Geomorphic Characteristics of Canadice Lake, NY, Watersheds and the Anthropogenic Effects on Watershed Output and Sensitivity

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Abstract

Land use and size of watershed catchment areas affects the overall health and water quality of Canadice Lake. Methods in ArcGIS Pro were used for high resolution imagery and topography data to analyze the geomorphology of watersheds at Canadice Lake. Watersheds were mapped using ArcGIS Hydrology tools by constructing flow direction and accumulation grids. In each individual watershed, total area of the watershed, area of residential and agricultural land use, and total length of roads was determined to evaluate which watersheds are most sensitive to human impact and which watersheds are likely to contribute the highest flow discharge and sediment load based on their size. Initial results indicate that upland streams in the watersheds that intersect roads are diverted by drainage ditches and are vulnerable to human impact. Also, the East side of Canadice Lake has the most human impact, with the highest percentages of residential areas, agricultural areas, and roads. The watersheds with both, the largest area of land cover and the largest percent of residential, agriculture and roads, are the most vulnerable watersheds and most likely the largest contributors to contaminants into the lake.

Introduction

Canadice Lake is a major source of drinking water for the Rochester, NY area. Canadice is Oligo-Mesotrophic; it has low-moderate levels of productivity (DEC, 2019). Canadice is on NYS private property, Hemlock-Canadice State Forest (Owens, 2017). There is residential, agriculture, and roads in the watershed catchment area that have potential to change the lake chemistry. Canadice is mostly impacted by agriculture, where nutrient rich runoff decrease water quality (Owens, 2017). A common pesticide for agriculture in the area, Atrazine, could affect the water quality of Canadice (USGS, 1998). The roads in the area a concern; according to the DEM data, drainage ditches significantly capture the watersheds along the east side of the lake, altering the watershed morphology and subjecting it to sand, salt, and human contamination. Canadice is largely unstudied because of its small size and remote location (Owens, 2017). The objective of this research is to shed light on anthropogenic effects, identify which watersheds have the largest input into the lake, and which are most effected by residents, agricultural, and roads. Future water and soil quality analysis can be done from the most sensitive locations in the watershed.

Figure 1. Size comparison of Canadice Lake in respect to Hemlock Lake.

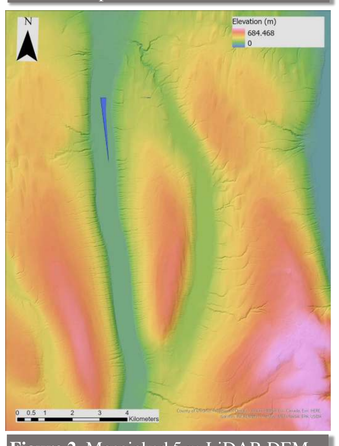

Figure 2. Mosaicked 5 m LiDAR DEM of Livingston and Ontario counties

Figure 3. World Satellite Imagery of the Finger Lakes for spatial reference of Canadice Lake

Methods

The LiDAR DEMs were chosen from https://gis.ny.gov/elevation/lidar-coverage.htm. The Livingston and Ontario county DEMs were mosaiced together at 5m per pixel, datum: NAD 1983 UTM Zone 18N. Using a flow direction and accumulation grid, stream networks were extracted in ArcGIS Pro using an upstream contributing area threshold of 0.01m^2. By snapping pour points to the end of each river that entered the lake, the hydrology watershed tool constructed individual watersheds. This raster format file was converted to vector format. Land use areas and roads were mapped using the ESRI World Imagery Layer at a scale of 1:8,000. Each individual watershed polygon was used to clip the land use area polygons and road polylines to evaluate human impact. Land use area and road density were calculated for each watershed. Using Excel, the watersheds with the most human impact by percent area and by total area were calculated. These data were inserted into the attribute tables for individual watersheds and a graduated color ramp was chosen to display the relative area coverage and road density.

Figure 4. Stream networks and individual watersheds from flow accumulation grid and pour points

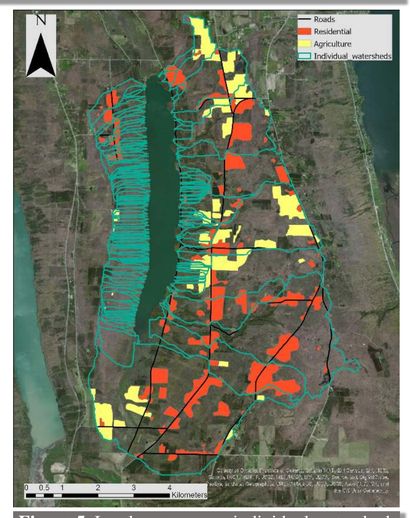

Figure 5. Land use map per individual watershed from polygon and polyline tools. Displays, residents, agriculture, and roads.

Results

Maps are at 1:51,000 scale. For each category, residential in orange, agriculture in yellow, and roads in black, there are two maps comparing the intensity of human impact per individual watershed. The land use maps are comparing human impact by percent area and human impact by total area of each watershed. The east side of Canadice is the most heavily impacted by humans in terms of residents, agriculture, and roads. The watersheds with the largest areas, in the southeast portion, contribute more water to the lake, therefore those watersheds influence lake health more than smaller watersheds that have high percentages of human impact.

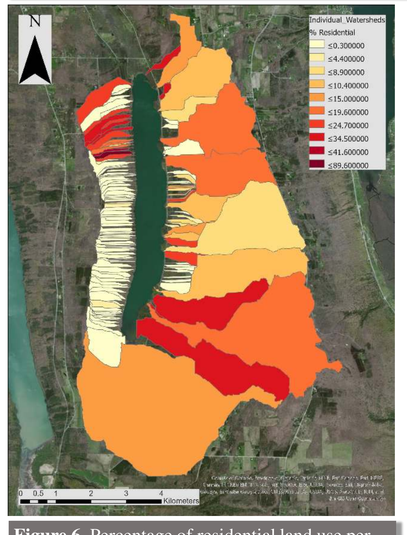

Figure 6. Percentage of residential land use per individual watershed based on area

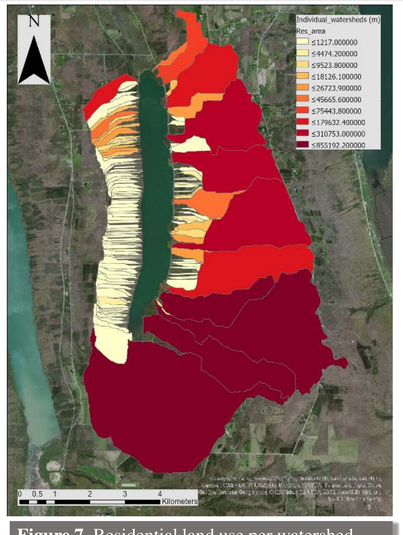

Figure 7. Residential land use per watershed based on total area in each watershed

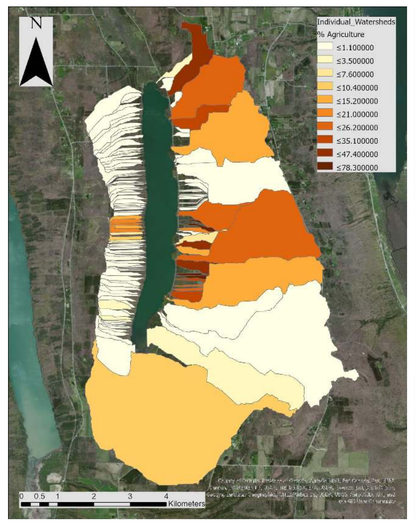

Figure 8. Percentage of agricultural land use per individual watershed based on area

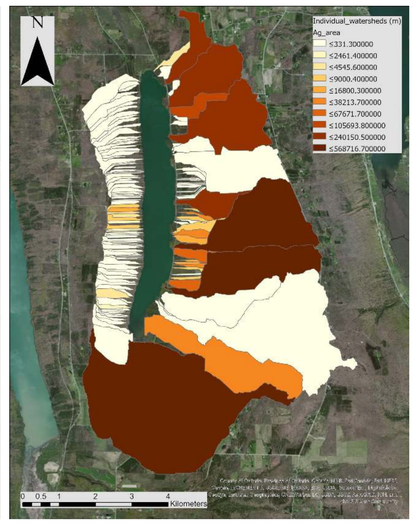

Figure 9. Agricultural land use per watershed based on total area in each watershed

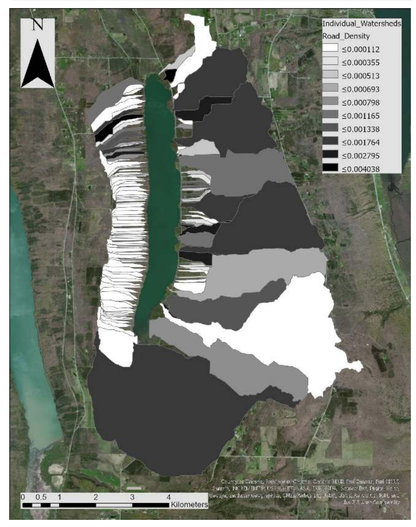

Figure 10. Road density per individual watershed based on area

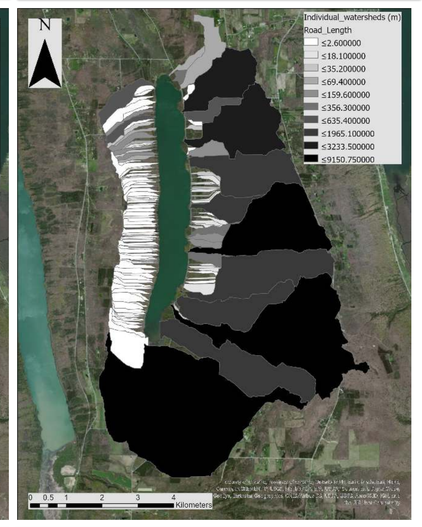

Figure 11. Road length per watershed based on total area in each watershed

Discussion

Initially there was concern of DEM error where watersheds follow a linear pattern. After investigation, roads and drainage ditches captured and altered watershed morphology. The watersheds come in contact with ditches, and are completely altered, and follow the trench until connected back to the lake with a slues pipe. This is an implication for negative human impact. The land use data is a proxy for watershed health; more human impact implies more detriment to lake health. The east side of the lake is most sensitive to human impact. The Northeastern area has high percentages of human impact per watershed, but the south east area has larger areas per watershed and therefore more contamination into the lake by area and should be studied further for soil and water quality.

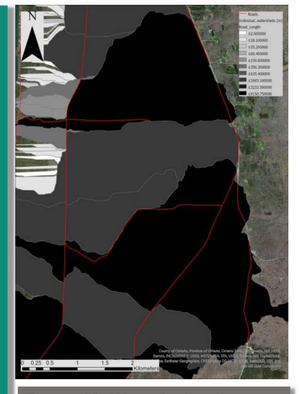

Figure 12. Watershed and streams captured by road and drainage ditches, alters the natural route of watershed and sediment supply into Canadice Lake.

References

Eckhardt, D., and Burke, S., 2000, Pesticide residues in Hemlock and Canadice Lakes and their tributaries in western New York, 1997–98: U.S. Geological Survey, doi: 10.3133/wri994271.

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