Potential Correlations Between Water Quality, Habitat Quality, and Macroinvertebrate Taxa

Jakob O'Neal '16 – Landmark College, Putney, Vermont

Abstract

Knowing how different elements of an ecosystem respond to each other is important to understanding how pollution affects our environment. This study aimed to discover if there was a significant relationship between macroinvertebrate taxa richness, water quality, and habitat quality. EPT richness, habitat assessment, and Total Suspended Solid measures were compared to each other using 3 scatter plots with a calculated linear regression. The results yielded a significant relationship between all three measures, indicating that changes in one significantly affect the other two. This not only shows how elements of an ecosystem are intertwined, but also how we can indicate pollution.

Introduction

- Macroinvertebrate diversity plays important role in maintaining health of an ecosystem
- Important food source for fish and can have important influence on nutrient cycles, primary productivity, decomposition, and translocation of materials (Wallace, J. B., & Webster, J. R. *et. al.* 2006)
- Factor that has been linked to a lack of diversity amongst macroinvertebrate taxa is degraded habitat quality due to human interference and pollution (Newbold *et. al.* 1983)
- Increases in suspended solid concentrations (often measured as total suspended solids, or *TSS*), which are also often caused by pollution, have also been found as contributors to decreases in macroinvertebrate diversity as well (Gray, L. J., & Ward, J. V. *et. al.* 1982)
- The purpose of this presentation is to either refute or further support these findings
- Using available data gathered in 2015 for macroinvertebrate taxa identifications, Habitat Assessments, and Total Suspended Solid measurements from various sample sights, this study aims to locate any correlations between these factors
- Since these measurements can be correlated with pollution of their sampling source, the study also explores if there is a relationship between amount of potential pollution and the predominant type of surrounding land
- This will hopefully further the understanding of how the various elements of ecosystem quality affect each other and which of these measures we can use as confident indicators of pollution
- I predict that there will be significant responses of EPT richness to TSS changes, TSS amounts to habitat scores, and EPT richness to habitat scores

Materials & Procedure

Figure 1.

Site Code	Location	Date Sampled	EPT Richness (averaged from multiple samples)	TSS (Mg/L averaged from multiple samples)	Habitat Assessment Score	Predominant Landscape
LCD_EngBrk_117	Burlington, VT	6/11/2015	3.667	42.05	21	Commercial
LCD_PoBrk_133	Potash Brook - Farrell St.	6/11/2015	21.893	78.407	44	Commercial
WR_DwvllBrk_649	Moretown, VT	8/16/2015	76.932	0.323	86	Forest
WR_LzBrk_809	Duxbury, VT	8/18/2015	71.426	6.303	84.5	Forest
WR_MdRvr_04288000	Moretown, VT	6/5/2015	75.148	0.997	55.5	Agricultural
WR_SIBrk_714	Richmond, VT	6/12/2015	47.904	2.01	45	Forest
LCD_UprLPltt_181	Shelburne, VT	9/17/2015	54.063	1.277	69.5	Agricultural
RGL_MrcutoCrk_46	Puerto Rico	9/13/2015	40	1.06	75.5	Forest
RHL_PthyR_79	Luquillo, PR	10/4/2015	80	7.657	74	Forest
WCC_PkCrk_112	Newark, DE	8/14/2015	71.699	16.943	72.5	Forest
WCC_PkCrk_156	Wilmington, DE	8/7/2015	76.487	1.703	63	Urban
WR_AllnBrk_361	Williston, VT	9/13/2015	51.331	9.38	63	Forest
WR_CeBrk_184	Burlington, VT	6/11/2015	31.43	66.947	30.5	Urban
WR_WBLRTribA_725	Stowe, VT	10/16/2015	61.08	0	60	Forest

- Over 2015, researchers affiliated with EPSCoR gathered samples and assessed the quality of various watershed sights (see Figure 1. for more info on locations and sampling dates)
- Three distinct measurements were made from the data collected (refer to Figure 1.)
- Kick-net riffle samples of macroinvertebrates were taken at all of the sites listed in Figure 1. These samples were picked and the macroinvertebrates within them were keyed as far as genus if possible. The EPT of these samples was then calculated
- EPT richness is the percentage of a macroinvertebrate sample that belongs to either the Ephemeroptera (mayflies), Plecoptera (stoneflies), or Trichoptera (caddisflies) family
- Since these macroinvertebrates have all shown evidence of sensitivity to pollution (Hamid, S. A., & Rawi, C. S. *et. al.* 2011), EPT is a good measure to use against other habitat measurements

- Total Suspended Solids (TSS), which are volume measurements of unfilterable solids in a sample of water, were also calculated from water samples gathered and averaged for use in this study
- Suspended solids are not only often caused by pollution, but they also block sunlight, making aquatic plants less efficient at using photosynthesis and less able to release dissolved oxygen into the water, making it less habitable for macroinvertebrates (Gray, L. J., & Ward, J. V. *et. al.* 1982)
- Finally, Habitat Assessments of each sight were made, which observed the quality of various elements of each sight and scored its overall health out of 100 possible points
- EPT richness, TSS, and Habitat scores were then compared using scatter plots and linear regression (refer to Figure 2-4.), to compare TSS (x)with EPT richness (y), habitat scores (x) with TSS (y), and habitat scores (x) with EPT richness (y)
- The null hypothesis ($p \geq 0.05$) was that there is no significant relationship between the axis of each of the three graphs. A *p* value less than 0.05 would then indicate a significant relationship between the two axis of the graph
- An *R* square value was also calculated, which indicates the percentage of the x-value that is explained by the y-value. Any value around 50% or higher can be assumed to indicate a strong responsive correlation between a y-value and its corresponding x-value

Results

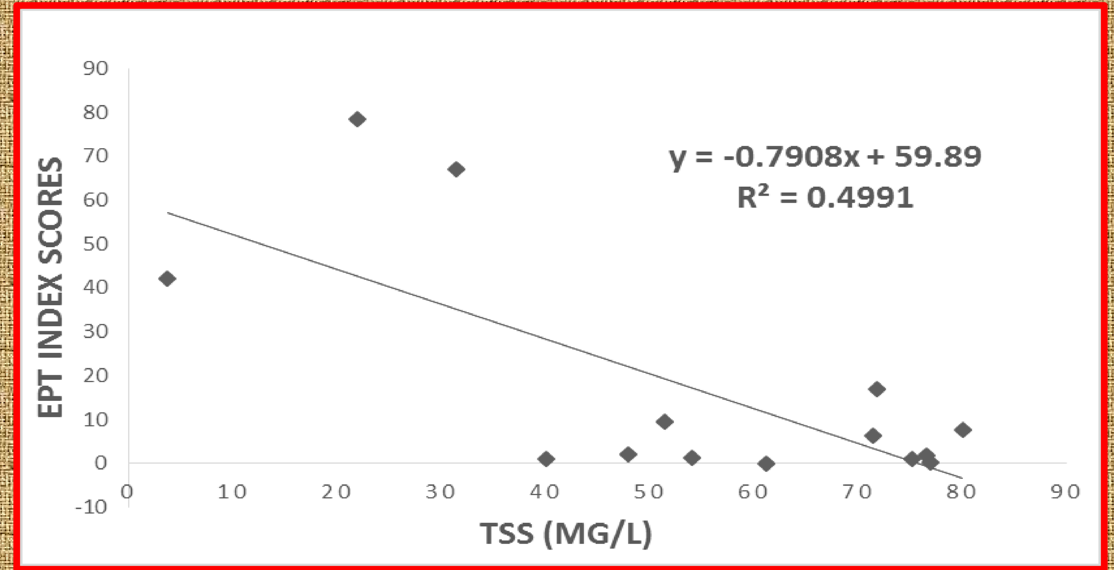

Figure 2. The Response of EPT Richness to the amount of Total Suspended Solids in a sample site.

Output	Value	Interpretation
P value	0.00473	There is a significant relationship between the amount of TSS and EPT richness.
Coefficient (of TSS)	-0.631	The slope is negative, meaning that as TSS increases, EPT richness decreases.
R square	0.499	TSS explains 49.9% of variability in EPT richness.

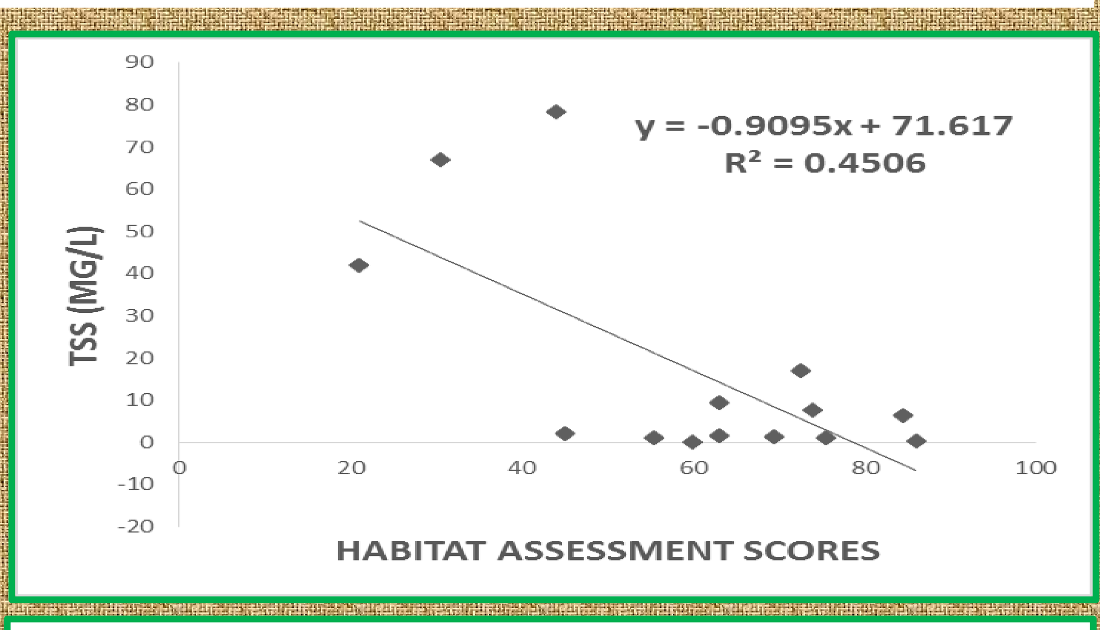

Figure 3. Relationship Between Habitat scores and Total Suspended Solid amounts (TSS).

Output	Value	Interpretation
P value	0.00857	There is a significant relationship between the Habitat Assessment scores and the amount of TSS.
Coefficient (of Habitat Assessment score)	-0.909	The slope is negative, meaning that as the Habitat Assessment score increases, the amount of TSS decreases.
R square	0.451	The Habitat Assessment scores explain 45.1% of the variability in TSS amount.

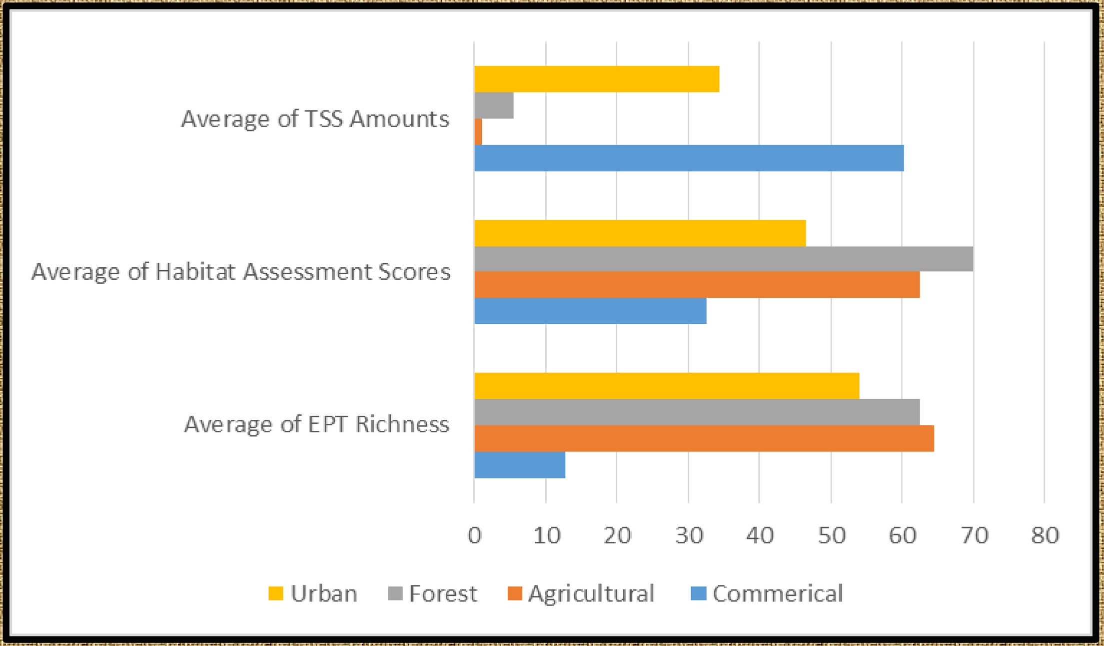

Figure 5. The Relationship between the predominant land type of the sites used to gather data and habitat quality, water quality, and EPT richness.

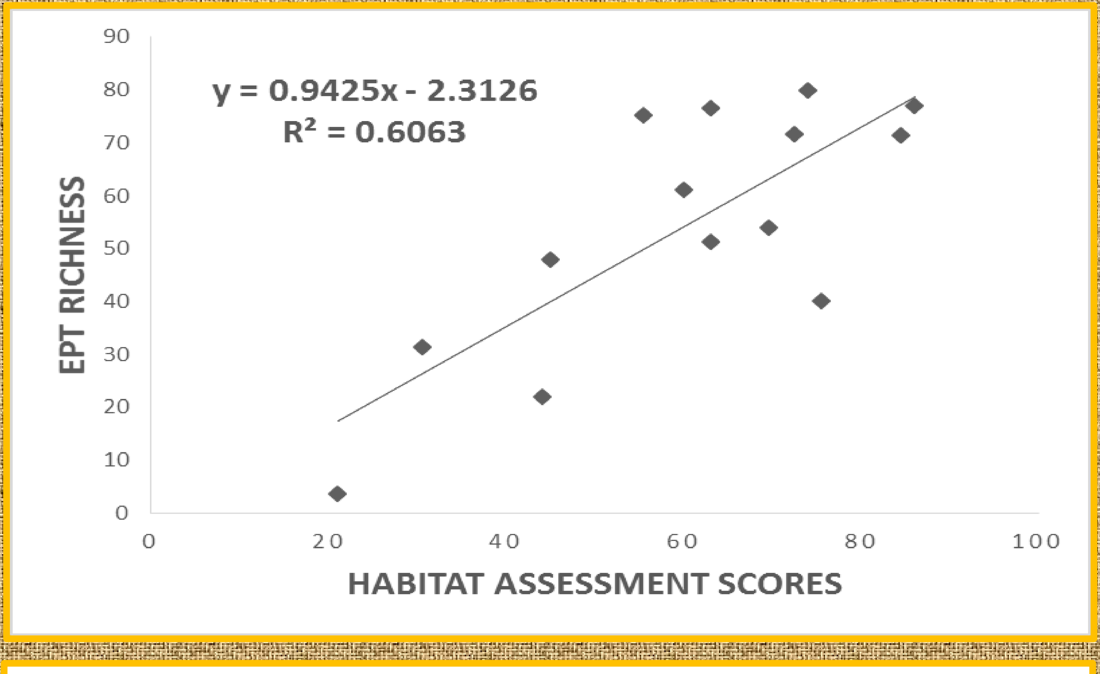

Figure 4. Relationship Between Habitat scores and EPT Richness.

Output	Value	Interpretation
P value	0.00103	There is a significant relationship between the Habitat Assessment scores and EPT richness.
Coefficient (of Habitat assessment score)	0.942	The slope is positive, meaning that as the Habitat Assessment scores increase, so does EPT richness.
R square	0.606	The Habitat Assessment scores explain 60.6% of the variability in EPT richness

Discussion/Conclusions

- As indicated by the calculated *P* values, all three scatter plots showed a significant relationship between the measures on the x and y axis
- This in combination with the coefficient of the linear regression function indicates that there is a significant decreasing response of EPT richness as TSS increases, a significant decreasing response in TSS as the habitat score increases, and a significant increasing response in EPT richness as the habitat score increases
- In addition, the *R* square value yielded by all three of the graphs indicates that a significant amount of variability in EPT richness, TSS, and EPT richness are respectively explained by TSS, habitat scores, and habitat scores
- These results support what has been previously discovered by other researchers (Newbold *et. al.* 1983; Gray, L. J., & Ward, J. V. *et. al.* 1982)
- What can be concluded is that increases in Total Suspended Solids does yield a significantly responsive decrease in EPT richness, that the amount of Total Suspended Solids decrease responsively as the quality of the habitat scores increase, and that the EPT richness responsively increase as the habitat scores increase
- This further supports the notion that macroinvertebrate taxa, habitat quality, or water quality can all be used as indicators of the relative quality of the other two
- Since TSS is an indicator of pollution (Gray, L. J., & Ward, J. V. *et. al.* 1982), this also indicates these measures can all be used to indicate pollution in habitat and its water
- In looking at correlations between predominant land use and the habitat measures used (see Figure 5.):
- The commercial and urban sites had significantly more suspended solids, commercial sites had the lowest average habitat score and significantly less EPT richness than any other land type
- Forest and agricultural sites showed the best health in all three categories, but it is important to note that each every land type except forest, which had 8 sample sights, had 2 sample sights, which creates a potential inconsistency
- The urban sites yielded inconsistent results, since they had high amounts of TSS but still showed relatively decent habitat quality and EPT richness in comparison
- A conclusion from these findings is that commercial sites show the most apparent indications of pollution
- Overall, this study supports further the responsive relationship of the various elements of an ecosystem, and shows how rippling the effects of pollution can be to them
- In future studies, I think we should look further into which pollutants most significantly contribute to increases in suspended solids, as we can then trace what significant causes of these pollutants are

Literature Cited

- Wallace, J. B., & Webster, J. R. (1996). The Role of Macroinvertebrates in Stream Ecosystem Function. *Annual Review of Entomology Annu. Rev. Entomol., 41*(1), 115-139.
- Newbold, J.D., J.W. Elwood, R.V. O'Neill, and A.L. Sheldon. 1983. Phosphorus dynamics in a woodland stream ecosystem: A study of nutrient spiraling. Ecology 64:1249–1265.
- Gray, L. J., & Ward, J. V. (1982). Effects of sediment releases from a reservoir on stream macroinvertebrates. *Hydrobiologia, 96*(2), 177-184.
- Hamid, S. A., & Rawi, C. S. (2011). Influence of substrate embeddedness and canopy cover on the distribution of Ephemeroptera, Plecoptera and Trichoptera (EPT) in tropical rivers. *Aquatic Insects, 33*(4), 281-292.

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