Geomorphic Traits and Water Chemistry as an Indicator of Fish Functional Diversity in Scott County, IA and Rock Island County, IL

UMC
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Diego Cruz, Kevin Geedey, and Ben Ford
Augustana College, Rock Island, IL

Introduction

Urbanization and mass scale agriculture have changed the hydrogeomorphic characteristics of streams and the composition of their biological assemblages. Species richness, Shannon's index, and Simpson's index are commonly used to understand fish assemblage health, despite critiques that these metrics may give an incomplete picture.[1] In this study we used a functional diversity approach to investigate differences between functional and species diversity and to identify any ecosystem correlates of functional diversity. Functional groups are groups of species that serve the same function in an ecosystem similar to ecological guilds, which are non phylogenetic groups that share the same resources.[2] Functional diversity may be a helpful way of understanding a gradient of stream disturbances by providing insight on species' interactions between their environment and food web that a species level analysis might miss. We want to assess the influence of geomorphic traits and water quality on streams fish functional diversity.

Furthermore, since higher trophic levels have been found to be more sensitive to environmental change, [2] we are interested in factors that drive the presence or absence of the predator functional group. This study is part of Augustana's Upper Mississippi Center's collaboration with the city of Davenport to improve stream health.

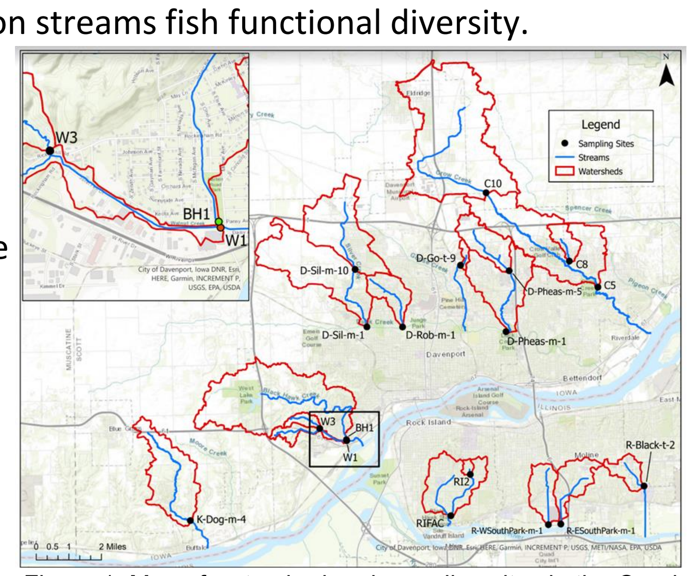

Figure 1: Map of watershed and sampling sites in the Quad Cities Area

Methods

- 19 stream sites in Scott County IA and Rock Island IL that vary in land use, water quality, and geomorphic characteristics along a 50m reach were shocked with a Electrofishing Systems AbP-4-MR-HP Pulsed-DC backpack
- Identified 1841 fish to 28 species and categorized species to respective functional feeding group benthic invertivore, filter, generalist, herbivore, insectivore, omnivore, parasite, top carnivore, or N/A in accordance to an IADNR reference[3]
- Assessed fish functional diversity by calculating Shannon's diversity index using guild group membership instead of species identity
- *Micropterus dolomieu* is the most dominant predator identified followed by less abundant *Micropterus salmoides* and *Esox americanus*
- Geomorphic and water quality parameters were collected as a part of the Upper Mississippi Studies Center's ongoing watershed study
  - Water chemistry measured using YSI PRO-Plus meters and a Seal AQ 300 discrete autoanalyzer
  - Calculated entrenchment ratio by measuring flood prone area and dividing by the average bankfull width
- Multiple regression was performed (SPSS) to find correlates of functional Shannon's. The full Upper Mississippi Studies Center's dataset was used, which included water chemistry: NO_3,NH_4 PO_4, pH, Cl, dissolved Oxygen %, suspended solids, conductivity, and geomorphic and habitat variables such as: discharge, stream width, sinuosity, entrenchment ratio, substrate type and diversity, and riffle and pool diversity.

Results

Shannon's diversity based on species identity was closely coupled to Shannon's based on functional diversity, but there were instances in which they did not completely match up (Figure 2, R^2 = .838, t = 9.096, F = 82.738, p < .00).

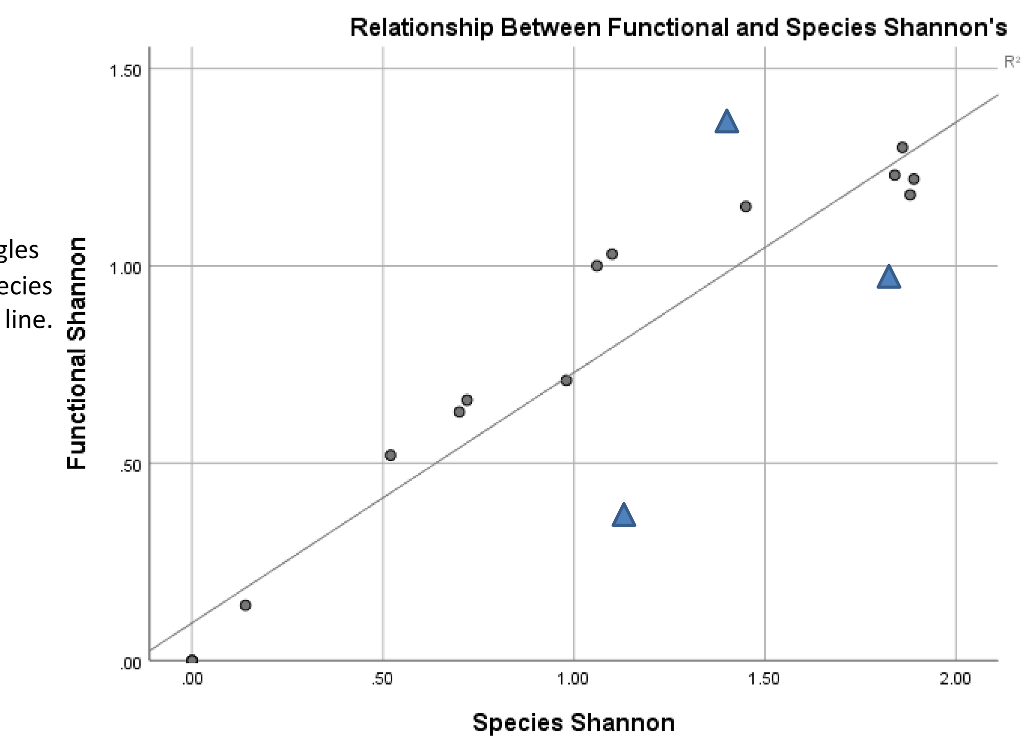

Figure 2: Linkage of Species and Functional Shannon's. Blue triangles indicate where functional and species diversity did not follow the trend line.

The combination of variables in multiple regression analysis that explained the most variation in functional diversity while being individually significant included stream width, entrenchment ratio, and chloride as independent variables. The 3 variables were jointly found to be strong and significant predictors of functional Shannon's (r^2 = .744, F = 11.598, p < .001). Within this model, stream width was most closely coupled to functional Shannon's (Figure 3, r^2 = .477, t = 3.998, p < .002), while entrenchment ratio and chloride were less closely associated, but remain reasonable predictors (r^2 = .194, t = -2.494, p < .028) and (Figure 4, r^2 = .141, t = -2.803, p = .016), respectively.

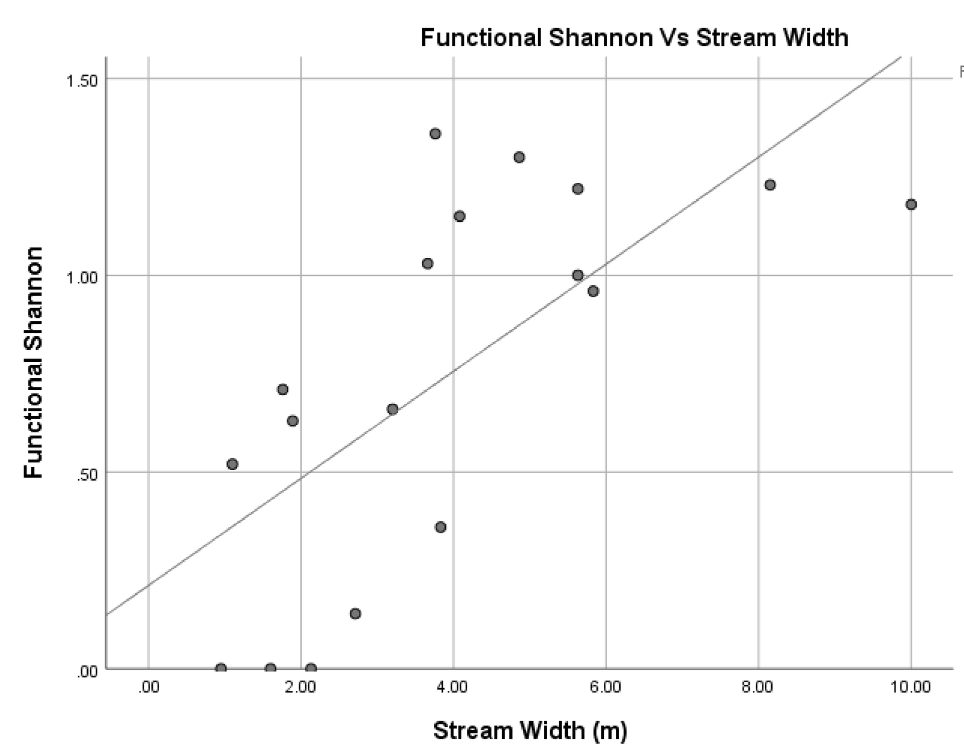

Figure 3: Functional Shannon's as a function of stream width.

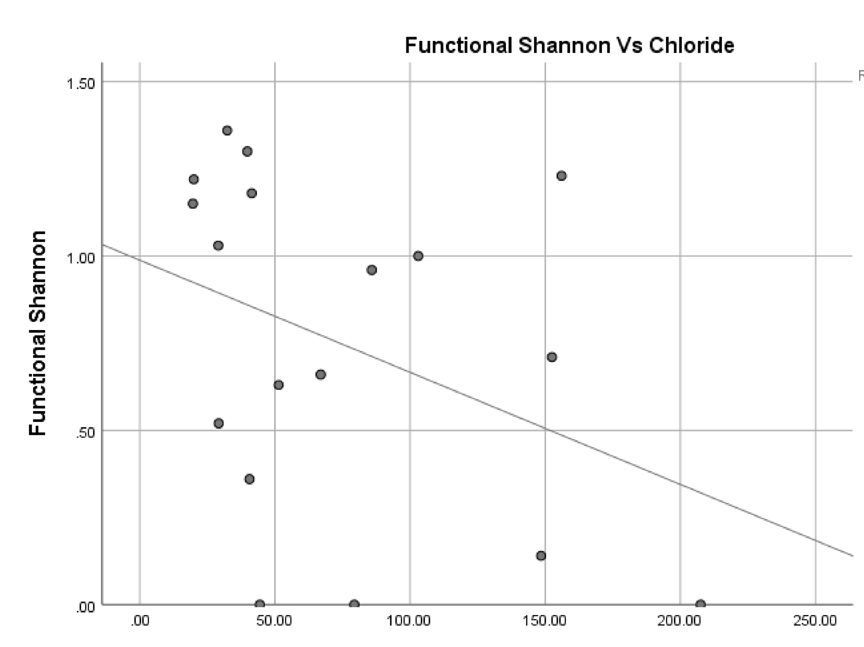

Figure 4: Chloride's influence on Functional Shannon's

Results

With respect to predators, stream width was most tightly linked to the predator, *M. dolomieu* (r^2 = .346, F = 8.473, t = 2.911, p < .010). Stream width is a weak predictor for the remaining two predators, likely because of the small sample size and was ultimately left out of individual predator analysis. Predators as a whole, appeared in stream widths ≥ 5 (Figure 5).

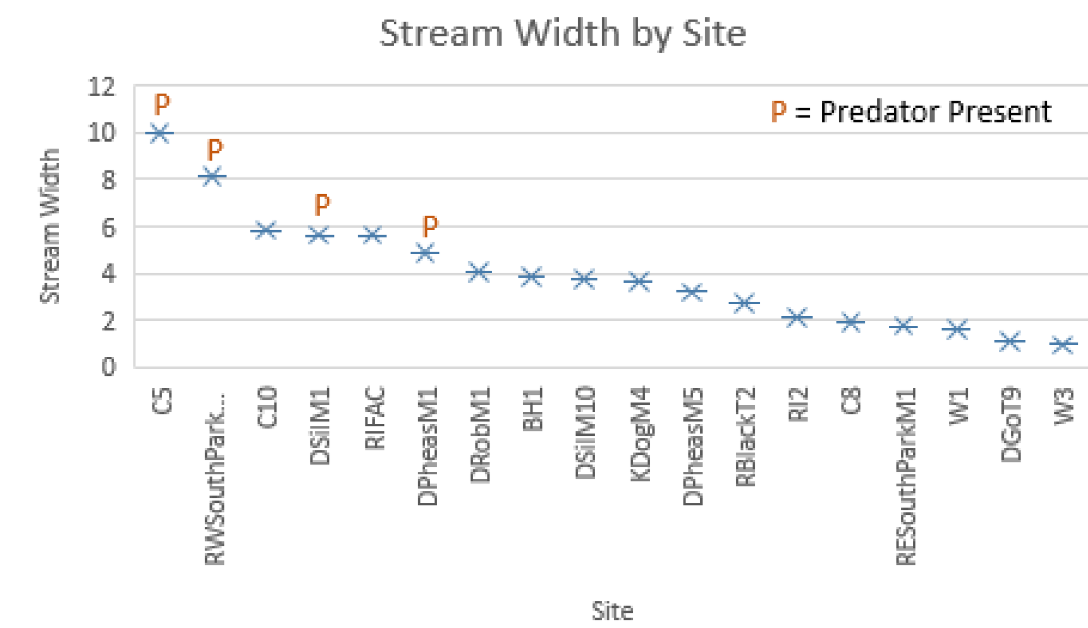

Figure 5: Box and whisker plot of sampled sites' stream width and identified sites with predators.

Discussion

Complementary to our study, the most intriguing finding was how closely knit stream width was to functional group diversity.[4] However, contrary to our study, there were substrate/instream habitat (% coarse substrate, % cobble, and % riffle) and stream bank/riparian (% bare bank, bank rating, and shade) variables that were equally as linked as stream width and less so for water quality (turbidity and nitrate).[4] For our study, a multiple regression of the above variables did not explain functional group diversity. Increased width of streams support more functional groups possibly through expanding space and limiting interspecific competition between different functional groups, and as a result, support predators. Stream widths ≥ 5 created viable conditions for top predators to be present in fish assemblages, and in specific, was a strong driver of *Micropterus dolomieu* presence. Because so few of our sampled streams were greater than 5 m in width, we have too small a sample size of streams with predators to discern other possible drivers of their abundance. It was interesting to see the lack of influence that was displayed by water quality variables, like DO, pH, and ammonia. In this study, some of these variables had a small range of values and we were only able to sample 19 sites for fish. These factors obscure our ability to assess whether drivers like pH or dissolved oxygen play a role in governing functional diversity. Another interesting finding is the strong linkage of species and functional Shannon's in our study. Possible reasons for this trend is that generally, species diversity boosts functional diversity, but this is not always the case.[5] Limitations of our study include that this was our first year conducting an analysis of fish assemblages in the Rock Island/Davenport area and with that came challenges that limited sample size and sites.

Literature Cited

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Authors Contact Information & Acknowledgements

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Diego Cruz (diegocruz19@augustana.edu), Dr. Kevin Geedey (kevingeedey@augustana.edu), and Ben Ford (benjaminford18@augustana.edu)