The effects of shoreline development on macroinvertebrate communities in Lake Champlain

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Abstract:

This study analyzed the relationship between macroinvertebrate health and the amount of shoreline development at three different buffer distances (15.2 meters, 50 meters, and 100 meters) from the shoreline of eleven sites. Six sites were dominated by macrophyte substrate, four sites by sandy substrates and one site by rocky substrates. I hypothesized that the indices would be negatively correlated with land development and that as the distance of land development from the lake increased, the strength of these relationships would decrease. I performed regression analyses with several indices including EPT abundance, EPO abundance and the COTE proportion. As predicted the each index was significantly negatively correlated to increasing land development. I was surprised to find however, that contrary to my prediction about the relationships, the strengths of the patterns increased as the distance from the lake increased. This emphasizes the strong impact that shoreline development can have, even when it is "far" from the lake.

Background:

The littoral zone of a lake is the near-shore area where light can still reach the bottom. This zone is critically important as a habitat for aquatic plants and as a part of the life cycles of many macroinvertebrates (Merrell et al. 2009). Shoreline redevelopment has been a rising trend since the 1980s as demands for lake-side residential homes and maintained recreation areas continue to increase, and there is a concern that shoreline development may reduce habitat complexity and consequently reduce macroinvertebrate species diversity (Brauns et al. 2007). Benthic macroinvertebrates are considered to be useful indicators of lake pollution and health, but few studies have compared the effects of shoreline development on macroinvertebrate community health. Furthermore, while conventional streams studies rely on indices such as EPT (Ephemeroptera Plecoptera Trichoptera) abundance to compare populations of different sites, indices must be reconsidered for a lakeshore study. The VTDEC guidelines for measuring characteristics of macroinvertebrate communities by determining the usefulness of common and lesser known indices. Percent Oligochaeta and the COTE proportion were recommended as useful indices for littoral zone sampling (Kamman 2007). This study will focus on the impact of different degrees of shoreline development on the health of macroinvertebrates living in sandy , rocky and macrophyte habitats and will comparatively use the indices proposed by Kamman as well as other indices that are considered useful in measuring littoral macroinvertebrate community health such as richness, EPT abundance, EPO (Ephemeroptera Plecoptera Odonata) abundance, and dominance. The indices will be compared to the percent of development at three different distances from the shoreline to ascertain if communities are still impacted by relatively distant buildings and structures.

Methods:

Field Protocol

- The littoral macroinvertebrate samples were a part of a larger 92-site study on the effects of lakeshore development on habitat quality .
- Samples from macrophyte habitat sites were taken with a .45m net to create a 10 meter transect area.
- Samples from sandy habitat sites were taken with a 45cm net to create a 1 meter transect area.
- Samples from rocky habitat sites were taken with a 0.7m net to create a .5 meter transect area. Macroinvertebrates and debris from the net for each sample were poured through a sieve and then transferred to a Whirl Pack containing 100% ethanol.
- ArcGIS mapping software and high-resolution aerial imagery was used to digitize a fine-scale land use/land cover dataset within a 150-m buffer of the Mallets Bay shoreline. The land cover dataset produced three development metrics: built developed; outdoor developed percentage; and total developed percentage (comprised of both built and outdoor developed features). These metrics were calculated for 15.2-m, 50-m, and 100-m buffer distances from each sampling site.

Figure 1. Developed features within a 100-m buffer of a sampling site.

Lab Protocol

•The samples were spread evenly on a standard cafeteria tray with water.
•The tray was divided into 12 numbered squares and a 12-sided die was used to randomly select squares to sub sample.
•Picking continued until a minimum of three squares and 80 invertebrates had been picked. In cases where three squares did not yield 80 invertebrates, additional full squares were picked until the 80-individual threshold had been exceeded.
•The picked macroinvertebrates were then placed into a vial with a label and 70% ethanol/1% glycerin.
•The macroinvertebrates of each labeled sample were identified down to family or genus using Merritt, Cummins, and Berg (2008).

Results:

Table 1. A summary of the p-values and Regression squared values of the relationship between each index measured at each site (an average of the site's samples) in comparison to the land development at three different distances (15.2 m, 50 m, and 100 m away) from each site.

	15.2 m Buffer		50 m Buffer		100 m Buffer	
Indices	P value	R^2 value	P value	R^2 value	P value	R^2 value
EPT Abundance	0.033	0.016	0.015	0.201	0.0061	0.336
EPO Abundance	0.005	0.084	0.0022	0.314	0.0023	0.344
Richness	< 0.001	0.038	< 0.001	0.106	< 0.001	0.131
% Oligochaeta (Average)	0.002	0.101	0.004	0.148	0.0037	0.215
Dominance	< 0.001	0.106	< 0.001	0.001	< 0.001	0.005
COTE/COTE + Oli +Chi	< 0.001	0.018	< 0.001	0.127	0.0003	0.209

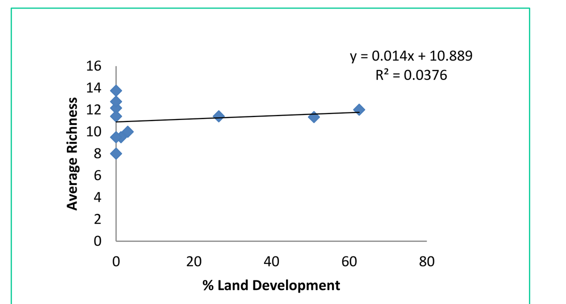

Figure 2. Average Richness vs. % Land Development at 15.2 m buffer

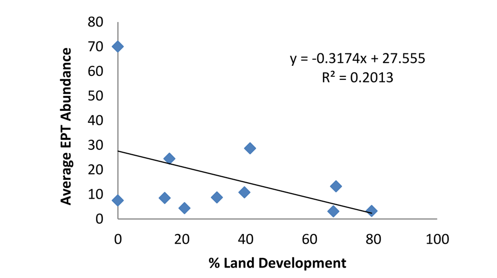

Figure 3. Average EPT Abundance vs. % Land Development at 50 m buffer

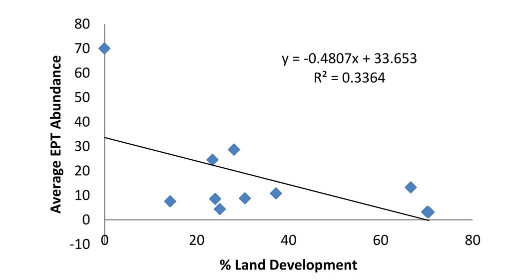

Figure 4. Average EPT Abundance vs. % Land Development at 100 m buffer

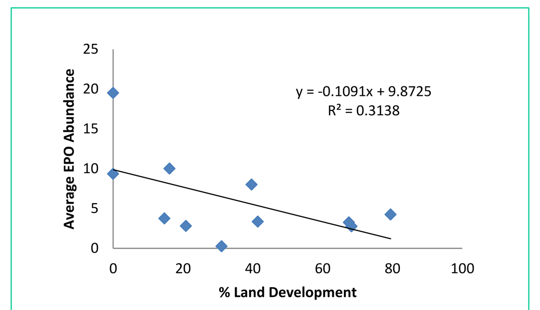

Figure 5. Average Abundance of EPO vs. % Land Development at 50 m buffer

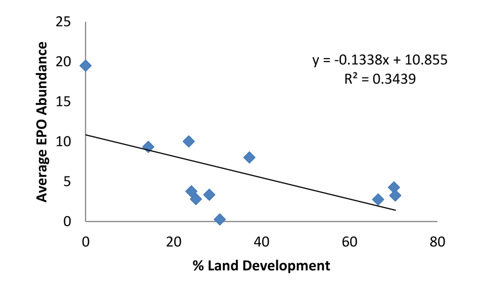

Figure 6. Average EPO Abundance vs. % Land Development at 100 m buffer

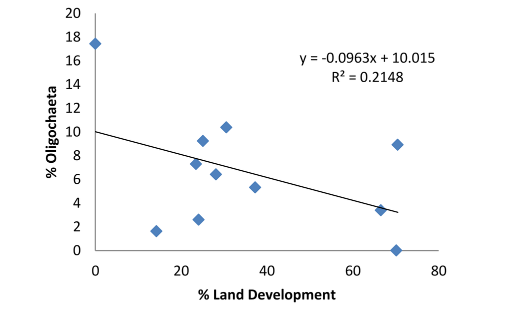

Figure 7. % Oligochaeta vs. % Land Development at 100 m buffer

Discussion:

There was a significant negative correlation between each index and amount of land developed at 15.2 meters, 50 meters and 100 meters away from the lake. Contrary to expectations, the farther away the development was from the stream, the stronger the pattern (the Regression values at the 15.2 development were consistently lower than the 50 m and 100 m values) for each index (Table 1).While still significantly ($p < .001$) lower with increasing site development, the average richness of species had one of the weakest patterns in relation to development (Figure 2). This weak correlation could mean that most of these species are relatively tolerant to pollution and habitat disruption or are affected equally by any amount of disruption, regardless of its distance away. Stronger correlations were noted with the EPT and EPO abundance indices. As the percent of land development increased, the average EPT abundance significantly decreased at each distance (p values in Table 1). As the distance away from the lake increased the pattern became stronger, with a weak trend at 15.2 m, a moderate trend at the 50 m buffer (Figure 3) and a stronger trend at the 100 m buffer (Figure 4). The EPO abundance and land development relationship was similar (Figures 5 and 6). Interestingly the relationship is slightly stronger for the EPO index than the EPT index, meaning that EPO is a potentially useful index for lakes due to the increased presence of odonates here (Brauns et al. 2007). In accordance with the guidelines from Kamman (2007), the COTE proportion and % Oligochaeta were both analyzed for relationships with land development. While both had significant negative correlations to land development at each distance, their patterns were only relatively moderate in strength. Like the other metrics discussed, the relationship grew stronger as the distance of the buffer increased, with the % Oligochaeta relationship being the stronger of the two (Figure 7). The COTE proportion may be omitted from future studies in favor of simpler, more reliable indices.

The results of this study were unexpected because it was expected that the development closest to the lake would have a strong relationship with most of the indices. This could be explained by the fact six of the sites had no development at the 15.2 m buffer whereas eleven sites were developed at the 100 m buffer. The fact that the pattern is strong when development is far away is alarming in terms of shoreline development-development can still impact macroinvertebrate community health via erosion and consequent habitat loss even if it is distant. In the future it would be useful to map the land use occurring 200 and 300 meters away from the lake in order to see if the pattern grows stronger or weaker, which could provide a sense of just how distant development needs to be in order to have no negative impacts on the benthic macroinvertebrates that live there.

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