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Seneca Lake Watershed
Land Use Land Cover Vs. Nutrient Loading

Introduction

This study intends to help the Seneca Lake watershed identify problems and pose solutions to improve the quality of the lake. In particular this study will look at land use land cover for seven of the Seneca Lake subwatersheds and see how it relates to the nutrient loading that we are finding in some of the lakes inlets. At this point in time we are finding that the nutrients in lake Seneca are increasing (Halfman, 2011) and that the overall lake quality is going down. Various previous studies have shown that nutrient loading can be related to the amount of agricultural land in a watershed (Allan, 1997, Evans, 2008, Makarewicz, et.al., 2008, Herlihy et. Al. , 1998). For my study I decided to break down the Seneca watershed and look at seven of its subwatersheds. The watersheds I looked at and had data for are: Wilson creek, Kashong creek, Keuka Lake outlet, Reeder creek, Plum Point, Big Stream, and Catherine Creek. The importance of this study is to show a possible relationship between the high levels of nutrients in the lake and the land use land cover. This lake serves as drinking water to tens of thousands of people in the region and its health and water quality are of great importance both culturally and commercially through things like fishing and drinking water. In the Seneca Lake watershed we see a wide variety of sources for nutrient loading. This study looks at nitrate, total phosphate, dissolved phosphate, silica and total suspended solids. All of these nutrients tell us something about the watershed. I hypothesize that when we look at the percent land use land cover in a given subwatershed we should see lower nutrient levels but higher suspended solid levels in the areas with higher percent forested area.

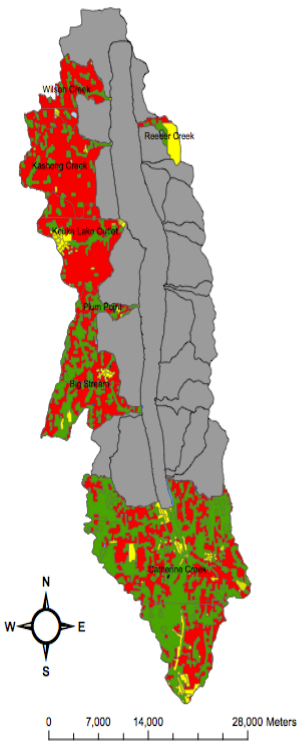
A previous study done of the Owasco Lake watershed uses computer modeling to show that on average, 56.9 percent of the annual phosphorous load for the watershed is coming from agricultural lands (Evans, 2008). In addition, a study done on the Mid Atlantic region US shows a direct correlation between the nitrate concentration in the river and the percent of the watershed in a forest (Herlihy, 1998). This study used hundreds of data points to show that as the percent of the watershed in the forest goes up, the nitrate concentration goes down logarithmically (Herlihy, 1998). These studies as well as other articles have led to the conclusion that nutrients in subwatersheds should act in a similar fashion.

With the information about what subwatersheds are being impacted most by agriculture, the Seneca Lake watershed will be able to use remediation techniques and best management practices more efficiently to try and mitigate the increasing levels of nutrients in the subwatersheds and therefore the lake.

Study Area

Of the seven subwatersheds this study examines, Catherine creek is the largest and Reeder creek is the smallest. Of these subwatersheds we can only hypothesize as to the reason for the levels of nutrients we see in the streams. Usually the amount of nutrients is controlled by, the soil/bedrock composition, the amount of precipitation, point source pollution and the surrounding area or land use land cover. It is important to note that Plum, Kashong, Catherine, and Big stream all have strip mines present within their subwatershed which is a large point source polluter. In addition some other nutrient inputs include lakeshore septic systems, lawn care, and municipal wastewater treatment facilities. For this study there was no way to incorporate these inputs into our analysis except to recognize that these inputs along with other factors that may contribute to error within what the data shows and what one might expect the data to show.

Figure 1



The nutrient data for the subwatersheds was collected near where the streams run into Seneca Lake, therefore almost all of the watershed is upstream from the test site in every case. All of the nutrient data was collected in terms of kilograms per day. This data was then converted to represent the percent of a total amount of nutrients that were being observed as a way to take into account the differences in stream size and flow.

Table 1

	% Industrial/urban/residential	% Agricultural	% Undevoloped/forest
Wilson	0.26	92.9	2.4
Reeder	15.13	70.7	13.8
Plum	0.38	59.6	10.8
Keuka	2.5	90.6	6.9
Kashong	0.42	71.4	7.6
Catherine	1.8	18.5	76.4
Big stream	0.27	31.3	64.1

Land Use Land Cover Vs. Nutrient Loading

To understand how the land use land cover might be effecting the lake, the land use land cover for each subwatershed was broken down into a three categories, urban/industrial/residential represented in Figure 1 by the color yellow, agriculture including orchards (Figure 1: Red), and Forests/scrub (Figure 1:

Green). The information provided in Table 1 was gathered from an analysis of the data used to construct Figure 1. Table one shows Wilson Creek and Keuka outlet as having the highest percent agricultural land with 92.2 and 90.6 respectively. This table also shows Catherine Creek and Big Stream as having the highest percent forested land with 76.4 and 64.1 respectively. Therefore we would expect to see the highest nutrient levels in Wilson and Keuka, and the lowest nutrient levels in Catherine and Big Stream. It is important to note that in table one, the percents for each of the different subwatersheds do not add up to 100. This is because certain things such as lake area, wetlands, and transition lands were left out of the three previously mentioned categories on which we based our analysis. Wetlands, including lakes, for Wilson, Catherine, Reeder, and Big Stream all added up to less than five percent of the subwatershed area. In Kashong Creek it wetlands are twenty percent of the land area and in plumb wetlands are roughly 29% of the watershed area.

Table 2

	Nitrate % daily flux	Phosphate % Daily Flux	Dissolved Phosphate % Daily Flux	Silica % Daily Flux	Total Suspended Solids %daily flux
Wilson	7.87	0.41	0.32	11.56	79.83
Reeder	10.83	0.77	1.16	24.27	62.96
Plum*	16.89	0.00	0.22	37.56	45.33
Keuka	3.41	0.15	0.08	3.36	93.00
Kashong*	9.91	0.28	0.17	15.59	74.05
Catherine*	0.36	0.08	0.03	4.92	94.60
Big stream*	8.95	0.30	0.87	27.65	62.23

Table two shows Catherine Creek, which has the greatest percent of agricultural land, has the lowest overall nutrient levels and the highest percent of suspended solids. With the data from Big Stream, the relationship was not quite as apparent. Although the phosphate levels in this stream were low, the nitrate and suspended solids were not where one would expect them to be. In addition the highest nitrate and silica levels are found in Plum creek, the highest phosphates are found in Reeder and the highest suspended solids are found in Catherine Creek.

Analysis

From this data we see a small relationship between the amount forest cover and the amount of nutrients. As expected, the subwatershed with the percent of forested lands had the overall lowest nutrient levels. But it was only Catherine Creek, with the highest forest percentage that fell into this pattern. For the most part the sub- watersheds seemed to have certain nutrients that they were high in. I believe that this may have to do with a variety of factors that must have an influence coming from upstream. I believe that an influence on the overall quality of a stream has to do with the amount of wetlands in a watershed and their relation to other sources of pollution. The Keuka Lake outlet has Keuka Lake upstream that works as a giant retention pond to help remove some of the nutrients and suspended solids before entering Seneca Lake (Halfman, 2011). Big stream has the Dundee wastewater treatment facility within its watershed that contributes to the nutrients in that area (Halfman, 2011). On the whole, the relationship between nutrient loads and what is happening in the subwatershed is more complicated then just looking at the land use land cover, one must incorporate other aspects and sources to fully understand where the nutrients in a watershed are coming from.

It is apparent that there is a problem of nutrient loading within the Seneca lake watershed. It is important to address the nutrients in the subwatersheds because the nutrients found in the subwatershed are the fluxes into Lake Seneca. In order to mitigate this problem there are many options of what can be done including both cultural and structural best management practices or BPMs. Structural BMPs change the transport of the pollutant to waterways while cultural BMPs minimize nutrient inputs to waterways through land management practices. The watershed is being helped two fold by emplacing these BMPs, it is one saving the lake from the increasing nutrient levels that could cause the lake to become eutrophic, and they are preventing the depletion of nutrients in the agricultural land (Makarewicz, et.al., 2008).

Also it is apparent that the watersheds that have the highest amount of nutrient flux into the lake are the ones with the largest area. What is important to understand is that the implementation of BMPs will have the greatest effect in areas where there is more agricultural land. For example, although Catherine Creek may be the largest watershed and contribute most to nutrient loading, the fact that it is only 18% agricultural land may limit the effect the implementation of BMPs would have on the watershed. Where as in areas of high % of agricultural land such as Wilson creek the effect of BMPs would be more apparent. As you can see in Table 3 (above) the largest

Table 3

	Total Flux(kg/day)
Wilson	434.40
Reeder	103.40
Plum*	45.00
Keuka	5186.60
Kashong*	602.40
Catherine*	10256.60
Big stream*	263.70

contributor to nutrients in the lake is Catherine Creek, but the implementation of BMPs might only have a small effect on the downstream environment because the small amount of agricultural land.

Recently a study was done on the Conesus watersheds that covered BMPs that had an effect on the streams (Herendeen, 2009). For this study they did not enforce any of the BMPs, they were all done voluntarily. Some of the BMPs that were used included, winter manure spreading being eliminated, manure management, fertilizer use reduced, subsurface drainage tiles, grass filter strips, contour tillage, roof water separation, fall tillage curtailed, cover crops added and cattle fenced out of stream, just to name a few and this was only for one of the watersheds within the Conesus watershed (Herendeen, 2009). This study found that the effects of BMPs had a substantial impact on the down stream aquatic system. In particular they found reductions of total phosphorus, soluble reactive phosphorus, nitrate, total Kjeldahl nitrogen, and total suspended solids concentration by the second and third year of implementation (Herendeen, 2009). In addition to improving the down stream environment the farmers reported savings of up to 3000 dollars for the farmers in some of the watersheds. Although some of the BMPs have an initial cost, the long term benefits make it worthwhile. In addition the study done by Herendeen (2009) found that the farmers are far more likely to implement the BPMs if they are taught by Extension Educators, and if they are provided with technical assistance and financial incentives. This one study shows the possibilities of what could happen with the implementation of BMPs in the Seneca Lake watershed.

Proposal

I propose that we implement a program to help educate farmers on the use of cost effective BMPs in the Seneca Lake Watershed. I believe that the Keuka outlet, Kashong Creek and Wilson Creek subwatersheds be considered for implementation of BMPs. I chose these three because they have the three highest agricultural Land cover as well as the three highest Fluxes in next to Catherine creek. I believe that through the implementation of BMPs in these subwatersheds Seneca Lake might be able to greatly reduce the nutrient fluxes into the lake. I think that if we brought about an education program to help farmers more efficiently use their existing resources and voluntarily implement any BMPs they are willing. I think that through this education program the watershed would be able to limit the costs to the farmers while significantly impacting the downstream environment.

Overall, there did not seem to be a strong relationship between the percent agriculture in the subwatershed and the amount of nutrients being put into the Lake. I feel that the land use land cover data is important to consider where the implementation of BMPs might be most effective and that these places with the highest agricultural percent land cover would be the best watersheds to implement effective BMPs. If future research is to be done on this topic, I suggest that more sites be sampled and one might fine that other sub-watersheds may have a greater impact on the lake then the ones that we had data for in this study.

Works Cited

Allan, J David, Donna L Erickson, and John Fay. "The influence of catchment land use on stream integrity across multiple spatial scales." *Freshwater Biology* 37 (1997): 149-161.

Evans, Barry M. "COMPUTER-BASED SIMULATION OF LOADS AND WATER QUALITY RESPONSES WITHIN THE OWASCO LAKE WATERSHED." *Penn State Institutes of Energy and the Environment* (2008)

Halfman, John D. "WATER QUALITY OF SENECA LAKE, NEW YORK: A 2011 UPDATE." *Seneca Lake Report* (2011)

Herendeen, Nathan, and Nancy Glazier. "Agricultural best management practices for Conesus Lake: The role of extension and soil/water conservation districts." *Journal of Great Lakes Research* 35 (2009): 15-22.

Herlihy, Alan T, John L Stoddard, and Colleen Burch Johnson. "The Relationship Between Stream Chemistry and Watershed Land Cover Data in the Mid Atlantic region, U.S." *Water, Air, and Soil Pollution* 105 (1998): 377-386.

Makarewicz, Joseph C, et al. "The impact of agricultural best management practices on downstream systems: Soil loss and nutrient chemistry and flux to Conesus Lake, New York, USA." *Journal of Great Lakes Research* 35 (2009): 23-36.

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