

The Relationship Between Nitrogen and Phosphorus Levels and Macroinvertebrate Diversity in Two Streams in Milton, Vermont

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Introduction

Nutrients are necessary for sustaining the life of living organisms. Two nutrients, phosphorus and nitrogen, have gotten much attention in the environmental arena due to the role they have in polluting our natural bodies of water such as lakes, rivers, and streams. In the right amounts, these nutrients play a key role in plant reproduction and growth. However, an excess presence of either of these two nutrients in environmental waters can prove to be detrimental to water quality and ability to support life. When these levels reach high amounts, plant growth accelerates. Events such as algae blooms and rapid growth of aquatic plants in turn, depletes dissolved oxygen in the water as those organisms die and decompose. This process of increased nutrients in a streambed, resulting in plant growth that fills the bed of a stream, is referred to as eutrophication. Normally this process should take thousands of years. Unfortunately, anthropogenic sources of pollution have unnaturally sped up the system, generating the term “cultural eutrophication”. Consequences of eutrophication include choking of the waterway, and the fatality of many fish and aquatic organisms due to the resultant reduction in dissolved oxygen required by the organisms. Human addition of phosphates and nitrogen enter waterways (stream, rivers, and lakes) from sources such as agricultural runoff, urban land fertilization, waste-water discharge, and erosion. Runoff from human activities such as these have led to serious impacts on communities of biological organisms such as macroinvertebrates.

Benthic macroinvertebrates are a very good indicator of water quality because they can exist in very large numbers; and while some can only live in clean, healthy waters, others have been able to adapt to live in polluted environments. Normally, phosphorus levels are extremely low (< 0.3 mg/L) (Osmond, et. al., 1995). When a stream has low nitrogen and phosphorus levels, water quality is quite high and the health of the stream is well maintained.

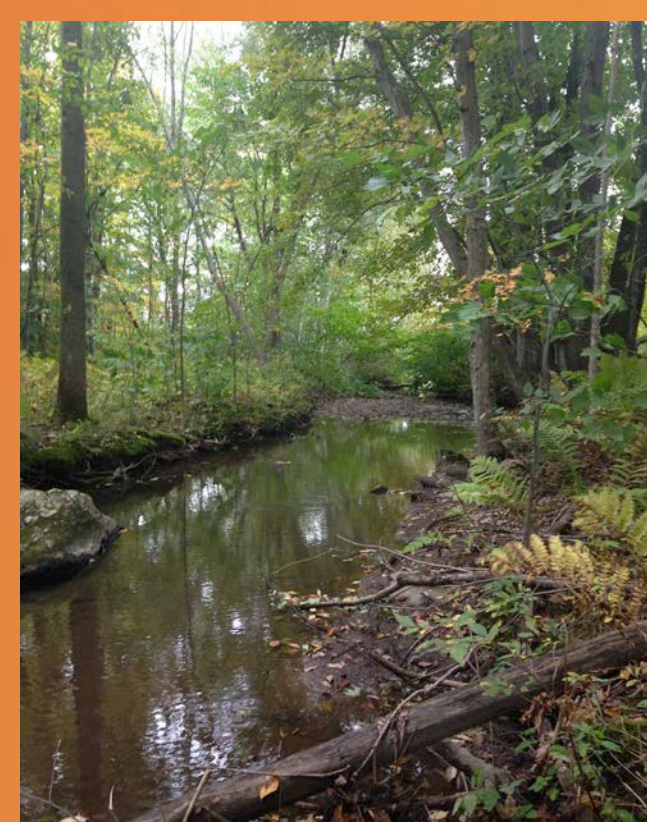


Image 1 - Above : Stone Bridge Brook

Image 2 - Right: Malletts Creek

Stream Comparison

	Malletts Creek	Stone Bridge Brook
Order	3rd order	4 th order
Watershed	Drains to Malletts Bay through a series of wetlands	Drains directly to the Lake Champlain Basin
Location Description	Rural Forested	Rural Forested
Catchment Area (Acres)	952.00	7742.11
% Agricultural Catchment	5.2%	29.2%
% Forested Catchment	90%	59.6%
Stream Type	Riffle	Riffle
Latitude/Longitude	44.643581-73.07245	44.6773011-73.205625



Purpose

The ultimate goal of our project was to juxtapose and evaluate the health of two streams - Malletts Creek and Stone Bridge Brook - in Milton, Vermont. We aimed to investigate the relationship between nitrogen and phosphorus levels and the impact on the macroinvertebrate populations found in each stream. We also wanted to note which natural, as well as anthropogenic changes could cause disruption to each of the streams overall well being. We focused only on the nitrogen levels and phosphorus levels of the stream, and the tolerance values of the macroinvertebrates as indicators of external sources of pollution. If elevations in either nutrient level occurred, or we saw a significant difference in tolerance values between the two streams, we would then further decode the surrounding environment of the stream and brainstorm potential threats such as agricultural runoff, recent weather, and location to human populations.

Hypothesis

In considering each stream, we hypothesized that Stone Bridge Brook (4th order stream) would show an increase in phosphorus and nitrogen levels due to the increased agricultural area and increased number of feeder streams in the catchment compared to Malletts Creek (3rd order stream). We also hypothesized that Stone Bridge Brook would show a larger distribution of pollution tolerant macroinvertebrates compared to Malletts Creek.

Methodology

Nitrogen and Phosphorus Data Collection:

Three water samples were collected at each site in accordance with RACC protocol. A blank sample was also prepared for each collection at each site. To collect each individual water sample, we used bottles and submerged them completely underwater without collecting benthic material. After filling the bottles (each at different points within the stream), we labeled and dated them and assured that they were sealed. They were then frozen and then sent to the lab for analysis.

Macroinvertebrate Data Collection:

In order to collect our macroinvertebrate samples, we followed the RACC protocol. All samples were obtained at different riffle sites within each stream. In the lab, we preserved, identified and counted macroinvertebrates according to RACC protocol.

Resources

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- The Effect of Different Levels of Nitrate and Phosphate on the Macroinvertebrate Populations in Different Streams. Retrieved from: <http://www.tjhsst.edu/~ibet/0506/science/tbrobst.htm>

Results

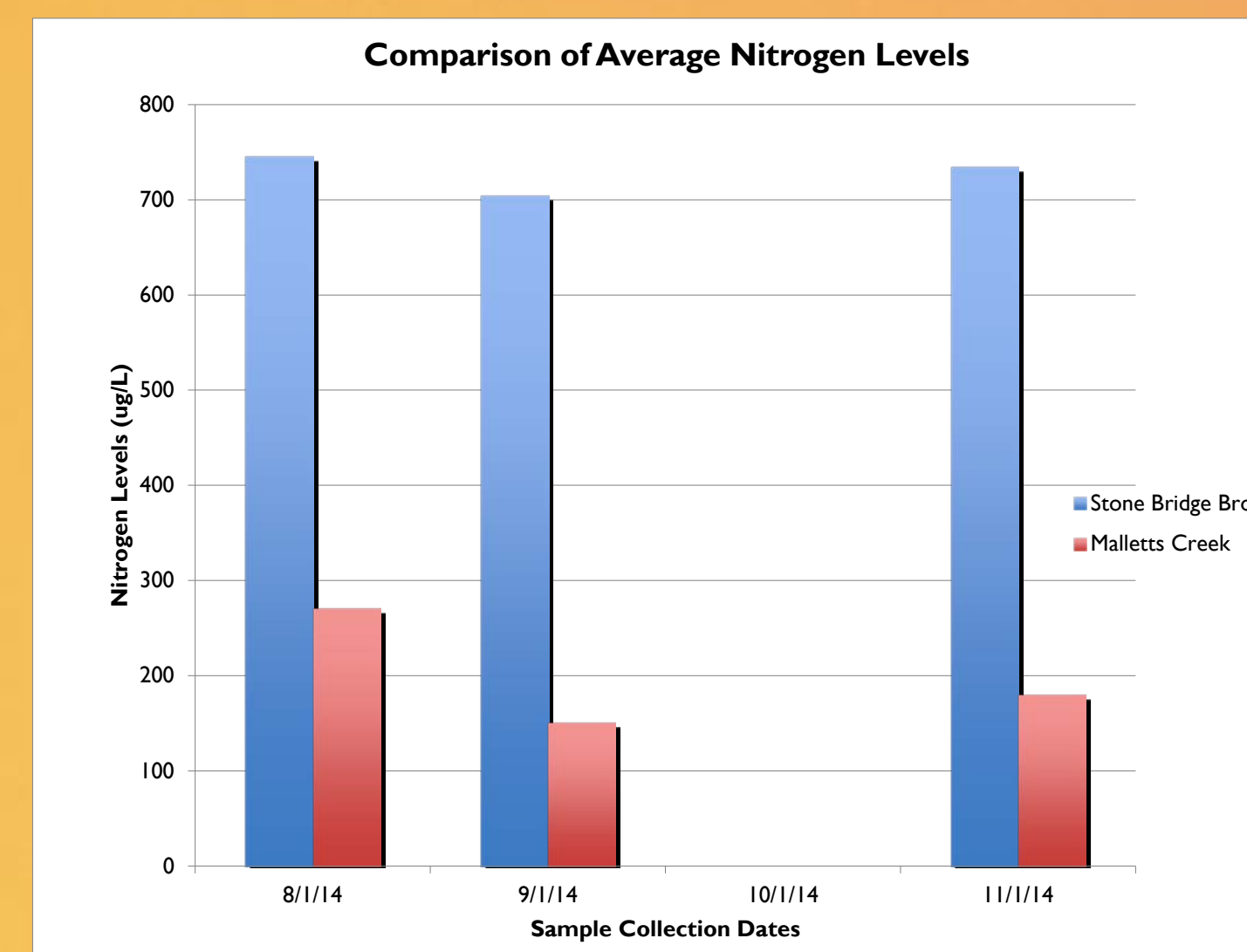


Figure 1 – This graph shows the comparison of average nitrogen levels between Stone Bridge Brook and Malletts Creek.

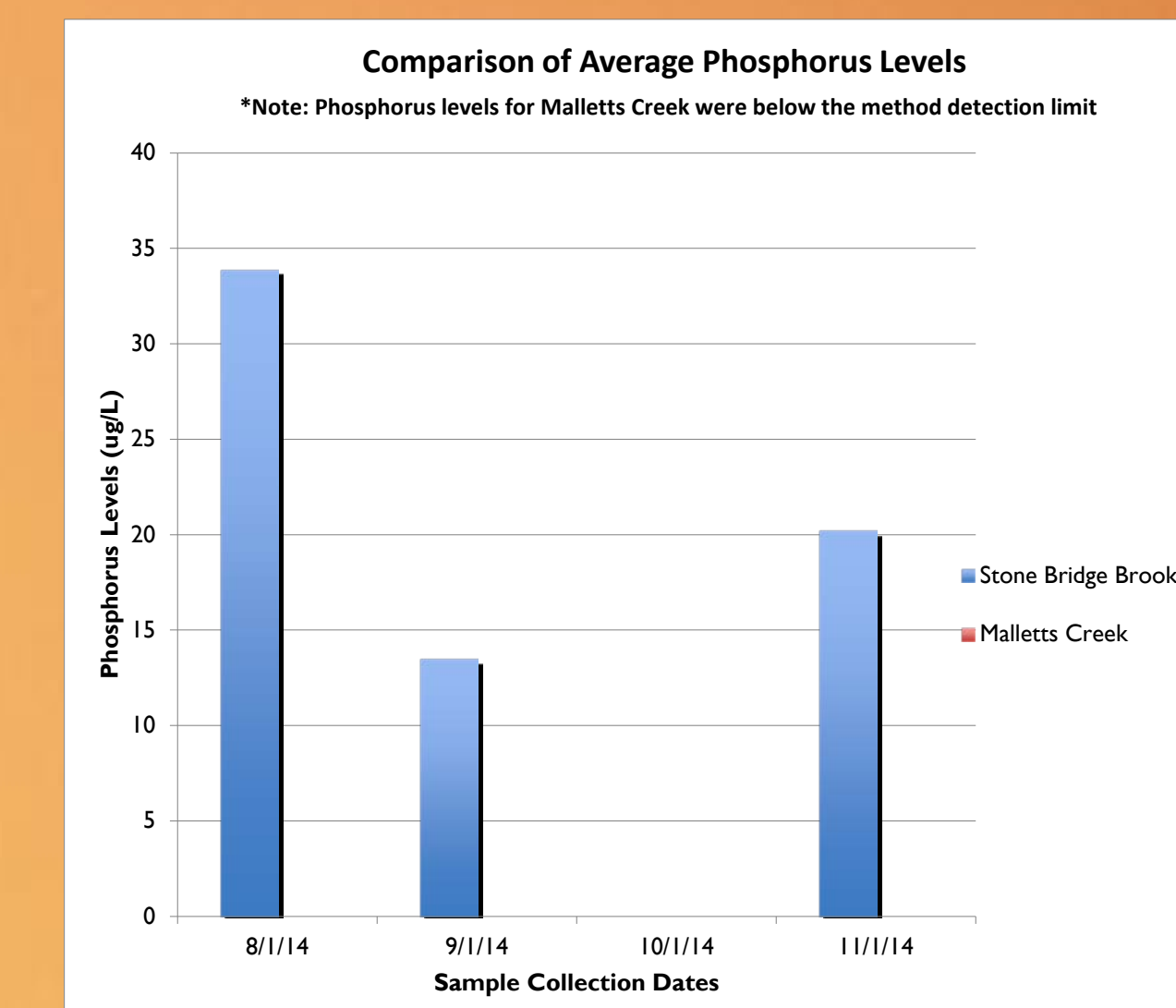
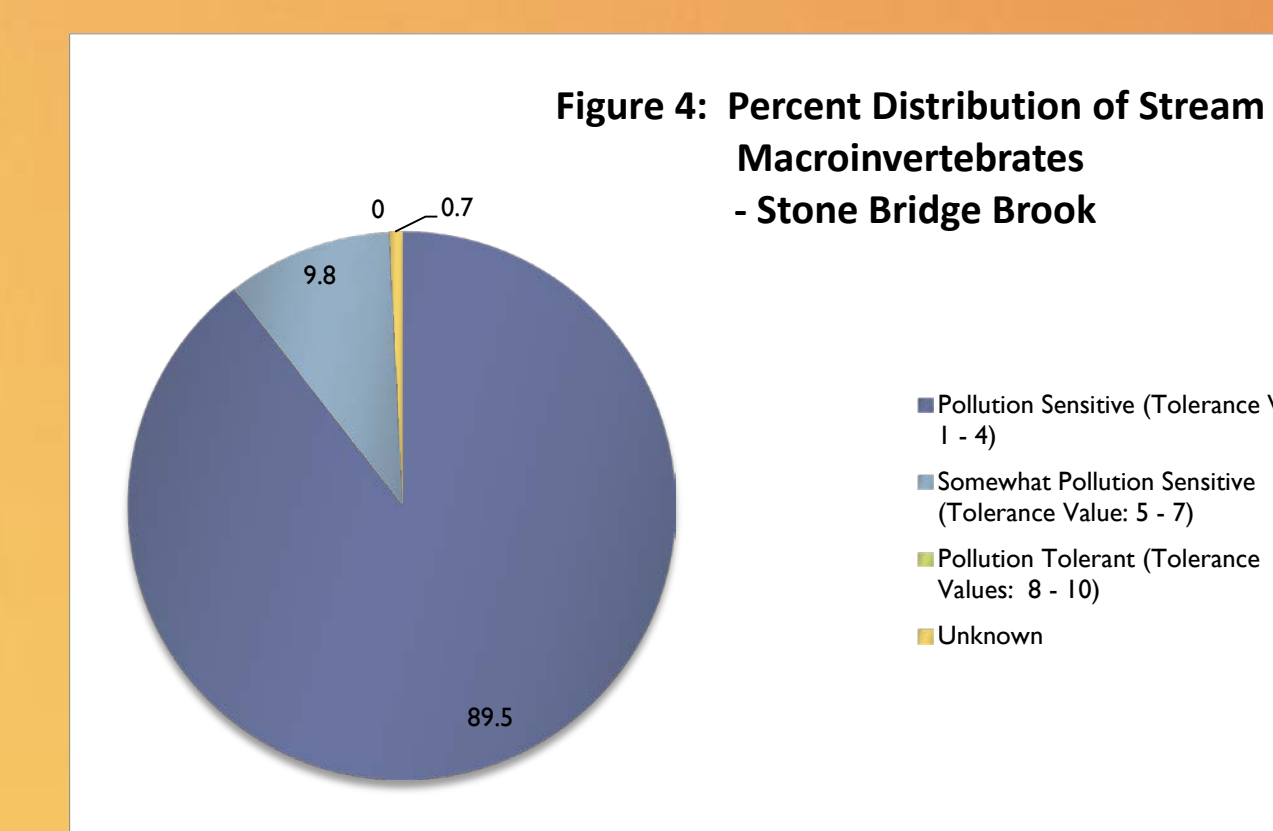
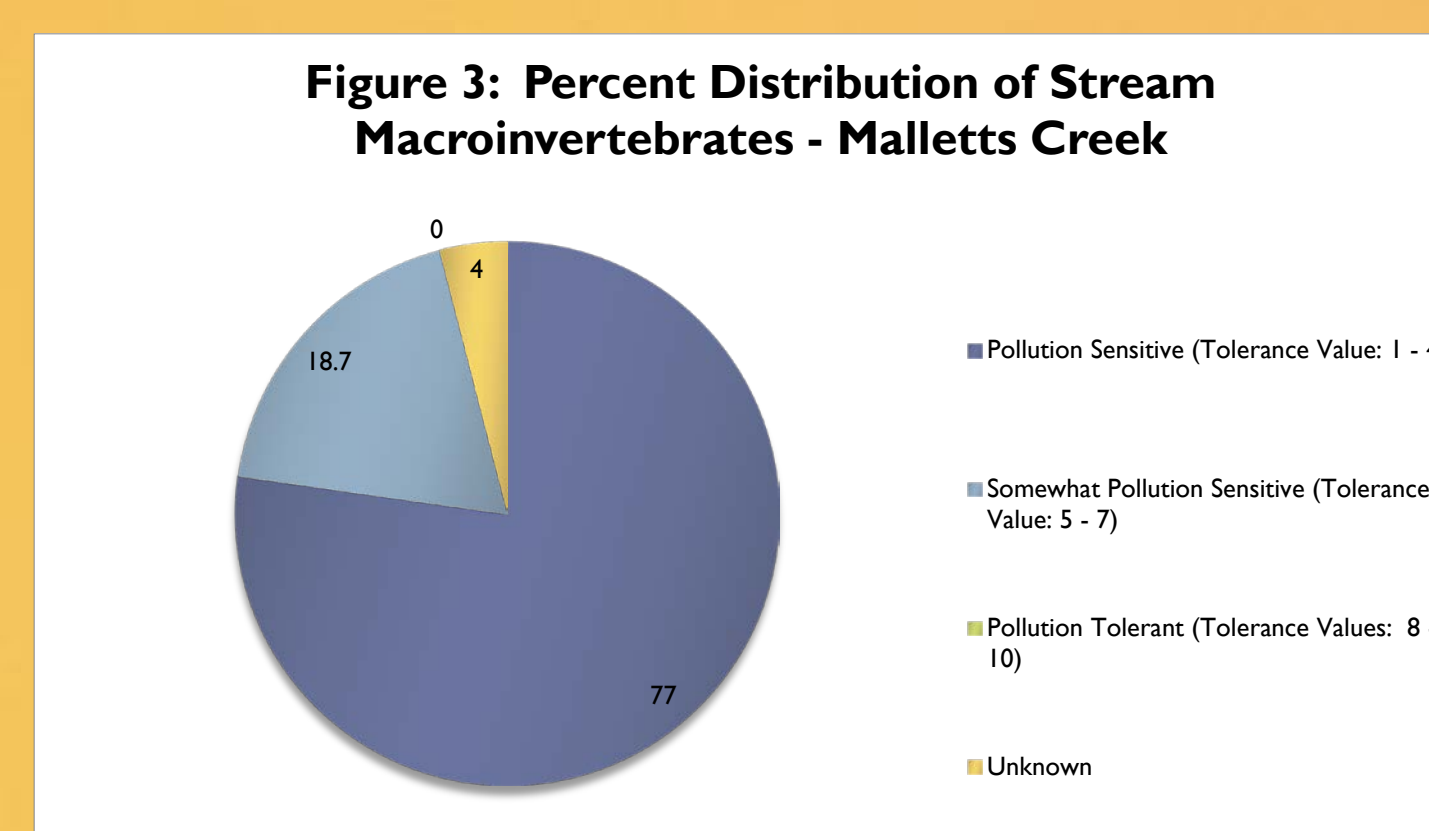


Figure 2 – This graph shows the comparison of average phosphorus levels between Stone Bridge Brook and Malletts Creek.



Figures 3 and 4— These graphs show the percentage of macroinvertebrates for each tolerance level at both streams, with Levels 1 – 4 being most pollution sensitive.

4-Part Pollution Tolerance Index (PTI)		
	Stone Bridge Brook	Malletts Creek
Total Index Value	22	18
Water Quality Rating	Good (17 – 22)	Good (17 – 22)
Reference: Mitchell and Stapp, <i>Field Manual for Water Quality Monitoring, 12th Edition</i>		

Table 1. Pollution Tolerance Indices and Water Quality Rating Results for Stone Bridge Brook and Malletts Creek.

Nitrogen levels measured higher in Stonebridge Brook than in Malletts Creek (Figures 1 and 2), however both are within the range outlined by the USEPA (nitrogen: .12 – 2.2 mg/L; phosphorus: .01 – 0.75 mg/L). The August measurement of phosphorus was the highest and was noted to coincide with a storm event that had occurred 1-2 days before sampling.

The macroinvertebrate data shows that 77% of the organisms collected from Malletts Creek were pollution sensitive while 18.7% are somewhat pollution sensitive. No organisms collected from Malletts Creek was classified to be pollution tolerant which suggests that there is very little pollution in this stream. In Stonebridge Brook, the macroinvertebrate data shows that 89.5% of the organisms were pollution sensitive while 9.8% were somewhat pollution sensitive. For this stream, there were also no pollution tolerant organisms collected. (Figures 3 and 4)

A 4-Part Pollution Tolerance Index was applied to both streams based on the type and number of organisms collected. Stone Bridge Brook had a Total Index Value of 22, and Malletts Creek a Total Index Value of 18. Both stream Water Quality Ratings were found to have a rating of “Good” which is supported by the nitrogen and phosphorus levels obtained.

Conclusion

In concluding our study, we found that our data did not support our hypothesis that Stone Bridge Brook would have a population of pollution tolerant macroinvertebrates due to higher phosphorus and nitrogen levels. We were surprised that, in fact, Stone Bridge Brook had a higher percentage of pollution sensitive organisms than Malletts Creek. In doing further research on Stone Bridge Brook, we found that this stream has been studied and monitored since 1997 and has had a number of management initiatives to help improve stream quality. Both chemical and biological parameters have improved over time. In 2011, the taxa of pollution sensitive macroinvertebrates has increased. Although both streams had nitrogen and phosphorus levels within the USEPA ranges, we were not surprised to find that Stone Bridge Brook had higher levels due to the larger percent of agricultural catchment than Malletts Creek.

Our study also suggests that the initiatives instituted in Stone Bridge Brook has been helpful in restoring a healthier stream water quality as shown by the type and number of pollution-sensitive organisms.

Further research questions include:

- How does the canopy affect the ability of photosynthesis in algae and other plant growth?
- Would the collection and terms of abundance and type of macroinvertebrates differ at different times of the year (fall vs. summer)?
- How do storm events affect the phosphorus and nitrogen levels and the types of macroinvertebrates collected?

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Image 3. Stonefly larva (Trichoptera hydropsychidae) – Pollution Sensitive organisms found in both streams



Image 4. Caddis fly larva (Plecoptera) – Pollution Sensitive organism found in both streams