

The Furman University River Basins Research Initiative: A Multidisciplinary Examination of Urban Influences on Piedmont Streams

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Urban land cover correlates negatively with water quality both chemically and biologically in river systems. Urban streams also tend to support less diverse biological communities than streams in rural landscapes. Furthermore, stream biota may experience physiological stresses from pollutants and from altered stream hydrology and temperature regimes in urban environments. The expansion of urban land cover in the upper piedmont of South Carolina, especially in the Greenville-Spartanburg metropolitan area, is occurring at one of the most rapid rates in the United States. Over the past several years, our multidisciplinary undergraduate research program, the River Basins Research Initiative (a National Science Foundation Research Experiences for Undergraduates site since 1999), has focused on the influence of urban land cover on streams in the Greenville vicinity. In particular, we have examined relationships between land cover, water quality, fish assemblages and environmental physiology, and stream geomorphology (Lewis et al. 2007, Muthukrishnan et al. 2007). We have worked primarily in the Saluda and Enoree River basins, although we recently have expanded our studies into the Pacolet and Tyger River basins. Major land covers in these river basins include forest, pasture, and urban (both high-density residential and commercial) cover (Muthukrishnan et al. 2007). The piedmont region provides an excellent setting in which to study influences of urban land cover on streams for several reasons. Because the underlying bedrock of gneisses and granites is relatively resistant to weathering, streams in the region naturally have low solute concentrations that do not obscure the chemical signature of urban land cover (Andersen et al. 2001, Lewis et al. 2007). Also, row-crop agriculture in the area is not a major land cover and tends to occur downstream of urban areas, which themselves tend to occur along watershed divides. As a result, the urban signature is not masked by agricultural inputs.

Sampling conducted during the drought years of 1999 and 2000 indicated that stream nitrate concentrations correlated positively with percent urban land cover and negatively with percent forest cover in sub-watersheds within the Enoree River basin (Muthukrishnan et al. 2007). However, concentrations of other solutes, such as chloride and sulfate, correlated poorly with percent land cover during those years. By contrast, during 2006-2007 (years of higher precipitation and stream flow), concentrations of most major cations and anions (including nitrate, sulfate, and chloride) correlated positively and strongly with both percent urban land cover and percent impervious surface cover. Impervious cover was a slightly better predictor of solute concentrations than was percent urban cover. Also, correlations typically were stronger in winter than in summer. Under summer baseflow conditions, stream turbidity tends to be higher in “rural” streams (draining mixed pasture and forest) than in streams draining mostly forested or mostly

urban sub-watersheds. Concentrations of suspended total coliform bacteria and *Escherichia coli* showed little if any correlation with land cover in both drought and non-drought years. However, the highest concentrations of total coliforms and *E. coli* tended to occur in the most urbanized sub-watersheds. *Enterococcus* concentrations did not differ significantly among urban and rural land covers.

As expected from studies in other regions, we have found that urban streams in the Enoree River basin respond to rain events with more pronounced storm flows than do rural streams. We also have documented sharp increases in water temperatures during summer storm events in urban streams as rain water drains from heated impervious surfaces. Streams in residential areas tend to have greater width/depth ratios than streams in rural areas. Contrary to our expectations, however, we have found no significant relationships between stream channel incision and percent impervious cover in a stream's watershed.

Fish species richness and diversity (Simpson's index) tend to be lower in streams draining commercial land cover than in streams draining residential or rural land covers. However, streams in all land covers tend to be dominated by two tolerant species: the bluehead chub (*Nocomis leptocephalus*) and yellowfin shiner (*Notropis lutipinnis*). Creek chubs (*Semotilus atromaculatus*) are also common in both rural and urban streams. According to several bioindicators (such as erythrocyte counts), creek chub health appears to be lower in urban than rural streams.

Incision of both rural and urban stream channels, as well as the relatively low fish diversity among land covers, perhaps reflects landscape alteration by intensive agriculture prior to the 1930's. Currently, we are attempting to identify specific mechanisms underlying the correlations between land cover and stream characteristics that we have identified. For example, we are beginning to examine spatial and temporal dynamics of nitrogen, sulfur, and other elements in atmospheric deposition and in groundwater. Also, we are using analyses of stable isotopes of nitrogen and oxygen to infer sources of nitrate to urban streams.

LITERATURE CITED

- Andersen, C. B., K. A. Sargent, J. Wheeler and S. Wheeler, 2001. Fluvial geochemistry of selected tributary watersheds in the Enoree River basin, SC. *South Carolina Geology* 43:57-71.
- Lewis, G. P., J. D. Mitchell, C. B. Andersen, D. C. Haney, M.-K. Liao and K. A. Sargent, 2007. Urban Influences on stream chemistry and biology in the Big Brushy Creek watershed, South Carolina. *Water, Air and Soil Pollution* 182:303-323.
- Muthukrishnan, S., G. P. Lewis and C. B. Andersen, 2007. Relations among land cover, vegetation index, and nitrate concentrations in streams of the Enoree River Basin, piedmont region of South Carolina, USA. In: D. Sarkar, R. Datta and R. Hannigan, editors. *Developments in Environmental Science*, vol. 5, Elsevier, pp. 515-539.