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Nutrient Composition and Sediment Size in Stream Sediments

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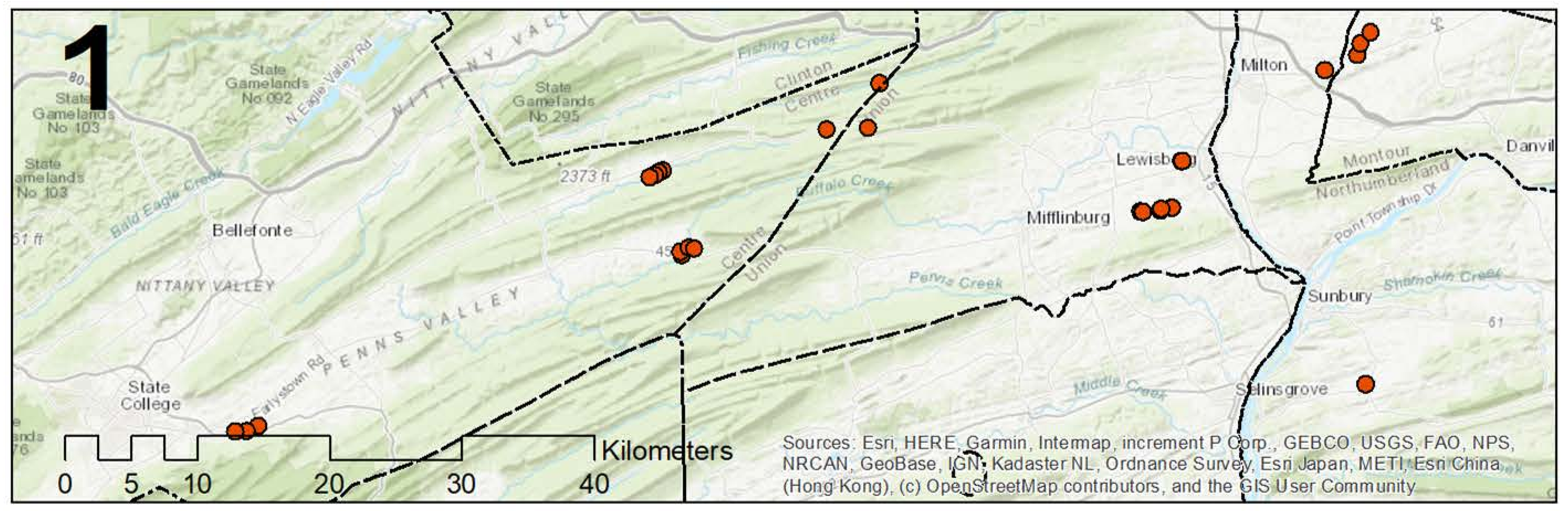


Figure 1: Sampling sites include reference streams and stream restoration locations in Centre, Montour, Northumberland, and Union Counties in Central Pennsylvania.

Figure 2 (top left): The crew electroshocking to determine populations of fish species.

Figure 3 (top right): An example of an agricultural impaired stream.

Figure 4 (bottom right): An example of a forested reference stream.

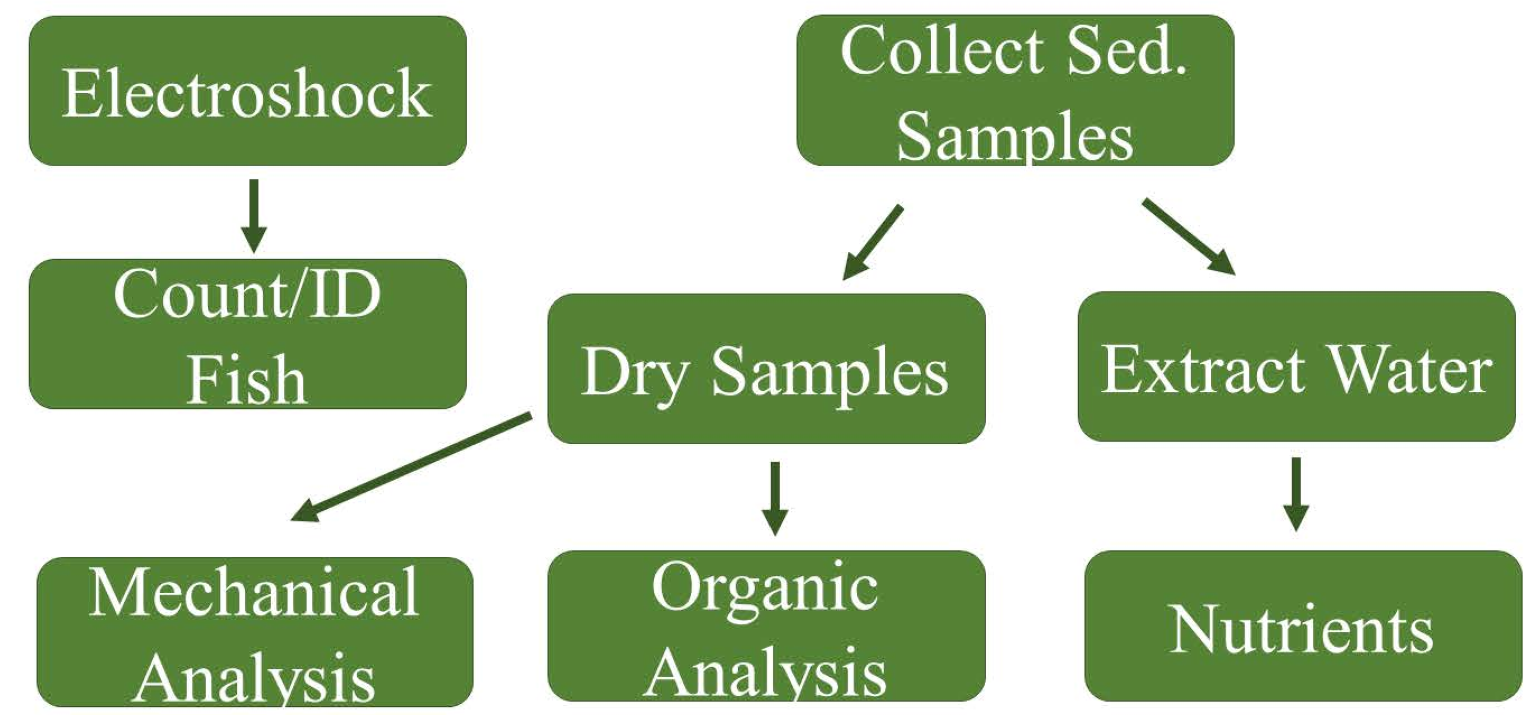
Introduction:

Precision conservation is using geospatial analysis of high-resolution datasets to determine the location where restoration will be the most effective based on elements like stream location, watershed size, and neighboring land use. Sediment size and composition are important components of streams. Organisms that use the stream bottom for feeding, burrowing, and breeding are known as lithophilic fish, and they require larger grain sizes, like sand and gravel. Highly agricultural areas tend to have lots of runoff that carry small particles, clay and silt, containing nutrients like nitrate, phosphate, and ammonia into streams which can lead to impaired quality and poor fish habitat. Restoration techniques such as riparian buffers and mud sills are installed to stabilize banks and filter out sediments and nutrients. A study done at Iowa State showed that riparian buffers were highly effective at filtering total sediment loads and nutrients from entering streams, but the percent clay entering the stream actually increased (Lee et al., 2003). Smaller particles, like clay, have a larger surface area per volume which allows for more nutrient bonding. Sediment particle size determines the mode of transport as well as the ion concentrations on the sediment surface (Evans et al., 2004). A key factor in improving the quality of agriculturally impaired streams is increasing mean grain size, limiting the percent of clay and silt which should reduce nutrient concentrations, and hopefully lead to an increase in fish populations. The purpose of this research is to determine if studying the correlation between sediment bound nutrient concentrations (nitrate, phosphate, and ammonia) and fish populations is a better indicator of stream quality than simply analyzing physical sediment characteristics alone.

Figure 5: Sampling sediment from a stream

Figure 6: Measuring the length of a brown trout.

Methods:



Mechanical Analysis:
- Sieve
- Hydrometers

Organic Analysis:
- LOI

Nutrients:
- TOC
- TN
- NH_4
- NO_3
- PO_4

Results and Discussion:

It is understood that a streambed dominated by coarse sediment particles is a more ideal habitat for most macroinvertebrates and fish than fine sediment. Restoration aims to improve stream quality by narrowing and deepening channels, adding meanders, and planting riparian buffers, all which reduce the nutrient carrying sediment that enters streams. In Figure 7, it is seen how the amount of organic matter significantly decreases as the percentage of sand in a sample increases. It is expected that fish populations will thrive in coarse substrates, which is supported by Figure 8. As mean grain size increases in size, the density of lithophilic fish was found to increase. Figure 9 also shows evidence that the smaller the sediment particles, the lower the density of lithophilic fish.

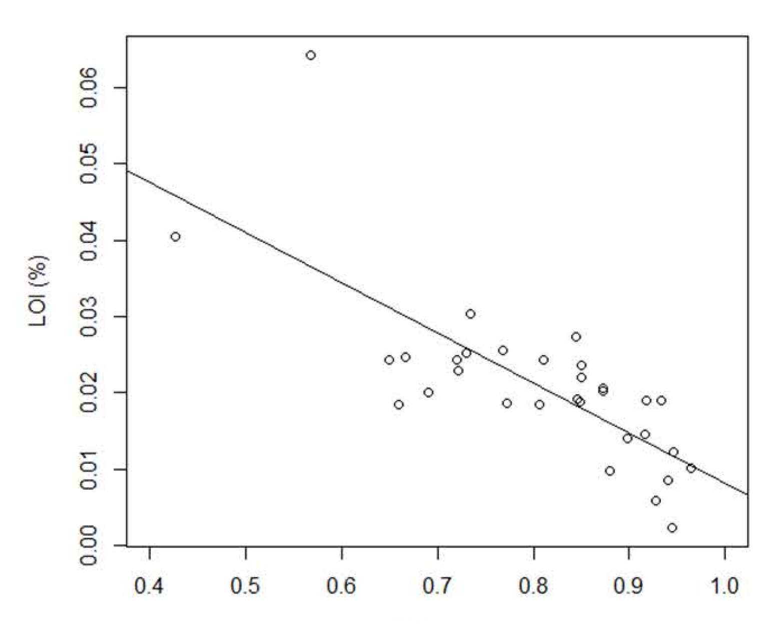


Figure 7: Loss on ignition decreases as the percent of sand increases per sample. R^2 value = 0.563, p-value = 1.17e-06

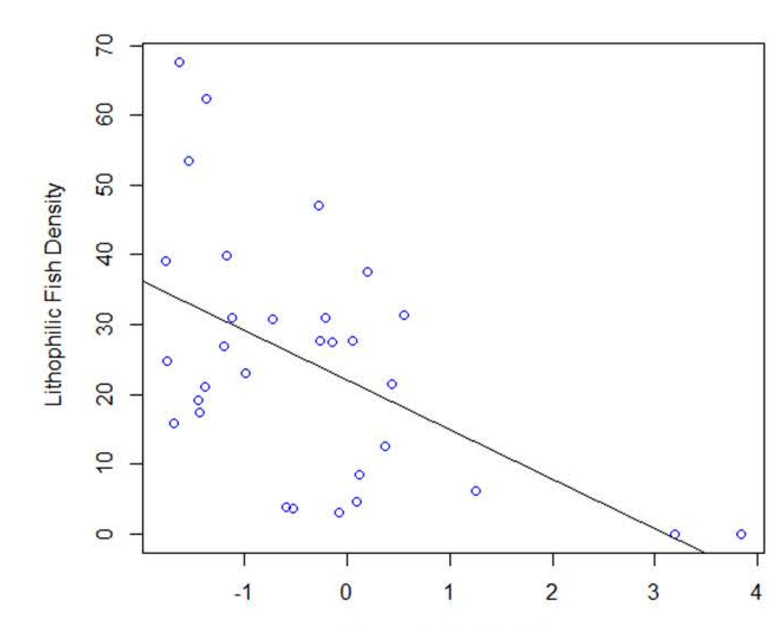


Figure 8: The density of lithophilic fish decreases as grain size gets smaller. R^2 value = 0.281, p-value = 0.0025

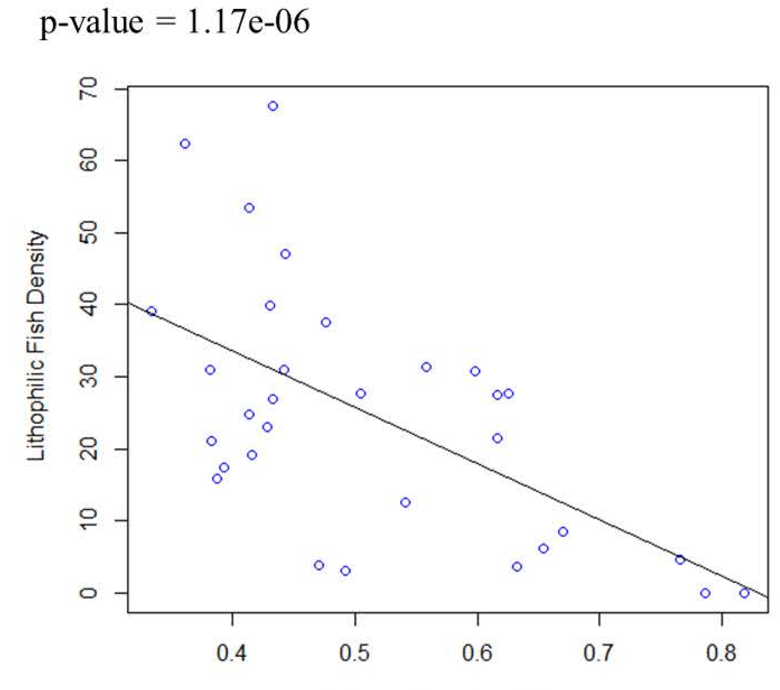


Figure 9: As the percent of fine earth fractions increases, the density of lithophilic fish decreases. R^2 value = 0.347, p-value = 0.000489

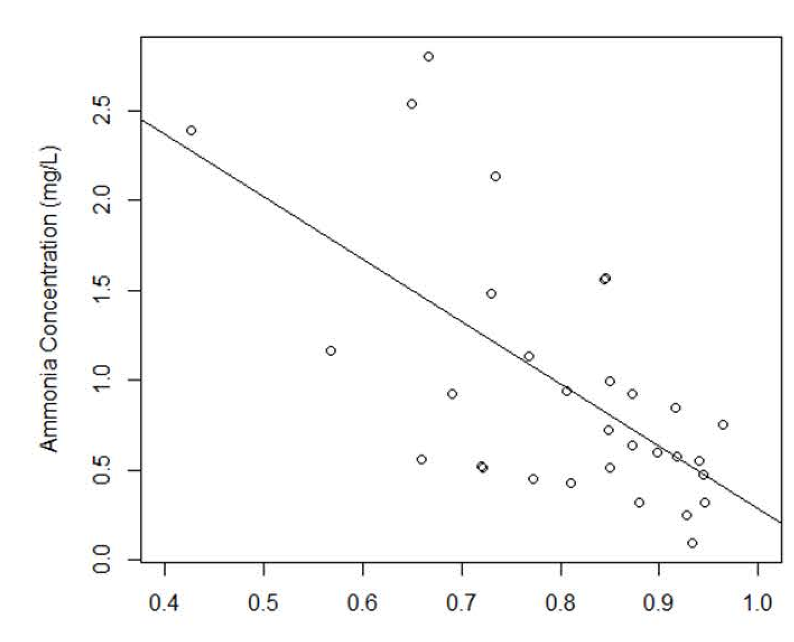


Figure 10: Ammonia concentrations decrease as the percent of sand increases per sample. R^2 value= 0.392, p-value = 0.000162

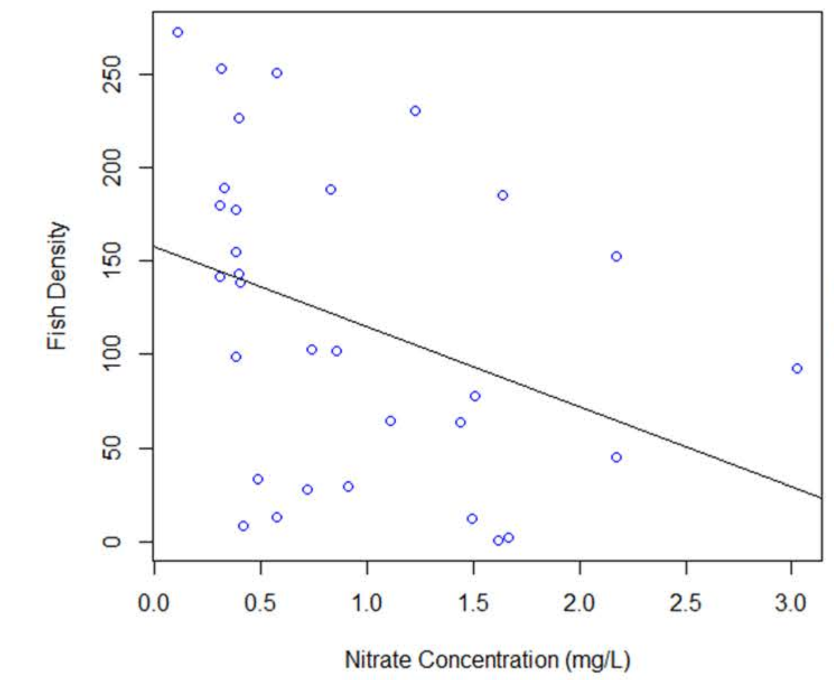


Figure 11: The density of all fish decreases as nitrate concentrations increase. R^2 value = 0.130, p-value = 0.046

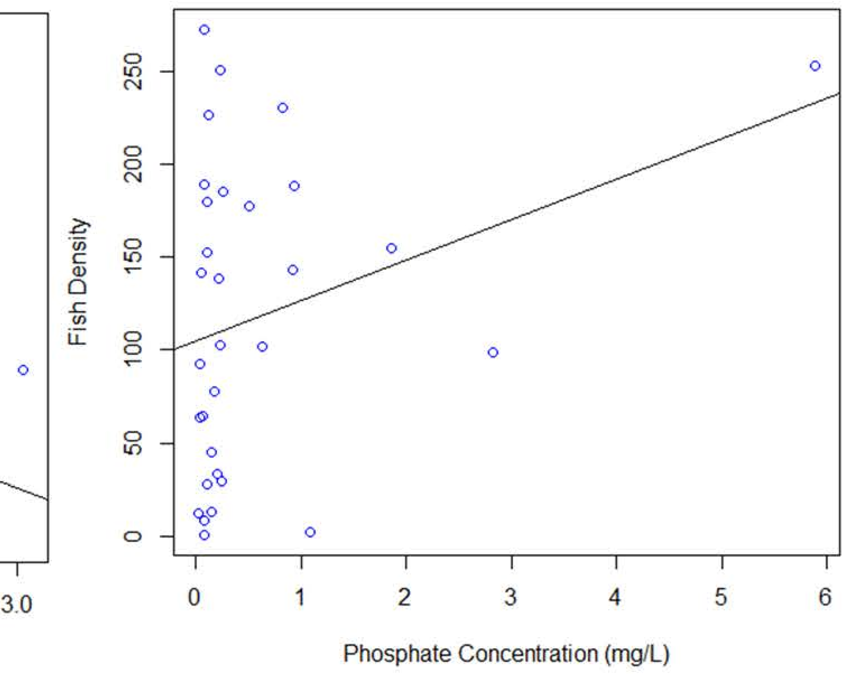


Figure 12: The majority of the phosphate concentrations were zero mg/L, and were very insignificant. R^2 value= 0.090, p = 0.1002

The hypothesis was partially supported as results showed that ammonia and nitrate concentrations in sediment were correlated to fish populations. Figure 10 shows the relationship between ammonia concentrations and the percent of sand present. Ammonia was very strongly correlated to sand, and it was previously noted that fish populations are effected by the mean grain size of a stream. While ammonia acts like a dependent variable, nitrate was found to independently effect fish populations. After performing an anova test and a step function which removed some variables, nitrate concentrations showed the most significance (Table 1) and provided the most insight towards the objective of the study. The phosphate results (Figure 12) were insignificant, which is hypothesized to be an error in methodology. Overall, the results showed that the research is stronger and more conclusive with the addition of nutrient analyses.

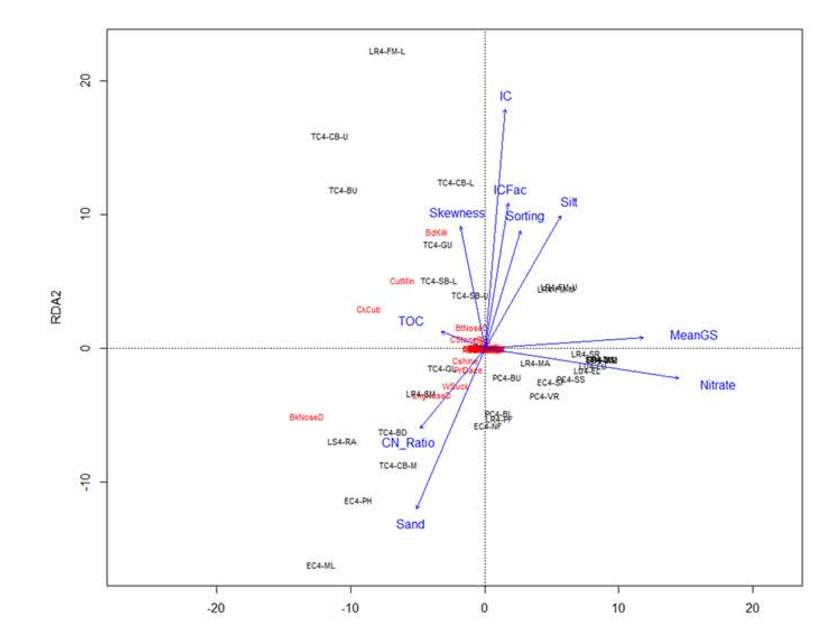


Figure 13: Redundancy analysis (RDA) shows the relationships between site locations, fish species, and the remaining variables after a step function was applied.

Table 1: Chi squared values comparing the significance of physical variables versus physical variables plus nutrients applied to all fish density.

	Chi Squared Values	
	Only Physical Variables	Including Nutrient Variables
Fish Density	114,953	44,918

Conclusion:

Sediments in the bottom of a stream channel can act as a storehouse of nutrients that dissolve back into the stream flow. Stream restoration techniques that support coarse sediments in the stream will provide a double benefit as better habitat for lithophilic fish as well as reduced capacity to store nutrients. As this project continues, we hope to see increased grain size which carry less nutrients into the streams. This should lead to larger lithophilic fish populations and boost the diversity of the aquatic environment.

References:

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