use is an aggregated measure that may mask underlying relationships.

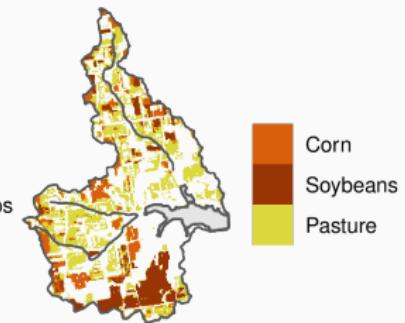
Total Ag



Ag Cover Type



Individual Crops

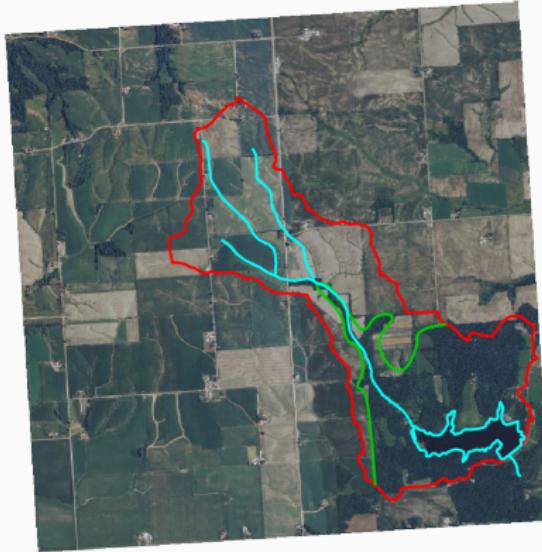


- Corn
- Soybeans
- Pasture

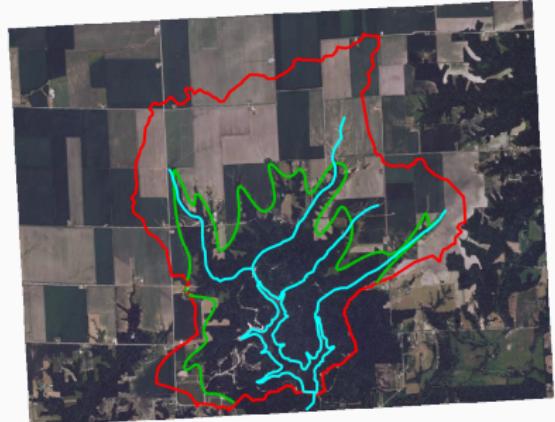
Background

Watershed land-use summaries are spatially coarse measures that may mask underlying relationships.

Lake Carlton – IL



Argyle Lake – IL



Background

		Granularity	
		Aggregated	Granular
Spatial Extent	Macroscale: many watersheds	Some studies	??
	Fine scale: 1 watershed	NA	Many studies

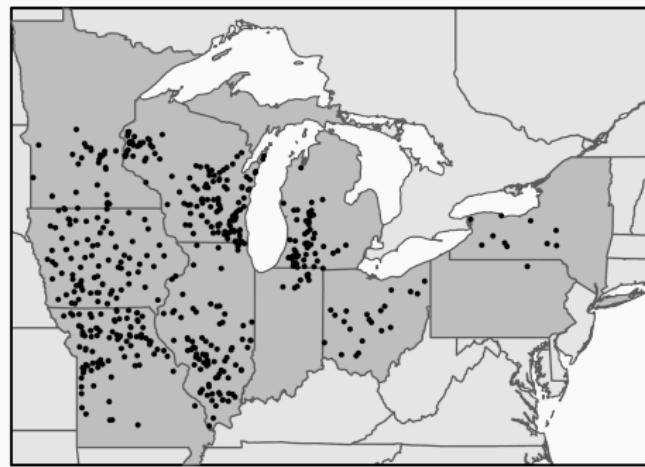
What are some things we've learned from fine scale, granular-data studies?

What are some things we've learned from macroscale, aggregated data studies?

Research Question(s)

- 1. Are more granular measures of Ag activity related to lake water quality (TN, TP) across hundreds of lakes and their watersheds?**
- 2. Do relationships between Ag activities and lake water quality vary spatially among hydrologic and climatic regions?**

Methods - 500 lake catchments



Trophic State

All Lakes



This Study



■ oligotrophic ■ eutrophic
■ mesotrophic ■ hypereutrophic

Lakes have high Ag land use (> 40%)

Methods - Granular Ag data



Nutrient inputs - Fertilizer and manure applications



Nutrient transport - Baseflow, soils, precipitation



Land-use cover - Specific crops, etc.

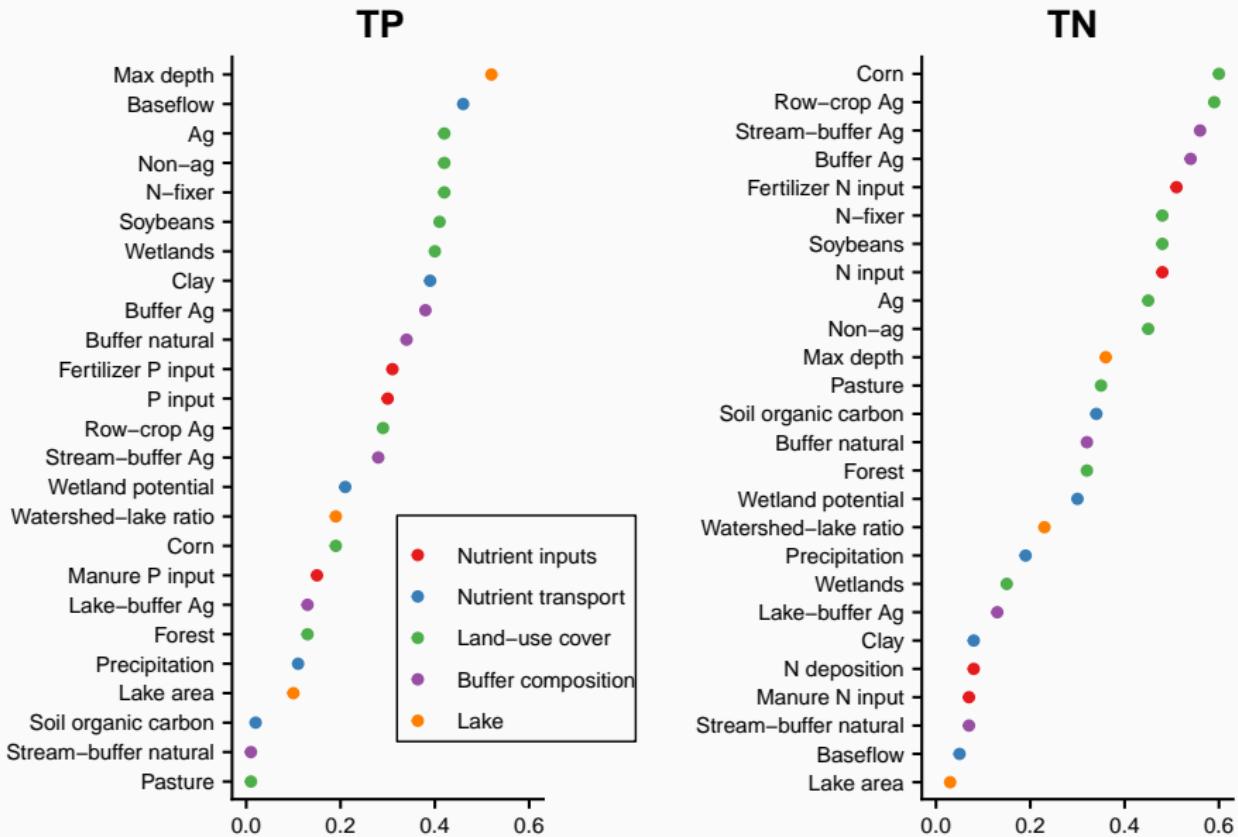


Buffer composition - *Land-use cover*



Lake characteristics - Depth, area, etc.

(Collins et al. 2017)



Methods - Statistical modelling

Build a multivariate model to explain nutrients in lakes
that is:

- 1. Tractable - Limited number of predictors, avoids multicollinearity**
2. Reliable - Provides an estimate of parameter uncertainty
3. Informative - Allows for interpretation of variable importance

Methods - Mixed modelling

One variable from each predictor category was treated as a global (fixed) effect

For TP, this was Buffer Ag, P fertilizer input, Baseflow, and Max depth.

For TN, this was Buffer Ag, N fertilizer input, Soil organic carbon, and Max depth.

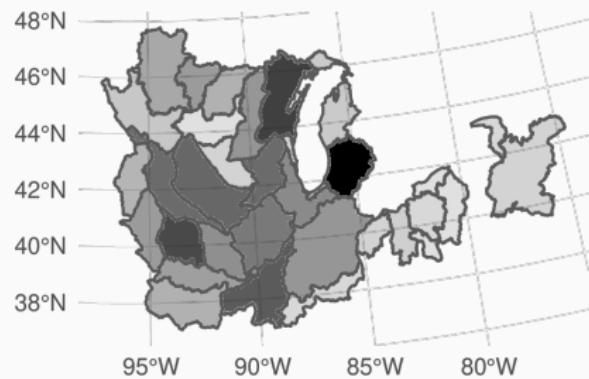
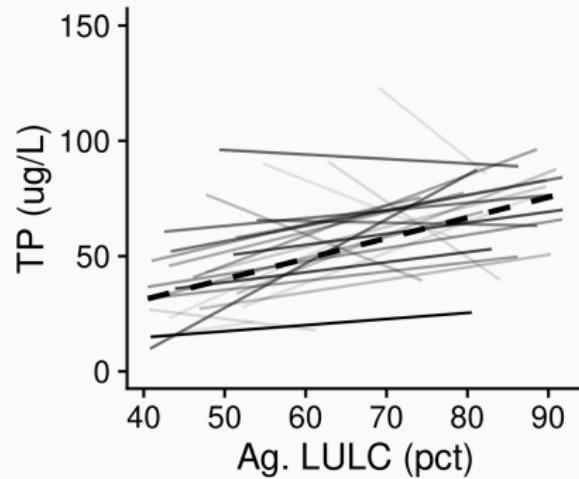
Watershed land-use cover was treated as a spatially varying (random) effect

For TN, TP, this was one of Ag, Pasture, Corn, Soybeans, etc.

Methods - Regression Modelling

Watershed land use is a proxy for many different specific activities which are likely to be regionally variable.

(Burcher, Valett, and Benfield 2007)



Methods - Statistical modelling

Build a multivariate model to explain nutrients in lakes
that is:

1. Tractable - Limited number of predictors, avoids multicollinearity
2. **Reliable - Provides an estimate of parameter uncertainty**
3. Informative - Allows for interpretation of variable importance

Methods - Statistical modelling

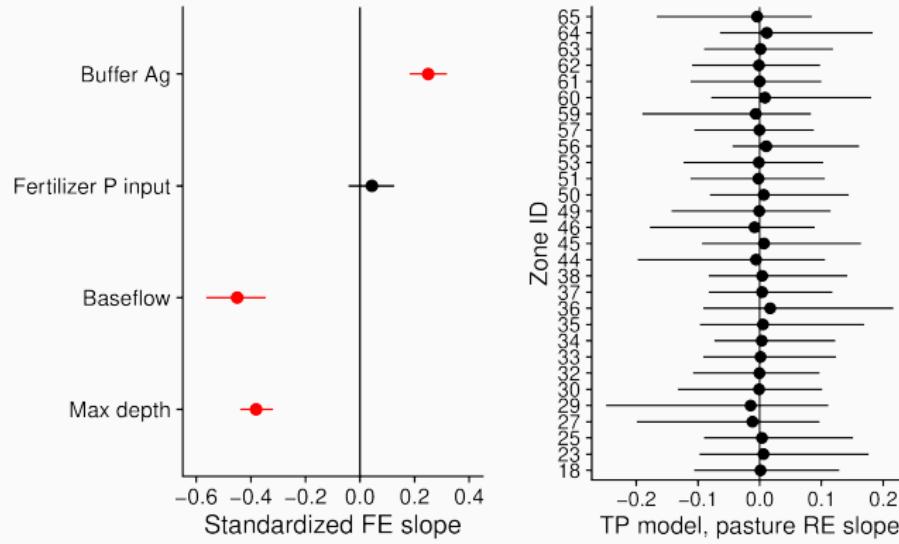
Build a multivariate model to explain nutrients in lakes
that is:

1. Tractable - Limited number of predictors, avoids multicollinearity
2. Reliable - Provides an estimate of parameter uncertainty
- 3. Informative - Allows for interpretation of variable importance**

Results - TP Model

Fixed effect coefficients were markedly different among predictor categories.

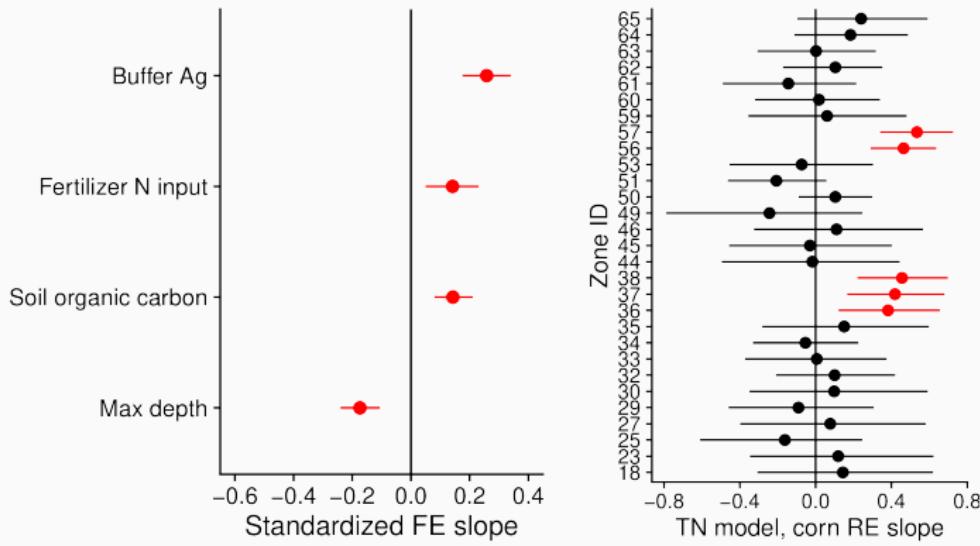
Spatial random effects cleanly capture additional variation.



Results - TN Model

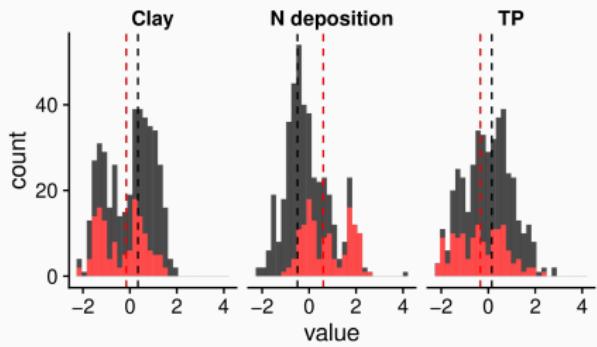
Fixed effect coefficients similar among predictor categories.

Specific regions have markedly different spatial random effect slopes.



Results - TN Model

Lake TN in highlighted regions is more sensitive to Ag relative to other regions.



Discussion

Lake TN in highlighted regions may be more sensitive to Ag because:

Fields in these regions have more direct drainage because they have wetland soils.

Lakes in these regions are P limited so excess TN accumulates in the water column (Filstrup and Downing 2017)

Lakes in these regions are less hypereutrophic (Wagner et al. 2011)

Lakes in these regions are affected by an interaction among multiple land use types.

Conclusions

1. Are more granular measures of Ag activity related to lake water quality (TN, TP) across hundreds of lakes and their watersheds?

Both lake TP and lake TN were related to granular measures of Ag activity.

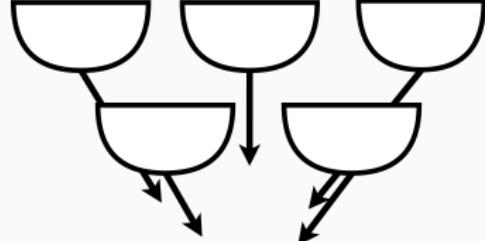
Lake TN concentration was strongly related to watershed corn cover and riparian buffer composition.

2. Do relationships between Ag activities and lake water quality vary spatially among hydrologic and climatic regions?

The relationship between lake TN and land-use cover was spatially variable.

Methods - Data

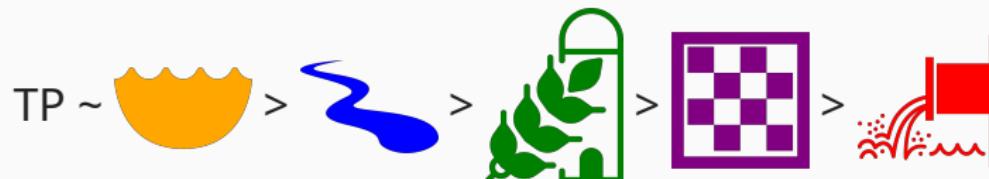
Correlation analysis to determine how lake nutrients are related to predictors from each category.



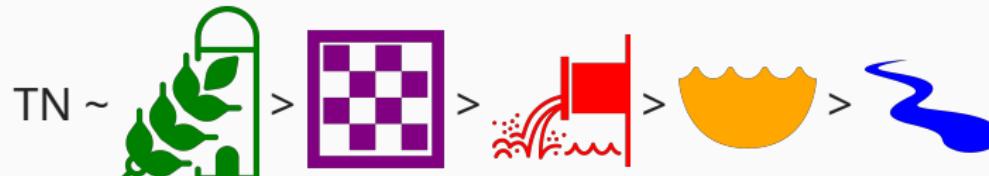
- | | |
|-----------|---|
| Inputs | - Fertilizer and manure applications |
| Land use | - Ag, Pasture, Row crop, Corn, Soybeans, N-fixers, Small grains |
| Transport | - Baseflow, Soil characteristics, Precipitation |
| Buffers | - See <i>Land use</i> |
| Lake | - Max depth, Area, etc. |

Results - Correlation analysis

Lake phosphorus concentrations are most strongly associated with lake characteristics and measures of watershed nutrient transport.



Lake nitrogen concentrations are most strongly associated with agricultural land use and the composition of riparian buffers.



References

- Burcher, C. L., H. M. Valett, and E. F. Benfield. 2007. "THE LAND-COVER CASCADE: RELATIONSHIPS COUPLING LAND AND WATER." *Ecology* 88 (1): 228-42. [https://doi.org/10.1890/0012-9658\(2007\)88\[228:TLCRCL\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2007)88[228:TLCRCL]2.0.CO;2).
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- Wagner, Tyler, Patricia A. Soranno, Katherine E. Webster, and Kendra Spence Cheruvellil. 2011. "Landscape Drivers of Regional Variation in the Relationship Between Total Phosphorus and Chlorophyll in Lakes: Relationship Between Total Phosphorus and Chlorophyll." *Freshwater Biology* 56 (9): 1811-24.
<https://doi.org/10.1111/j.1365-2427.2011.02621.x>.