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# MACROINVERTEBRATE DIVERSITY AND FOREST DENSITY

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## ABSTRACT

We hypothesize streams with higher foliage and vegetation densities will have a higher number of macroinvertebrates present. In other words, larger quantities of larvae including caddisflies, mayflies, stoneflies, and more indicate better water quality. Our null hypothesis is that there is no relationship between forest density and macroinvertebrate diversity. Our study is important because streams in Huntingdon contribute to the drinking water supply. Identifying the quality of a stream based on foliage can help determine how to treat the site or water. For example, if a stream has lower quality water because of a lower vegetation density, planting vegetation in the riparian buffer area would make the water cleaner and could be treated in a facility differently. Results of our study indicated that there was no significant relationship between vegetation and count of macroinvertebrates. However, limitations to this study, including sample size and time restraints, contributed to the lack of data we were able to analyze. Using a multivariate linear analysis, our p-value was 0.88, which is greater than the 0.05 threshold. The findings of our study imply that streams in the Huntingdon area are not largely impacted by vegetation density.

*Keywords*: *Abundance, Macroinvertebrates, Riparian buffer*

## INTRODUCTION

Through this study, we wanted to see if there was a relationship between the abundance of macroinvertebrates in a stream compared to the density of the surrounding vegetation. We hypothesized that streams with higher foliage and vegetation densities will have a higher abundance of macroinvertebrates. Our null hypothesis states that there is no relationship between forestation density and macroinvertebrate abundance. Our study is important because the quality of water can be predicted with foliage coverage. In other words, understanding the relationship between water quality and riparian buffer density may indicate how to treat water that is of a low quality. If a relationship is found between forest density and macroinvertebrate density, increasing the foliage would increase water quality, which can be applied to how water is currently being treated in the Huntingdon area.

We are studying the abundance of stream macroinvertebrates; including stoneflies, caddisflies, leeches, water pennies, midges, mayflies, blood worms, amphipods, sow bugs, and true flies.

Riparian buffer zones have shown to impact water quality and protection (Conigley, *et al* 2017). With a wider riparian buffer zone, less runoff is likely to funnel into water sources, protecting the organisms in the water from foreign nutrients and pollution. Previous literature has not focused entirely on the connection of aquatic ecosystems and vegetation, but more on the pollution of sediments (Nieminen, *et al* 2005). The makeup of riparian buffer zones, and the difference between grass-dominated versus tree-dominated areas impact the temperatures of the water. Cooler water temperatures

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are known to have higher dissolved oxygen content, which is favorable for many species. In addition, larger land predators are less likely to enter cluttered riparian buffer zones because of restricted mobility.

Several feeding groups of macroinvertebrates exist, including grazers/scrapers, shredders, collectors/gatherers, and filter-feeders. Water quality factors, which may be impacted by riparian buffer factors, are shown to impact the prevalence of the different feeding groups. For example, collector-gatherers are most abundant based on land-use changes (Mangadze, *et al* 2019). The density of vegetation around streams impacts the community dynamics of an ecosystem.

Our study aimed to demonstrate how vegetation density impacts the presence of different macroinvertebrate species in different streams around Huntingdon, Pennsylvania. The outcomes of this study can build community engagement with an overall goal of improving water quality in the area.

*Images 1 & 2: Researchers Janie Corbin & Siena Guttormson at the Standing Stone site.*

## METHODS AND MATERIALS

To test our hypothesis, we tested 3 different streams around Huntingdon. For our tests, we took 5 random samples with a kicknet along the width of the stream we were at. To use the kicknet, we placed it in the water while holding the handle and stood upstream of it. Then, we kicked up the sediment and rocks in front of the net for about 30 seconds to ensure that we collected the macroinvertebrates from the area. After we used the kicknet, we would take it to the stream bank and thoroughly look through the samples. We placed any macroinvertebrates we found into a collection pan. This then allowed us to count and identify the macroinvertebrates collected. As we counted them, we would move them from one side of the pan to the other to ensure there was no recount. After we counted, we used an excel file to keep track of location, species, quantity, and the percentage of vegetation surrounding the stream. After we counted and identified, we released the macroinvertebrates back into the stream.

Materials used for our experiment:

- Waders and boots
- Kicknets
- Forceps
- Examination pans

We collected samples from 3 different field sites. All sites had varying levels of vegetation, which we measured with a percentage of coverage. The densest area we collected from was the Standing Stone site, with 60% vegetation. Our second site, Muddy Run, had a vegetation concentration of 20%. Finally, our third site, was an upstream tributary of Standing Stone, referred to as the Standing Stone Tributary, with 0% vegetation.

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*Images 3, 4, 5, & 6: Standing Stone site images of surrounding vegetation and results from first kicknet capture.*


*Images 7 & 8: Muddy Run site images of surrounding vegetation.*

*Image 9: Standing Stone Tributary site of surrounding vegetation.*

## RESULTS

We used a multiple linear regression to analyze our data because there were two independent variables (x1 = location, x2 = percent of vegetation) and a quantitative dependent variable (y = number of macroinvertebrates).

To measure our location, we qualitatively stated which site we collected data from with the title of the site. To measure the vegetation, we quantitatively used a percentage on a scale of 0-100,

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100 indicating a highly dense forested site. When running the statistical test, we changed the value to a decimal (i.e.: 20% changed to 0.2). To measure the number of macroinvertebrates, we identified and recorded the species and the numerical count of each sample. From our first site, Standing Stone, we had a sample of 39 total macroinvertebrates and 5 different species. From our second site, Muddy Run, we had a sample of 36 total macroinvertebrates, and 6 different species. From our third site, a pristine Standing Stone tributary, we had a sample of 33 and 4 different species.

With a p-value of 0.88, we found our data to be insignificant, as our p-value is greater than 0.05. We accept our null hypothesis that there is no relationship between the percentage of vegetation and number of macroinvertebrates in a given stream.

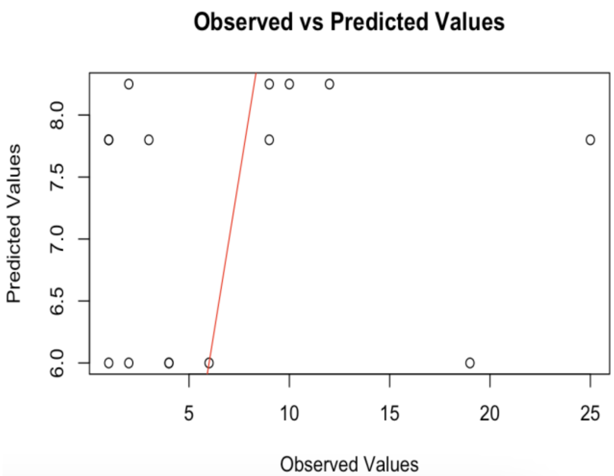


*Fig. 1: Observed vs. predicted values of sample. The x-axis indicates the observed values of the number of macroinvertebrates, and the y-axis depicts the predicted values. (2024, Pennsylvania)*

Figure 1 compares the observed and predicted values of macroinvertebrates when anticipating a high vegetation to provide a high number of macroinvertebrates. Because of the high variation and distance from the red line (a model with high significance would likely have points directly or close to the line, which is 45°), our data illustrates insignificance. The red line in Figure 1 would be 45° if the axes were scaled in a 1:1 ratio.

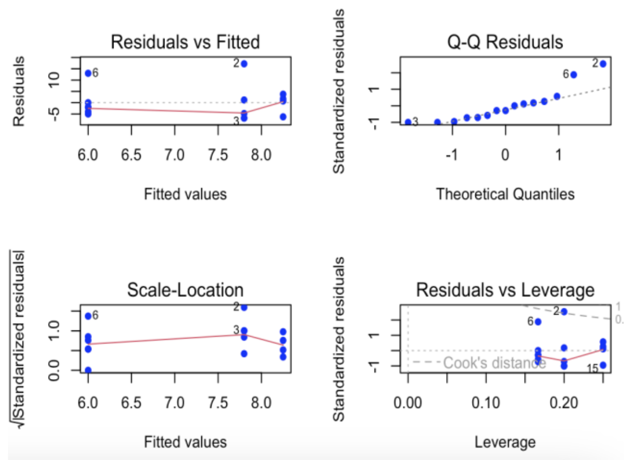


*Fig. 2: Diagnostic plots. Residuals vs. Fitted plot compares the residuals of the number of macroinvertebrates to the expected values. The Q-Q Residuals plot takes the log of the number of macroinvertebrates and plots them on a linear line. The Scale-Location compares the square root of the standardized values of the residuals of the number of macroinvertebrates and the fitted values of macroinvertebrates. The Residuals vs. Leverage plot uses the Cook's Distance check to see if there are influential observations. (2024, Pennsylvania)*

Because our data had an insignificant result, we needed to run diagnostic plots to visualize the assumptions of the multiple linear regression model and if we could fix the violations to get a better result. In the Residuals vs. Fitted plot, the points are not evenly distributed, with a high variance of residuals. The Q-Q plot would show significance if the points were close to the dashed line. Outliers, or points far from the line, are important in indicating insignificance in a study. Because there are three outliers visible on this plot, we know the data is not normal. The Scale-Location plot indicates homoscedasticity, or even distribution of residual points from the line. Because the blue points are not evenly scattered, the data is heteroscedastic and fails the homoscedasticity assumption. Finally, the Residuals vs. Leverage plot shows decreasing variance and a high Cook's distance number, which indicates the presence of influential observations, which impact the outcome of the data.

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Because our data does not fit a normal distribution, we needed to check the assumptions of the test to make sure the correct test statistic was used. Since the results from the multiple linear regression were not significant, we modified our test to see if the wrong statistical model was used. Because we were looking for a relationship between the percent of vegetation and number of macroinvertebrates present, we used a Spearman's Rank correlation (a non-parametric test to compare two continuous variables). When modifying the test, we classified the percent vegetation as the manipulated variable (x) and the number of macroinvertebrates as the dependent variable (y). The Spearman's Rank correlation coefficient we got was -0.25. This number indicates no to a weak negative association between our variables. After adjusting our statistical models, we still found that we should accept our null hypothesis.

*Chart 1: The statistical results from the Multiple Linear Regression. (2024, Pennsylvania)*

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Residuals:
   Min     1Q Median     3Q    Max
-6.800 -4.900 -2.000  1.475 17.200

Coefficients: (1 not defined because of singularities)
                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                  7.800      3.385   2.304   0.0399 *
X1Muddy Run Weis            -1.800      4.583  -0.393   0.7014
X1Standing Stone Tributary   0.450      5.078   0.089   0.9308
X2                              NA         NA      NA       NA
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Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.569 on 12 degrees of freedom
Multiple R-squared:  0.02114,	Adjusted R-squared:  -0.142
F-statistic: 0.1296 on 2 and 12 DF,  p-value: 0.8797
```

The results from Chart 1 demonstrate the numerical results from the Multiple Linear Regression. The F-statistic, or the Multiple Linear Regression coefficient, indicated by the 0.13 value, shows insignificance of data. In addition, a p-value greater than 0.05, or 0.88 in this case, also indicates insignificance.

## DISCUSSION

Our results showed that there was no correlation between the number of macroinvertebrates and the vegetation around the stream they are inhabiting. From our results we can conclude that we could have taken our data differently. While we were collecting data, we could have taken ten samples rather than five or gone to more than three sample sites. This would have given us more data and allowed us to have results that make more sense. Other research shows there is a positive correlation between macroinvertebrates and surrounding vegetation and if our study had more time to continue sampling, our data could have been stronger. Our results do not match literature, and this could be because of the time of year the study was conducted, how many samples we collected, and how many streams we visited. A study done at the University of Utrecht showed that there was a positive correlation between the vegetation surrounding a ditch and the amount of diversity within an ecosystem (Achterberg, *et al* 1984). Although our data was found to be insignificant, there are a couple of factors that may have affected our data. This spring season was cold and very rainy. These conditions could have majorly affected the macroinvertebrates, especially since we were sampling during a time of flooding. As we reflect on our project, we decided that for this project to be successful we would need to conduct research for a longer period of time than just a couple of months to ensure more data points.

If we were to replicate our experiment, changing our study design to have more planned sites may have an impact on the results of our study. The biggest limitation of our study was finding streams that were open to the public, which impacted how many sites we had time to collect samples from. We attempted to collect data from the Juniata River, Crooked Creek, Garner Run, and Laurel Run. We researched the streams based on how close they were in proximity to Juniata College and couldn't find any information prior to physically going on if we were allowed to sample data. We found "No trespassing" signs at all of these locations, and were unable to sample macroinvertebrates from those streams.

Information on macroinvertebrate abundance and the relationship to vegetation density is a developing study in Huntingdon, Pennsylvania. While our findings were insignificant, future directions of adjusting this study can help determine how to improve the water quality in various locations.

## ACKNOWLEDGMENTS

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