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The Effect of Riparian Buffer Zones of Macroinvertebrate Biodiversity and Stream Health

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Abstract

Riparian buffer zones are the forested areas between a stream and the surrounding land. They help preserve stream quality, and in doing so, help preserve biodiversity. Riparian buffer zones have an affect on a vast array of stream attributes, macroinvertebrate biodiversity, and the health of stream ecosystems; it is for this reason that they are important.

Macroinvertebrates are often considered an indicator of ecosystem health and therefore the way that buffer zones affect macroinvertebrate species richness and abundance are often indicative of how they affect the rest of the ecosystem. The purpose of this project was to collect macroinvertebrates to test for differences between riparian and non-riparian zones. The data were collected once during each of the calendar seasons (twice during the fall) in the Yellow Breeches Creek in Cumberland County, Pennsylvania. Richness and abundance are not greater in riparian zones. However, the Shannon index and Becks scales are statistically greater in riparian zones; indicating greater biodiversity in riparian zones.

Introduction

Riparian buffer zones do much to help maintain stream health. These buffer zones will moderate temperatures in the buffer zones as well in the stream itself by approximately 5 degrees Celsius (Meleason and Quinn 2004). Temperature in turn has an impact on macroinvertebrate species richness and abundance, so any variation in temperature resulting from buffer zones would be important (Rutherford et al 1997). According to Milner and Gloyne-Phillips, riparian zones offer significantly more habitat, as well as habitat types not found in non-riparian zones (2005). Also, forested reaches of stream are wider than deforested regions. This slows stream velocity and creates a healthier stream (Sweeney et al 2004). This is primarily due to forested regions shading out herbaceous grasses that encroach on stream banks in deforested areas.

Further, ammonium uptake is much higher in forested reaches of stream than deforested reaches, partially due to a decreased velocity (Sweeney et al 2004).

Macroinvertebrates are often considered an indicator of ecosystem health (Resh et al 1995). The way buffer zones affect macroinvertebrate species richness and abundance should be indicative of how they affect the rest of the ecosystem. Macroinvertebrates are a prime candidate for study of healthy versus unhealthy ecosystems because they usually have short generation times, are intolerant of pollutants, and occupy a variety of niches. Further, many other animals feed on macroinvertebrates, so they are a crucial element of the food chain. For instance, fish eat many macroinvertebrate larvae and many flying adult macroinvertebrates meet their end in the stomach of birds in the family Tyrannidae, the flycatchers (Lambert and Hannon 2000). Some studies give an indication as to how riparian zones affect stream characteristics and macroinvertebrate biodiversity (Sweeney et al 2004).

We wanted to determine if macroinvertebrate abundance is greater in riparian or non-riparian zones. We also wanted to compare riparian and non-riparian zones to determine which one had greater biodiversity by looking at species richness, the Hilsenhoff Biotic Index (HBI), the Shannon index, modified Becks scale, percent intolerance and trophic feeding groups. Further, we wanted to determine if perhaps the Ephemeropteran, Plecopteran, and Tricopteran (EPT) taxa could be used as a shortcut method of macroinvertebrate surveying.

Materials and Methods

Three sites were chosen along the Yellow Breeches Creek (Cumberland County, PA). For each of these sites, we designated both a riparian and a non-riparian zone within a half mile of each other. These sites were chosen using aerial photographs of Cumberland and York Counties in ArcGIS. By using this program, we could easily account for differences in land use and try to account for that in our site selection by choosing sites of similar land usage. After site selection, we sampled each site during each of the four calendar seasons, with fall samplings occurring in both 2007 and 2008.

Water chemistry (total hardness, calcium hardness, pH, chlorides, alkalinity, nitrates, and phosphates) were tested using EPA approved methods found in the *Water Analysis Handbook* second edition by the Hach Company. For each sample, water depth and stream velocity was tested with a Global Waters flowmeter for each individual sample type. Conductivity was tested using an Oakton Instruments ECTester. These accounted for any difference in habitat due to variables other than riparian zones versus non-riparian zones.

The sampling process involved taking 3 randomized sets of samples from cobble and one sample from riffle habitat types at each site. A 600 μm mesh D-net was used for macroinvertebrate sampling in riffle habitats and a 600 μm mesh Surber sampler to sample from cobble in riffle habitats. After collecting samples, they were deposited in 1 L containers with 70% ethanol for preservation and were identified to genus level using a dissection microscope and several taxonomic keys to macroinvertebrates of Pennsylvania (*An Introduction to the Macroinvertebrates of North America* 3rd edition by Merritt and Cummins and *Freshwater Macroinvertebrates of Northeastern North America* by Peckarsky et al.

After organisms were identified, the data was organized for each site by riparian versus non-riparian zones. Intolerance and functional feeding groups were taken from the PA DEP's 'Taxa Tolerance and Trophic Classification Table.' The Hilsenhoff biotic index (HBI) accounts for the intolerance of organisms and their abundance within the collection and was used to adjust for total stream health. It is important to note that for HBI, higher values are not better. A modified Becks scale was used to analyze the quality of organisms. For this scale, only organisms with an intolerance level between 0 and 2 (according to the PA DEP) were used. Each individual of a 0 intolerance was given a weight of 3, each individual of a 1 intolerance was given a 2, and each individual of a 2 tolerance was given a 1. This accounted for highly intolerant species present as well as their abundance. Percentage was calculated for each trophic group for each season, as well as percent intolerance (intolerance included those organisms with an intolerance of 0-4). The Shannon index was also used to calculate biodiversity. This index accounts for unique organisms as well as species evenness in the data and collections with high species richness and evenness score higher in this index.

ANOVA tests were used for comparison between seasons and T-tests were used to compare within seasons. An alpha value of 0.05 was used to test for significant difference between riparian and non-riparian zones. After determining if there was any significant statistical difference between riparian and non-riparian zones, the "quality" of the organisms caught was evaluated. As is the case in all taxa, some species are considered to be generalists and will thrive in any environment whereas others will be more specialized and need certain habitats and other factors. The difference between the generalists and the specialists were meant to be a better indication of stream health than just species abundance would be. In order to determine the "quality" of our macroinvertebrates, we looked at the total number of taxa, the number of Ephemeroptera taxa, the number of Plecoptera taxa, the number of Trichoptera taxa, and the total number of Ephemeroptera, Plecoptera, and Trichoptera taxon. This gave us an idea of the species richness in each of our sites and the tests already listed gave us an idea of percent composition and trophic differences.

Results

Of the over 13,000 individuals collected from the cobble samples, mean abundance (table 1) was higher in riparian zones than non-riparian zones for all of the five sampling seasons except the fall and winter of 2008. Abundance was highest during the summer and fall of 2008 (p=0.043 and 0.015 respectively), both seasons in which abundance was higher in riparian zones.

The mean richness was greater in the riparian zone for every season, however none were statistically significant. Mean HBI was approximately equal for every season, the only statistically significant season being the spring of 2008 in which the mean in riparian zones was higher (p=0.014). Similarly, percent intolerance is statistically different in the fall of 2007 (p=0.022) in which the percent intolerance was 73.6% for the riparian zone and 57.1% for non-riparian zones.

In the modified Becks scale (table 2) means are greater in riparian zones than non-riparian zones with statistical differences present in the summer of 2008 and overall (p=0.007 and 0.005 respectively). The Shannon index had a higher mean in riparian zones for all seasons except for the summer and fall of 2008; results were significant in the winter and spring of 2008 as well as overall (p=0.018. 0.001, and 0.03 respectively—see table 3).

For every season which macroinvertebrates were collected, the mean EPT taxa was higher in riparian zones than non-riparian zones except for in the fall of 2007. The data were only significant in the summer and fall of 2008 as well as overall (p=0.023, 0.041, and 0.027 respectively—see table 4).

Of the seasonal EPT taxa data (figure 1), only the non-riparian zones had statistically significant results (p=0.023) across the seasons. The EPT taxa present in the non-riparian zones steadily dropped off from the winter, with the winter and fall of 2008 being the most different.

The seasonal HBI shows similar results; HBIs were highest for both the riparian and non-riparian zones in the summer samples with each in their own statistical category.

Data from the seasonal Becks scale showed that the mean was higher for every season in the riparian zones and for both the riparian and non-riparian zones winter and spring were in their own statistical categories (see figure 2). The seasonal riparian Shannon data (see figure 3) was not statistically significant, but it was still highest during same sample periods in which it was lowest in the statistically significant non-riparian zones (p=0.013).

Of the functional feeding groups, only three groups were statistically significant across seasons: the collector gatherers, the predators and the scrapers (p=0.000, 0.050, and 0.002 respectively). Of all the trophic groups, only the collector gatherers (table 5) and the scrapers (table 6) had overall significance in T-tests (p=0.002 and 0.050 respectively).

Discussion

There are some statistical differences between riparian and non-riparian zones. One of the working hypotheses behind this project had been that abundance would be greater in non-riparian zones due to more sunlight and therefore more energy put into the system whereas biodiversity would be greater in riparian zones. However, this was not the case as mean was not statistically higher in any season for non-riparian zones. However, the summer and fall of 2008 had significantly greater abundance in riparian zones—perhaps as a result of a thermal buffer or an increase of food availability due to organic material falling into the stream.

It had been hypothesized that richness would be greater in the riparian zones than in the non-riparian zones. Although the mean was higher for every single season as well as overall in the riparian zone, for no season was the richness statistically different.

Two particularly useful tests of biodiversity show that biodiversity is greater in riparian zones than in non-riparian zones. The Shannon index was significantly greater in the riparian zones than the non-riparian zones in the winter, spring, and overall. In the modified Becks scale, all seasons had a higher mean for the riparian zone and there was an overall statistical difference. Since the Becks scale only includes individuals with intolerance ranked by the PA DEP as 0 through 2, this scale only includes the most intolerant of Pennsylvania's macroinvertebrates. As a result, this scale gives a good indication as to where organisms of the greatest 'quality' exist as well as providing information about abundance. This would seem to show that riparian zones have a better diversity and abundance of so-called 'quality' organisms, those with the most intolerance. For comparison, the percent intolerance is only statistically different for one season. This is due to the discrepancy between what is classified as an 'intolerant' organism in these two scales, as we included organisms with intolerance levels of 3 and 4 in our definition of intolerant. Since the Becks scale does not, it does not include many of the intolerant or moderately intolerant organisms that were collected and contains fewer organisms overall. The results from the Becks scale and the Shannon index seem to indicate that biodiversity is indeed greater in riparian zones than it is in non-riparian zones.

Another aim was to determine differences in stream health between riparian and non-riparian zones. HBI results were similar with statistical difference only occurring in the spring of 2008 when the riparian mean was higher, which indicates a less healthy stream. It is interesting to note that this statistical difference occurs only in the spring when ephemeropterans, plecopterans, and trichopterans are most abundant and one would conjecture would have a positive influence on stream health.

Another goal of this project was to determine whether or not the EPT group could be used as a method of a short survey. The data indicates that this is not possible to do in the Yellow Breeches. However, a look at just the EPT group certainly provides insight into much of the data collected from the stream. The Shannon index was only significant between seasons in the non-riparian samples. However, the seasons in which the Shannon index is in the statistical category with the lowest mean for the non-riparian sites are the winter and spring which are 2 of the seasons with the highest Shannon index in the riparian zones. This all indicates that the EPT group plays a large role in Shannon values based on life cycle. The data from the Shannon index is only statistically different in the winter and spring months—the months when EPT numbers are highest. Therefore from the EPT group's influence one would expect the biodiversity to be greater in riparian zones in the winter and spring, which it is. The seasonal EPT data does indeed back this up as the non-riparian zones were statistically significant, even though the riparian zones were not. The mean for the non-riparian zones steadily dropped off from the winter, when EPT abundance and diversity should be highest, with the winter and fall of 2008 being statistically different. This seems to indicate greater numbers during the winter and spring months and more intolerant individuals in the summer and fall.

The possibility of using the EPT group as a shortcut survey method is not supported by the data for richness, and the data about biodiversity is not significantly different enough. This seems to eliminate using the EPT taxa as a shortcut survey method as a possibility in the Yellow Breeches. However, the Breeches is a healthy stream and results between riparian and non-riparian zones would be exacerbated in a less healthy stream. It can therefore be conjectured that in these streams the EPT short survey would be sufficient.

In conclusion, riparian zones do not have greater richness or abundance than non-riparian zones. Biodiversity was greater in riparian zones than non-riparian zones, as indicated particularly well by the Shannon index. Stream health did not differ statistically between riparian and non-riparian zones. Finally, a shortcut survey of macroinvertebrate populations with the EPT taxa does not seem possible in a stream as healthy as the Yellow Breeches.

Appendix

Table 1. Two-sample T-test results for riparian and non-riparian mean abundance and p-value where *=p<.05, **=p<.01, and ***=p<.001.

Abundance (Total inds.)	R or NR	Mean	p
F07	R	95.3	0.243
	NR	198	
W08	R	209	0.196
	NR	338	
Sp08	R	156	0.545
	NR	124.8	
Sum08	R	240	0.043*
	NR	124.4	
F08	R	177.7	0.015*
	NR	84.7	
All Seasons	R	181	0.870
	NR	176	

Table 2. Two-sample T-test results for riparian and non-riparian mean modified Becks scale and p-value where *=p<.05, **=p<.01, and ***=p<.001.

Becks	R or NR	Mean	p
F07	R	7.33	0.500
	NR	6.33	
W08	R	11.89	0.119
	NR	9.44	
Sp08	R	11.67	0.663
	NR	10.67	
Sum08	R	9.22	0.007**
	NR	5.56	
F08	R	6.78	0.077
	NR	4.67	
All Seasons	R	9.52	0.005**
	NR	7.15	

Table 3. Two-sample T-test results for riparian and non-riparian mean Shannon index and p-value where *=p<.05, **=p<.01, and ***=p<.001.

Shannon	R or NR	Mean	p
F07	R	2.167	0.989
	NR	2.165	
W08	R	2.317	0.018*
	NR	2.094	
Sp08	R	2.427	0.001***
	NR	2.044	
Sum08	R	2.362	0.259
	NR	2.265	
F08	R	2.326	0.882
	NR	2.339	
All Seasons	R	2.331	0.003**
	NR	2.193	

Table 4. Two-sample T-test results for riparian and non-riparian mean EPT data and p-value where *=p<.05, **=p<.01, and ***=p<.001.

EPT Data	R or NR	Mean	p
F07	R	7.33	0.379
	NR	8.33	
W08	R	9.89	0.393
	NR	9.11	
Sp08	R	9.11	0.715
	NR	8.50	
Sum08	R	10.44	0.023*
	NR	7.56	
F08	R	8.22	0.041*
	NR	6.33	
All Seasons	R	9.12	0.027*
	NR	7.90	

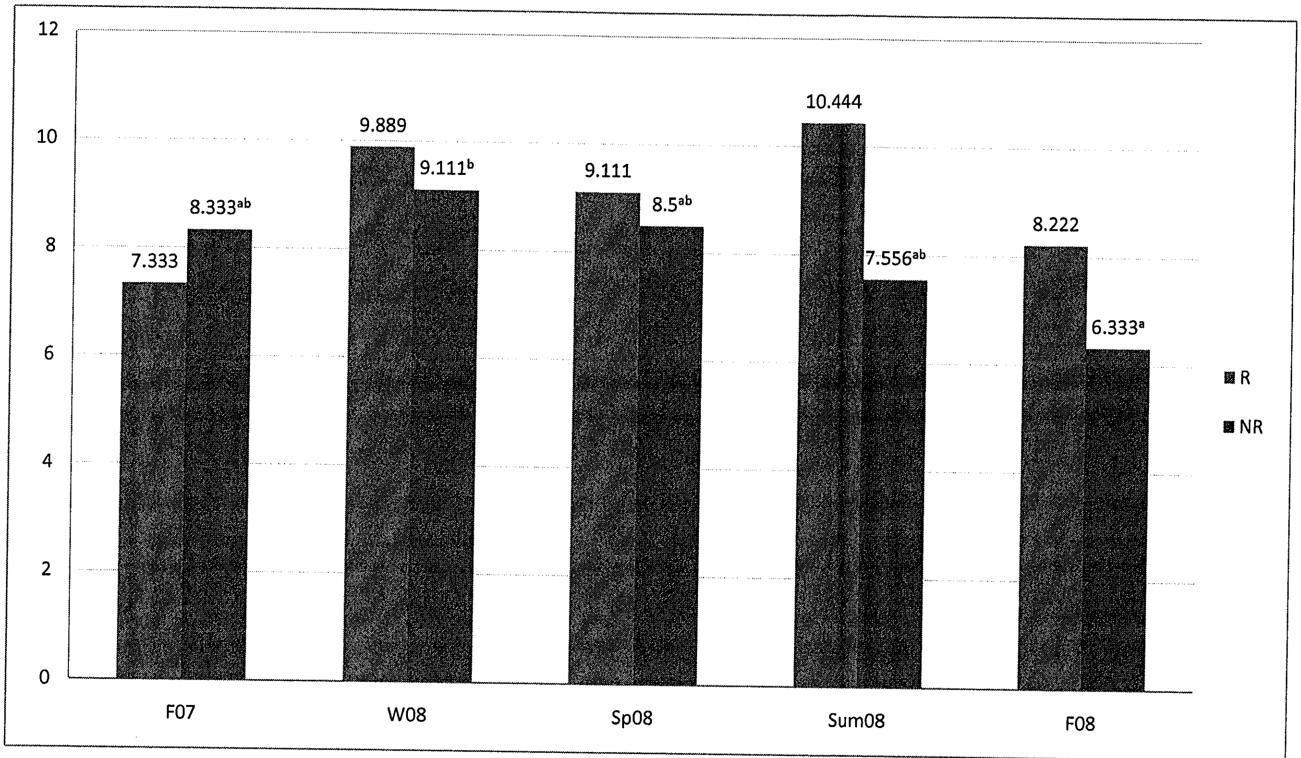

Figure 1. One-way ANOVA test results for EPT data across seasons with statistical categories represented as alphabetical superscripts.

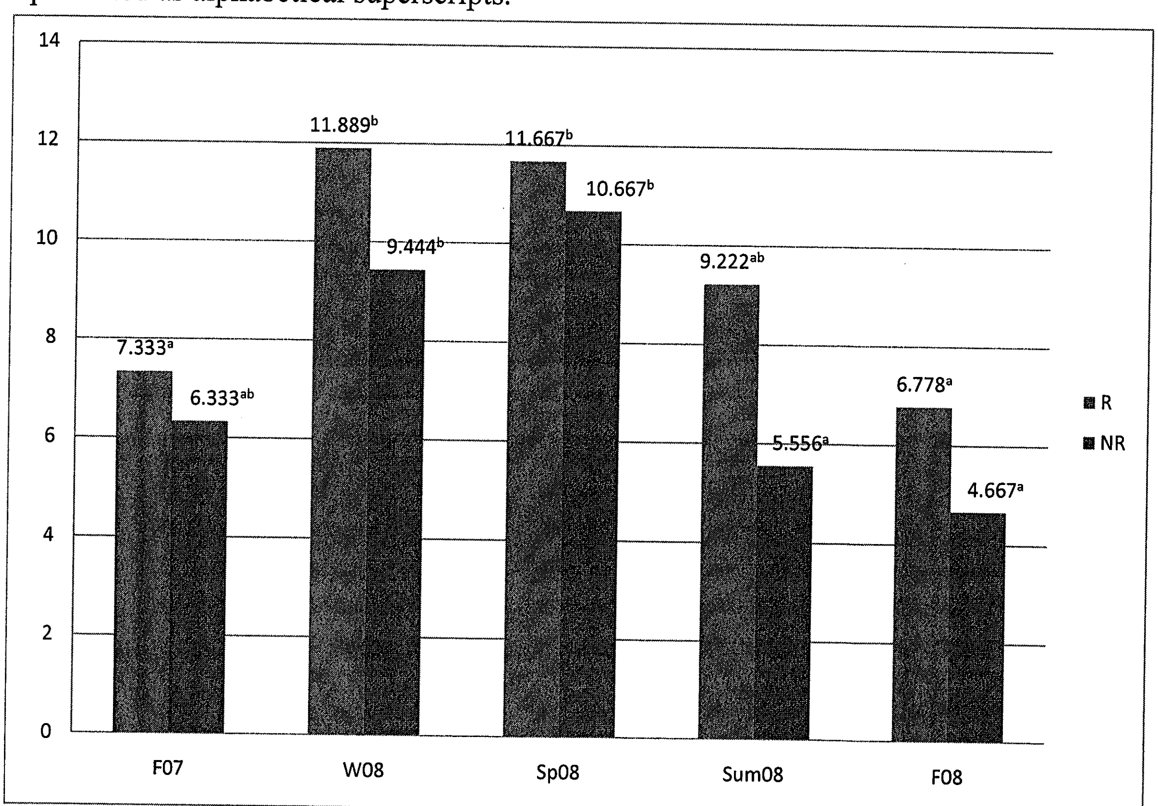

Figure 2. One-way ANOVA test results for Becks data across seasons with statistical categories represented as alphabetical superscripts.

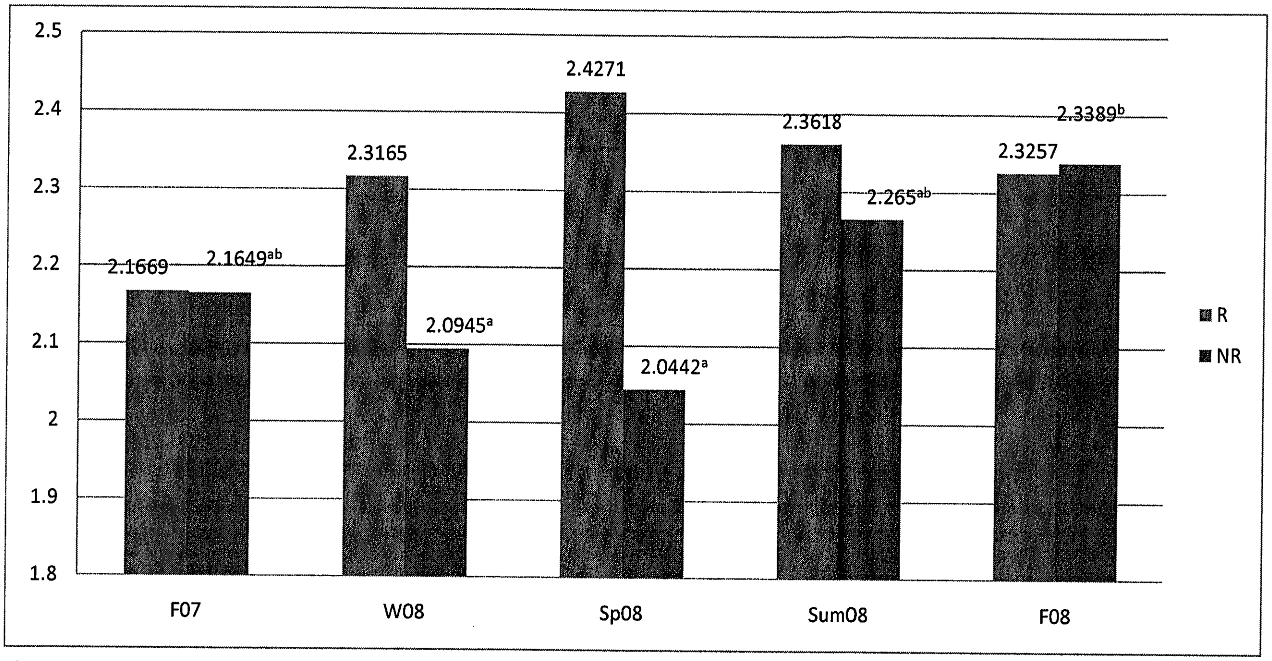

Figure 3. One-way ANOVA test results for Shannon index data across seasons with statistical categories represented as alphabetical superscripts.

Table 5. Two-sample T-test results for riparian and non-riparian mean collector gatherer data and p-value where *=p<.05, **=p<.01, and ***=p<.001.

CG	R or NR	Mean	p
F07	R	17.92	0.185
	NR	28.0	
W08	R	36.9	0.029*
	NR	51.0	
Sp08	R	45.87	0.007**
	NR	59.71	
Sum08	R	19.23	0.006**
	NR	37.3	
F08	R	31.35	0.595
	NR	32.87	
All Seasons	R	31.1	0.002**
	NR	41.5	

Table 6. Two-sample T-test results for riparian and non-riparian mean scraper data and p-value where *=p<.05, **=p<.01, and ***=p<.001.

SC	R or NR	Mean	p
F07	R	64.5	0.011
	NR	44.9	
W08	R	40.8	0.147
	NR	28.7	
Sp08	R	37.2	0.038
	NR	27.68	
Sum08	R	40.7	0.931
	NR	41.4	
F08	R	46.2	0.763
	NR	44.2	
All Seasons	R	44.5	0.050
	NR	37.5	

Literature Cited

Banks, J.L., Li, J., Herlihy, A.T. 2007. Influence of clearcut logging, flow duration, and season on emergent aquatic insects in headwater streams of the Central Oregon Coast Range. J. N. Am. Benthol. Soc. 26(4):619-631.

Hawkins, C.P., Murphy, M.L., Anderson, N.H. 1982. Effects of canopy, substrate composition, and gradient on the structure of macroinvertebrate communities in Cascade Range streams of Oregon.

Lambert, J.D., Hannon, S.J. 2000. Short-term effects of timber harvest on abundance, territory characteristics, and pairing success of Ovenbirds in riparian buffer strips. The Auk. 117(3):687-698.

Meleason, M.A., Quinn, J.M. 2004. Influence of riparian buffer width on air temperature at Whangapoua Forest, Coromandel Peninsula, New Zealand. Forest Ecology and Management 191: 365-371.

Milner, A.M., Gloyne-Phillips I.T. 2005. The role of riparian vegetation and woody debris in the development of macroinvertebrate assemblages in streams. River Res. Applic. 21:403-420.

Moldenke, A.R., Ver Linden, C. 2007. Effects of clearcutting and riparian buffers on the yield of adult aquatic macroinvertebrates from headwater streams. For. Sci. 53(2):308-319.

Perkins, D.W., Hunter, M.L. Jr. 2006. Effects of riparian timber management on amphibians in Maine. Journal of Wildlife Management. 70(3):657-670.

Quinn, J.M., Boothroyd, I.K.G., Smith, B.J. 2003. Riparian buffers mitigate effects of pine plantation logging on New Zealand streams. Forest Ecology and Management. 191:129-146.

Resh, V.H., Norris, R.H., Barbour, M.T. 1995. Design and implementation of rapid assessment approaches for water resource monitoring using benthic macroinvertebrates. Austral. J. Ecology 20: 108-121.

Rutherford, J.C., Blackett, S., Blackett, C., Saito, L., Davies-Colloy, R.J. 1997. Predicting the effects of shade on water temperature in small streams. NZ J. Mar. Freshw. Res. 31, 707-721.

Sovell, L.A., Vondracek, B., Frost, J.A., Mumford, K.G. 2000. Impacts of rotational grazing and riparian buffers on physiochemical and biological characteristics of Southeastern Minnesota, USA, streams. Environmental Management 26(6):629-641.

Sweeney, B.W., Bott, T.L., Jackson, J.K., Kaplan, L.A., Newbold, J.D., Standley, L.J., Hession, W.C., Horwitz, R.J. 2004. Riparian deforestation , stream narrowing, and loss of stream ecosystem services. PNAS 101: 14132-14137.

Sweeney, B.W., Vannote, R.L. 1986. Growth and production of a stream stonefly: Influences of diet and temperature. Ecology 67: 1396-1410.