Modeling effectiveness of agricultural best management practices to reduce nutrient loading in lakes with endangered cisco

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Introduction

Objectives:

1. Model estimated non-point pollutant loads for each of the seven cisco catchments.
2. Model non-point nutrient load reductions that could be achieved from recommendations described in management plans.

Percent Land Use	Failing	Crooked	Gage	South	Eve	North	Indiana
Open Water	14%	22%	12%	17%	9%	15%	14%
Open Space/Park	11%	18%	9%	5%	2%	3%	2%
Low-Density Residential (general 1/3 - 2 ac lots)	11%	1%	6%	7%	1%	6%	9%
High-density Residential (townhomes to 1/4 ac lots)	11%		3%				1%
Commercial/Industrial/Transportation			2%				
Barren Land							
Shrub; Scrub		1%					
Deciduous Forest	13%	28%	2%	3%	8%	2%	2%
Evergreen Forest			1%	1%			1%
Mixed Forest							
Grassland; Herbaceous	3%	2%					
Pasture/Hay			12%	11%	15%	13%	10%
Cropland generalized agriculture		25%	28%	43%	49%	50%	57%
Woody Wetlands (swamp)	37%	1%	23%	14%	15%	12%	4%
Emergent Wetlands (marsh)		2%					1%
Dominant Land Use	**Wet.**	**For.**	**Ag.**	**Ag.**	**Ag.**	**Ag.**	**Ag.**

Table 1. Percent land-use for the seven lake catchments in Indiana with remnant cisco populations.

- In Indiana, cisco (*Coregonus artedii*) are listed as a state endangered species. Species occurrence has dropped from 42 lakes in 1955 to less than 10 in 2016.
- Local extirpations of cisco appear to be related to nutrient loading and resulting hypoxia (Honsey et al., 2016).
- Agricultural production is commonly linked to increased nutrient loading (Capel et al., 2018).
- Larger catchments are likely subject to higher nutrient loading (Honsey et al., 2016).
- L-THIA is a hydrological model used to compute average annual run-off and predict nutrient loading. It provides insight to into hydrological impacts of land-use scenarios.

Methods

- Inland lake catchment data provide by the Midwest Glacial Lakes Partnership (MGLP)

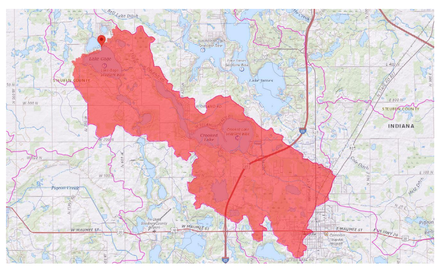

Figure 1. Map of the lake catchment for Lake Gage, the largest of the seven remaining lakes in Indiana occupied by cisco

- L-THIA uses long-term climate records, soil data, current land-use, and curve number to estimate average annual run-off and nutrient loads.
- Using L-THIA, we predicted total nitrogen, total phosphorus, and total suspended solids loading for cisco lakes in Indiana.
- Calculated nutrient loading by land-use within the catchment area.
- Calculated loading reductions after the implementation of BMPs and after changes in land-use from agriculture to forest.

Results

Nutrient loads vary in the cisco lake catchments. Lake Gage experiences the largest pollutant loading. This may indicate it is at the highest risk for hypoxia.

NPS Pollutant Loads

Lake	Crooked	Eve	Failing	Gage	Indiana	N. Twin	S. Twin
Total Nitrogen (lbs)	1809	226	94	12636	1257	889	1085
Total Phosphorus lbs)	508	64	26	3656	368	260	317
Total Suspended Solids (lbs)	40787	5359	2080	309251	30373	21525	26170
Total Annual P Load/Unit Volume ($gm^{-3}yr^{-1}$)	0.021	0.033	0.028	0.134	0.040	0.043	0.032

Table 2. Estimated average annual total nitrogen, phosphorus, and suspended solids loads (lbs) and total annual phosphorus load per unit volume ($gm^{-3}yr^{-1}$) with no BMPs. These values reflect the baseline values for our analysis.

Utilizing BMPs to mitigate phosphorus loading shows less impact compared to the conversion of agriculture to forest land use.

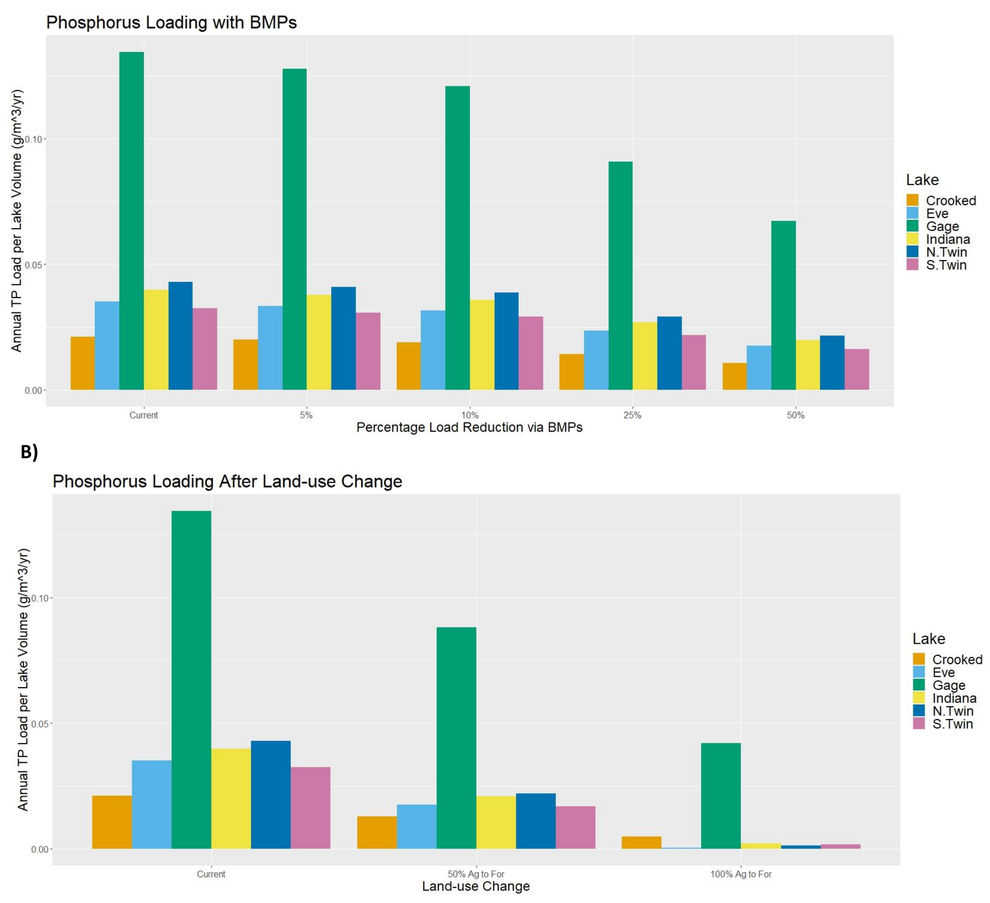

Figure 4. Reductions in phosphorus loading after **A)** Implementation of BMPs and **B)** Changes in land-use from Agriculture to Forest.

Agriculture is the dominant source of phosphorus loading in cisco lakes, with the exception of Failing Lake. Excess phosphorus is a major driver of eutrophication.

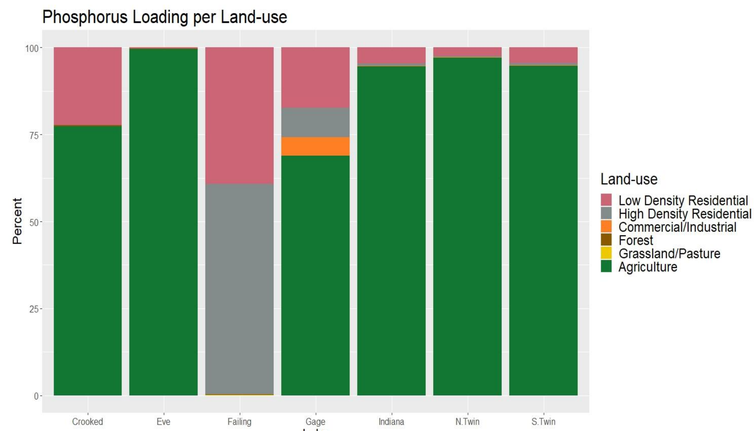

Figure 3. Percent phosphorus loading per land-use for each lake.

Discussion

In Indiana, cisco lake catchments are dominated by agriculture. Agriculture land use is responsible for disproportionate amounts of phosphorus loading which likely accelerates eutrophication and hypoxia. Lake Gage experiences the highest amount of nutrient loading leading us to hypothesize that it may be the most at risk for eutrophication and resulting hypoxia. Converting agriculture land-use to forests is likely the most promising strategy for diminishing phosphorus loading and mitigating consequent eutrophication.

Future Work

Further analyses will examine the success of specific BMPs such as no till farming, cover crops, nutrient management (i.e., reduced fertilizer application) to reduce pollutant loading in the cisco watersheds. We will examine load reductions using both individual and combinations of BMPs. Due to the limitations of L-THIA, we will use additional hydrological models to estimate nutrient load reductions.

Acknowledgements

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References

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