ORGANIC MATTER RETENTION DURING BASEFLOW AS A FUNCTION OF STREAM SUBSTRATE SIZE

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Abstract. Terrestrially derived organic matter (OM) supports important stream functions but can be reduced in urban streams due to high discharge events and altered substrate sizes. In this study, we sought to 1) investigate the relationship between catchment %ISC and stream substrate particle size and 2) assess whether particle size was related to OM retained during baseflow. Four headwater streams -- two heavily urbanized (high %ISC) and two less impacted (low %ISC) sites -- in Athens-Clarke County, Georgia were measured during a period in Fall 2016 that was characterized by low precipitation and extended baseflow. Streams were sampled for substrate size composition, percent canopy cover (%CC), and retained OM. Linear regressions were used to test whether %ISC was positively correlated with mean substrate size and whether mean substrate size was positively correlated with OM standing stock. There were moderate but non-significant correlations between our focal parameters. We believe that these preliminary findings merit further study and suggest that future research include a more complete gradient of urban development.

INTRODUCTION

Allochthonous organic matter (OM) supports important stream functions by providing carbon and other nutrients to stream organisms. Urban streams commonly have lower standing stocks of OM than streams in forested catchments. Loss of riparian vegetation and high percentages of impervious surface cover (%ISC) in the surrounding watershed are major drivers in low organic matter stocks within urban stream channels (Miller 2013).

High-energy urban stormflows erode, transport and deposit larger substrata than streams with lower peak stormflows (Maas-Hebner and Duham 2014); which results in urban streams having larger substrate than forested catchments with similar geology. Additionally, cobble- and boulder-sized riprap implanted on urban stream banks to reduce erosion can become displaced during stormflow and also populate streambeds. Concomitant effects of high energy flows and stream armoring can significantly alter streambed substrate and the organic matter retention potential of the stream (Berkowitz et al. 2014).

Stream OM retention can improve during baseflow – a condition that reduces physical fragmentation and, thus, can slow mechanical decay rates. When water levels are low, more streambed substrata protrude beyond the water surface and can interrupt OM transport at the water surface

In this study, we sought to 1) investigate the relationship between catchment %ISC and stream substrate particle size and 2) assess how particle size relates to OM retention during baseflow.

METHODS

Site Description

The four sites are located in Athens-Clarke County, Georgia within the Upper Oconee watershed (Figure 1). Bear Creek and Turkey Creek, serve as reference streams with low %ISC. The 2.07 km^2 catchment of Bear Creek has <1 %ISC, and the 3.64 km^2 catchment of Turkey Creek has 5 %ISC. Lilly Branch and Tanyard Creek represent urban streams. The Lilly Branch 1.45 km^2 catchment includes 41 %ISC, while the Tanyard Creek 1.24 km2 catchment includes 46 %ISC.

Meteorological Conditions

There were no stormflows during the period of this study. From August 29 to November 19, Athens-Clarke County received 1.58 inches of precipitation distributed through small low intensity precipitation events that cause no noticeable alteration in stream flow. The largest event during the study period occurred on September 18, spanned 6 hours, and deposited 0.9 inches of precipitation.

Data Collection

Percent ISC within each upstream catchment was determined using the USGS NWIS Mapper. The intermediate axis of streambed substrata was measured through a reach in each stream. Percent canopy cover was measured along each reach using a concave spherical densiometer. OM standing stock was collected across transects within a reach of each stream using a 0.25 m^2 quadrant. Wet mass and oven dry mass were recorded for each sample. Correlations for each parameter pair were calculated to determine relationships between canopy and impervious cover with standing stocks of organic matter.

RESULTS

The mean substrate sizes in the urban streams were markedly larger (20 mm and 30 mm) than in the references streams (7 mm and 9 mm). There were moderate non-significant positive relationships between %ISC and mean substrate size (R = 0.8728, p = 0.4491) and between percent canopy cover and OM standing stock (R = 0.8887, p = 0.5263) (Figure 2, Figure 3). There was a slight positive relationship between mean substrate size and OM standing stock, though it was not statistically significant (R = 0.6344, p = 0.1237) (Figure 4).

DISCUSSION

Streambeds in catchments with high %ISC appear to have larger substrate than streambeds in forested catchments. Standing stock OM quantities correlates stronger with percent canopy cover than with mean substrate size. The OM samples were collected at the beginning of autumn leaf fall and the timing probably elevated the correlation of OM with canopy cover.

We only investigated four streams, which limited the results obtained in this study. The limited scope in this study did not account for the effects of geology, channel gradients and straightness, catchment size, and management histories on peak stormflow and other streambed substrate characteristics. In the future we believe that repeating this study with a larger sample set prior to leaf fall could the impact of %ISC . We also believe that future study should account for catchment size, channel gradient, and stream management histories.

CONCLUSION

Our study identified a moderate correlation between percent impervious surface cover and mean streambed substrate size as well as between the density of organic matter standing stock and percent canopy cover. There was also a slight correlation between mean streambed substrate size and the density of organic matter standing stock. We believe that the relationships we identified in our preliminary findings merit further investigation. Ideally, future studies would investigate these parameters along a gradient of stream disturbance and land use histories. Additionally, these data indicate a relationship between the physical structure of stream beds and organic matter dynamics at our focal sites. Which supports the critical nature of restoring the stream physical environment during restoration.

LITERATURE CITED

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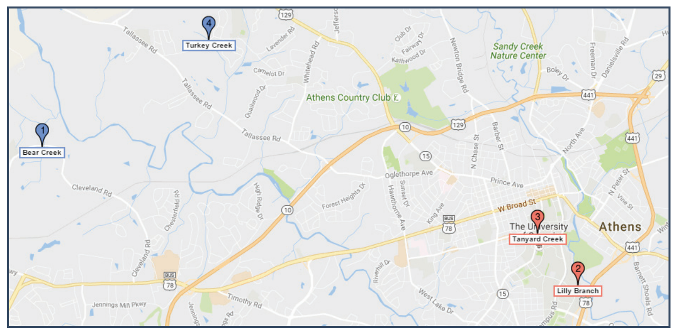

Figure 1. Map of urban sites: Tanyard Creek and Lily Branch (red) as well as reference sites: Bear Creek and Turkey Creek (blue).

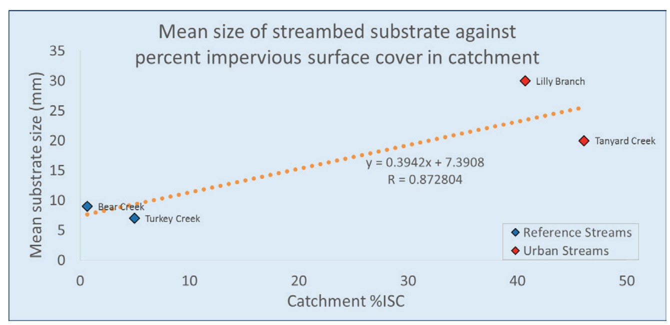

Figure 2. Streambed-substrate size vs. %ISC.

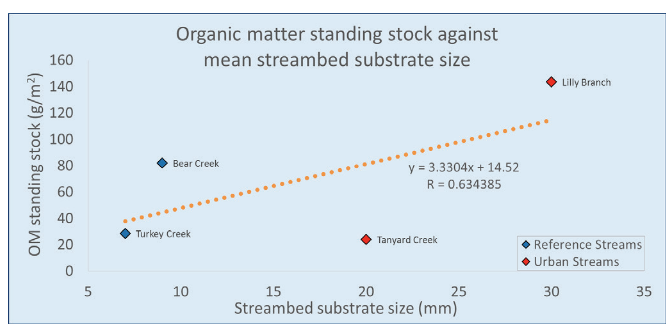

Figure 3. Streambed-substrate size vs. organic matter standing stock.

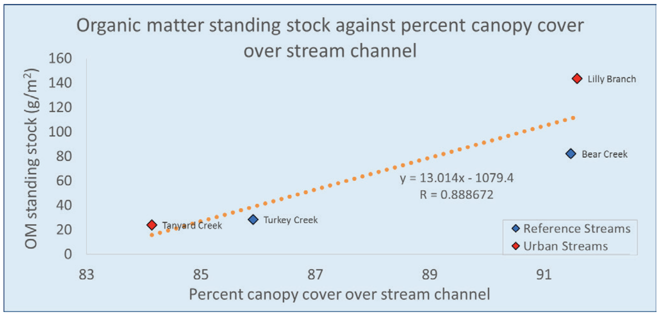

Figure 4. Percent canopy cover vs organic matter standing stock.