Phosphorus Levels in Relation to Land Use and Stream Hydrograph in the Lamoille River Basin, Vermont

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Introduction

In Vermont, eutrophication is of major concern within Lake Champlain . The main contributor to this problem is phosphorus. Phosphorus is believed to be the main source of algal blooms and poor water quality in the Lake. In an effort to reduce phosphorus levels in the lake, tributary monitoring has been on going since 1991.

The largest issue associated with phosphorus loading is immense amount of non-point sources. Non-point sources contribute approximately 90% of the total phosphorus load in the Lamoille River mouth that flows into Lake Champlain. Understanding how phosphorus load is affected by Lamoille tributary discharge and land use may give rise to understanding non-point phosphorus sources in relation to the whole of the Champlain basin.

The purpose of this study was to determine if there is a phosphorus load differentiation during a high discharge storm event in the Lamoille river basin. More specifically, during the rise period of the Lamoille hydrograph, or the fall period, and if the largest loads of phosphorus correspond to the percentage of forested habitat within the tributaries' total catchment.

Materials & Methods

Stream water samples were collected at the nineteen stream sites weekly during the summers of 2008-2013. The samples were then process by a Automated Discrete Analyzer (AQ2) using the 4500-P J. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus. A FlowTracker (Sontek/YSI Inc., San Diego CA) was used to determine stream discharge at each of the sample periods. The USGS online site was used to determine the rise or fall of the Lamoille tributaries during high flow sample periods. Microsoft Excel was used to interpret data and Analysis of Co-Variance (ANOVA) was used to simplify interpretations of multiple correlating factors found in the data.

Results

-Multivariate ANOVA results found a correlation between total phosphorus and percent agricultural land to be .157 and to percent urban land to be .112 (Figure 3).
-ANOVA results found there to be a .397 correlation between total phosphorus and the high flow days found in the hydrograph (Figure 3).
-From the significance matrix in the 1-tailed analysis it was found that total phosphorus with high flow and also percent urban and agricultural lands had high significance when compared (Figure 3).
-Figure 2 compares percent forested land and total phosphorus. There was found to be an R^2 value of .2757 for the day before the peak, and value of .0624 on the peak day and a value of .1791 for the day after the peak.

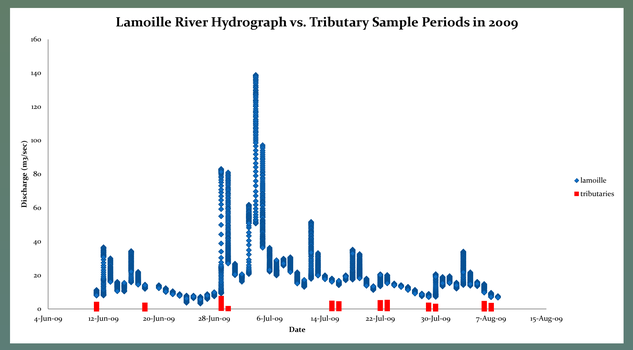

Figure 1. Lamoille river hydrograph over the 2009 sampling period.

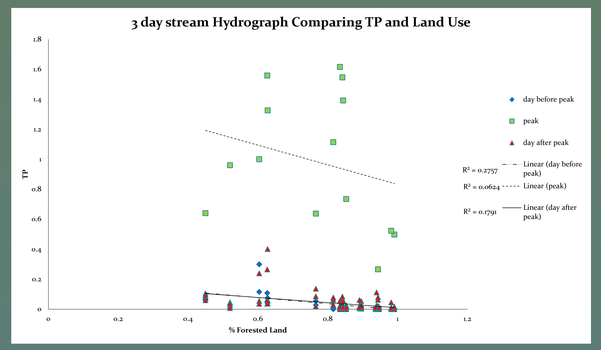

Figure 1. Three day hydrograph comparing TP and percent forested land use.

Correlation Matrix

		Elevation_ft	Year	Discharge_mysec	Hydrographa	AgPct	UrbanPct	ForestPct	TP_ugL
Correlation	Elevation_ft	1.000	-.011	-.148	-.149	-.557	-.565	.594	-.113
	Year	-.011	1.000	-.034	.418	.029	.027	-.029	-.050
	Discharge_mysec	-.148	-.034	1.000	-.075	-.191	-.188	.177	.012
	Hydrographa	-.149	.418	-.075	1.000	.146	.153	-.149	.397
	AgPct	-.557	.029	-.191	.146	1.000	.649	-.992	.157
	UrbanPct	-.565	.027	-.188	.153	.649	1.000	-.729	.112
	ForestPct	.594	-.029	.177	-.149	-.992	-.729	1.000	-.159
	TP_ugL	-.113	-.050	.012	.397	.157	.112	-.159	1.000
Sig. (1-tailed)	Elevation_ft		.425	.007	.006	.000	.000	.000	.030
	Year	.425		.188	.000	.397	.329	.314	.200
	Discharge_mysec	.007	.188		.204	.001	.001	.001	.421
	Hydrographa	.006	.000	.204		.007	.005	.006	.000
	AgPct	.000	.397	.001	.007		.000	.000	.004
	UrbanPct	.000	.329	.001	.005	.000		.000	.031
	ForestPct	.000	.314	.001	.006	.000	.000		.004
	TP_ugL	.030	.200	.421	.000	.004	.031	.004	

Figure 2. Multivariant ANOVA Correlation and 1-tailed significance results.

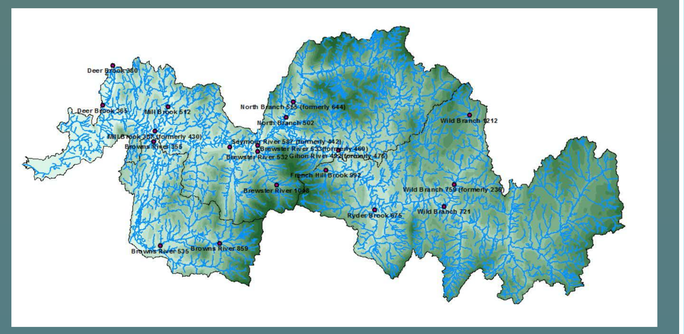

Figure 4. The 19 stream sites of the Lamoille river.

Conclusions

Excess nutrient loading and plant growth is an increasing problem in Lake Champlain. As seen throughout the world, increased human population has lead to a transformation of forested land to urbanized and agricultural land. As a result of this development the overall percentage of forested land has decreased. Lower percentage of forested land correlates to increased phosphorus levels due to non-point sources generated by runoff and a lack of buffer zones.

The correlation between high water flow events and total phosphorus have been linked to the percent of forested land within the stream catchment. As expected, phosphorus levels rose as percent forested land decreased. The ANOVA results support this expectation. ANOVA results show a correlation between total phosphorus and the hydrograph data, however this is a weak correlation.

Further studies on buffer zones along entire streams lengths and stream phosphorus levels may give further insight into non-point sources of phosphorus given land use.

References

1. Rice, EW; Baird, RB; Eaton, AD; Clesceri, LS. 2012. 4500-P J. Persulfate method for Simultaneous Determination of total Nitrogen and T. Phosphorus. American Public Health association, Washington, DC 20001-3710.
2. Persulfate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus.

Acknowledgements

I thank Dr. Robert Genter and EPSCoR for the experience and mentoring throughout this internship. I also thank the Stream team (Jess, Abbie, Saul, Ed, Dave and Steph), for their work , support and a great summer!

Funding provided by NSF Grant EPS-1101317