A Comparative Study of Freshwater Mussels in Burt Lake Canal: related to Land Use and Nutrient Input

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Abstract

Years of herbicide and fertilizer use by residents in the Burt Lake Canal has led other home owners on Burt Lake to wonder the implications of this use on the ecosystem of the lake. The purpose of this project is to examine the ecosystem of the canal and see how the canal differs from the lake and if and how the canal ecosystem disperses into the lake. The Burt Lake Canal was built in the 1960's as a way to increase home values by allowing water access. Past residents of the canal have used copper sulfates as a way of regulating plant growth but have since switched to spraying herbicides. There is also a large amount of run-off from fertilizer use and drainage pipes from nearby roads. Mussels were surveyed for as a bioindicator of canal health. Nutrients, temperature, pH, and dissolved oxygen were all tested for to see how the canal ecosystem meets the niche of these unionids. Several species of freshwater mussels, *Dreissena polymorpha, Ligunia nasuta,* and *Pyganodon grandis* were found within the canal. *D. polymorpha* was the only specie found outside of the canal. Nutrient concentrations and the diversity of mussel species suggest that the canal has a diverse specialized environment that does not impact the rest of the lake.

Introduction

The Burt Lake canal is a place of debate among lakeside residents. The Burt Lake canal was built as a way to increase property values in the 1960's by adding more housing with lake access. The houses along the canal frequently use both lawn fertilizers for aesthetics and herbicides to clear aquatic plants to allow boat passage. The canal also has drainage pipes from nearby roads and farms. Other lake users worry about the impacts from these inputs on organisms in both the canal and the remainder of the lake.

Herbicide and lawn fertilizer use leads to an increase of nutrient levels, especially of nitrogen and phosphorous. The goal of herbicide use is to remove plants in the canal. Less plant life would result in less nitrogen and phosphorous uptake, in addition to the decomposition of the dying plant matter releasing nutrients. The use of lawn fertilizers and input from drainage pipes also adds nitrogen and phosphorous to the system. The end result of the increase in nutrient concentrations from both the pulse of herbicides and the press of fertilizers and road drainage is decreased oxygen in a system and the system eventually turning anoxic. When a large amount of plant death occurs, there is a substantial increase in plant matter to be broken down. There are not sufficient decomposers to take up the nutrients and recycle them, which leads to an additional increase in nitrogen and phosphorous. This in turn leads to an increase in primary productivity, there are also not sufficient predators to maintain primary production levels and more die off occurs and is deposited at the bottom of the canal. Another result of increased nutrients is a change in algal cell composition. This change in composition can change the composition of organisms that exist.

Mussels can serve as an important bioindicator of the health of an ecosystem. As filter feeders, mussels filter primary productivity, sediment, organic matter, phytopankton, and bacteria out of the water column (Grabarkiewicz and Davis, 2008). Mussel populations are influenced by the temperature, the pH, food, space, dissolved oxygen, and substrate (Jones and Narimatsu, 2000).

Since the introduction of *Dreissena polymorpha*, freshwater mussel populations have decreased substantially (Cosewic 2007). This is due to competition for space and resources and *D. polymorpha* being able to attach to other mussels and essentially suffocating them. Unionids generally prefer areas with a fine sand or muddy substrate and thrive in areas of slack water (Cosewic 2007). This niche may be slightly different than that of *D. polymorpha* due to the fact that *D. polymorpha* needs current to move disperse its eggs for reproduction. Mussels are affected by dissolved oxygen levels and will not survive well with low levels of dissolve oxygen (Grabarkiewicz and Davis, 2008). This is likely due to the fact that low levels of dissolved oxygen will result in low levels of primary production, which would reduce food supply for unionids.

The purpose of this paper is to examine how the use of herbicides and fertilizers impacts the ecosystem of the Burt Lake Canal, especially focusing on how unionid species diversity is impacted. Land use and nutrients levels along the canal were compared to see if the ecosystem within the canal is different from the lake and how that difference impacts the lake.

Methods

In order to survey for mussels present in the canal on Burt Lake, samples were taken in six designated sections moving from the end of the canal to where the canal meets open water. In each section, one transect of $1m^2$, along the edge of the canal, was surveyed by one individual for 15 minutes. Mussels were searched for by sight and touch (Crail, Krebs, and Zanatta, 2011). The found mussels were counted, identified, photographed, measured, and returned to their original location.

In order to compare the canal mussel diversity with the rest of the lake, sites along the shoreline of Burt Lake were surveyed. Surveys were taken two sites at Carp Creek, one site in Maple Bay, and one site on Maple River. Carp Creek has a large amount of groundwater input; the surrounding water is very cold. The substrate is sandy to marl. Wave action is high during the day. Maple Bay had a muddy substrate with lots of vegetation and minimal water movement or wave action. Maple River had a sandy bottom with a large amount of flow. The sites on either side of the canal were surveyed 10 and 20 meters away from the canal entrance; this area has a sandy substrate and receives large amounts of wave action. Random sites were chosen within Carp Creek, Maple Bay, and the Maple River. The surveys were taken at a depth of less than 1.5 meters and used sight and touch. The same processing was used for the mussels.

To better our understanding of how the canal ecosystem serves the mussels niche, samples were taken concerning pH (units), dissolved oxygen (mg/L), temperature (℃), and specific conductivity (mS/cm) using a hydrolab. These samples were taken at ten sites within the canal and two in open water in Burt Lake.

Nutrient samples were taken at the same ten sites within the canal, two open water sites, the four sites on either side of Burt Lake Canal, the two sites at Carp Creek, and the sites within Maple Bay and Maple River. Total phosphorous, total nitrogen, silica, nitrate, ammonia, and phosphate were all measured.

A land use survey was also conducted to see how different land uses along the canal influenced both mussel diversity and nutrient levels. This was compared to land use at the sites on either side of the canal, in open water, at Carp Creek, and at Maple Bay.

Results

A total of 879 *D. polymorpha* were found in the canal, 855 of which were found in the site closest to the opening of the canal, where exchange between the canal and the lake occurred. Twenty one *Ligumia nasuta* were found within the canal, but not within any of the other sights surveyed. *Pyganodon grandis* were also found within the canal. Site 6 had the greatest diversity of native freshwater mussels. *D. polymorpha* were found twenty meters from the canal on either side. Only three *D. polymorpha* were found in Carp Creek. No mussels were found in Maple Bay. Two freshwater clams were found in Maple River.

Nutrient level samples revealed that nitrogen levels were very low. The ratio of phosphorous to nitrogen decreased approaching the open waters of Burt Lake (Fig. 1). At site 6 there is a drastic increase in phosphorous, the concentrations increases from 33.5 ug P/L to 42.1 ug P/L. This is also the site with lower nitrogen, a concentration of .451 mg N/L. Phosphorous levels were considerably lower at sites 9 and 10, dropping to 16.7 ug P/L at site 9 and 4.9 ug P/L at site 10. These phosphorous levels are more similar to the levels at the other sites surveyed within the lake, which range from 2.0 to 6.5 ug P/L. Nitrogen levels were also lower at the other sites surveyed ranging from .162 to .505 mg N/L.

The dissolved oxygen (mg/L) levels did not exhibit a particular trend, but did seem to increase with depth (Fig. 2). The dissolved oxygen levels ranged between 4.31 mg/L and 7.68 mg/L between sites 1 through 8. In sites 9 and 10 the dissolved oxygen was elevated at 5.85 to 9.35 mg/L.

The pH levels were relatively high, mostly remaining near 9. There was a spike in pH at Site 5, of 9.91. This is also approaching the site with the highest phosphorous concentration as well as the highest mussel diversity (Fig. 2).

<u>Discussion</u>

Two species of native unionid mussels were found in the Burt Lake Canal: *Ligunia nasuta* (commonly known as the Eastern pondmussel) and *Pyganodon grandis* (Giant Floater). *Dreissena polymorpha* (Zebra mussel) was also found. It is interesting that *L. nasuta* is more frequent within the canal, while *D. polymorpha* numbers are increasingly frequent moving towards the lake side of the canal. This suggests that there is something about the canal that is conducive to *L. nasuta* and other unionids, but not *D. polymorpha.* This also suggests that the environment in the canal is different than the lake but becomes increasingly similar and more influenced by the lake around the bend of the canal.

It is also interesting to note the corresponding spike in phosphorous levels, and mussel diversity found in Site 6. Dissolved oxygen and pH were also slightly higher. This may be linked to the land use. Along site 6 there is no seawall which means there is increased erosion into the canal. The land use of site 6 is a residential building that uses gravel and rock ground work. This suggests that the reason phosphorous is elevated is due to increased run off from the gravel.

Generally, *L. nasuta* is found in sheltered areas of lakes, and areas with slow water movement, which can include rivers and lakes (Cosewic 2007). *L. nasuta* is primarily found in fine sand and mud in less than a meter of water. *L. nasuta* population size has vastly decreased with the addition of zebra mussels into the ecosystem, due to competition for space and resources (Cosewic 2007, Holland et al., 1995). *P. grandis* also prefers areas with slow moving currents. *P. grandis* are able to tolerate many substrates, and can live in mud, gravel, or sand but avoid areas with sand movement. *P. grandis* are very tolerant mussels. Living in a wide variety of conditions, *P. grandis* will not be easily impacted by different substrates or human activity (Cosewic 2007).

D. polymorpha is an invasive species which has appeared in many lakes in Northern Michigan. *D. polymorpha* generally lives in areas with some current, because it disperses it's larvae into the water column to be moved to their new residence. *D. polymorpha* is known for adding to the eutrophication of lakes by filtering out of the water column, allowing for more light penetration to the benthic areas of the lake; as well as expelling large amounts of nitrogen and phosphorous through feces (Holland et al., 1995). The low water movement in the canal may be protecting both *L. nasuta* and *P. grandis* from competition with *D. polymorpha* by isolating *D. polymoprha* larvae.

Unionid mussels are characterized by a special parasitic larval phase that involves attachment of the larval to a host fish species where the larvae live and encyst until they are rereleased into the sediment to form a shell (Corey et al., 2006). This discovery of mussels also indicates that there are fish living in the canal to serve as carriers for the larvae.

Although most unionids prefer areas of slack water, it has been shown that channelization events have been destructive to mussel communities (Cosewic, 2007; Grabarkiewicz and Davis, 2008). More research will need to be conducted, especially over mussel generations to see how the community is impacted. Copper exposure from the sediment can also result in DNA strand breakage; sediment needs to be tested to compare copper levels with mussel diversity (Grabarkiewicz and Davis, 2008).

Limitations to this study stem from the inability to locate and identify all mussels within the canal. The water visibility in the canal is very bad, so it is difficult to locate mussels in areas too deep to reach from the surface. Most mussels are buried under sedimentation, so it is possible that they were not located within the quadrant.

Within the canal, a gradient of nutrient concentration and productivity occurs moving towards from the end to the corner of the canal. Figure 3 and Figure 4 demonstrate an increase in pH, dissovled oxygen, and zebra mussels as the lake is approached. Levels of phosphorous decrease and levels of nitrogen remain essentially the same. This is likely due to the dispersal of nutrients into the lake by flow. In all of these data, sites 9 and 10 show the most extreme differences due to the increased flow and influence of the lake. The environment created in sites 9 and 10 either no longer meets the niche of *L. nasuta* or *P. grandis* or better meets the niche of *D. polymorpha* allowing it to outcompete the native unionids.

The lack of water movement within the canal causes the ecosystem to be very different than the lake. Given the found mussels and the nutrient and land use data it can be inferred that the canal ecosystem is very productive. The data also suggest that the majority of the canal (sites 1 through 8) does not influence the lake. The canal ecosystem is stagnant and is contained within itself until passing the corner.

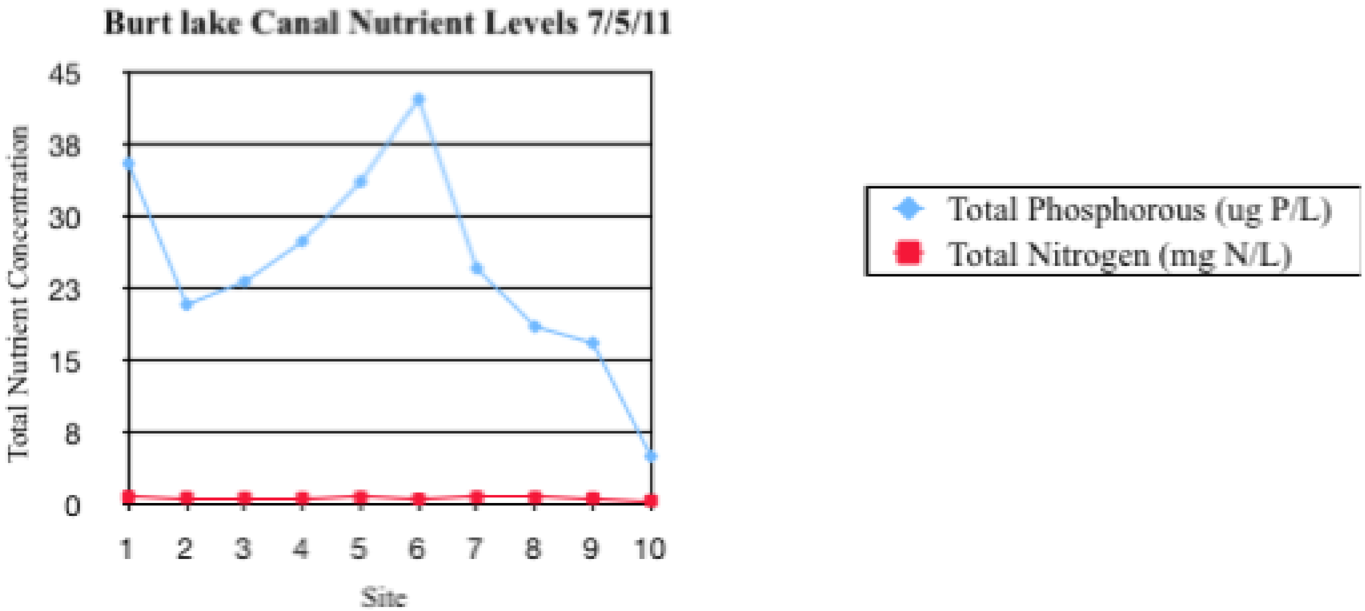

Figure 1. Nutrient concentrations of nitrogen and phosphorous in the Burt lake canal. Nitrogen levels are low and relatively constant compared to phosphorous which varies greatly, decreasing towards Burt Lake.

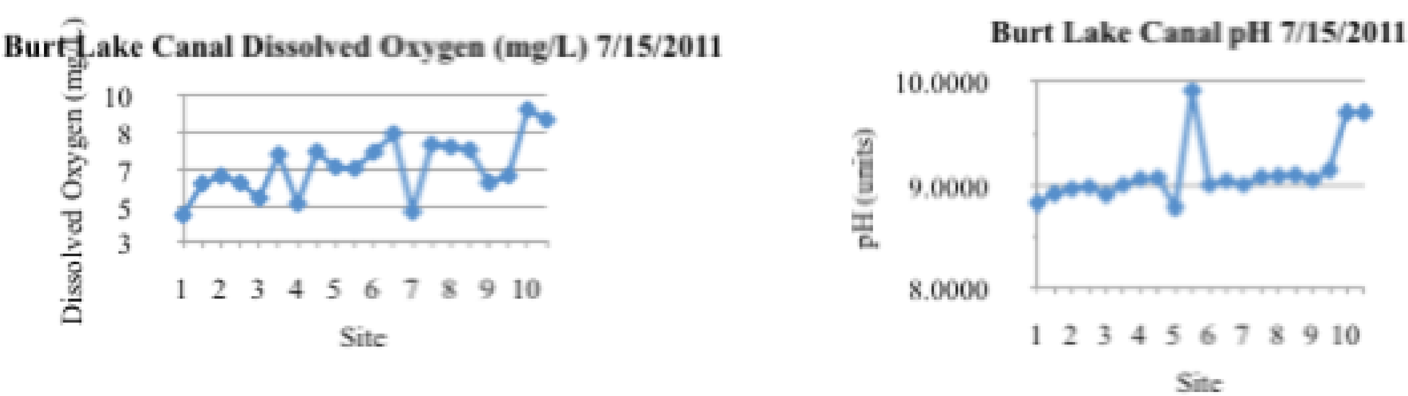

Figure 2. Levels of pH and dissolved oxygen recorded in the Burt lake canal moving from the end of the canal to open water; pH levels are highest at site 6.

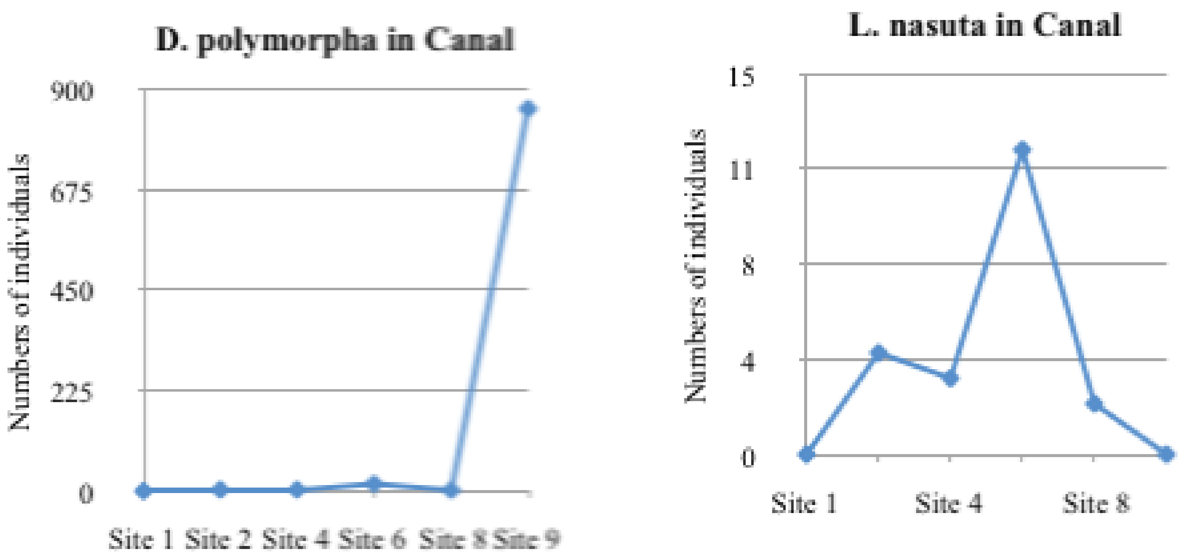

Figure 3. Numbers of *D. polymorpha* and *L. nasuta* found in canal at six different sites moving from the end of the canal to open water. *L. nasuta* is found in higher numbers towards the end of the canal. *D. polymorpha* is more abundant closer to Burt Lake.

Appendix A

Figure 1. Total numbers and species names of mussels found in the Burt lake canal.

Burt Lake Mussel Survey	*D. polymorpha*	*L. nasuta*	*P. grandis*	Freshwater clam
Right Side of Canal				
10 m	-	-	-	-
20 m	47	-	-	-
Left Side of Canal				
10 m	-	-	-	-
20 m	622	-	-	-
In Canal				
Site 1	-	-	-	-
Site 2	3	4	-	-
Site 4	3	3	-	-
Site 6	16	12	2	-
Site 8	2	2	-	-
Site 9	855	-	-	-
Total Canal	879	21	2	-
Carp Creek				
Site 1	-	-	-	-
Site 2	3	-	-	-
Total	3	-	-	-
Maple River Bay				
Site 1 - on Bay	-	-	-	-
Site 2 - on River	-	-	-	2
Total - All	1551	21	2	2

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