MACROINVERTEBRATES IN HEADWATER STREAMS OF THE PIEDMONT

M.A. Churchel[1], D.P. Batzer[2], and C.R. Jackson[3]

AUTHORS: [1]Graduate student, [2]Associate Professor, Department of Entomology, The University of Georgia, [3]Associate Professor, Warnell School of Forest Resources, The University of Georgia, Athens, Georgia, 30602.
REFERENCE: Proceedings of the 2005 Georgia Water Resources Conference, held April 25-27, 2005, at The University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. The objective of this study is to develop reference standards for headwater streams in the Piedmont physiographic region of Georgia. We predict that these standards will be influenced by physical parameters of the stream ecosystem, including historical sedimentation from agriculture. Streams with similar substrates might contain similar aquatic macroinvertebrate communities, but those with different substrates may differ significantly.

INTRODUCTION

Piedmont Streams

The Piedmont physiographic region has a long history of human development. During the 1800's, European settlers almost completely deforested the region for agricultural production (tobacco and cotton). When agriculture in this area declined, the forests reestablished themselves. From the 1930's to the 1980's, agricultural land use decreased from 30 to 12 percent of the landscape, while coniferous forest increased from 5 to 41 percent (Turner and Ruscher 1988). Urban land use increased from 1 to 3 percent over the same period. In the Etowah River Basin, near the metropolitan Atlanta area, another shift was observed between 1973 and 1997 (Roy et al. 2003a). While agricultural land cover decreased from 1973 to 1987 in the catchments studied, it increased again from 1987 to 1997. Forest cover decreased an average of 13% from 1973 to 1997 in these catchments.

Agriculture in the Piedmont has had a severe impact on the current water quality of this region's streams. In the Apalachicola-Chattahoochee-Flint River Basin, streams in areas with extensive land use for poultry production have high concentrations of suspended sediments, nitrate, ammonia, and total phosphorus (Frick et al. 1998). High nitrate results from the use of poultry litter as a fertilizer. By contrast, streams in areas that are predominantly forested have low yields of these nutrients and suspended sediments. High ammonia concentrations were found in urban areas and attributed to wastewater discharge upstream.

Roy et al. (2003b) found a strong correlation between land use and macroinvertebrate communities. Streams in urban areas had much less diversity than streams in forested areas. This was attributed to an increase in solutes and sediment transport in urbanized areas. Fine bed sediment, which was also found in urban areas, was also significantly related to low richness and density. Poultry production may be affecting stream ecology because streams in areas with high poultry production were found to have a higher EPT Index score, which is based on the number of pollution-intolerant insect taxa, than streams in areas with urban or suburban land use (Frick et al. 1998). A high EPT Index score usually indicates good water quality in streams due to an abundance of sensitive taxa, but in this case probably reflects enhancement of the low natural nutrient levels in Piedmont streams. Frick et al. suggest that high nutrient inputs in areas of agricultural land use may increase the diversity of food resources available.

While some research has been dedicated to the effects of land use on aquatic ecosystems, few studies have shown if there has been a shift in macroinvertebrate assemblages over time with changing land use. Nelson and Scott (1962) collected 45 taxa of aquatic macroinvertebrates between 1956 and 1957 in the Middle Oconee River in the Piedmont region of Georgia. The number of taxa collected in each sampling interval ranged from 28 to 44, but no seasonal variation in the number of taxa was observed. Grubaugh and Wallace (1995) repeated this study in 1991-1992 to determine if the decrease in agricultural land use had impacted the aquatic macroinvertebrate community. Physical parameters including daily temperature and discharge did not differ significantly between the two periods, nor did the mean annual macrophyte standing crop. In 1991-92, 42 taxa of macroinvertebrates were collected, but the composition varied greatly from the 1956-57 study with only 27 taxa being present in both studies. Nine of the taxa found only in 1991-92 were EPT taxa, while four of the taxa found only in the 1956-57 study were EPT taxa. Comparisons of abundances and biomass show that abundance decreased over time, while biomass increased. Grubaugh and Wallace (1995) attribute this to a shift in dominant taxa of each functional group, with larger taxa replacing smaller taxa. Their conclusion was that the condition of the Middle Oconee River had improved between 1956 and

1991, leading to changes in the aquatic macroinvertebrate assemblage.

Headwater Streams

The studies cited above generally concentrate on larger systems, such as the Middle Oconee River (Grubaugh and Wallace 1995). Work on small headwater streams in the Piedmont has been limited. Basic reference conditions for Piedmont headwater streams have yet to be described. Reference standards need to be developed to assess current impacts in this region. However, these standards will need to take into account the historical impacts of agriculture and changing land use.

The objective of this study is to develop quantitative reference standards for headwater streams in the Piedmont. We predict that these standards will be influenced by physical parameters of the stream ecosystem, including historical sedimentation from agriculture. Streams with similar substrates might contain similar aquatic macroinvertebrate communities, but those with different substrates may differ significantly.

STUDY AREA

The headwater streams for this project are located in the Oconee River Watershed of Georgia. We chose six streams in this region in areas that are owned and protected by government agencies. The six streams were:

- Stream 1 is a tributary of Glady Creek in Oconee National Forest in Putnam County. It is a sandy-bottomed stream with a large amount of clay and some small cobble.
- Stream 2 is a tributary of Glady Creek in Oconee National Forest in Putnam County near Stream 1. It is a sandy-bottomed stream with a large amount of clay and some small cobble.
- Stream 3 is Scull Shoals Creek, a tributary of the Middle Oconee River in Oconee National Forest in Greene County. It is a predominantly sandy-bottomed stream with no cobble and some gravel.
- Stream 4 is a tributary of Sandy Creek in Oconee National Forest in Greene County. It is predominantly sandy-bottomed with some cobble.
- Stream 5 is a feeder tributary to Rock Eagle Lake in Rock Eagle 4-H Center in Putnam County. It has predominantly large cobble as its substrate.
- Stream 6 is a tributary of the Middle Oconee River in The State Botanical Garden of Georgia, off the Orange Trail. It has predominantly large cobble as its substrate.

We believe that these streams could be used as references because they are in areas that have been protected for 40 to 100 years. Although there is no such thing as a pristine stream in the Piedmont, these streams are perhaps among the best protected in the Georgia Piedmont.

METHODS

Sampling was initiated in September 2002 immediately after tropical rains had ended an extensive drought. Streams 1, 3, and 5 had dried completely during the drought while Streams 2, 4, and 6 retained some water in the form of isolated pools (a second goal of this study was to assess the drought recovery process of macroinvertebrate communities).

Streams were sampled monthly for the first three months, and then every 3 months for one year). In Streams 1 through 4, three randomly selected sites were sampled for each subhabitat (riffles, runs, and pools). Riffles were sampled with a core sampler, forcing the sampler into the streambed and removing all of the contents down to 7.5 cm. The water in the core was removed and filtered through a 250 μm sieve and the contents were rinsed into the collection. Three core samples were taken in each riffle and placed in the same bag. Runs and pools were sampled with a Hess sampler (860 cm^2). The Hess sampler was placed into the streambed and the top 15 cm of substrate was removed into the bag. The residual water was then filtered through the bag as the sampler was removed from the substrate. Combining the Hess and core samples yielded a quantitative sample for each stream. Wood samples were also taken in each of these streams by removing randomly selected pieces of woody debris that were at least 1 cm in diameter. Sampling of Streams 5 and 6 consisted of four randomly selected sites for each of two subhabitats (riffles and pools, they lacked runs). Riffles were sampled with the core sampler and pools were sampled with the Hess sampler. A wood sample was also collected. These samples were collected following the procedure described above.

All samples were preserved in ethanol and returned to the lab where they were elutriated and divided into >1 mm and <1 mm portions. Large samples were subsampled as needed. Invertebrates were removed from the samples and identified to genus when possible.

DATA ANALYSES

We intend to use cluster analysis to assess similarities and differences in the aquatic macroinvertebrate assemblages among these streams. We anticipate that more than one reference condition exists in the Piedmont. For example, streams with substrates of predominantly large cobble are expected to differ in macroinvertebrate community structure from streams with substrates of predominantly sand.

LITERATURE CITED

Frick, E.A. and others, 1998. Water Quality in the Apalachicola-Chattahoochee-Flint River Basin, Georgia, Alabama, and Florida, 1992-95: U.S. Geological Survey Circular 1164, 38 p.

Grubaugh, J.W. and J.B. Wallace, 1995. Functional structure and production of the benthic community in a Piedmont river: 1956-1957 and 1991-1992. *Limnology and Oceanography* 40: 490-501.

Nelson, D.J. and D.C. Scott, 1962. Role of detritus in the productivity of a rock-outcrop community in a Piedmont stream. *Limnology and Oceanography* 7: 396-413.

Roy, A.H., M.C. Freeman, J.L. Meyer and D.S. Leigh, 2003a. Patterns of land use change in upland and riparian areas in the Etowah River Basin. In: *Proceedings of the 2003 Georgia Water Resources Conference*, held April 23-24, 2003, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Roy, A.H., A.D. Rosemond, M.J. Paul, D.S. Leigh and J.B. Wallace, 2003b. Stream macroinvertebrate response to catchment urbanisation (Georgia, U.S.A.). *Freshwater Biology* 48: 329-346.

Turner, M.G. and C.L. Ruscher, 1988. Changes in landscape patterns in Georgia, USA. *Landscape Ecology* 1: 241-251.