Impacts of rapid urbanization on eutrophication and water quality of a shallow kettle lake in southern Ontario (Lake Wilcox)

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Motivation and Objective

- Phosphorus (P) enrichment of freshwater aquatic ecosystems results in eutrophication, including the occurrence of harmful algae and hypoxia.
- Urbanization significantly alters P export to receiving water bodies.
- Predicting the magnitude and forms of P exported from urban areas is key to understanding how P loading deteriorate water quality in receiving waters.

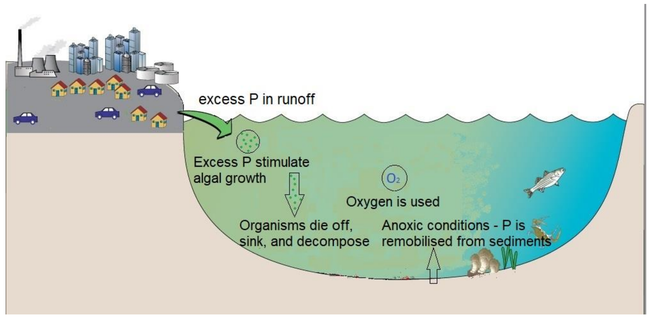

Figure 1.
Urban P enrichment impact on lakes (adapted from: recon.sccf.org)

- **Research Objective: d**etermine how urbanization of Lake Wilcox watershed has impacted the temporal trajectories of lake water quality parameters: dissolved oxygen (DO), total P (TP), dissolved inorganic P (DIP), and chlorophyll-a (chl-a).

Study site

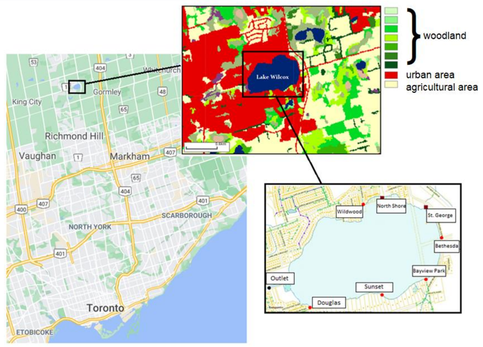

Figure 2. Map of Lake Wilcox showing the watershed land use/land cover and the six tributary inflow monitoring sites

- Lake Wilcox (LW) is a kettle lake in Richmond Hill, ON that frequently experiences cyanobacterial blooms.
- LW's watershed has become increasingly urbanized starting in the early 1900s, with the most intense phase of urbanization since the 1980s..

Methods

- ***Datasets:***
- TP and DIP concentrations and water flows for six inflow monitoring sites, bi-weekly or monthly from 2010 to 2018.
- Water column and sediment pore water DO, TP and DIP concentrations collected bi-weekly or monthly from 1995 to 2018.
- Sediment core geochemical analyses: 1 M HCl-extractable "Total P" extraction (after Aspila et al., 1976).
- Watershed impervious land cover data collected using topographic map, aerial photo and satellite image analysis.
- ***Data analyses:***
- Calculation of anoxic factor (AF) using DO data (method of Numberg, 1995).
- Statistical analyses: Correlation analysis among water quality variables, and linear regression models .

Results

- *Changes in land cover:*

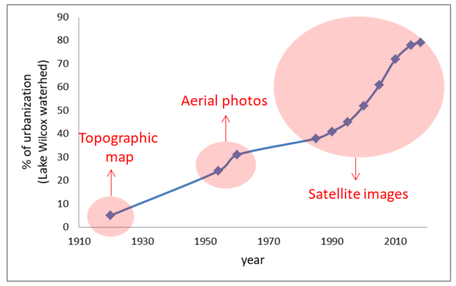

Figure 3. Changes in total impervious surface area of LW watershed.

- *Total P (TP) concentrations in LW sediment core show distinct increase in the past 10-20 years:*

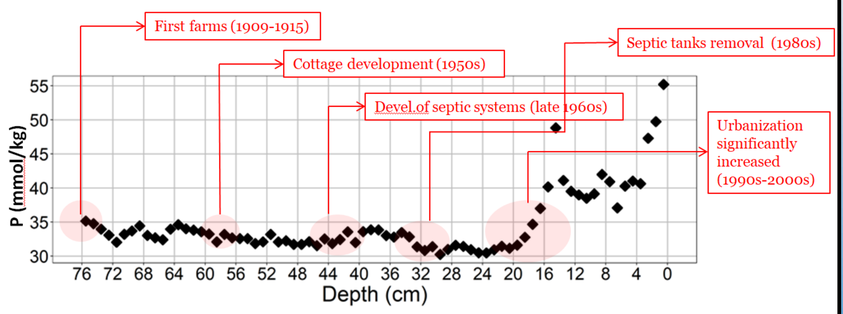

Figure 4. Concentration depth profile of TP in (dated) sediment core of LW.

Results

- *DO concentration in water column through the years:*

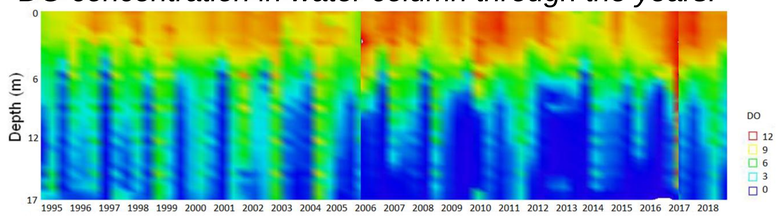

Figure 5. Heat map showing changes in water column DO as a function of depth and time.

- Period of anoxia increased from June-August to May-September/October after 2011.
- Average depth of anoxia is 6 m (4.8 m in extreme years such as 2008)
- *Correlation analysis*:

Correlation between variables, R	Inflow R	Urbanization R	DIP R
Inflow		0.801	
TP	0.812	0.744	0.891
Cyanobacteria	-0.619	0.732	-0.678
Chlorophyll	0.325	0.492	-0.688
Phytoplankton	0.497	0.711	-0.673

Conclusions & Perspectives

- Urban land cover in LW's watershed greatly expanded in the past 30 years, with major impacts on water quality.
- TP loadings increased during urbanization, as seen from the sediment record.
- Water quality degradation is manifested in decreasing water column DO concentrations and extending period of anoxia.
- Correlation analysis show significant relationship between urbanization and algal productivity.
- Climate change is also an important driver of changes in water quality parameters: → Next step: evaluate the relative contributions of climate change and urbanization to LW water quality changes

References & contact

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