Is Lake Champlain's Phosphorus Loading a Result of the Ever-Increasing Burlington Population?

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INTRODUCTION/BACKGROUND

Background:

- Clean water is of paramount importance for maintaining a diverse and healthy aquatic ecosystem. It allows for necessary ecosystem functions to follow through in their intended manner.
- A lake's cleanliness, for example, "is an expression of the character of its watershed and the activities taking place there" (Budd & Meals, 1998, p. 252).
- So, if a lake's watershed is prone to any source of pollution, the lake ultimately will face the repercussions of that pollution. Lake Champlain's watershed is riddled with phosphorus pollution that "[causes] algal blooms, [reduces] water clarity and [causes] rapid growth of other aquatic plants" (Hickey, Hoerr & Stickney, 2001, p. 218).
- Lake Champlain's watershed area to its surface area is 19:1. In other words, the area of water that flows into Lake Champlain is 19 times bigger than surface area of Lake Champlain itself. This calls for lots of land that could potentially contribute to phosphorus stormwater runoff. In the case of Lake Champlain's watershed, phosphorus is disproportionally entering the lake from urban land uses compared to other land uses (Hickey, Hoerr & Stickney, 2001).

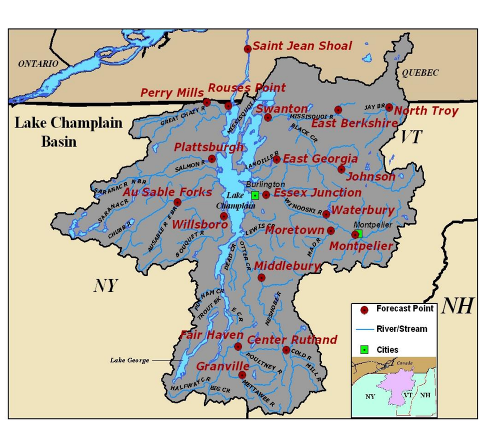
Major Problem #1

- Phosphorus runoff disproportionally comes from urban areas in the Lake Champlain drainage basin. 5% of the watershed is covered by urban areas but contributes a whopping 37% of the non-point source phosphorus pollution for the entire watershed. In fact, urban non-point source phosphorus pollution accounts for almost half of the total non-point source phosphorus pollution in Lake Champlain. (Hickey, Hoerr & Stickney, 2001).
- A city like Burlington, where it is highly populated and urbanized, is a hotspot for urban non-point source phosphorus runoff. This is due to Vermont's end of the watershed having more shoreline, more intensive land use, and a large, growing population (Bowden, 2016, p. 512).

Major Problem #2

- Despite the efforts to control the phosphorus runoff from entering Lake Champlain, it is harder to control the fact that "urban land in the basin is projected to increase steadily in the next 20 years" (Hickey, Hoerr & Stickney, 2001, p. 219).
- Since this urbanization will come to cities like Burlington, it will allow the city to support a larger population. Therefore, the projected growing human population in Burlington will only "increase 'urban' non-point source pollution from construction of future residential areas and associated development" (Hickey, Hoerr & Stickney, 2001, p. 219).

Polluted Watershed



→ Algal Blooms

Figure 1. Lake Champlain's water quality is a representation of the type of water that flows into the lake from its surrounding watershed. I depict in this figure, not only the size of the watershed, but if the water in the watershed is filled with pollutants, it will deteriorate the water quality in Lake Champlain. Of the types of pollutants in the Lake Champlain watershed, phosphorus is by far the most abundant and is creating a problem in Lake Champlain where excessive phosphorus loading is creating seasonal algal blooms. Photos from the National Weather Service (no author) and Ry Rivard from the Times Union.

METHODS

Experimental Design:

- I am conducting a meta-analysis because the ecological question I am putting forth is best answered by inspecting data that has previously been published on these topics.
- My independent variable is population growth, and my dependent variables are total phosphorus concentration (mg/g) and phosphorus accumulation rate ($g/m^2/y$).
- To test a relationship between these variables, I must gather time series data that analyzes phosphorus accumulation in Lake Champlain and population growth in Burlington, Vermont. Consistent with a meta-analysis, I will then regress the increasing Burlington population over the amount of phosphorus found in Lake Champlain.
- There would need to be two separate regression tests done since phosphorus, in the study I used, was measured in two different ways. One regression test would have total phosphorus concentration (mg/g) as the dependent variable and population growth as the independent variable. The second regression test would have phosphorus accumulation rate (in $g/m^2/y$) as the dependent variable and population growth, again, as the independent variable.
- If there is a significant relationship, then I can conclude that Burlington's increasing population is a key contributor to phosphorus accumulation in Lake Champlain.
- Below are desirable datasets necessary for the conduction of my analysis.

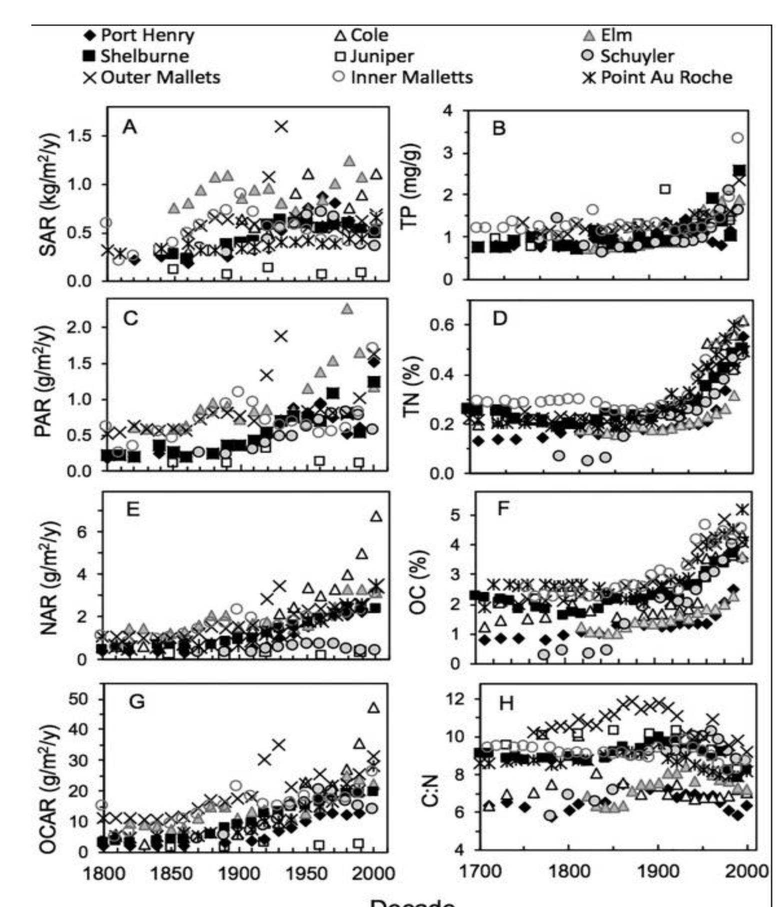


Fig. 3. The left-hand photo shows eight different graphs, each looking at a different nutrient and its abundancy in Lake Champlain. The graphs on the left-hand side range from 1800-2000 while the graphs on the right-hand side range from 1700-2000. This data was received from sediment cores in 9 different locations in Lake Champlain: Port Henry, Shelburne, Outer Mallets, Cole, Juniper, Inner Malletts, Elm, Schuyler, and Point Au Roche. Since my study is only interested in phosphorus, graphs B and C are the focus. In graph B, TP (mg/g), on the y-axis, stands for total phosphorus accumulation. In graph C, PAR ($g/m^2/y$), on the y-axis, stands for phosphorus accumulation rate. Photo from Volume 44 from the Journal of Great Lakes Research.

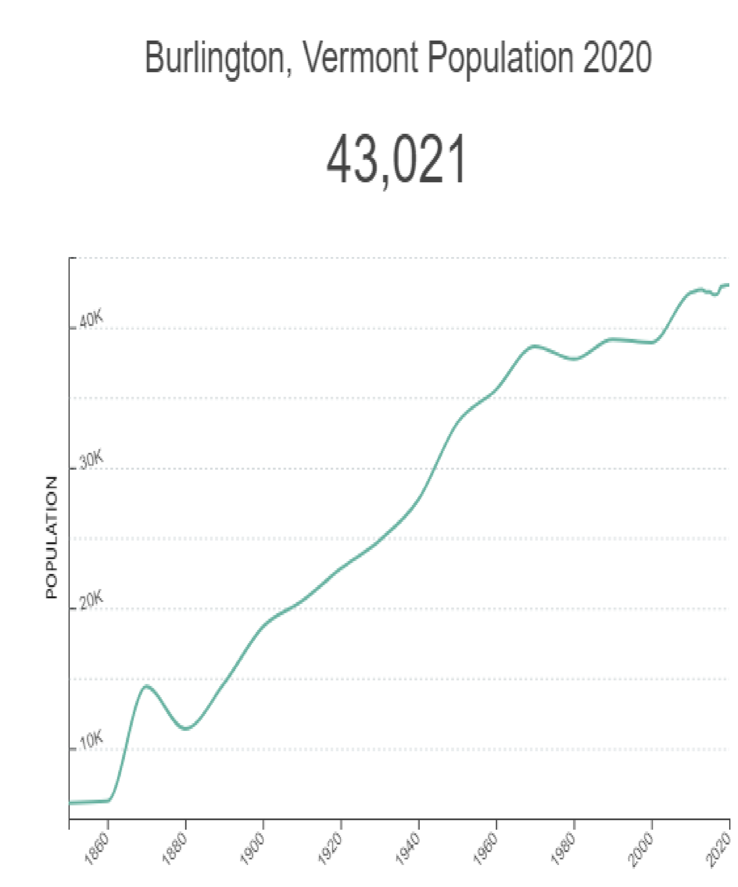


Fig. 4. The right-hand photo shows the population growth in Burlington, Vermont. It encapsulates the population of Burlington from 1860-2020. Photo from World Population Review (no author).

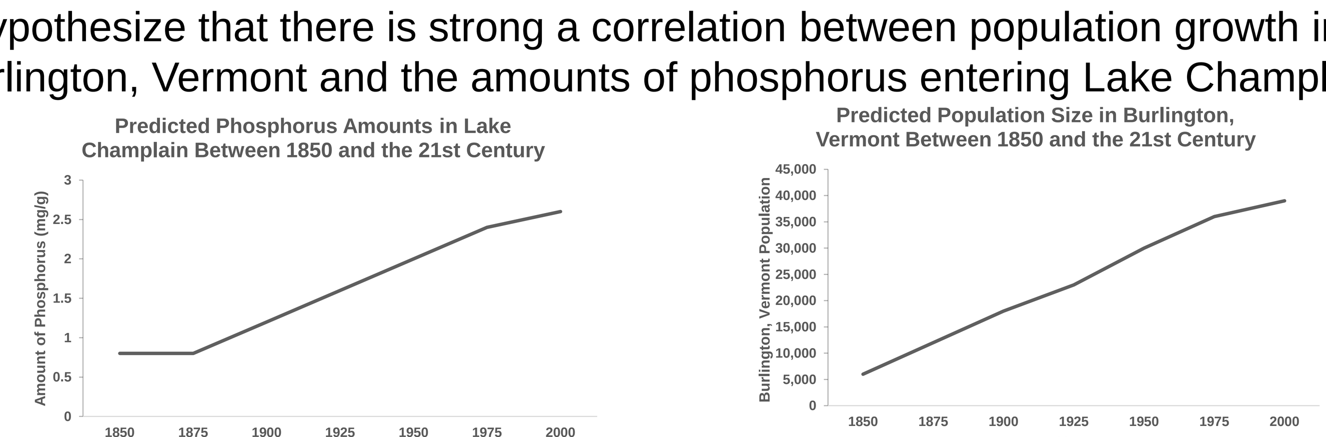
OBJECTIVES

Motivation:

- Over the past two centuries, Lake Champlain has been subject to anthropogenic influences that have changed the physical and chemical makeup of the lake. The rapid increase in the human population of the area surrounding the lake has been found to have a significantly deleterious impact the watershed (Facey et al., 2012).
- This study examines whether the increasing human population in Burlington is causally related to the increasing phosphorus loading observed in Lake Champlain.

Hypotheses / Predictions:

- I hypothesize that there is strong a correlation between population growth in Burlington, Vermont and the amounts of phosphorus entering Lake Champlain.



- I predict that the amount of phosphorus found in Lake Champlain, measured in mg/g, is significantly positively correlated to the population growth of Burlington, Vermont (Figure 2).

Fig. 2 My predictions between the population in Burlington, Vermont and the amount of phosphorus found in Lake Champlain, measured in mg/g, between the year 1850 and the beginning of the 21st century.

INTENDED ANALYSIS

- This design will reveal any significant relationships between the amount of phosphorus in Lake Champlain and the population in Burlington. Based on my prediction, I would expect a regression analysis indicating a significant positive correlation between increasing phosphorus levels in Lake Champlain and population growth in Burlington. This relationship would look like the graph(s) below:

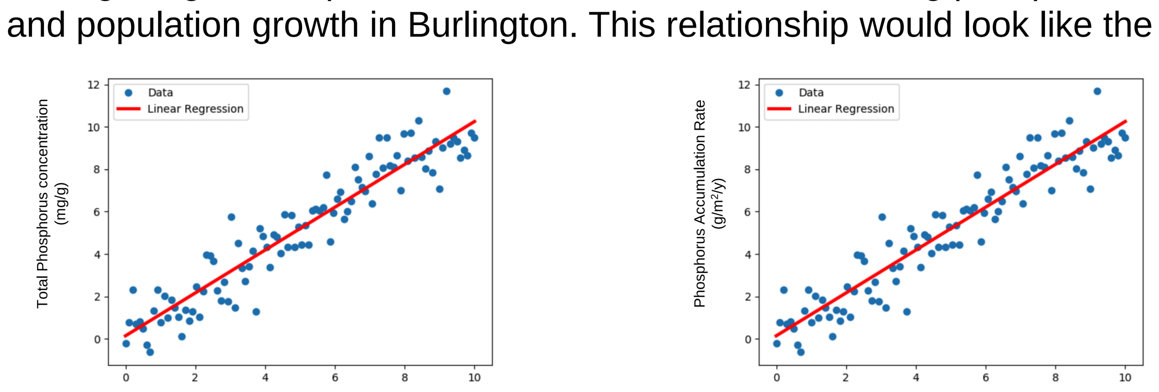


Fig. 5. The left-hand graph shows the hypothetical relationship if I regressed population growth over total phosphorus concentration. The right-hand graph shows the hypothetical relationship if I regressed population growth over phosphorus accumulation rate. Graph from Research Gate by Hieu Tran.

- Testing both dependent variables and regressing the independent variable on both dependent variables, respectively, would allow correlations to be made between phosphorus loading in Lake Champlain and the population growth of Burlington, Vermont. If the correlation is significant, then the amount of phosphorus loading in Lake Champlain is a result of the population growth in Burlington, Vermont.
- Even if I found a significant relationship between the study's variables, there still are sources of bias to consider
- Population growth may not be the best metric to explain the increase in phosphorus accumulation. Farming and agriculture is also a large source of phosphorus runoff into Lake Champlain, as it accounts for "66% of non-point source phosphorus pollution" (Hickey, Hoerr & Stickney, 2001, p. 219). My study does not consider this huge source of phosphorus accumulation.
- However, such a small portion of the watershed, urban areas, is responsible for almost a third of the phosphorus runoff. Moreover, Burlington is the most populated urban area in the watershed. With immense population growth over 19th, 20th, and 21st century, it poses as an ideal location to test whether an increasing population is significantly correlated to phosphorus accumulation in Lake Champlain.
- Although Burlington is the most densely populated and urbanized city in the Lake Champlain watershed, it still would not account for all the phosphorus runoff that is dependent on population growth in neighboring areas. There are other highly populated cities in the Lake Champlain watershed that contribute to phosphorus runoff, but since Burlington is the densest and likely contributes more phosphorus runoff, given such a relationship exists, than any city in the watershed, it was an ideal city to base my research question around.

WORKS CITED

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