PIEDMONT STREAM LITTER INPUTS AND FLUXES: CORRELATIONS WITH RIPARIAN CONDITIONS AND URBANIZATION.

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Abstract. Leaf litter inputs, processing, and retention in aquatic ecosystems are controlled by biological, physical, and chemical factors that can be related to both local reach conditions and large scale watershed features. It is well known that leaf litter is an essential driver of river ecosystem structure, but the complexity of input, transport, and utilization processes has obscured the effects of land management on litter availability. In this study, we evaluated how urbanization affects litter stocks by comparing autumn and spring standing crops in urban and forested streams in the Piedmont of Georgia. We also measured vertical leaf litter inputs across a gradient of canopy coverage and compared the shredder fraction of the macroinvertebrate assemblages between urban and forested streams. Our results indicate that in Georgia Piedmont streams shading appears to be influenced by condition of the riparian zone at the reach scale, while leaf litter seems to be controlled by catchment conditions and factors indirectly tied to land use, such as velocity and timing of inputs. Overall, sites with less urbanization have greater litter inputs during December, however higher rates of retention occur in more urbanized areas, where channels receive continuous inputs from lawns and storm drains. Macroinvertebrate taxa and intolerant species were negatively affected by watershed landuse, although shredder abundance was not.

INTRODUCTION

Quantity and quality of organic matter inputs varies seasonally and annually between streams, but also within a single stream, even in relatively undisturbed forests (Webster and Benfield 1986, Allan 1995, Benfield 1997). Breakdown of organic matter inputs is influenced by several factors (i.e. biological processes, physical forces, channel features, temperature, and precipitation). Both the quantity and processing of inputs may be related to changes in landuse.

It has been suggested that urbanization decreases leaf litter inputs and accelerates leaf litter breakdown and flushing (Paul and Meyer 2001). However, in Australia, Miller and Boulton (2005) found that urbanization increased leaf litter inputs by extending the source area to gutters and ditches.

In this study, we evaluated how urbanization affects litter stocks by comparing autumn and spring standing crops in urban and forested streams in the Piedmont of Georgia.

OBJECTIVES

The objective of this project is to address the following issues affecting changes in landuse associated with urbanization:

1. Canopy coverage in urbanized streams would be lower than in rural streams.
2. Vertical leaf litter inputs would increase with increased canopy.
3. Autumn leaf litter standing stocks would be lower in urban streams due to reduced vertical inputs.
4. Net leaf litter flushing would be greater in urban streams due to more frequent and larger stormflows.
5. The shredder fraction of macroinvertebrate assemblages would be lower in urban streams due to leaf litter availability.

METHODS

Canopy cover measurements and basin land use were determined for 42 streams across the Piedmont of Georgia and Alabama (figure 1). Leaf litter inputs, leaf litter standing stocks, and macroinvertebrate assemblages were measured on a subset of 13 streams, which were randomly chosen from a continuum of canopy coverages and land use.

All sites were selected from the Georgia DNR- WRD data base of Index of Biotic Integrity (IBI) and Index of Well Being (IWB) scores. ArcGIS 9 was used to quantify land cover within each watershed. Watershed boundary information was obtained from Georgia DNR Wildlife Resources Division (DNR-WRD).

Between 1810 and 1930 land in the Piedmont was converted from hardwood and pine forests to row crop agriculture. Sediment from this period still clogs the re -

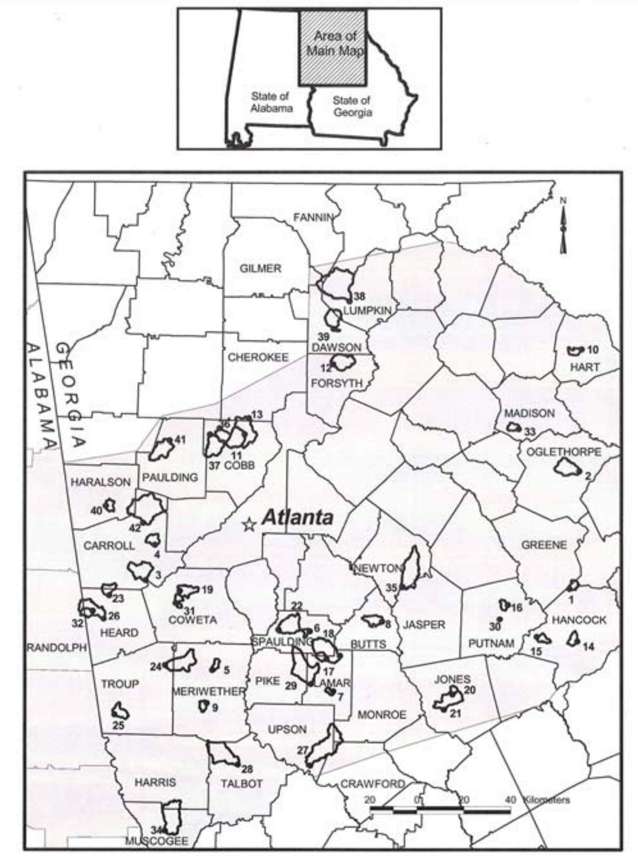

Figure 1. Locations of watersheds (outlined in black) and study sites (represented by black dots) within the Piedmont ecoregion of Georgia.

gion's streams and rivers (Jackson et al. 2005). After 1930, much of the region returned to mixed oak, hickory, pine forests (Griffith et al. 2001). Today, the area is heavily influenced by urban sprawl of metropolitan Atlanta.

Canopy cover was measured at three transects using spherical densiometer. The measurements were averaged for each site.

Leaf litter traps were placed at three points adjacent to the stream. Litter was collected once every three weeks during peak leaf fall (December) and again in the spring (March). Leaf litter was separated from sticks prior to oven drying (Cummins et al. 1989, Herbert 2003).

Velocity was estimated using the dye method, over a 30 m distance, during baseflow conditions.

Macroinvertebrates were collected between October and February in a 100 m sampling reach (Ga EPD 2004). All available habitat types were sampled at each location and compiled for subsampling.

Regression analysis was used to determine relationships between multiple variables.

RESULTS

Mean canopy cover varied between 0 and 95 percent, but only three streams had values at the low end of the spectrum. Although two of the highly urbanized sites featured zero overhead canopy, there was no consistent relationship between reach-scale canopy cover and watershed urbanization (figure 6).

Mean leaf litter standing stock was variable for both December and March samples. Sites with greater urbanization tended to receive less initial inputs, but had more litter at the beginning of the new growing season than less urbanized sites. With the exception of one site, less leaf litter was available in March for all sites with less than 50 percent urbanization (Figure 8).

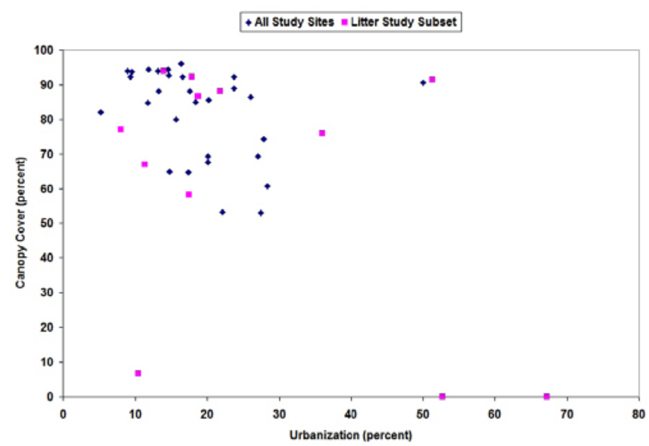

Figure 6. Relationship between urbanization and percent canopy cover.

Leaf litter weighed between 0.95g and 62.66g. Increasing with increased canopy (figure 7).

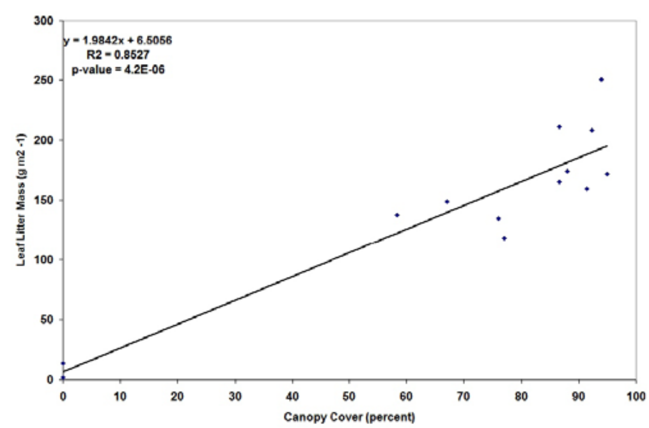

Figure 7. Relationship between percent canopy cover and leaf litter mass.

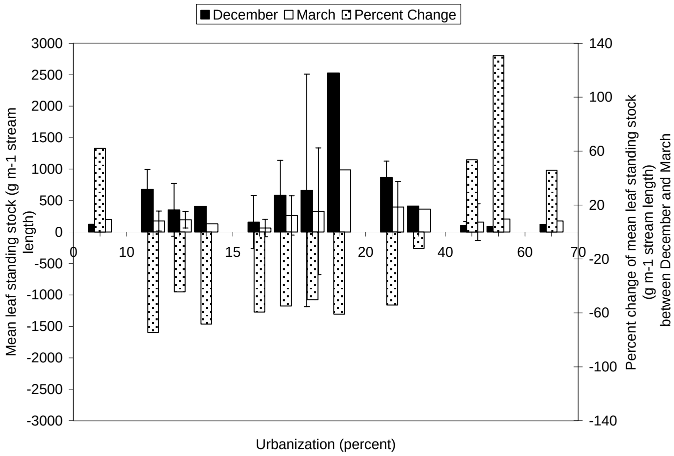

Figure 8. Mean leaf litter standing stock (g m-1 stream length) in December 2005 (solid bars), March 2006 (open bars), and the difference between the two months (stippled bars).

Total number of invertebrate taxa ranged between 12 and 42. Total taxa and number of intolerant taxa were significantly related to percent urbanization (Figure 9).

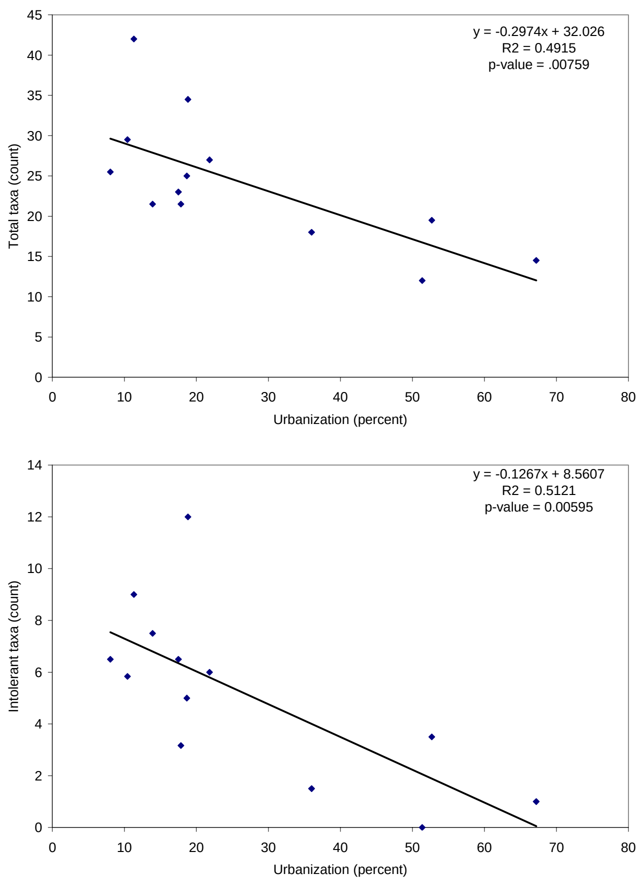

Figure 9. Relationship between (top) macroinvertebrate taxa and (bottom) intolerant taxa and percent urbanization within the watershed.

DISCUSSION AND CONSLUSIONS

Stream shading and leaf litter inputs/retention are linked to landuse factors, but at different scales. Stream shading appears to be influenced by condition of the riparian zone at the reach scale, while leaf litter seems to be controlled by catchment conditions and factors indirectly tied to landuse, such as velocity and timing of inputs. Lack of a strong relationship between urbanization and mean percent canopy cover suggests riparian buffers in urbanized areas provide shading similar to the riparian zone of forested watersheds. Buffer widths required to maintain adequate shade tend to be smaller than those that supply large wood debris and leaf litter. Researchers found that temperature could be maintained with buffer widths ranging between 15 and 72 meters, while 28 to 102 meter buffers were required to sustain supplies of large woody debris and leaf litter following deforestation (Lynch et al. 1985, Broadmeadow and Nisbet 2004).

Unlike canopy coverage and quantity of leaf litter, leaf litter processing may not be a simple linear relationship between inputs and landuse. Overall, we found that sites with less urbanization have greater litter inputs during December, however higher rates of retention occur in more urbanized areas, where channels may be receiving continuous inputs from lawns and storm drainage systems. Continuous inputs coupled with losses that are deposited in the wetted perimeter during higher flows, which can become re-entrained in the aquatic food web, may serve as a steady source of litter material in more urbanized watersheds.

Finally, the typical relationships between macroinvertebrate taxa and landuse are most likely related to changes in habitat and food availability due to increased sedimentation. Macroinvertebrate taxa and intolerant species were negatively affected by watershed landuse, although shredder abundance was not. Lack of shredder abundance may not be a significant factor in rates of litter processing or amount of litter retention. Other researchers have found equal rates of processsing despite differences in shredder abundances (Short and Smith 1989, Grubbs and Cummins 1994).

We have shown that landcover patterns and human activities can potentially impact leaf litter resources in Georgia Piedmont streams, but that these are complex relationships.

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