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

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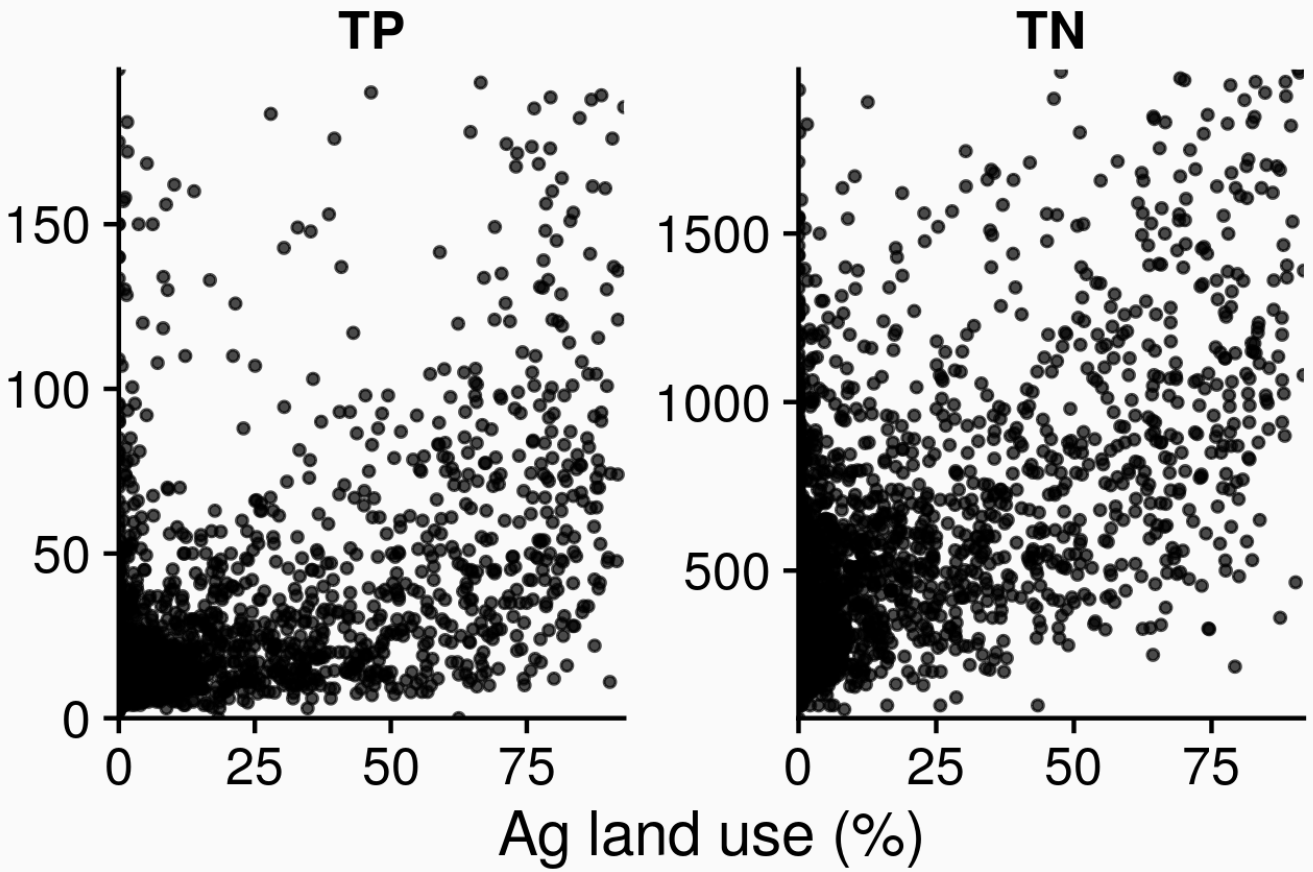
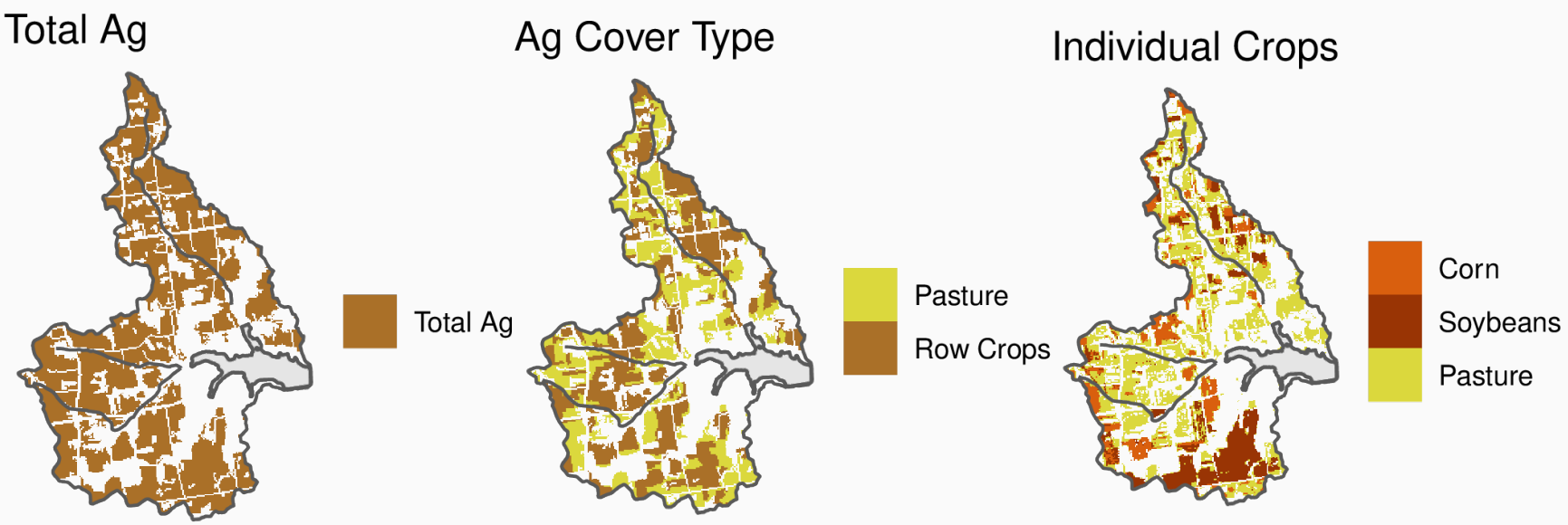
Introduction

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



Background

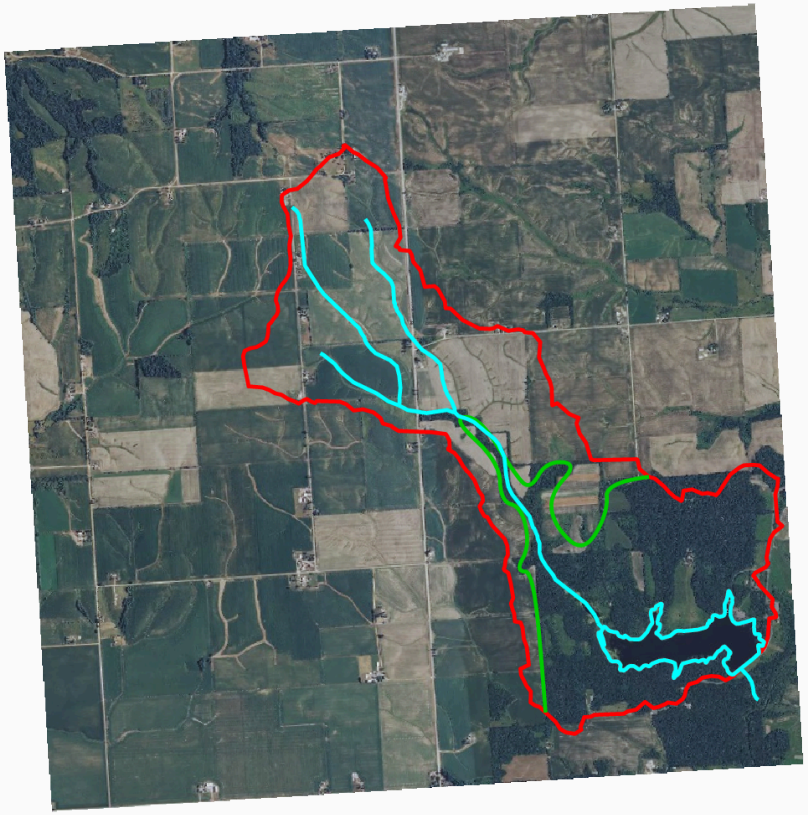
Ag land-use is an aggregated measure that may mask underlying relationships.



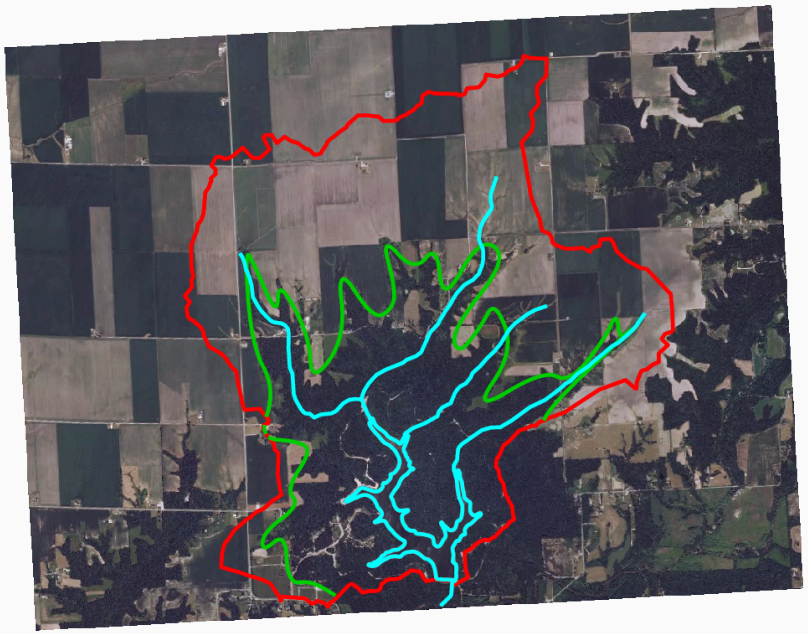
Background

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

Lake Carlton – IL



Argyle Lake – IL



		Granularity	
		Aggregated	Granular
Spatial Extent	Macroscale (many watersheds)	Some studies	??
	Fine scale (1 watershed)	-	Many studies

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

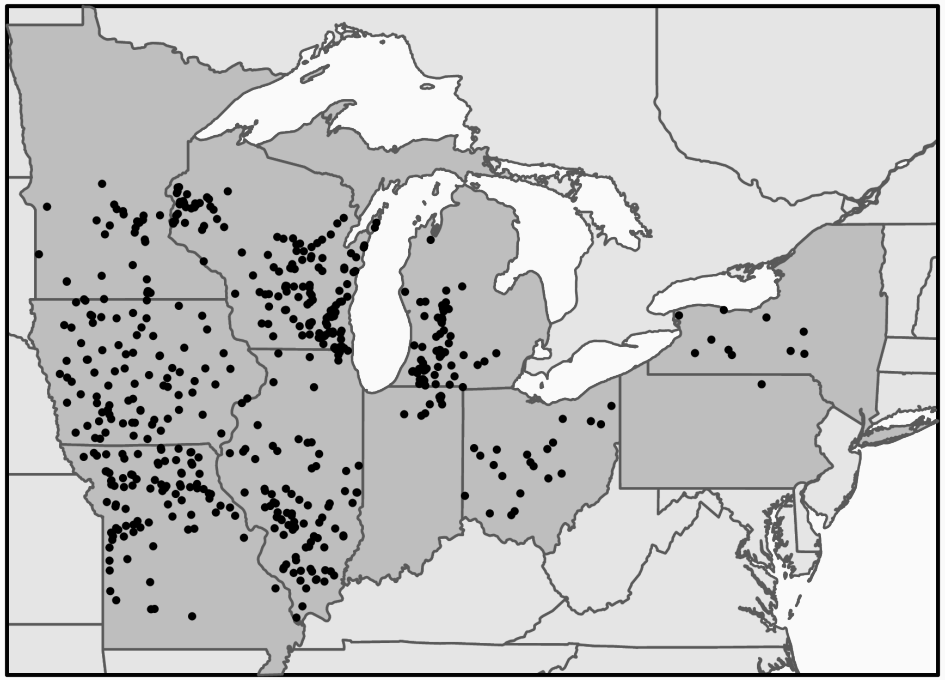
What are some things we've learned from macroscale, aggregated-data studies?

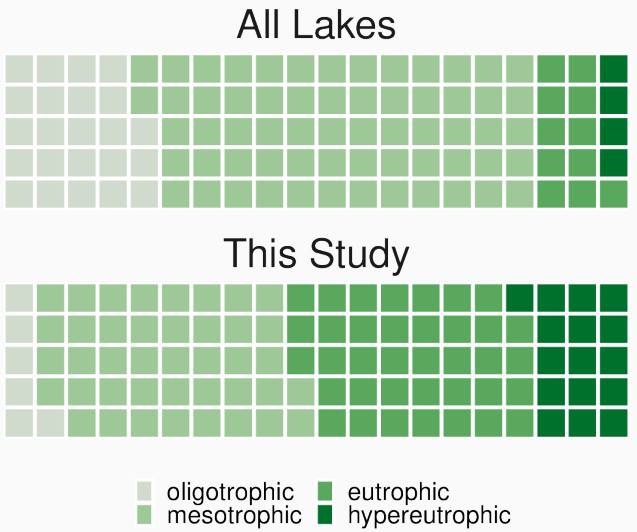
Research Question(s)

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

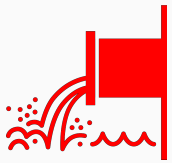




Our study lakes have high Ag land use (> 40%).

Our study lakes are more often eutrophic relative to lakes in general.

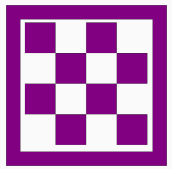
Methods - Granular Ag data



Nutrient inputs - Fertilizer and manure applications

Nutrient transport - Baseflow, soils, precipitation

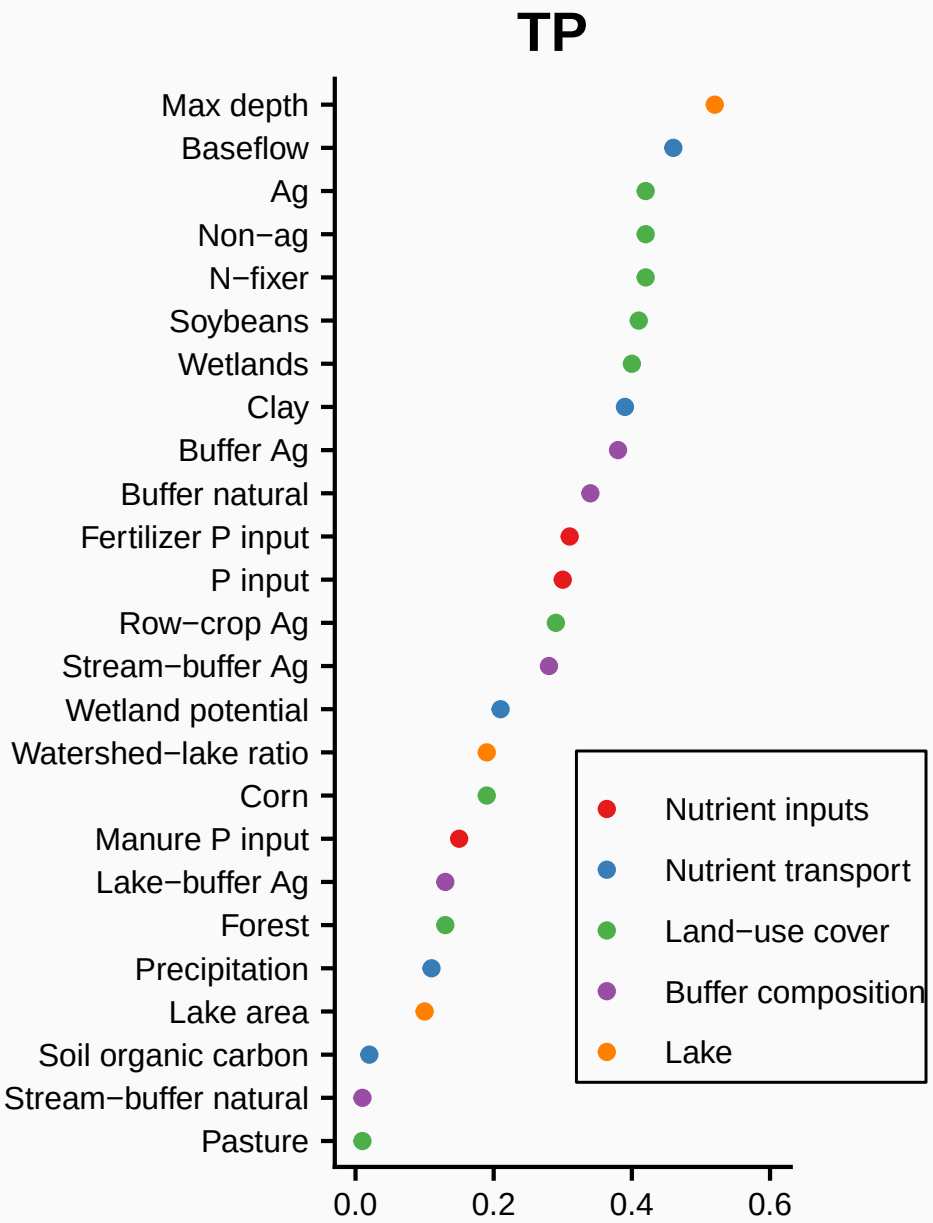
Land-use cover - Specific crops, etc.

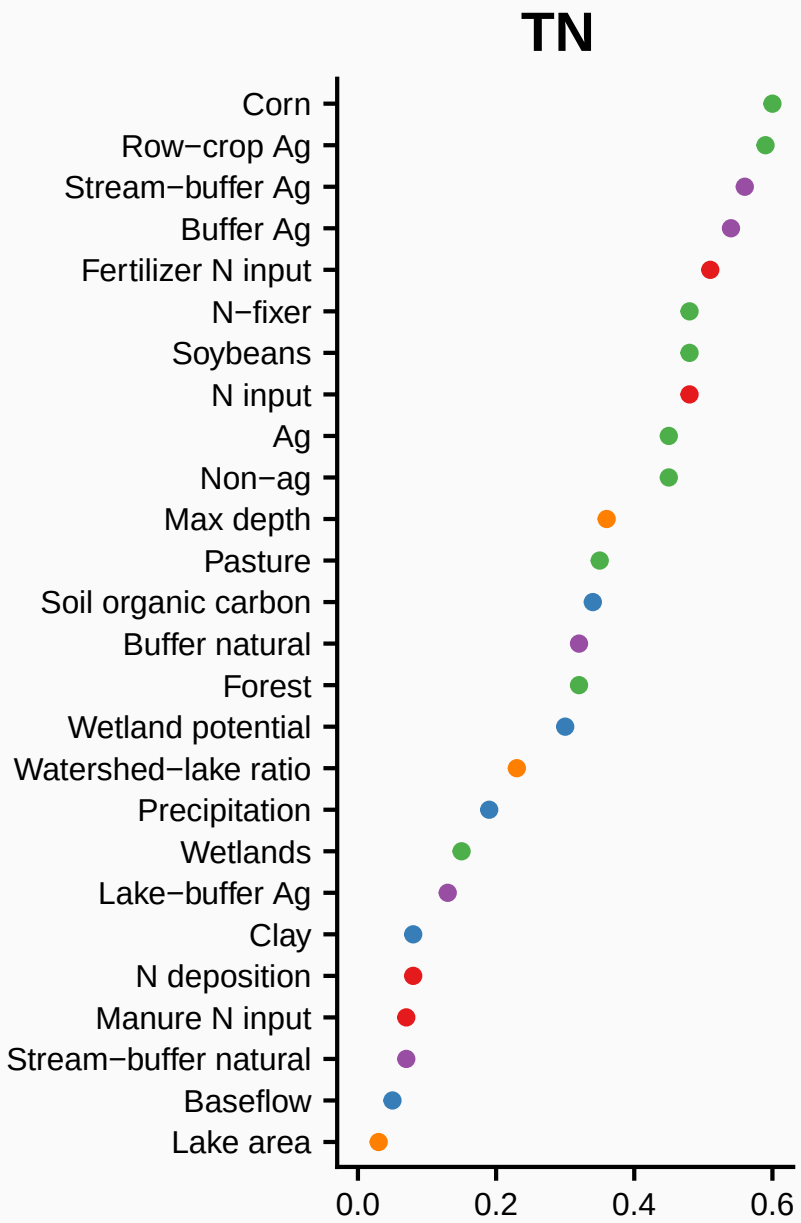


Buffer composition - *Land-use cover*

Lake characteristics - Depth, area, etc.

(Collins et al. 2017)


TP
Max depth
Baseflow
Ag
Non−ag
N−fixer
Soybeans
Wetlands
Clay
Buffer Ag
Buffer natural
Fertilizer P input
P input
Row−crop Ag
Stream−buffer Ag
Wetland potential
Watershed−lake ratio
Corn
Manure P input
Lake−buffer Ag
Forest
Precipitation
Lake area
Soil organic carbon
Stream−buffer natural
Pasture
0.0
0.2
0.4
0.6
Nutrient inputs
Nutrient transport
Land−use cover
Buffer composition
Lake


TN
Corn
Row−crop Ag
Stream−buffer Ag
Buffer Ag
Fertilizer N input
N−fixer
Soybeans
N input
Ag
Non−ag
Max depth
Pasture
Soil organic carbon
Buffer natural
Forest
Wetland potential
Watershed−lake ratio
Precipitation
Wetlands
Lake−buffer Ag
Clay
N deposition
Manure N input
Stream−buffer natural
Baseflow
Lake area
0.0
0.2
0.4
0.6

Methods - Statistical modelling

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

1. **Tractable - Limited number of predictors, avoids multicolinearity**
2. Reliable - Provides an estimate of parameter uncertainity
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.

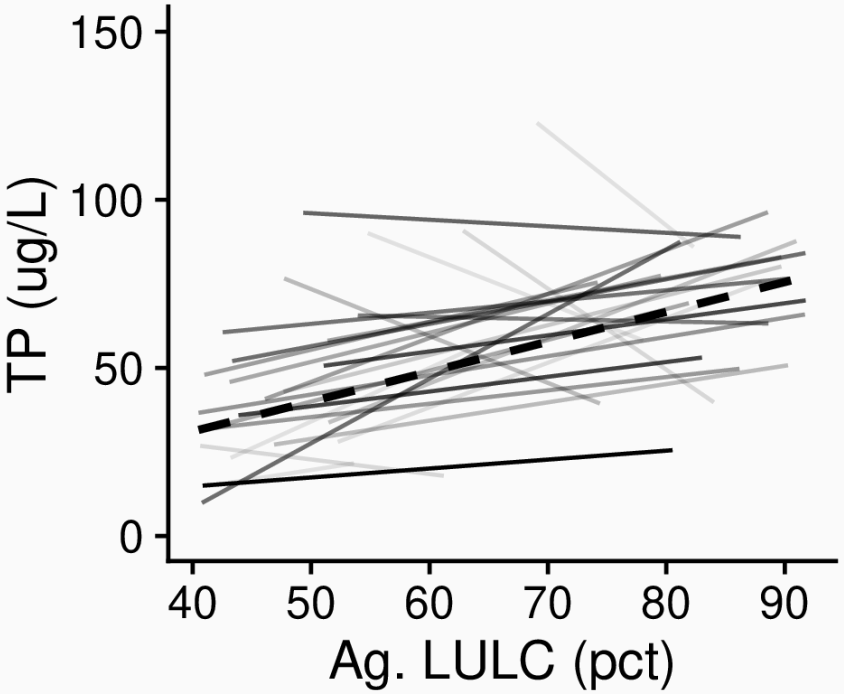
Watershed land-use cover was treated as a spatially varying (random) effect

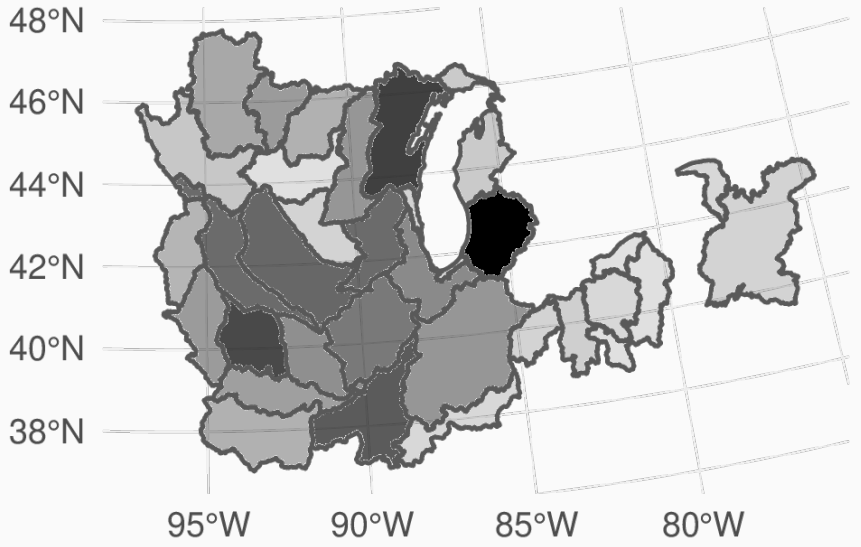
For TN, TP, this was one of Ag, Pasture, Corn, Soybeans, etc.

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:

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Methods - Statistical modelling

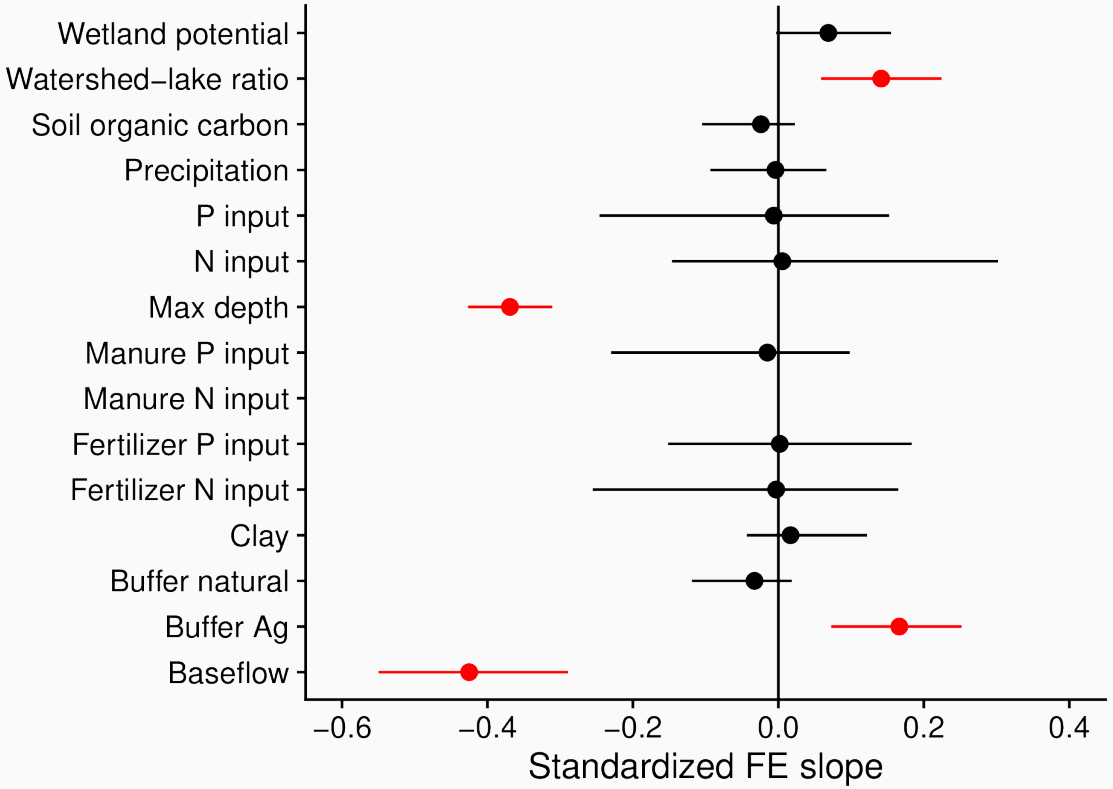
Build a multivariate model to explain nutrients in lakes that is:

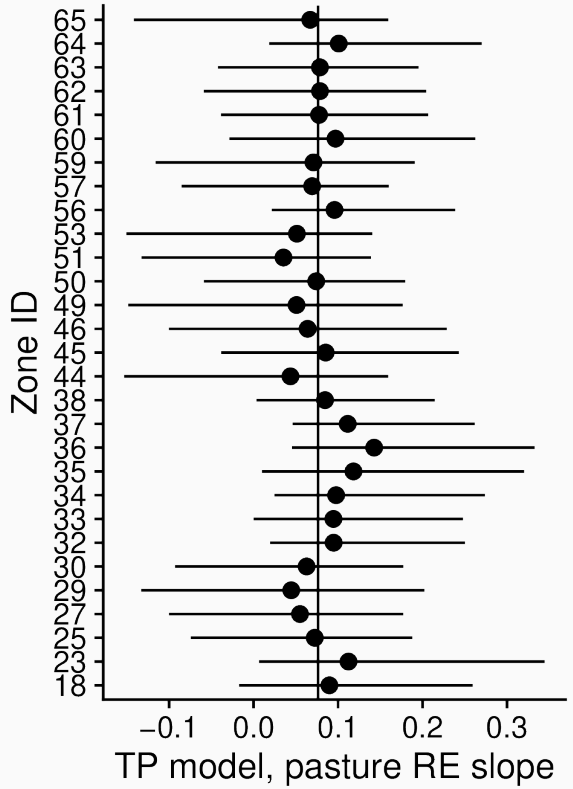
1. Tractable - Limited number of predictors, avoids multicolinearity
2. Reliable - Provides an estimate of parameter uncertainity
3. **Informative - Allows for interpretation of variable importance**

Results - TP Model

Fixed effect coefficients were markedly different among predictor categories.

Spatial random effects cleanly capture additional variation.

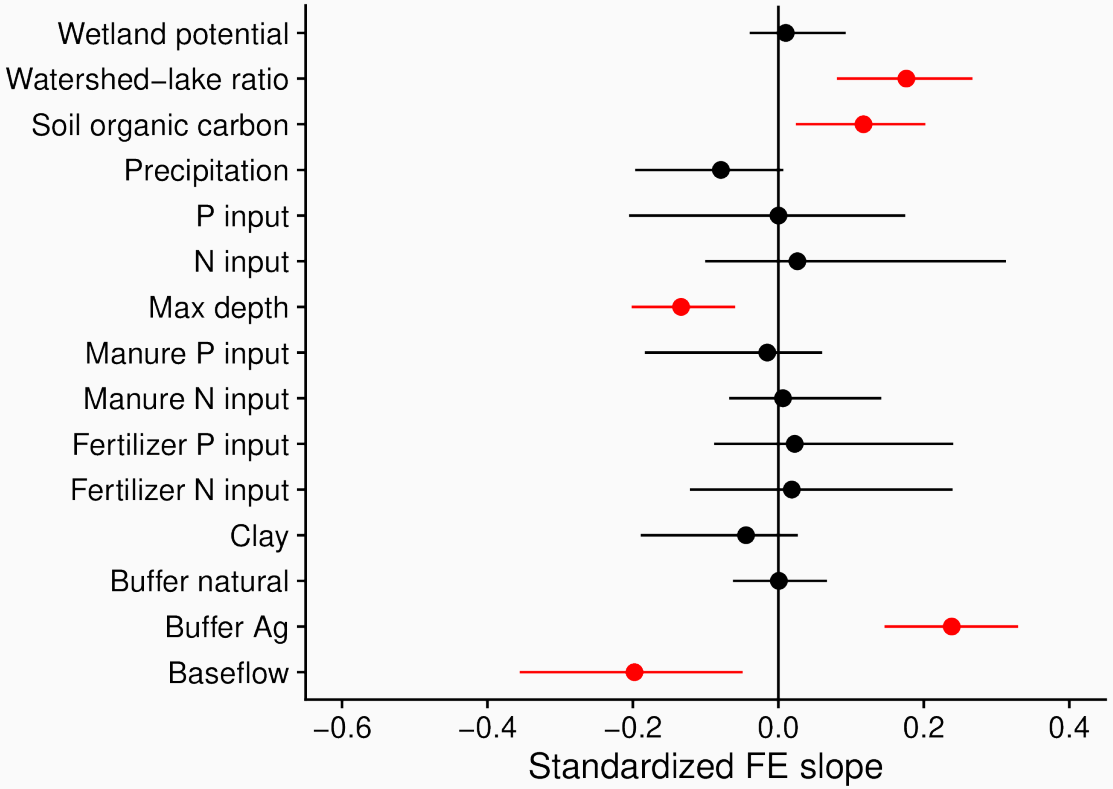


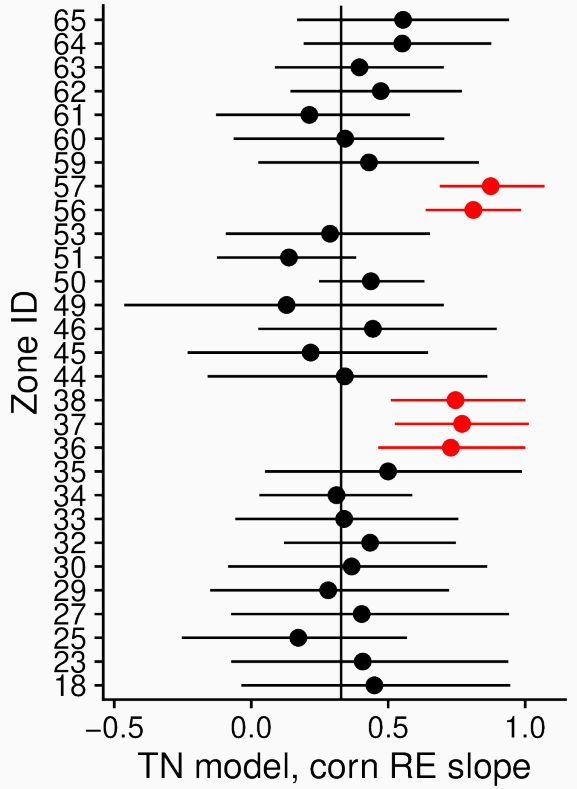


Results - TN Model

Fixed effect coefficients similar among predictor categories.

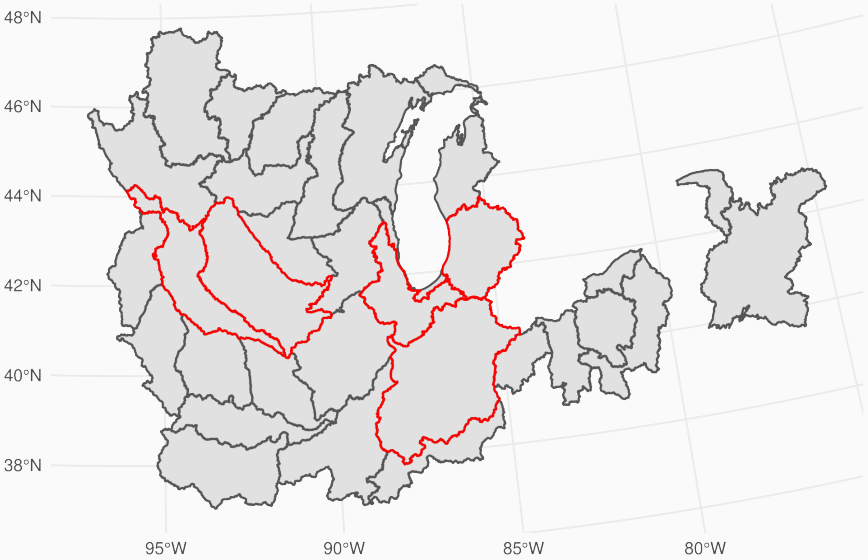
Specific regions have markedly different spatial random effect slopes.

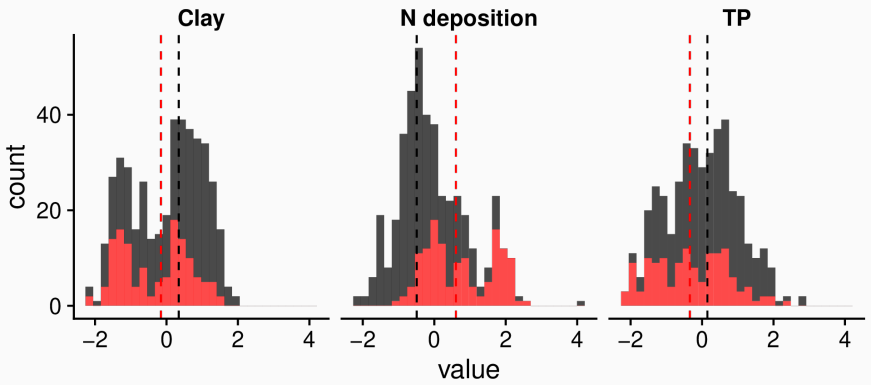




Results - TN Model

Lake TN in highlighted regions were 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.

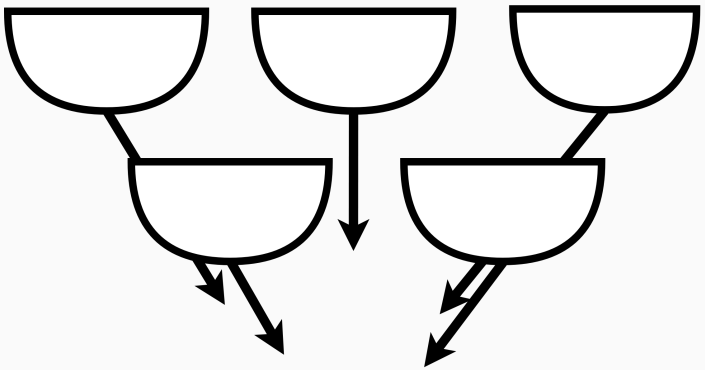
Lake TN concentration was strongly related to watershed corn cover and riparian buffer composition.

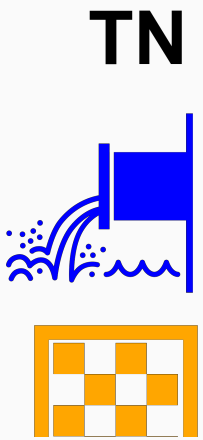
2. Do relationships between Ag activities and lake water quality vary spatially among hydrologic and climatic regions?

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.

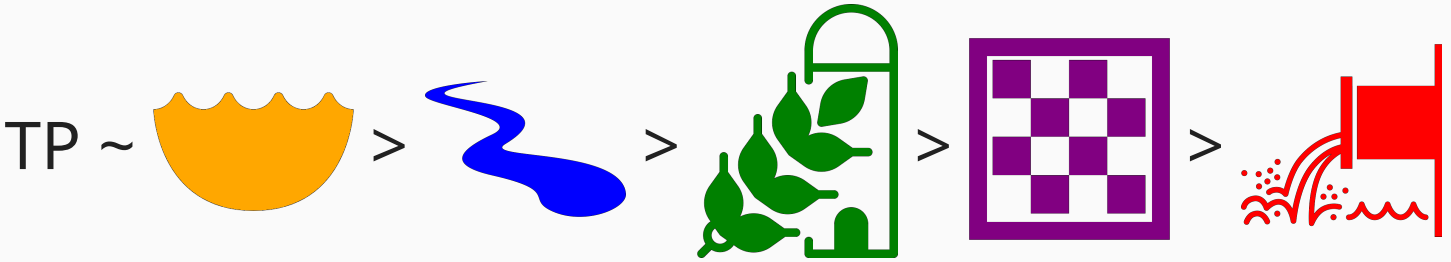




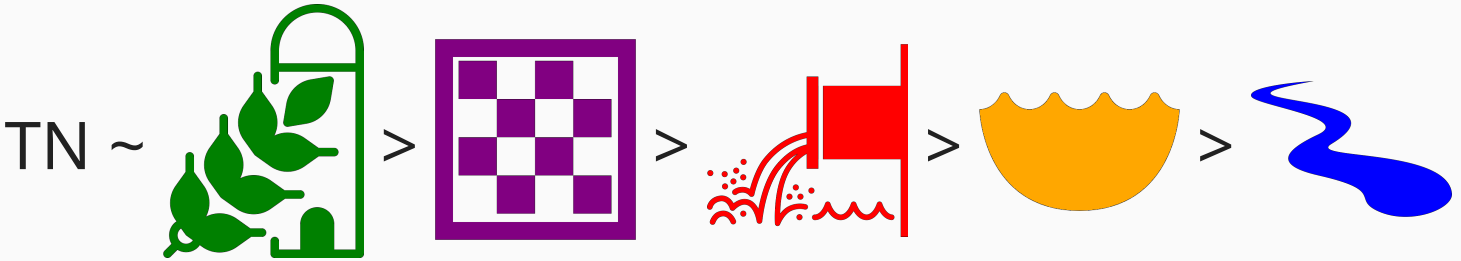
Inputs - Fertilizer and manure applications
Land use - Ag, Pasture, Row crop, Corn, Soybeans, N-fixers, Small grains
Transport - Baseflow, Soil characteristics, Precipitation
Buffers - See *Land use*
Lake - Max depth, Area, etc.

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.



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