Utilizing the Relationship Between Agriculture and Total Phosphorus to Study the Efficacy of Best Management Practices in Vermont Watersheds

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Saint Michael's College 2016

Introduction

- Excessive nutrient loading of nitrogen and phosphorus into bodies of water is a main factor contributing to eutrophication, which is a serious water quality issue. Agricultural nonpoint source pollution coming from fertilizers is a significant contributor of nitrogen and phosphorus loading (Wu *et al.*, 2012).
- As a result of such contamination, legislation has been introduced in many states to mitigate the negative effects of agriculture on aquatic ecosystems (Taylor *et al.*, 2016).
- In this study, I examined the degree to which agriculture impacted water quality by measuring the average total phosphorus levels at various sites throughout the state. The percent of the catchment of each site that is agricultural was used to measure the degree to which agriculture impacted each site.
- The Best Management Practice (BMP) program in Vermont is a program which helps farmers to implement practices that aim to reduce nonpoint source pollution of waterways, such as cover cropping, reduced tillage, and so on (Vermont Agency of Agriculture).
- In order to study the efficacy of these BMPs, the correlation between percent of the catchment that is agricultural and the total phosphorus levels was compared to the funds that have been allocated to the BMP contracts in Vermont. I expected that as the amount of money designated for BMPs increased, the percent of a catchment that is agricultural would have less of an impact on phosphorus levels.

Materials & Methods

GIS

- Land use data was obtained using Geographic Information System (GIS) data stored in the Vermont EPSCoR database.

BMP

- BMP data was culled from Natural Resources Conservation Service (NRCS) records.
- The data consisted of a list of contracts that the NRCS had entered into with farms in Vermont that included how much money the NRCS had set aside for each practice within a contract (practice obligation).
- For each year, the practice obligations of the completed practices were totaled and compiled to get the total amount of funds allocated by the NRCS each year, which was then converted to 2015 US dollars to account for inflation.

Phosphorus

- Phosphorus samples were collected in 125 mL acid-washed bottles and were then transported to Johnson State College where they were tested for total dissolved phosphorus using a Seal Analytical AQ2+ Auto Analyzer.
- The samples were combined with a sulfuric acid solution and a digestive reagent was added. Samples were then autoclaved before undergoing the ascorbic acid reduction method in the auto analyzer. Samples were reported in mg P/L, which was then converted to µg P/L.
- By year, all phosphorus data in a given watershed was averaged.

Results

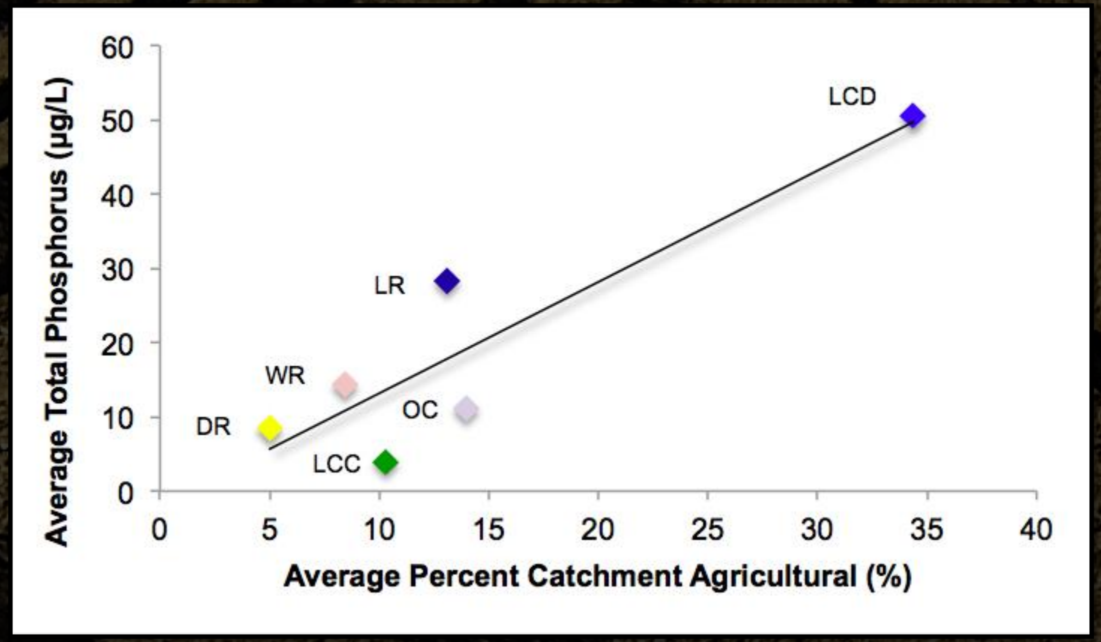

Figure 1. Average total phosphorus in µg/L compared to the average percent catchment that is agricultural in 2008. $R^2 = 0.80868$; *p*-value = 0.01471.

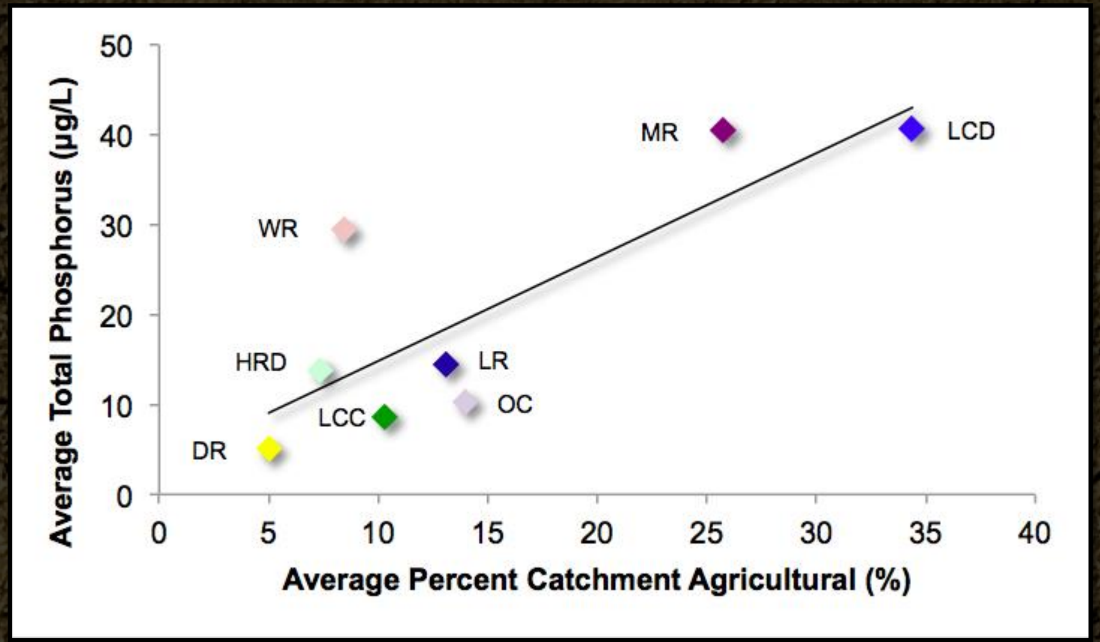

Figure 2. Average total phosphorus in µg/L compared to the average percent catchment that is agricultural in 2009. $R^2 = 0.66117$; *p*-value = 0.01411.

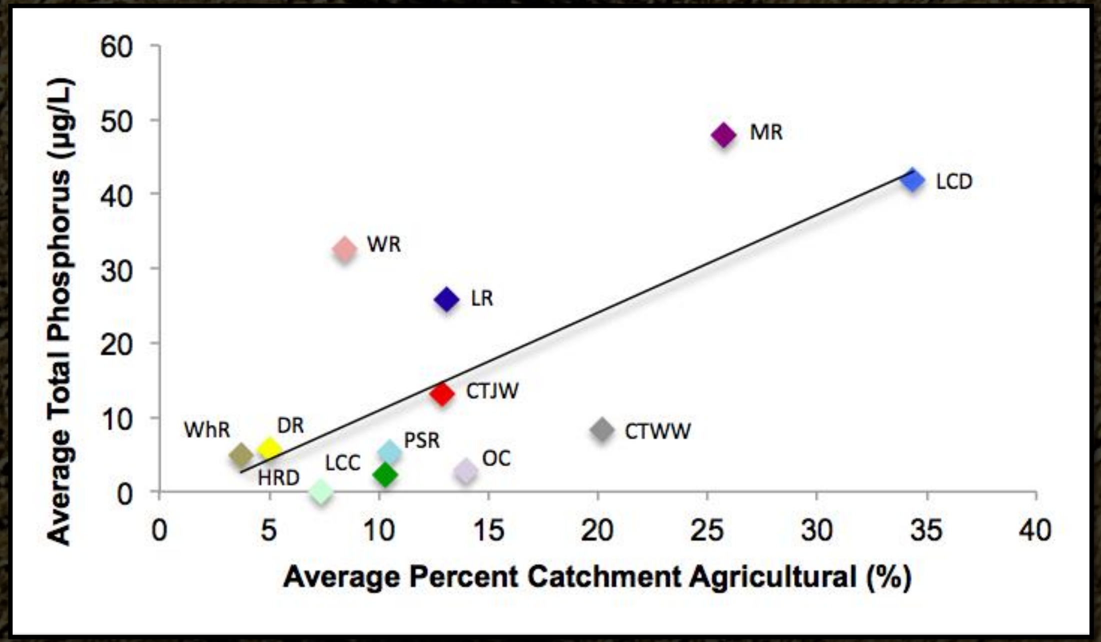

Figure 3. Average total phosphorus in µg/L compared to the average percent catchment that is agricultural in 2010. $R^2 = 0.49501$; *p*-value = 0.01067.

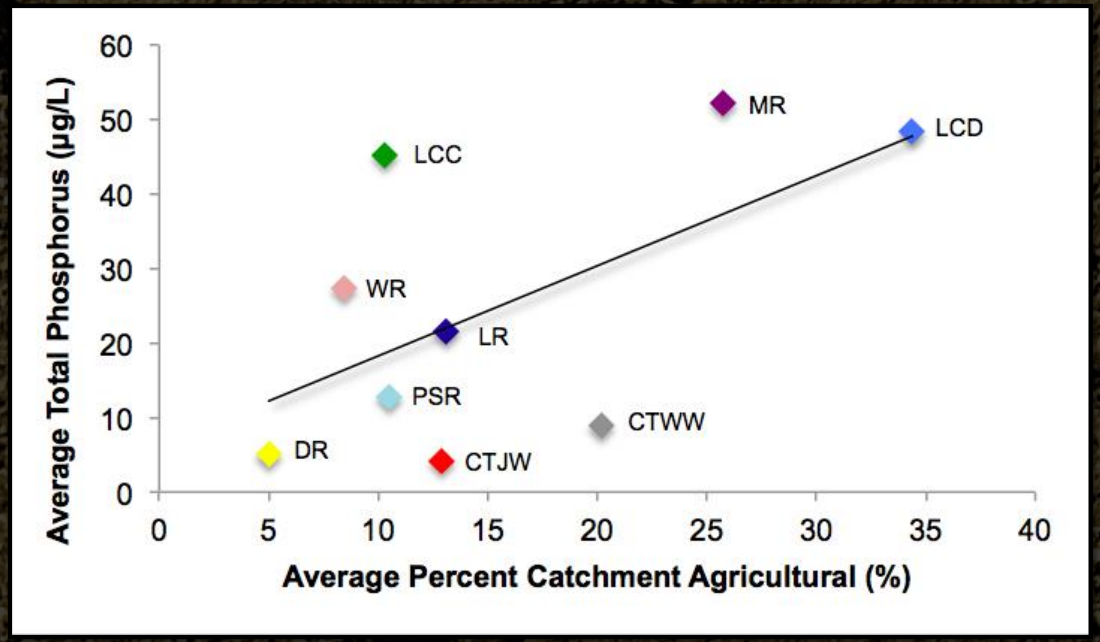

Figure 4. Average total phosphorus in µg/L compared to the average percent catchment that is agricultural in 2011. $R^2 = 0.35106$; *p*-value = 0.09271.

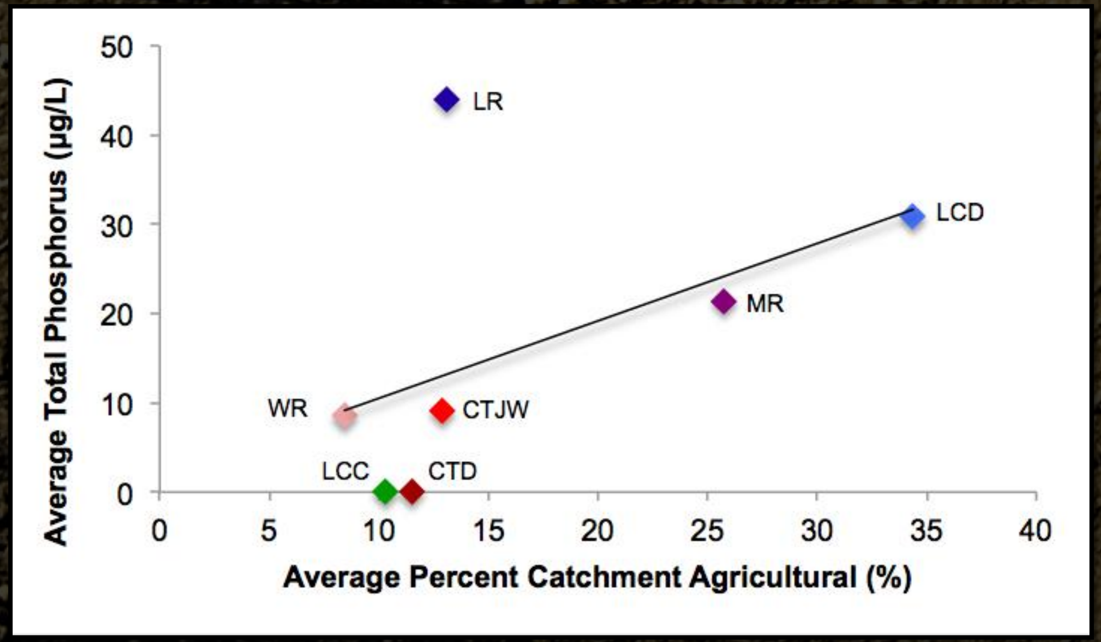

Figure 5. Average total phosphorus in µg/L compared to the average percent catchment that is agricultural in 2013. $R^2 = 0.25464$; *p*-value = 0.2481.

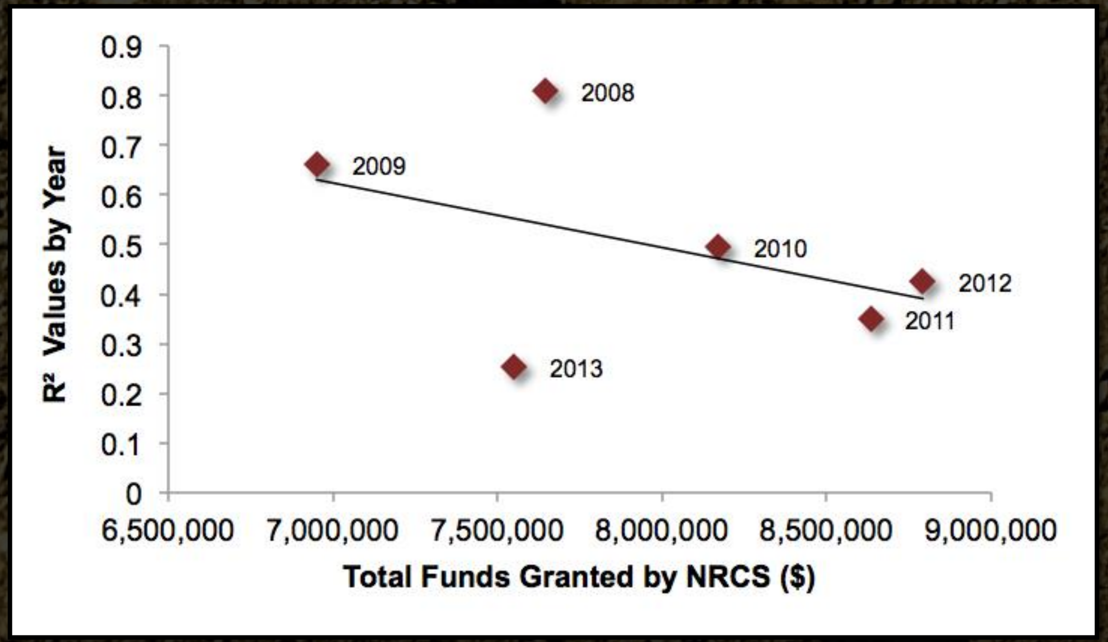

Figure 6. R^2 values of average total phosphorus and average percent catchment agricultural comparison, compared to the average total funds granted by the NRCS by year in 2015 dollars. $R^2 = 0.20053$; *p*-value = 0.37319.

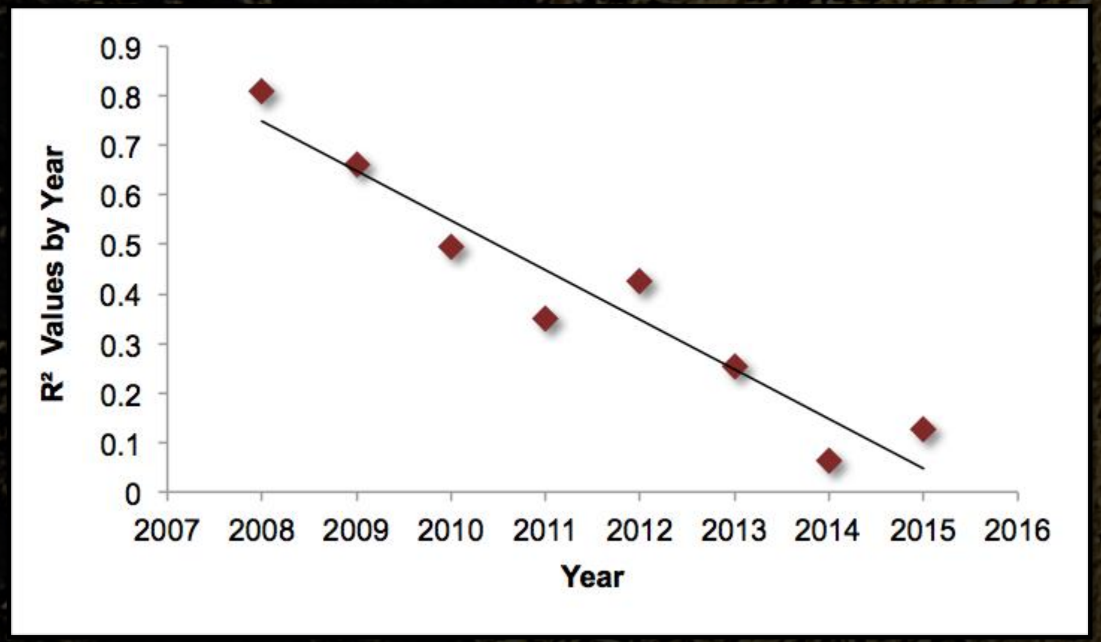

Figure 7. R^2 values of average total phosphorus and average percent catchment agricultural comparison by year. $R^2 = 0.92178$.

Table 1. Watersheds used in this study and their respective data labels.

Watershed	Datapoint Name
Connecticut River Direct	CTD
Connecticut River - John to Waits	CTJW
Connecticut River - Waits to White	CTWW
Deerfield River	DR
Hudson River Direct	HRD
Lake Champlain Canal	LCC
Lake Champlain Direct	LCD
Lamoille River	LR
Missisquoi River	MR
Otter Creek	OC
Passumpsic River	PSR
White River	WhR
Winooski River	WR

Discussion

- Agriculture can be the dominant anthropogenic source of nutrients in aquatic ecosystems depending on land use (Blaas and Kroeze, 2016). Thus, I expected that average total phosphorus levels would be greater at sites whose catchment was more agricultural. My results supported this hypothesis, as the average total phosphorus levels for each year exhibited positive correlations with the percentage of the catchment that is agricultural (Figures 1-5).
- A 2016 study in Eastern England found that agricultural best management practices such as the introduction of a red clover cover crop and establishing a 6 meter buffer zone to arable land could reduce phosphorus concentrations by 1.6% and 16.9% respectively over the long-term (Taylor *et al.*, 2016).
- I also expected that as the total funds granted by the NRCS for BMPs in Vermont increased, nutrient runoff as a whole would decrease (Blaas and Kroeze, 2016), which would be seen by a decreasing correlation between phosphorus levels and the percent of each catchment that is agricultural. Although the relationship was not statistically significant, I did observe a slightly negative relationship between the R^2 values and the total funds allocated by the NRCS (Figure 6).
- Interestingly, when the R^2 values from the phosphorus and land use comparison were graphed over time, there was a strong negative correlation, suggesting that agriculture is having less of an impact on phosphorus levels in Vermont as time goes on (Figure 7).
- It is important to note the limitations of the data in the sense that the prevalence of BMPs was measured solely based on the total funds that had been granted in Vermont. In order to create a more isolated and controlled experiment in future studies, it may be more effective to look at what BMPs are in place on a watershed basis (Bosch *et al.*, 2013).

Acknowledgements

I would like to thank Saint Michael's College for providing access to the facilities and resources that made this work possible. Special thanks to Steve Scheinert, PhD., and Yu-shiou Tsai, PhD., for providing access to data and for their willingness to help in any way possible. I would also like to thank my coworkers this summer - Kaylee Jackson, Mariah Witas, and Elise Prehoda - for all of their help and support. Funding provided by NSF EPS Grant #1101317.

References

- Blaas, H., Kroeze, C. 2016. Excessive nitrogen and phosphorus in European rivers: 2000–2050. Ecological Indicators. 67: 328-337.
- Bosch, N. S., Allan, J. D., Selegean, J. P., & Scavia, D. 2013. Scenario-testing of agricultural best management practices in Lake Erie watersheds. Journal Of Great Lakes Research. 39(3): 429-436.
- Taylor, S. D., He, Y., Hiscock, K. M. 2016. Research article: Modelling the impacts of agricultural management practices on river water quality in Eastern England. Journal Of Environmental Management. 180: 147-163.
- Vermont Agency of Agriculture. [Internet]. Cited 2016 Jul 21. Best Management Practices (BMPs). Available from http://agriculture.vermont.gov/water-quality/farmer-assistance/bmp.
- Wu, L., Long, T., Liu, X., Guo, J. 2012. Impacts of climate and land-use changes on the migration of non-point source nitrogen and phosphorus during rainfall-runoff in the Jialing River Watershed, China. Journal of Hydrology. 475: 26-41.
- Background photo available from https://unsplash.com/photos/RgyPR4AysMA.