GIS Analysis of Nutrient Loading to Wapato Lake from Sheet Flow

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Abstract

Urban lakes are valuable recreation sources and play a key stormwater management role. Unfortunately, these two needs conflict as nutrient loading often limits recreational use. The goal of this project was to use GIS software to estimate an annual nutrient load from sheet flow to the south basin of Wapato Lake. We created a land use distribution for the contributing watershed area, assigned runoff coefficients , obtained precipitation data, and used student-collected nutrient data from sheet flow samples . Using this method a mass flux was calculated to add to a comprehensive nutrient model to be used for recommending management actions for Wapato Lake.

Introduction

- Lake systems are affected by changes in nutrient loads.
- Excessive nutrients will lead to eutrophication and blue-green algal blooms.
- There are several sources of runoff phosphorus and nitrogen.
- Some of these are anthropogenic (grass fertilizers) and some are natural (see geese below).
- The nutrient amount that enters the lake is affected by total precipitation and land type.

Photo by author

Methods

The first step was to establish a watershed area. This would aid in finding the total area that will drain into Wapato by sheet flow. In the first stage of analysis, a sub-basin shapefile from City of Tacoma was used. This area was based on the topography and did not take into account for the city drainage system. A smaller shapefile was obtained from City of Tacoma that was used for a previous project and remedied this issue as well.

Methods (cont.)

The next step was to find the total area for each land cover type. Visiting the lake allowed for ground truthing these types. The image classification toolbar in ArcGis was first used to create a land cover map by classifying based on the color patterns of 'sample' areas. This method was decided against because the shadows in the aerial photo that was used affected the classification, and the cement paths were not classified accurately because of canopy cover. Polygons relating to the land cover types were manually digitized through the editor toolbar (fig. 3). Area was then calculated in the attribute table and exported to Excel.

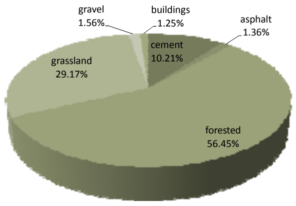

Figure 1: watershed area by percent

The final step was calculating an estimated nutrient inflow to the lake. Runoff coefficients were used in this calculation to account for varying types of land cover (fig. 1). Student-collected precipitation data was obtained for October 2009 to September 2010, and added to find an annual total. Literature values for total phosphorus and total persulfate nitrogen were used from a Department of Ecology report on local watersheds (Ecology, 2011). From this report, three different concentration types were used: commercial, residential, and forested. Student-collected overland flow data was used that showed nitrogen and phosphorus concentrations. By multiplying concentrations, total rainfall, land cover areas, and runoff coefficients a mass flux (grams per year) into the lake was calculated.

land cover types	runoff coefficients	phosphorus conc. (g/ft^3)	nitrogen conc. (g/ft^3)
asphalt	0.70-0.95	1.529	10.874
concrete	0.80-0.95	1.529	10.874
heavy soil, 2-7% grade	0.18-0.22	2.605	51.961
roofs	0.75-0.85	1.529	10.874
smooth bare packed soil	0.30-0.60	0.934	11.355
woodlands	0.05-0.25	0.934	11.355
pervious concrete	0.35-0.65	1.529	10.874

Figure 2: coefficient and concentration values

Results

Minimum and maximum runoff coefficients were used in the calculations to find a range. Total phosphorus input had a range of 1029 to 1573 gpy (grams per year), and a mean of 1305 gpy. Total nitrogen input had a range of 13428 to 20318 gpy, and a mean of 16873 gpy. By adding an additional 10% forested and taking away 10% grassland, there was a reduction of 121 gpy or a 9.3% decrease for total phosphorus. For nitrogen, there was a reduction of 2778 gpy or a 16.46% decrease. By replacing all cement pathways with pervious cement, there would be a reduction of 187 gpy or a 14.38% decrease for total phosphorus. Total nitrogen would have a reduction of 1331 gpy or a 7.89% decrease.

Figure 3: watershed area by land cover types

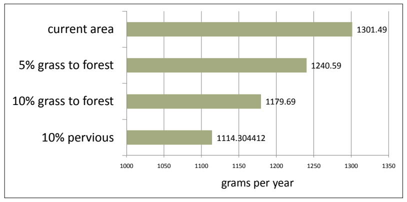

Figure 4: mean total phosphorus

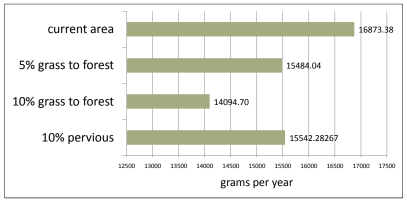

Figure 5: mean total nitrogen

Discussion

Based on this model, a reduction in grassland and increase in forested land should reduce nutrient loading in the lake. Another possible reduction to nutrient loading would be replacing impervious cement pathways with pervious alternatives, which would greatly decrease the runoff potential of these paths.

The student collected concentrations for nitrogen and phosphorus had a much higher mean then the literature values, but they had high variability. They were also only collected from grassland. These are two issues that might affect the accuracy when assessing the full watershed area. The mean total phosphorus input calculated using these values was 35328 gpy. The mean total nitrogen was 68642 gpy. There would need to be more research done to determine which values would be more accurate.

The results seem to show that nitrogen would have a greater decrease than phosphorus when changing grassland to forested, but a lesser decrease than phosphorus if pathways were replaced with pervious cement. This is because the only variable changed in the pervious cement calculations was the runoff coefficient. The same concentrations were used for pervious and impervious concrete. In the grassland to forested calculations, the concentrations were also changed. There was a substantial difference between nitrogen grassland and forested concentrations.

Another possibility for controlling nutrient loads would be the installation of buffer strips, bioswales, or rain gardens to catch runoff. Installations like rain gardens can greatly reduce the amount of pollution and nutrients that will reach the lake body.

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