Effects of beaver (Castor canadensis) lodges on fish populations

BIOS 35502: Practicum in Environmental Field Biology

Amy G. Smith

Advisor: Dr. Todd Crowl

Abstract

Preserving natural biodiversity is critical to preserving ecosystems; the loss of one species can start a domino effect that leads to the destruction of that system. This is the case for the American beaver, (*Castor canadensis*), which was nearly driven to extinction in the early 1900s. In their ecosystems, they build dams and lodges that create open water, structure for the littoral zone, increased fish and riparian vegetation, providing habitat for larval fish, river otters, and other aquatic organisms. In this study, I sampled the fish populations around four beaver lodges on the University of Notre Dame Environmental Research Center property to see how the beaver lodges would affect the local fish populations. Though there were trends in the data, the beaver lodges had no significant effect on the fish populations. Future research should be carried out over a longer period of time to gain a better understanding of the dynamics between the fish and lodges.

Introduction

Introducing new individuals into ecosystems will always create some amount of change. In every ecosystem, there is a network of organisms all doing their part. If a species is removed from this web, the balance can be disrupted; the more pieces of the ecosystem that are removed, the weaker the system becomes until it may one day collapse (Austin Water, 2013). Whenever an organism is lost from the food web or reintroduced, effects are felt throughout the ecosystem (Beschata et al. 2006). This same effect can be seen in the case of the American beaver, (*Castor* canadensis). After nearly going extinct due to fur trading in the early 20^{th} century, their population has begun to recover (Gibson et al. 2014). Their recovery has proven to be beneficial to many ecosystems, as they improve fish populations and riparian zones. The American Beaver (*Castor canadensis*) is found throughout North America inhabiting freshwater streams, marshes, lakes, and bogs. They often build a dam across a waterway, creating an area of deep, low-flow open water where they can build the lodges in which they dwell. These beavers prefer to build their lodges in areas with high vegetation richness, large amounts of open water, deciduous swamplands, and fens that are nutrient-rich (Mumma et al., 2018). Beavers are often seen as a nuisance as their dams can cause flooding and reduce the amount of water going to farmers downstream. As they cut down trees for their lodges and dams, *C. canadensis* can cause serious damage to lumber and agricultural businesses, even up to $2.5 million worth of losses (Shwiff et al. 2011). As they build, the beavers can flood large areas, causing plants to rot or become diseased and destroying hectares of lumber and crops (Shwiff et al. 2011). However, the beaver is actually a very helpful environmental engineer; through the slowing of water flow, beavers can improve habitat for the local flora and fauna.

By slowing flow and impounding water, beaver dams can increase pool habitat for fish by fourfold and provide juvenile chinook salmon (*Oncorhynchus tshawytscha*) three times as much area in shrub zone channels (Hood 2012). Riparian sites with beaver dams had a 33% increase in the number of herbaceous plant species compared to those without any history of beaver activity (Wright et al. 2002). In Washington, Oregon, Utah, and other western states, beavers are often relocated to the headwaters of rivers to restore the river systems (Le 2014). Similarly, engineers build Beaver Dam Analogues to replicate the effects beaver dams have on rivers and improve habitats in these the riparian areas and streams (Lautz et al 2019).

Beaver lodges are also environmentally and economically beneficial. Fish fry, such as chinook salmon, use beaver lodges and similar debris as cover from predators; the addition of structures like beaver lodges in the Nechako River showed chinook fry dwelling most densely around the in-stream cover (Goldburg 1995). With increased habitat for young salmon, more salmon can survive to adulthood, and seafood companies can benefit from the increase in fish. Additionally, beaver lodges allow woody debris and sediment to accumulate, giving the littoral zones of lakes a new structure and providing important resources for communities of littoral species (France 1997). They also provide the open water and riparian vegetation that river otters prefer in their habitats, giving these otters a spot in their ecosystem (LeBlanc et al. 2007). Beavers can be managed in many ways. In Wisconsin, the DNR manages the *C. canadensis* populations by allowing trapping during appropriate seasons, educate the public on how to live with beavers peacefully, give landowners options for safely removing beavers, and using barriers to discourage beavers from gnawing trees and colonizing (Wisconsin DNR). One location with a unique beaver management strategy is the University of Notre Dame Environmental Research Center (UNDERC) on the Wisconsin/Michigan border. There are over 25 lakes and 6 bogs documented, plus additional unmarked ponds and vernal pools throughout property, providing the local *Castor canadensis* with plenty of space to build their lodges and dams. Because of the damages the beavers end up creating when damming the culverts, the maintenance often must trap and kill beavers, resulting in very few dams and lodges around. Since this property is used for research, I believe it would be worthwhile to focus on the benefits that beavers bring.

Given that beavers prefer building their lodges in nutrient-rich areas and provide structures that are beneficial to many fish species, I began to wonder just how beaver lodges would affect the fish species present at the University of Notre Dame Environmental Research Center (UNDERC) in Michigan. There has not yet been research on the beavers present at UNDERC, and without knowledge of the benefits they may bring, there is only one management strategy for dealing with beavers here; if the beavers cause a flood, they are trapped and killed. Given the data found by previous studies, I hypothesized that areas closest to beaver lodges would have a higher number of fishes, and that there would be more species richness around lodges.

Materials and Methods

I sampled at four sites, two of which were in ponds (North Gate and North Pond) and two of which were on streams (Brown Creek and South Gate), at the University of Notre Dame Environmental Research Center (UNDERC) property (see Figure 1). UNDERC encompasses about 3035 hectares of land on the border of Wisconsin and Michigan's Upper Peninsula (46° 13' N, 89° 32' W). In recent years, over 60 beavers were known to inhabit UNDERC property (G. Belovsky, pers. communication), but the population has not been surveyed recently. I selected four currently active beaver sites, two in ponds and two in streams.

At the North Gate site, I sampled for five days using nine minnow traps for the treatment and control. Around the lodge, I set up three, six-meter transects radiating out from the lodge with roughly 120 degrees between each. Along these transects, I set a minnow trap at 2 meters, 4 meters, and 6 meters away from the lodge. Each trap was emptied after 24 hours and after recording the contents, the organisms released. This was repeated for the control, except that transects radiated from the water's edge. Each was sampled a minimum of three days. At the North Pond site, this sampling technique was repeated using two 6-meter transects because of the natural topography. This technique was also used at the Brown Creek site, with one transect angling from the lodge upstream and one from the lodge downstream. For the controls, I set up two sets of traps upstream of the lodge. I repeated this at the South gate site, angling one treatment upstream and one treatment downstream. The control traps were placed upstream of the lodge.

For all four sites, I used a YSI 55 Dissolved Oxygen Meter (Yellow Springs Instruments, Yellow Springs, OH, USA) to measure the dissolved oxygen levels and temperature along a 15 meter transect. For the treatment, the DO and temperature were measured on this transect at 0 meters, 5 meters, 10 meters, and 15 meters from the lodge. If there was not enough room for 15 meters, the transect and measurements stopped at 10 meters. For the control, this was repeated away from the lodge, parallel to the treatment transect. Both the treatment transect and control transect were measured the same day with the same angle and length. All DO levels and temperatures were recorded.

At the Brown Creek and the South Gate sites, I used a JDC FLOWatch flowmeter (JDC Instruments, Yverdon-les-Bains, Switzerland) to measure the flow rate along the same 15-meter transect as before, measuring the flow at 0 meters, 5 meters, 10 meters, and 15 meters. The flow was measured 15 cm below the water's surface and recorded to the nearest tenth.

I also recorded the sediment and vegetation coverage at the 0, 5, 10, and 15-meter marks on the transects. The coverage was measured in an area of one square foot at each mark.

For my data analysis, I identified the species of fish and recorded the total number for each species found at each trap. The numbers were totaled for the controls and treatments of my sites, then divided by the number of days I trapped. I calculated the species richness using the following equation:

$$richness = \frac{\#\ species\ in\ sample}{\sqrt{total\ \#\ of\ species}}$$

The species richness was graphed to show the trends in species richness between sites. Statistics were done using R (R 3.6.1). I ran the richness for the controls (far from the lodge) and the treatments (near the lodge) at each site through a paired t-test to find its significance. To test the differences between sites, I used *Umbra limi*, which was found at all four sites. I subtracted the average number of *Umbra limi* found on the control transect from the average found near the lodge, transformed that data, and used a Shapiro-Wilks test to confirm that it was normal. After joining the data of the creek sites (Brown Creek, South Gate) and the pond sites (North Gate, North Pond), I ran an ANOVA. I ran a t-test on the average level of dissolved oxygen at each site as well.

Results

When the species richness data was graphed, the data suggested that species richness in the pond sites was less by the lodges and greater further away from the lodges, while the richness in the creek sites was greatest near the lodges and least upstream of the lodge (Figure 1). Despite this seemingly clear trend in the data, there was no significant difference between the richness near or far from the lodges ($t = 0.39083$, $p = 0.722$, df=3; Figure 2). There was no significant difference between the number of fishes caught at each site ($t = -1.4495$, $p = 0.2431$, df=3; Figure 3). There was also no significant difference between the data near and far from lodges with respect to the presence of mud minnows (*Umbra limi*) at each site ($t = -0.75505$, $p = 0.5051$, df = 3; Figure 4). There was no significant difference between the dissolved oxygen levels near lodges as opposed to far from lodges ($t = -1.6257$, $p = 0.2025$, df = 3, Figure 5).

Discussion

My experimental results were not significant, but did show a trend between the species richness and the presence of a beaver lodge. It appears that the species richness is greater closer to lodges in ponds, and in creeks, the richness is lower near lodges and higher upstream. However, the results of the paired t-test proved that there was no significant difference between the species richness near lodges versus far away from lodges. There could be several explanations for this, the first of which being the habitat conditions. At the pond sites, the dissolved oxygen was highest near the lodges and lower away from the lodges. There was also a lot less vegetation near the lodges and most of the sediment was silt. In the creek sites, the dissolved oxygen was relatively high near the lodges and lower further from the lodges. There was also a greater amount of course, woody debris around the lodges than elsewhere. The average level of dissolved oxygen was drastically different between the creek and pond sites, but there was no significant difference between the dissolved oxygen levels near the lodges as opposed to far from the lodges. This lack of oxygen at the pond sites may have only allowed fish with a tolerance for low oxygen levels, such as the central mudminnow, *Umbra limi* (Growe-Raney 2011), the black catfish, *Ameiurus melas* (Rose 2006), and creek chub, *Semotilus atromaculatus* (Anderson 2104), and may have led to lower species richness.

Additionally, there was no significant difference between the number of fishes found near lodges versus those found far from lodges. There were, however, a larger number of fishes caught in ponds as opposed to creeks. This may be because the most caught species, the central mudminnow, (*Umbra limi*), is well adapted to areas with low dissolved oxygen levels, allowing them to flourish in the ponds with very little competition.

Lastly, when comparing the average number of mudminnows caught near lodges versus far from lodges at each site, there was no significant difference between areas near lodges and those far from lodges. Again, there was a higher number of mudminnows in the ponds than in the creeks, which can be explained by the abundance of competitors in creeks versus lakes.

There is a lot of room for this research to grow. I believe my results would have been more significant if I had trapped for more days. I also mistakenly put out more control traps than treatment traps at my Brown Creek site, forcing me to drop data in the end. On more than one occasion, the resident beavers at my North Pond site stole one of my traps, leaving me missing data for that trapping section. There was also a mix up with the propeller used to measure the water flow. However, the flow was checked using the correct piece and the flows were the same. At the creek sites, there was an abundance of invasive Chinese Mystery snails (*Cipangopaludina chinensis*), which may have altered the microbial communities (Olden et al. 2013) and by extension affected the resident fish populations. The weather during my last week of sampling included several days of severe thunderstorms, which may have changed the fishes' behavior, resulting in less fishes caught those days. In the future, more time should be allotted, as well as correct use of equipment and proper markings on traps. I also believe that the management of the *c.canadensis* on UNDERC property could be dealt with in a more positive way. To prevent the beavers from damming up culverts and flooding roads, maintenance could install wire fencing across the culvert openings, discouraging beavers from building there. By managing the beavers without having to resort to extermination, the beavers could improve the local aquatic and riparian ecosystems, and residences could reside with the beavers peacefully.

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Figures

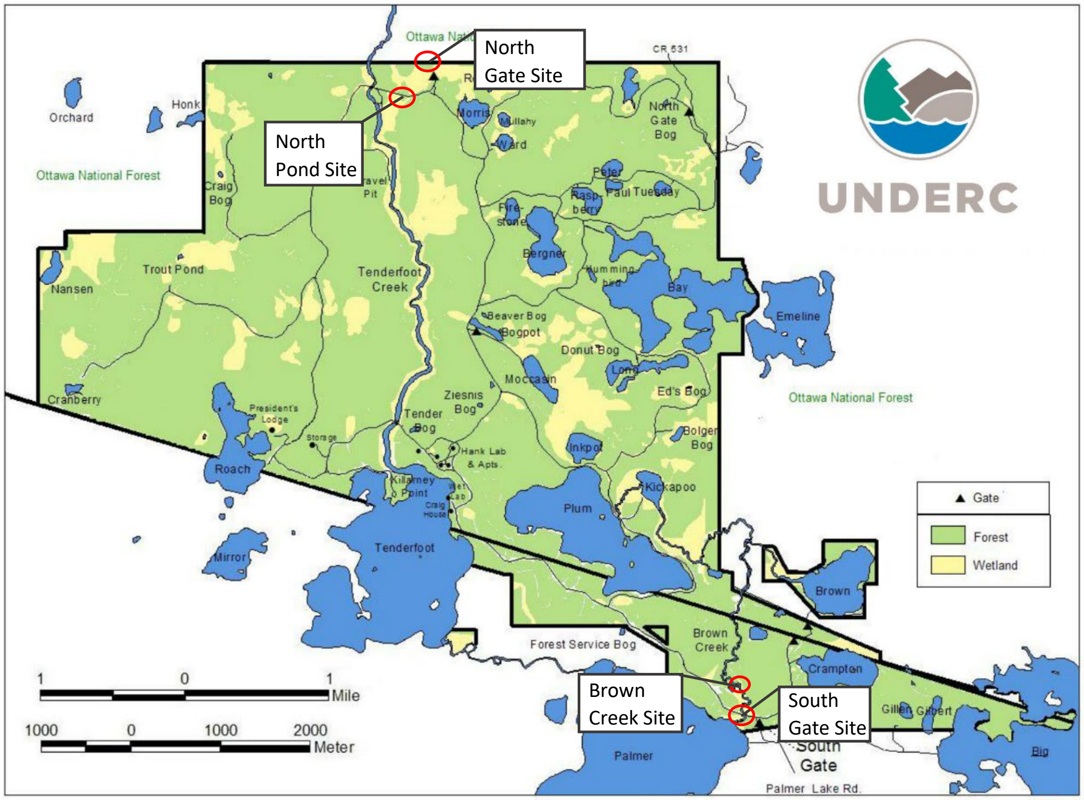

Figure 1. Map of UNDERC property including my research sites, shown with red circles and labelled.

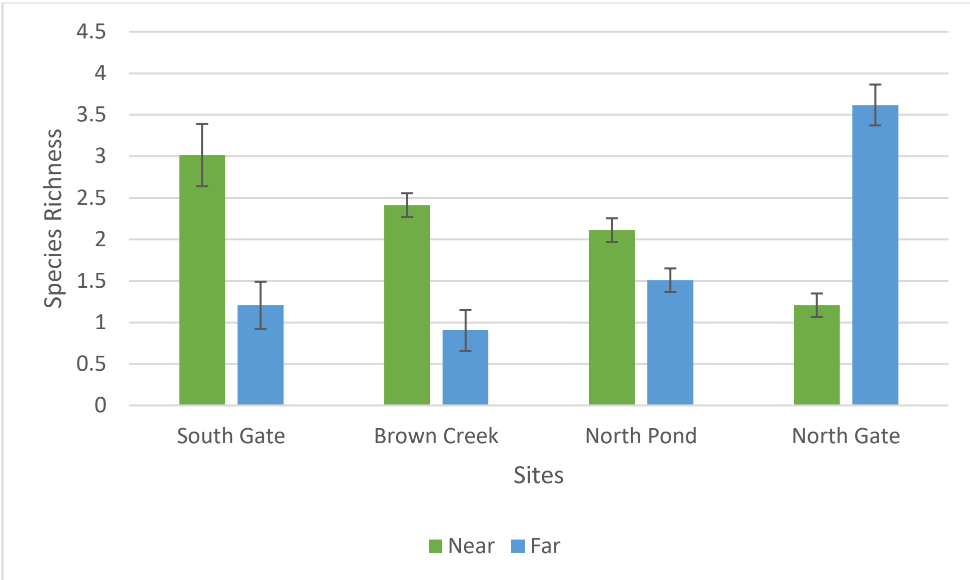

Figure 2. Species richness by site. South Gate and Brown Creek were stream sites, and North Pond and North Gate were pond sites.

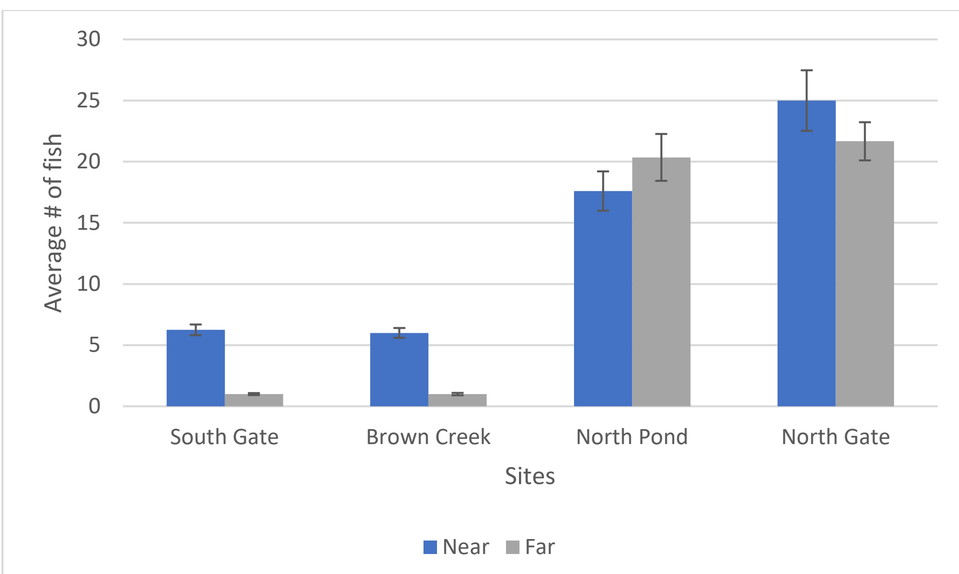

Figure 3. Average number of fish by site. South Gate and Brown Creek were stream sites, and North Pond and North Gate were pond sites.

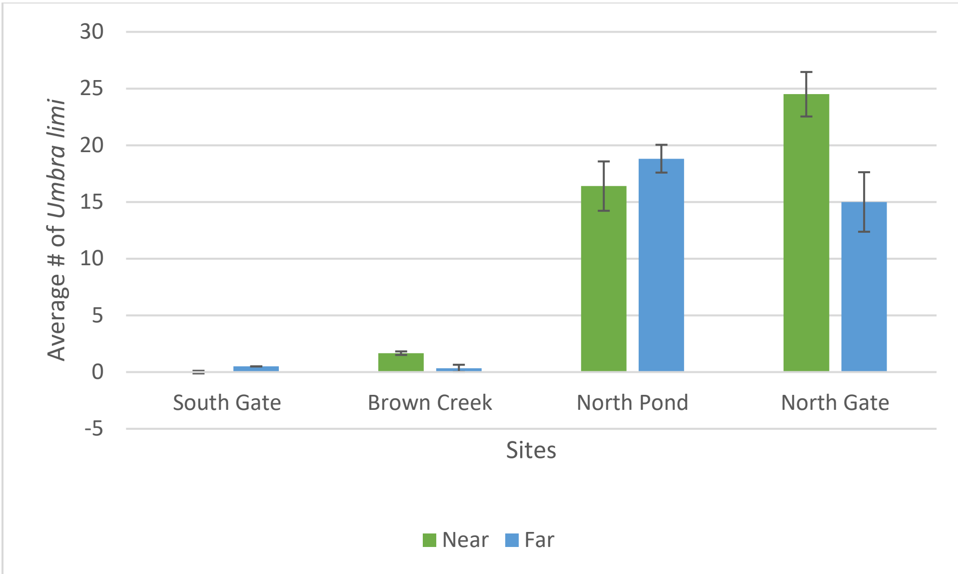

Figure 4. Average number of *Umbra limi,* the mud minnow, by site. South Gate and Brown Creek were stream sites, and North Pond and North Gate were pond sites.

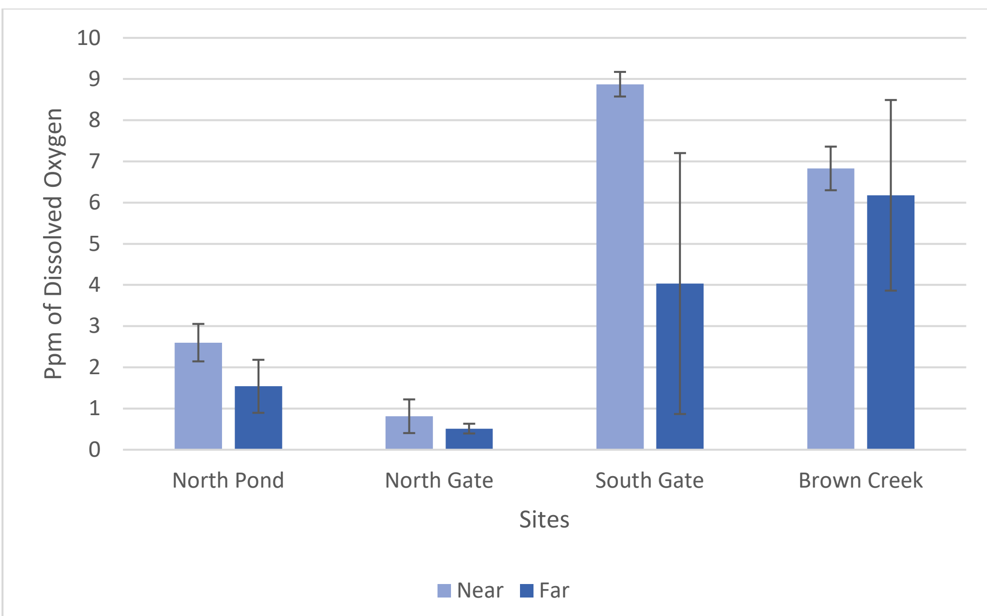

Figure 5. Average parts per million (ppm) of dissolved oxygen by site. South Gate and Brown Creek were stream sites, and North Pond and North Gate were pond sites.

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