The effects of urbanization on sediment size and benthic macroinvertebrate communities

Patrick Bousquet and Declan McCabe

Abstract

Urbanization is the negative impact humans have on an ecosystem by developing an area. Macroinvertebrates, because of their vulnerability to changes in the environment, are used as indicator species of water quality. In this study, I looked at the impact of urbanization on the Browns River in Underhill, VT and Potash Brook in South Burlington, VT by measuring the sediment percentages and macroinvertebrate community dynamics. To do this, I collected sediment samples and identified the macroinvertebrates in the samples. The abundance and diversity of each stream was different. However, there was no difference in sediment size percentages. Furthermore, there was no correlataion between sediment size and species diversity.

Background

Urbanization of Landscapes

- Ecosystem modified by human settlement (Taylor and Owens 2009)
- Complete impact on wetlands not known for certain (Faulkner 2004) aside from diminished habitats (Cheimonopoulou *et al*. 2011)

Watershed Function

- Link ecosystem through hydrologic pathway (Faulkner 2004)
- Urbanization causes divergence from natural sedimentation (Taylor and Owens 2009)
- Sediment size influences what species of macroinvertebrates can live in the area (Richards and Bacon 1994)

Macroinvertebrates useful as indicator species

- Respond to changes in water quality (Cheimonopoulou *et al*. 2011)
- Plecoptera, Ephemeroptera, and Trichoptera (Jones *et al*. 2011)

Hypotheses:

- Expect with more of an impact from urbanization, stream would have more fine sediment
- Expect with more of an impact from urbanization, macroinvertebrate populations would be less dynamic

Methods

Site Description

- Browns River (N 44.507873,W 72.894424)
- Potash Brook (N 44.446799,W 73.203278)
- Both streams have similar flow, riffles, width, and depth

Data Collection

- 4 x5 array
- Dig sediment using a trowel to collect sediment and macroinvertebrates
- Put in Ziplock with 100% EtOH

Data Processing

- Separate sediment and macroinvertebrates
  - ID macroinvetebrates to genus
  - Sieve analysis of sediments

Data Analysis

- Student's T-test on abundance of Browns River vs. Potash, diversity of Browns River vs. Potash, and percent of fine sediment of Browns River vs. Potash
- Regression of percent fine sediment and abundance and percent fine sediment and diversity

Results

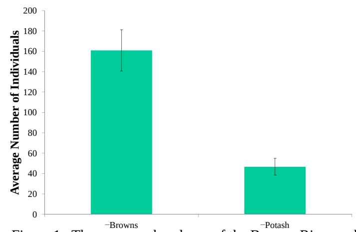

Figure 1. The average abundance of the Browns River and Potash Brook. The Browns River had roughly 114 more individuals per sample than Potash ($P < 0.001$).

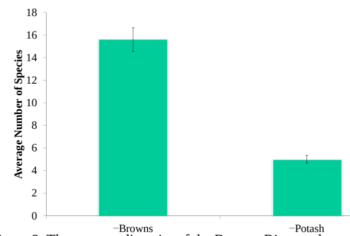

Figure 2. The average diversity of the Browns River and Potash Brook. The Browns River had ten more species per sample than Potash ($P < 0.001$).

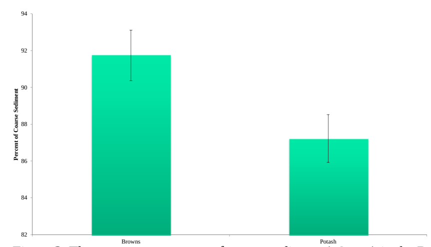

Figure 3. The average percentage of coarse sediment (>2 mm) in the Browns River and Potash Brook. The Browns River had 91.74% while Potash had 87.22% coarse sediment ($P < 0.05$).

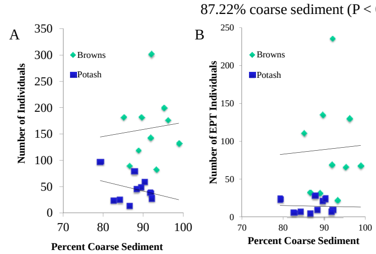

Figure 4. A) The relationship between percentage of coarse sediment and abundance. B) The relationship between coarse sediment and abundance of EPT's. In both figures, the Browns River is represented by green and Potash is represented by blue. There were no correlations between coarse sediment and abundance ($P > 0.05$).

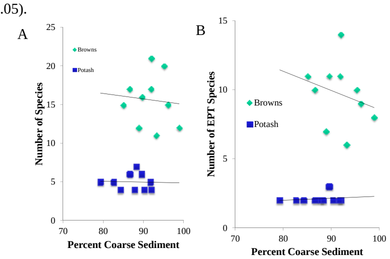

Figure 5. A) The relationship between percentage of coarse sediment and diversity. B) The relationship between coarse sediment and diversity of EPT's. In both figures, the Browns River is represented by green and Potash is represented by blue. There were no correlations between coarse sediment and diversity ($P > 0.05$).

Discussion

There is a clear difference in abundance and diversity of macroinvertebrates between the Browns River and Potash Brook(Figures 1 and 2). As expected, the Browns River was significantly more abundant and diverse than Potash ($P < 0.001$). Chon *et al*. (2001) found a similar comparison with temperature as their disturbance. They found that lower temperatures, similar to urbanization, inhibited a community from becoming more diverse.

There was significantly more coarse sediment (> 2 mm) in the Browns River than in Potash ($P < 0.05$) (Figure 3). This was also expected because the Browns River is less impacted from urbanization than Potash. Urbanization leads to soil erosion, which washes into streams (Meade 1982).

There was no correlation between the percent of coarse sediment and abundance of macroinvertebrates in genera, nor was there a correlation between the percent of coarse sediment and the abundance of EPTs (Figure 4). There was also no correlation between the percent of coarse sediment and diversity of macroinvertebrates, nor was there a correlation between the percent of coarse sediment and diversity of EPTs (Figure 5). This contradicts the study of Richards and Bacon (1994). They suggested the exact opposite: with more fine sediment, the community's abundance and diversity would be lower.

Perhaps my sieve analysis data is different from other studies because some sediment was lost during the shaking process. Because each sieve was only about 3 cm tall, rocks larger than 3 cm would not fit. Therefore, they would be taken out and not included in the sieve analysis.

Works Cited

Cheimonopoulou, M. T., Bobori, D. C., Theocharopoulos, I., and Lazaridou, M. 2011. Assessing ecological water quality with macroinvertebrates and fish: a case study from a small mediterranean river. *Environmental Management*. **47**: 279-290.

Chon, T., Kwak, I., Park, Y., Kim, T., and Kim, Y. 2001. Patterning and short-term predictions of benthic macroinvertebrate community dynamics by using a recurrent artificial neural network. *Ecological Modelling*. **146**: 181-193.

Faulkner, S. 2004. Urbanization impacts on the structure and function of forested wetlands. *Urban Ecosystems*. **7**: 89-106.

Jones, J. I., Murphy, J. F., Collings, A. L., Sear, D. A., Naden, P. S., and Armitage, P. D. 2011. The impact of fine sediment on macroinvertebrates. *River Research and Applications*. **28**: 1055-1071

Meade, R. H. 1982. Sources, sinks, and storage of river sediment in the United States. *The Journal of Geology*. **90**: 235-252.

Richards, C. and Bacon, K. L. 1994. Influence of fine sediment on macroinvertebrate colonization and hyporheic stream substrates. *Great Basin Naturalist*. **54**: 106-113.

Taylor, K. G. and Owens, P. N. 2009. Sediments in urban river basins: a review of sediment contaminant dynamics in an environmental system conditioned by human activities. *J Soils Sediments*. **9**: 281-303.

Acknowledgements

I would like to thank Vermont EPSCoR for funding this study, and Saint Michael's College (Colchester, VT) for providing lab space and other necessary resources. Thanks to Professor Declan McCabe (St. Michael's College) for his help in coordinating the macroinvertebrate lab and for his help with data collection and analysis, and Miranda Lescaze for her coordination of the Streams Project. I would also like to thank Anne Burnham and Jared Peick for their help with sample collection and processing. Funding provided by NSF Grant EPS-1101317.