

Fish Density and Diversity Changes in Response to the Removal of Aquatic Vegetation in Douglas Lake, Michigan

Hannah Jo Maier

Abstract

The rapid development of land is destructive to aquatic habitats. The removal of woody debris and the raking of littoral vegetation during development are harmful to organisms that use this organic matter for reproduction and defense. The purpose of this study is to see if vegetation removal impacts the number of fish present in a certain area and fish biodiversity in Douglas Lake, MI at the University of Michigan Biological Station. We placed 12 minnow traps across three areas that differed in vegetative cover (non-vegetated, vegetated, heavily vegetated), and we recorded the number of fish found in each trap. We used the Shannon Wiener Diversity Index to calculate fish biodiversity within each section and used a Kruskal Wallis test to determine if the amount of fish between each section was significantly different. The vegetated section held the highest fish biodiversity, as well as the highest species richness. The amount of fish collected was significantly different between each section (p -value=0.03807). There was no correlation between temperature and the amount of fish found. We concluded that fish prefer to occupy vegetated areas because they provide protection from predators and act as a refuge for fish of all ages and species.

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Introduction

The removal of vegetative cover by humans in aquatic communities changes the community composition of in freshwater ecosystems by destroying habitats for organisms such as fish. This can result in less species diversity and a difference in the spatial distribution of fish (Scheuerell *et al.* 2004).

Fish prefer habitats structured with woody debris and vegetation because it provides cover that decreases the risk of predation, it reduces contact between fish, and it acts as a refuge that helps fish conserve energy (Crook *et al.* 1999). Vegetation also attracts macro invertebrates that are a source of food for the small fish in Douglas Lake.

As humans continue to respond to climate change by partitioning water and grooming artificial lakes for drinking water and recreation, they add stress to fish in natural and artificial lake communities (Ficke *et al.* 2007).

In order to create lakes that serve these purposes, people rake littoral vegetation and remove fallen logs and woody debris from the lake. Through the anthropogenic changing of the littoral zone of lakes, the species of fish present in lakes can change, altering the lake ecosystem and species biodiversity (Lake *et al.* 2000).

Savino *et al.* 1989 implemented a study that explored the feeding behavior of *E. lucius* and *M. salmoides* on *P. promelas* in relation to their preference of vegetative cover. The predators resided in densely vegetated covering and preyed on minnows that came to close to their covering; the predators only occasionally traveled out into the no cover zone to prey on minnows.

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In addition, Paterson *et al.* 2000 found that shallow water habitats in southern African estuaries were not used by bigger fish that were common in deeper parts of the estuary. This study concluded that shallow estuarine areas provide refuge for smaller fishes that are more vulnerable to predation.

In a study by Heck *et al.* 1994, the authors attributed smaller fish's affinity to vegetated areas to be a result of increased food supply in vegetated areas as well as increased survival rates.

The purpose of this experiment is to explore the implications of development on littoral habitats through a study on Douglas Lake fish diversity and density in different vegetative covers (heavy vegetation, vegetation, or no vegetation).

This study investigates the relationship between fish density and aquatic vegetative cover as well as fish diversity and aquatic vegetative cover.

We predicted that there would be a decrease in the density of fish as vegetation cover decreased because ecologists have studied and documented that small fish in the littoral zone use vegetation as protection. We also hypothesized that there would be a decrease in the diversity of fish as vegetation cover decreased because ecologists such as Sevino *et al.* 1998 have shown that there are more complex communities in vegetated areas than non-vegetated areas.

Methods

Experimental Set-up

We placed four steel round minnow traps in a heavily vegetated area (dense cover), four minnow traps in an area of low vegetation (cover), and four minnow traps in an area without vegetation present (no cover) in Douglas Lake at the University of Michigan Biological Station

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in Pellston, Michigan in order to simulate the removal of vegetation across an aquatic area due to development.

The no cover area was mostly sand at the start of the experiment, and any loose vegetation was pulled and raked out of the experimental area. The four traps in each section were held together by a rope and placed in their desired section of vegetation using a spiral anchor. The three sections were separated using buoys. The section of low vegetation was oriented north. The section of dense vegetation was oriented south. *Figure 1.*

The traps in each section were about 1 m apart. The three sections were placed 1 m apart from each other. The three sections were roughly 4.3 m from the shoreline. The traps were placed at a depth of roughly 1.4 m.

Collection

We baited all twelve traps with 7-8 kibbles of Purina Dog Chow on Day 0 of our experiment. The following day (Day 1) we identified the quantity and the species of individuals that we found in each of the three sections as well as re-baited each of the twelve traps with 7-8 kibbles of Purina Dog Chow.

When we finished counting and identifying individuals, we released them down the shoreline in order to prevent them from entering the traps again at the start of each day. In total, we collected data from Day 1 through Day 14, except for Day 5 and Day 8 due to poor weather conditions.

We monitored weather conditions using in field observations as well as *The Weather Channel's* observed temperature and precipitation for Pellston, Michigan.

Statistical Tests

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We ran a Kruskal Wallis test using the program RStudio to determine if there was a significant difference in the quantity of fish present between each of the three treatments.

Results

Through the use of a Kruskal Wallis test performed on RStudio statistical analysis software, we found that there was a significant difference (p-value=0.03807) between the amount of fish found in each of the three treatments: no vegetation, intermediate vegetation, and vegetation. (*Table 1*).

We calculated the species richness in each section by recording the number of species that were present in each section. *Figure 2*. We found that the greatest observed species richness was in the heavily vegetated area, while the least observed species richness was in the intermediate area. The non-vegetated area was lower in species richness than in the heavily vegetated area.

We used the Shannon Wiener Diversity Index to calculate the diversity within the three different sections. We found that the heavily vegetated area had the most biodiversity, while the section of intermediate vegetation had the least biodiversity. All three sections were significantly different in diversity. *Figure 3*.

We also recorded the high temperature of the surrounding area (Pellston, Michigan) of each day of sampling using *Weather Underground* as well as the total number of fish caught each day. There was no correlation between the temperature/weather conditions and the number of fish captured on a particular day ($R^2=0.00854$). *Figure 4*.

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Discussion

Our results rejected our null hypothesis that there would be no change in fish density and diversity when vegetation is changed. It also supported our alternative hypothesis that there would be a change in fish density and diversity when vegetation is changed. Our results agreed with the results of Sevino *et al.* 1998; we did find the greatest fish density, richness, and diversity in the most heavily vegetated area. We also observed that fish density increased as submerged vegetation increased, as did Randall *et al.* 1996 in a study that related total fish species richness to the amount of bottom cover. Randall *et al.* 1996 found that fish species richness increases with an increase in the amount of bottom cover.

We found that the area of intermediate cover had the lowest species density, richness, and diversity. These results were not similar to those of Grenouillet *et al.* 2002, studies in which juvenile fish were found most abundant in intermediate cover areas. Grenouillet *et al.* 2002 found that there was higher species richness in intermediate cover areas as well, but he determined that there was no correlation between species richness and vegetative cover. We predict that if we had the same species of plant vegetation and density as Grenouillet *et al.* 2002, then we might have achieved similar results.

The actual biomass of vegetation as well as the plant species of the vegetation in our experimental area was not recorded. The density of vegetation in our area as well as the species may have influence the foraging of small fish (Heck Jr. *et al.* 1994).

We found the least biodiversity as well as the least species richness in the section of intermediate vegetation. We predict that this is a result of predation. Some species of fish may

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have chosen to live in the non-vegetative section rather than the section of intermediate vegetation because the sections of vegetation are a part of the niche of their predators.

In our study, we captured mostly *P. flavescens* in each of the three sections. It is possible that our traps were placed in vegetation that was too dense to support smaller minnows and juvenile fish. The bait that we used may have also been too large to attract juvenile fish and minnows. Upon replication of this experiment, it would be beneficial to use different types of bait to determine if the type of bait that we used influenced the species of fish that were captured.

In addition, in each of the three sections on each day of sampling, we captured many crayfish that we counted but did not identify. It is possible that the crayfish may have eaten the minnows in the trap before we recorded them. Instead of using steel round minnow traps, it may be beneficial to use traps that are better at excluding crayfish. If that is not possible, then we may be able to use the design of this study to explore the relationship between crayfish and *P. flavescens* in Douglas Lake.

Upon collection, we noticed that multiple fish of the *P. flavescens* species seemed to have abnormal spotting and coloration. With further research, we discovered that the spots and discoloration of *P. flavescens* might be due to parasites that use *P. flavescens* as a host organism.

The health of *P. flavescens* may help determine the water quality of Douglas Lake. If this experiment was repeated every summer and we were able to qualitatively record the amount of *P. flavescens* captured as well as their health condition and coloration, then we might be able to use this information to test and keep a record of the water quality of Douglas Lake, Michigan.

Upon further replication, a detailed record of weather and temperature at the site should be kept in order to determine how abiotic variables impact biodiversity within sites and as well

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the amount of fish present in each site. In addition, it may be beneficial to implement more traps in order to create a larger sample size.

The experimental area should also be expanded to areas in the littoral zone that are out of boat traffic in order to remove human disturbance as a possible confounding variable. Although Douglas Lake is undisturbed as compared to other public lakes near developed areas, we could make our experimental boundaries known to the residents on Douglas Lake so that they are aware not to disturb our experimental areas with fishing, boating, or other experiments.

We recorded the number of fish and species of fish collected in each section, rather than in each trap. Recording the number of fish and species of fish collected in each trap may provide us with further information as to why the fish in Douglas Lake preferred to occupy areas of intermediate vegetation.

If we knew the traps in which most fish in each section aggregated, then we could determine if fish preferred the middle of the section or the sides of the section that bordered other areas of vegetation. We predict that fish would prefer the trap in the area of heavy vegetation that bordered the intermediately vegetated section because fish would be able to hunt in intermediate vegetation and then retreat back to a heavily covered area of protection.

Before beginning this experiment, it would have been interesting to implement insect emergent traps in order to identify the composition of adult insects and insect larvae present in each area of cover. The species of fish that we found in each section may be related to the type of macro invertebrates that each area held. Fish use insects as a food source, and it is possible that fish occupied the area of intermediate cover not only because of vegetation, but because of insect diversity as well.

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Dissecting a sample of captured fish would allow us to determine what their main choice of diet is. We could determine the health of captured fish while they are alive, and then we could dissect them to see what their diet preference is. This would allow us to see if there is a correlation between fish diet, fish habitat, and fish health.

If we decide to replicate this experiment we could also test to see if fish aggregation changes down the water column by placing traps at different depths in vegetation. This could help us explore how the consequences of the removal of vegetation in the littoral zone differ from the consequences of the removal of vegetation outside of the littoral zone.

To further this experiment after we have replicated it using our experimental sections of vegetation, we could expand our experiment to different areas around Douglas Lake. We could place traps in the more developed areas (around lake houses) and in the less disturbed areas (area of shoreline near the University of Michigan's Biological Station) of Douglas Lake to see how vegetation removal around developed areas influences fish number and density when compared to natural areas with undisturbed vegetation. We predict that fish number and density will decrease with an increase in shoreline development based on a previous study by Radomski *et al.* 2008 in which they found that the relative biomass of *E. Lucius* declined as shoreline development increased.

Our statistical analysis could have been furthered, but was not due to insufficient observations. We could have recorded a more detailed set of data of the weather conditions at the specific coordinates of our experimental locations using temperature and weather recording technology such as Ibutton. If we had these results, then we could have run an anova to determine the relationship between weather (rain, thunderstorm, cloudy skies, clear skies),

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temperature, and the total number of fish observed for each sampling day. This information would have allowed us to see if these other variables confounded our results.

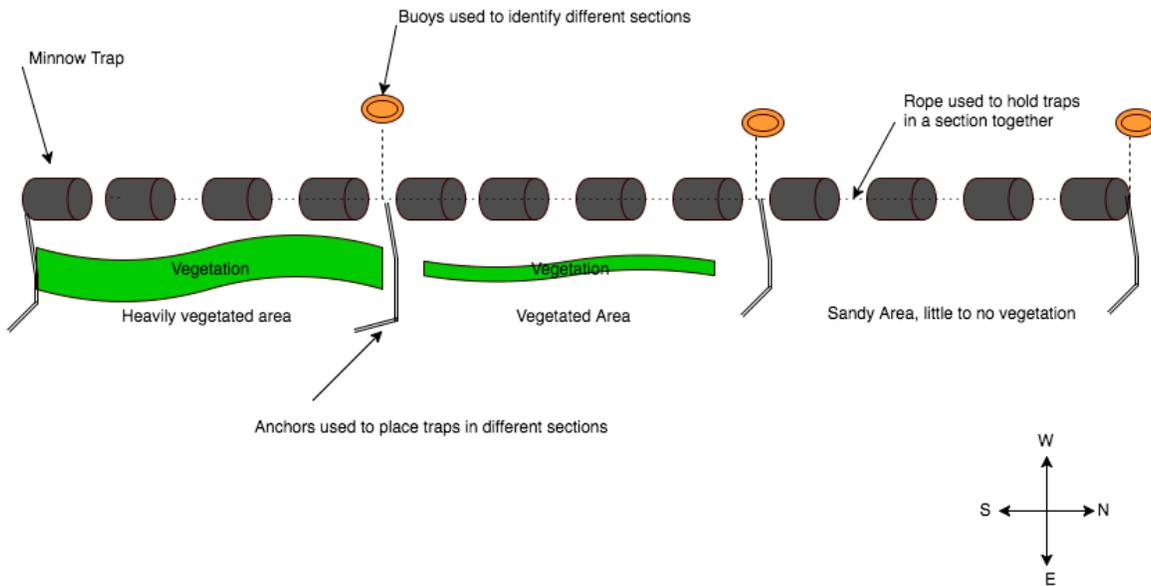
We could have predicted the ages of the fish that we captured by measuring and recording their species, length, markings, and colorations. This would've allowed us to create a more focused research question. We would have been able to determine if there was a relationship between fish age and the vegetative cover that they preferred. If we replicate this experiment in the future and include this question, then we hypothesize that there will be a relationship between fish age and vegetative cover. We predict that younger fish will prefer heavy vegetative cover because cover allows them to hide from predators while providing resources for food.

In conclusion, we found that the greatest biodiversity and species richness was found in the area of heavy cover. We also found that fish density and diversity did differ between areas that differed in cover. We hope to replicate this experiment in order to learn more about why heavily vegetated areas are attractive to fish that occupy the littoral zone habitat in Douglas Lake. We also would like to further explore the relationship between intermediate vegetation cover and fish biodiversity, and what fish in Douglas Lake preferred an area of no cover to one of intermediate cover. Replication of this study will allow us to learn more about the foraging behaviors of the different fish species that occupy the littoral zone in Douglas Lake.

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Figure 1. Diagram of Experimental Set-up.

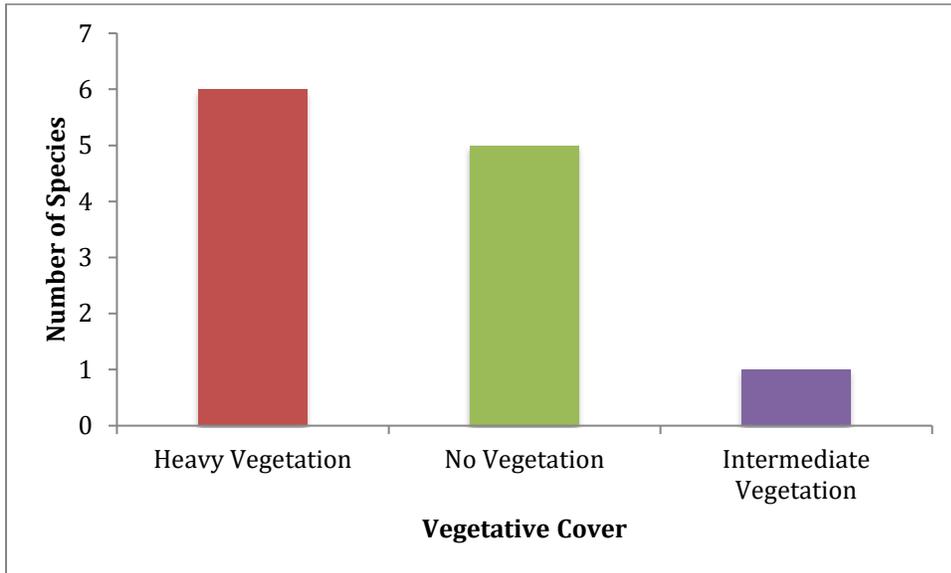


The figure above is a diagram of our experimental set-up. Four minnow traps were placed in three different sections that contained differing densities of vegetation.

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Figure 2. *Species Richness.*

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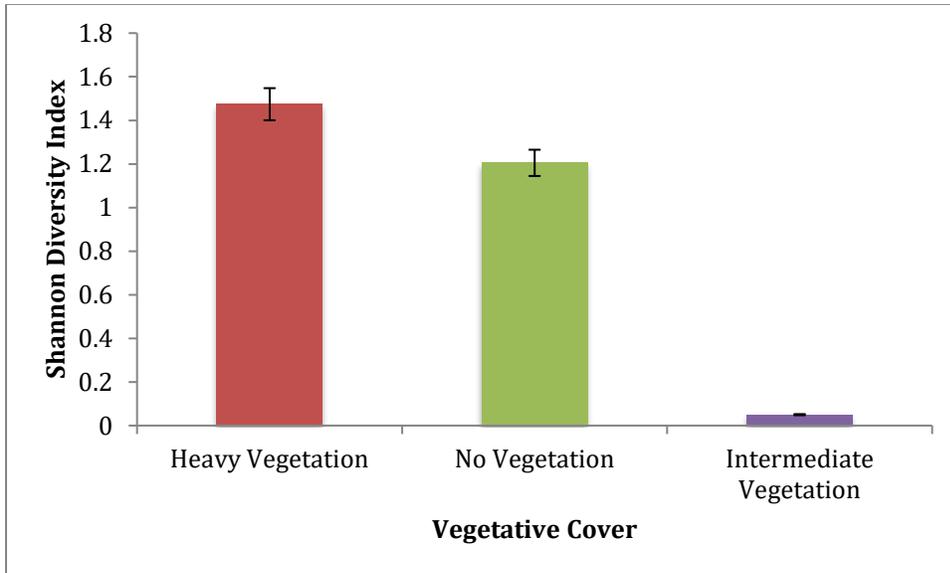


The figure above shows the species richness of fish across areas of differing vegetation. The section of heavy vegetation is shown in red and had the highest species richness. The section of intermediate vegetation is shown in purple, and it had the lowest species richness.

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Figure 3. Species Diversity.

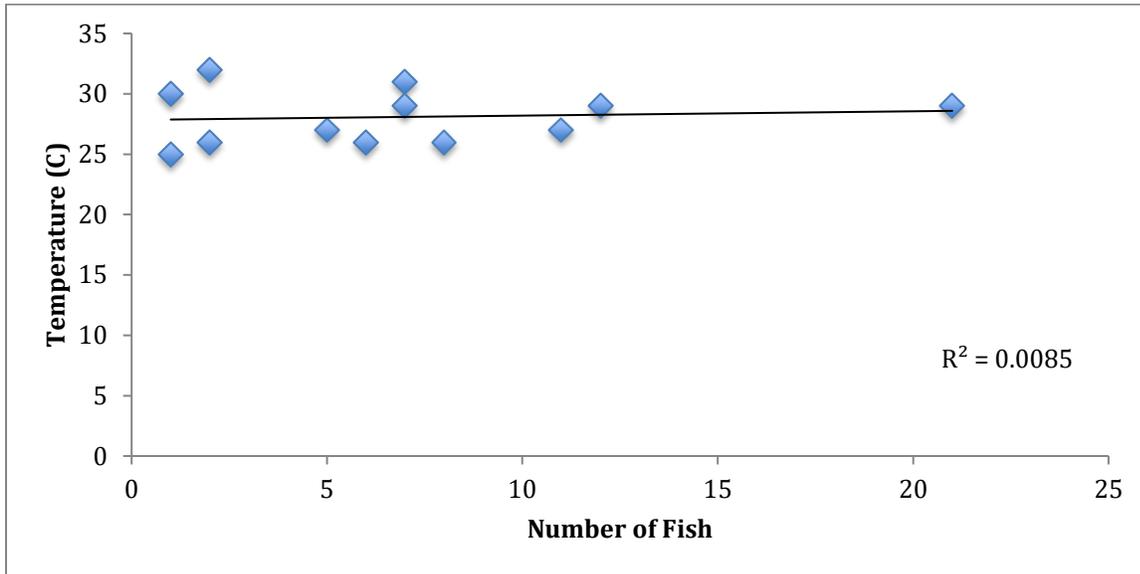


This figure shows the calculated species diversity for each section. The diversity present in each section was calculated using the Shannon Diversity Index. The vegetated section shows the highest biodiversity, while the intermediate vegetation showed the least.

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Figure 4. Linear Regression: Temperature vs. Number of Fish



The graph above is a linear regression that shows the relationship between the number of fish recorded and the temperature observed for each sampling day. There was no correlation between temperature and the number of fish collected on each day.

Table 1. Kruskal Wallis test results.

Chi-Squared	Degrees of Freedom	P-Value
6.5366	2	0.03807

We found that there was a significant difference between the numbers of fish present in each of the three sections at a significance level of 0.05.

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