PRIORITIZING RIVER RESTORATION SITES IN THE ETOWAH RIVER, GEORGIA

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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. Etowah River shoals were surveyed to identify sediment sources, prioritize restoration sites, and investigate the relationships among stream geomorphology, in-stream habitat, and aquatic fauna. An essential and unique part of the survey was to integrate traditional geomorphic data collection with ecological information in order to build an understanding of which restoration techniques and sites would have the maximum ecological benefit to federally listed, rare, and endemic shoal-inhabiting species. The following analysis examines 1) whether entrenchment ratio, a commonly used indicator of geomorphic degradation, can be used to predict in-stream shoal habitat and restoration site selection and 2) whether paired comparisons of shoals up- and downstream from tributaries are useful in assessing sediment input. Our preliminary findings indicate that no relationship between entrenchment and five in-stream shoal habitat variables exist. Additionally, upstream-downstream comparisons of shoals show no overall trend.

INTRODUCTION

The Etowah River system harbors 91 fish species including four endemic and three federally listed fishes. This diversity is partly attributed to the abundance of shoal habitats. Shoals in the Etowah River are shallow, distinct geomorphic channel units, usually dominated by gravel, cobble, and bedrock. They vary widely in slope, bed texture, fish assemblages, and riverweed (*Podostemum ceratophyllum*) density- a plant species which some imperiled species are associated (Freeman et al. 2003).

Shoals harbor endemic and imperiled fishes including the endangered Etowah (*Etheostoma etowahae*) and amber darters (*Percina antesella;* Burkhead et al., 1997), and the state listed freckled darter (*Percina lenticula*) and Coosa Madtom (*Noturus* sp. cf. *N. munitus*; Freeman et al. 2003). The high species diversity, large number of imperiled species, presence of ecologically important shoal habitats, and encroaching development from Atlanta make the upper Etowah River a high priority for preservation and restoration (Freeman and Wenger, 2000).

The following analysis is only one component of a much larger study aimed at evaluating relationships among shoal geomorphology, habitat, and species distributions. Defining these relationships will help managers identify priority restoration sites and techniques. The results presented here specifically question whether entrenchment ratio is a useful indicator of shoal habitat conditions and a useful method of selecting restoration sites. This study also questions the use of upstream shoal reference sites to measure downstream sediment inputs.

METHODS

Site Selection. The Etowah River between Yellow Creek Road and State Route 52 (between Dahlonega and Canton) was surveyed because it encompassed the range of several endemic and federally listed species and is considered “high priority” for preservation and restoration (Freeman and Wenger, 2000). High priority river segments extend both upriver and downriver from this segment. Upriver sites were not surveyed because floatability was not possible during the survey period. Downriver sites were not surveyed due to time constraints.

Third order or greater tributaries were identified using ArcMAP® software. Subsequent field reconnaissance mapped shoal locations above and below tributary confluences. The first shoal in a straight river reach above and below the tributary was surveyed.

Survey Method. Shoals were surveyed at baseflow during the summer and fall, 2004. Channel cross-sections were measured at the shoal midpoint using a rod and tagline. Bank dimensions were measured from top of water to top of bank using tagline height. Height and distance data were adjusted for tagline slope, as determined from the two top of water measurements and the assumption that water surface is planar. Channel dimensions below the water were measured to top of water and were then added to the bank measurements. Major elevation changes and bankfull locations were measured.

Wolman (1954) pebble counts were conducted at equidistant transects throughout the entire shoal. The pebble count was amended to include the maximum length of *P. ceratophyllum*. Maximum length was chosen as it provided a less biased estimate of *P. ceratophyllum* quality than an estimate of average length.

Qualitative assessments of tributary channel conditions were made at 100-200m upstream from the confluence. Assessments included channel width, bank height and bankfull measurements.

Data analysis. Entrenchment ratios were calculated from the cross-section survey using width of the flood-prone area at twice the mean bankfull depth/ bankfull width (W_{fpa}/W_{bkfl}). W_{fpa} was determined from channel cross-section plots. At sites where W_{fpa} exceeded the cross-section plots, a conservative estimate of W_{fpa} was made using the maximum distance along the transect. Entrenchment ratios for those sites are underestimated.

For each pebble count, the diameter at which 50% and 84% of the measured particles are smaller (D50 and D84, respectively) was calculated. Fine sediments were measured as the percent of the particles less than 2, 4, and 8 mm. *P. ceratophyllum* density was calculated as the percent of particles with any *P. ceratophyllum* growth.

Contingency tables and chi-square analysis were used to test for significant differences in fine sediments between shoals upriver and downriver from tributaries. Simple linear regressions were used to examine the relationships between entrenchment ratio and habitat (i.e. % fines, D50, D84, *P. ceratophyllum* density and length) among all sites. All variables were screened for normality using the Kolmogorov-Smirnov test and were transformed if necessary for the preceding analyses.

RESULTS

Entrenchment ratios derived from river channel cross sections ranged from 1.0 to 1.8 (average 1.2 +/- 0.3; n=15). Using criteria defined in Rosgen (1996), 14 sites were entrenched, and one was moderately entrenched. Visual assessments of tributary geomorphology indicated entrenchment at all sites.

Statistics derived from pebble counts were variable among sites. D50 ranged from fine gravel to small cobble (average was coarse gravel or 24.1 +/- 15.8 mm; n= 17). D84 ranged from coarse gravel to large cobble (average was small cobble 78.0 +/- 43.5 mm; n=17). Paired comparisons of fine sediments at sites upstream and downstream from inflowing third order tributaries

Table 1. Paired Comparisons of % Fine Sediments in Shoals Above and Below Third-order Tributaries.*

Creek name	<2mm	<4mm	<8mm
Proctor and Russell		---	---
Unid. Tributary 1			+
Unid. Tributary 2	++	+	
Amicalola Shoal	++	++	+
Unid. Tributary 3	+	--	---
Brewton Creek		---	---
Settingdown		---	---
Yellow	+++	+++	++

*Shoals below tributaries are represented by a "+" and "-" for more and less fine sediment than the upstream shoal, respectively. Chi-square p-values are represented by one, two, or three symbols for $p<0.05$, $p\leq0.01$, and $p\leq0.001$, respectively. Blanks indicate no significant relationship.

revealed mixed results. Broadly, three sites below tributaries had significantly more fines, four had fewer fines, and two sites showed no difference (Table 1). Simple linear regression analysis across all sites revealed no significant relationship between entrenchment ratios and %fines or D50 and D84 ($p>0.15$).

The density of rocks with *Podostemum ceratophyllum* ranged from 3.0% to 36.0% (average 20.0% +/- 10.2; n=17 sites) and the average maximum length was 91.3 mm +/- 54.4 across all sites. Simple linear regressions indicated no relationship between entrenchment ratio and *P. ceratophyllum* density or average maximum length ($p>0.15$).

CONCLUSION

The results presented here illustrate the complexity of prioritizing river restoration sites for ecological purposes. Indicators of geomorphic degradation, such as entrenchment ratio, are used to guide the selection of river restoration sites. However, there is apparently no relationship between entrenchment ratio and the in-stream habitat variables chosen for this analysis (i.e. sediment sizes and *P. ceratophyllum* density and length). This calls into question whether such indicators should be used to guide the selection of restoration sites, especially if the goal is to benefit shoal habitats and fauna.

The use of upstream reference sites for pairwise comparisons above and below tributaries should be interpreted with caution. Undoubtedly, tributaries contribute both large and small sediments to the river where they are redistributed during bed mobilizing events. However, differences in fine sediment quantity may reflect localized variation in sediment deposition arising from differences in slope, distance to the tributary, and the presence of mid-channel bars and large woody debris.

The next step to prioritize restoration techniques will be to quantify other geomorphological and hydrological variables that may influence Etowah River shoal ecology. Determining which variables are predictors of endemic and imperiled shoal fauna will help us understand which variables limit species distributions and will aid in our selection of appropriate restoration techniques.

ACKNOWLEDGEMENTS

We would like to thank the Georgia Forestry Commission for facilitating access to sites in Dawson Forest. We would also like to express sincere appreciation to FWS staff for technical and field support, as well as U.S. FWS volunteers that assisted in the field: Christina Alessi, Bridget Kelley, Kevin Middlebrooks, and Paul Rhodes. Special thanks are extended to Dr. David Leigh for his advice throughout the project duration.

CITATIONS

Burkhead, N.M., S.J. Walsh, B.J. Freeman, and J.D. Williams. 1997. Status and restoration of the Etowah River, and imperiled southern Appalachian ecosystem. In: *Aquatic Fauna in Peril: The Southeastern Perspective*, eds. G.W. Benz and D.E. Collins. Special Publication 1, Southeast Aquatic Research Institute, Lenz Design & Communications, Decatur, GA, 554 pp.

Freeman, B.J., C.A. Straight, P.A. Marcinek, S. Wenger, M.M. Hagler, and M.C. Freeman. 2003. Distribution and status of the “Coosa” Madtom (*Noturus sp. cf. N. munitus*) and freckled darter (*Percina lenticula*) in Georgia. A report submitted to U.S. Geological Survey.

Freeman, B.J. and S. Wenger. 2000. Prioritizing streams for buffer preservation and restoration in the Etowah River Basin. University of Georgia, Institute of Ecology.

Rosgen, D. 1996. *Applied River Morphology*. Printed Media Companies, Minneapolis, Minnesota.

Wolman, M.G. 1954. A method of sampling coarse river-bed material: *Transactions of the American Geophysical Union (EOS)*. 35, 951-956.