THE EFFECTS OF RIPARIAN CANOPY DISRUPTIONS ON PERIPHYTON AND MACROINVERTEBRATE DIVERSITY IN LOW ORDER STREAMS

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Abstract. Periphyton and aquatic macroinvertebrate metrics are commonly used as indicators of stream quality due to their responsivenss to changing conditions. Riparian canopy disruptions may increase light exposure, increase water temperature, and decrease terrestrial carbon inputs, the primary nutrient source in low-order and headwater streams The purpose of this paper is to explore how the size of the gap affects community diversity within and below gaps in riparian forest cover in low-order streams.

INTRODUCTION

Riparian buffer zones determine the type and availability of basal carbon sources to streams, particularly in headwater or low-order streams (Vannote et al., 1980; Lennat, 1993; Hilsenhoff, 1988). The loss of these riparian buffers results in changes to both physical and biological characteristics of streams (Hynes, 1975; Gregory et al., 1971; Sweeney, 1993; Allen, 2004). Riparian forests restrict the amount of autochthonous primary production that can occur via canopy shading, but provide allochthonous carbon inputs in the form of leaf litter and woody debris, and serve to retain channel morphology as well as restrict photoperiod and temperature changes (Naiman and Decamps, 1997).

A temperature increase as small as 2-3.5°C can result in reduced macroinvertebrate abundances and richness (Worthington et al., 2015). Periphyton and aquatic macroinvertebrate metrics are commonly used as indicators of stream quality due to their sensitivities to changing conditions (Li et al., 2013; Verb and Vis, 2005).

In streams with highly fragmented forest buffers, the forested reaches tend to have more diverse macroinvertebrate communities and pollution-sensitive taxa (Rios and Bailey, 2006), and macroinvertebrate diversity tends to increase with increasing stream size in healthy streams (Heino et al, 2005). Periphyton diversity is less well-studied, but has been found to correlate strongly to water quality index values (Yan, et al., 2014). Periphyton biomass has been shown to increase with decreasing riparian buffer width and decreasing canopy cover, though this effect is somewhat mitigated by macroinvertebrate grazers (Kiffney et al., 2003; Feminella et al, 1989).

This study utilized macroinvertebrate and periphyton assessment data from low-order streams with riparian buffer gaps of varying size to explore how gap length, channel width, canopy cover, and catchment area relate to macroinvertebrate and periphyton diversity changes within gaps and whether these effects are continued downstream of gaps.

METHODS

Sampling took place at 10 sites within the Upper Little Tennessee Watershed in North Carolina and northern Georgia, between late May and July of 2015. Each site was divided into three reaches: within the gap (Gap), upstream (Above), and downstream (Below). The Above reaches served as reference reaches to which the others were compared. Protocols for macroinvertebrate sampling were based on rapid bioassessment methods utilized by the Georgia Department of Natural Resources Environmental Protection Division, and protocols for periphyton sampling were derived from rapid bioassessment protocols developed by the United States Environmental Protection Agency.

Data collection for this study was performed in conjunction with a study of physical properties (Coates, unpublished). Samples were fixed on site, then subsampled, identified, sorted, and enumerated in the lab. Macroinvertebrates were identified to the family level and periphyton to genus.

Out of the ten initially sampled sites, the periphyton report and macroinvertebrate report included eight of the sites with six in common between the two. The periphyton report excluded Chastain creek and Tiger creek due to recent rainfall events. Rainfall events have been found to have only a weak impact on macroinvertebrates in low order streams (Bispo et al 2006), so they remain in the macroinvertebrate assessment. Two sites (Tessentee 1 and Tessentee 2) were excluded from the macroinvertebrate assessment due to the samples being too degraded to process.

Diversities for macroinvertebrates and periphyton were calculated for each reach location using the Shannon Weiner Diversity Index (SWDI):

$$SWDI = \sum P_i \ln(P_i)$$

where P_i is the proportion of specimens in taxa i relative to the total number of specimens.

From these SWDI values, proportional change in SWDI between the three reaches (Above, Gap and Below) were calculated and compared to gap length (m), gap channel surface area (m^2), and unshaded gap channel surface area (m^2)* (Table 2).

Table 1. Reach SWDI values of periphyton and macroinvertebrates at each Sample Site

	Periphyton			**Macroinvertebrate**		
Site	**Above**	**Gap**	**Below**	**Above**	**Gap**	**Below**
Alarka	1.701	1.428	1.730	1.019	0.969	1.044
Burningtown	1.586	1.628	1.602	0.932	0.892	0.714
Chastain	N/A	N/A	N/A	1.188	1.004	1.202
Commissioner	1.760	1.286	1.589	1.024	1.083	0.995
Crawford	1.262	1.283	1.008	1.007	1.154	1.143
Dick's Creek	1.497	1.568	1.511	0.894	0.536	0.455
Poplar	1.498	1.525	1.650	1.200	0.928	1.102
Tessentee 1	1.423	1.581	1.738	N/A	N/A	N/A
Tessentee 2	1.933	1.627	1.699	N/A	N/A	N/A
Tiger	N/A	N/A	N/A	0.866	1.051	0.853

Table 2. Within-gap measurements for each site, including estimates of surface area. Unshaded bankfull surface area found using length x width x (1- Canopy Cover).

Site	**Length**	**Bankfull Width**	**Canopy Cover**	**Bankfull Surface Area (m^2)**	
	(m)	**(m)**	**(%)**	**Total**	**Unshaded**
Alarka	156.5	12.17	8.84	1,904.6	1,736.2
Burningtown	142.4	14.37	24.70	2,046.3	1,540.9
Chastain	99.2		2.34	337.3	32.9
Commissioner	36.0	3.42	18.20	123.1	100.7
Crawford	85.4	3.10	35.62	264.7	170.4
Dick's Creek	243.3	4.25	3.64	1,034.0	996.4
Poplar	190.0	5.80	47.58	1,102.0	577.7
Tessentee 1	121.5	4.79	18.98	582.0	471.5
Tessentee 2	45.7	10.50	12.64	479.9	419.2
Tiger	80.7	N/A	N/A	N/A	N/A

RESULTS

There was a moderate positive correlation in proportional macroinvertebrate diversity loss between the above and gap reach locations, and a less strong but still moderate positive correlation between the above and below reach locations. There were weak (but present and similar) negative correlations between periphyton proportional diversity loss for both the Above:Gap and Above:Below comparisons (Figure 1).

The only other significant correlation between diversity loss and the gap measurements was a parabolic relationship between macroinvertebrate diversity loss and unshaded gap surface area (Figure 2). This correlation is very strong for diversity loss between the Above and Gap reach locations, and moderately strong but still significant between the Above and Below reach locations. Both appear to have a maximum net diversity loss at 1000 m^2.

CONCLUSION

The very small sample size of this preliminary study makes it impossible to draw definitive conclusions. However, macroinvertebrate and periphyton diversity appear to demonstrate responses to changes in channel and gap dimensions and shading that are worthy of future study. The unresponsiveness of periphyton to unshaded gap surface area in particular indicates that some variable other than those discussed here may be an overriding factor for periphyton diversity changes or perhaps that periphyton has a different response to unshaded gap area than an increase or decrease in diversity. It may be valuable to explore biomass changes or water chemistry changes.

Overall, relative periphyton diversity increases with increasing gap length, both within the gap and downstream. Macroinvertebrates displayed a more dramatic variation in relative diversity changes. Macroinvertebrates displayed an increasing proportional diversity loss with increasing gap lengths, and a similar increasing degree of diversity loss with increasing unshaded gap reach surface area with diminishing effect after 1000m^2. This may have land management implications and warrants further investigation.

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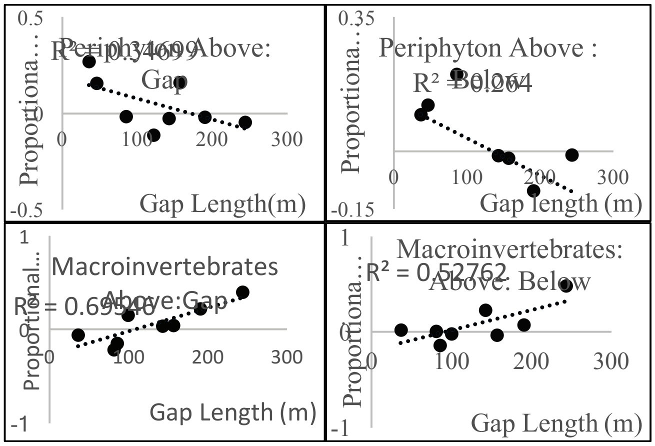

Figure 1. Correlations between proportional diversity loss and gap length for macroinvertebrates and periphyton.

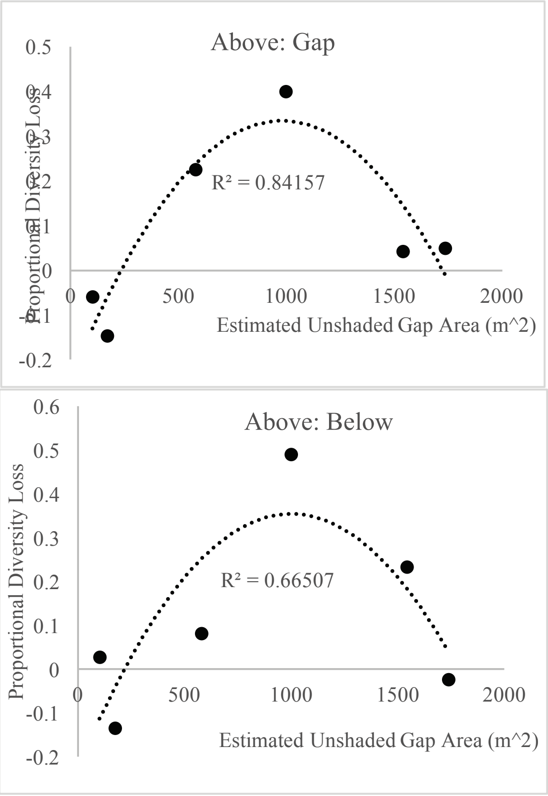

Figure 2. There are strong parabolic correlations between diversity loss and estimated unshaded gap surface area (Above:Gap r=0.8416; Above: Below r=0.665).

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