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Abstract

Stream-bank vegetation significantly influences the morphology of streams in the Piedmont region of the United States. We surveyed the morphology of 26 paired stream reaches in southeastern Pennsylvania, northern Maryland, and Delaware. One member of each pair has a forested riparian zone, whereas the other has a riparian zone composed primarily of grass. The paired reaches are nearly contiguous, so all significant channel-forming variables except riparian vegetation are held constant. The extent of urban development of the watersheds upstream of the paired reaches also varies considerably, allowing us to determine the combined influence of riparian vegetation and urbanization on channel morphology. Statistical analyses indicate that (1) channels with forested riparian zones are wider than channels with nonforested riparian zones, (2) channels in urbanized watersheds are wider than channels in nonurbanized watersheds, and (3) the effect of riparian vegetation is independent of the level of urbanization.

Research Questions

Our study was designed to answer three questions concerning channel morphology:

- 1) Does forested riparian cover affect stream-channel morphology?
- 2) Does the level of urban development in contributing watersheds affect stream-channel morphology?
- 3) If riparian forests do influence stream-channel morphology, is the influence of riparian forest observed regardless of the level of urbanization in the watershed?

Study Sites

The study includes 26 paired stream reaches with drainage basins of 0.39–50 km² in southeastern Pennsylvania, northern Maryland, and Delaware (Fig. 1). This region is characterized by a gradient of land cover ranging from mixed agricultural uses with a fragmented, mixed-hardwood deciduous forest in more rural areas, to suburban and highly urbanized land uses in and around Philadelphia. The study reaches are self-formed alluvial channels with gravelly beds and cohesive banks composed of sandy silt.

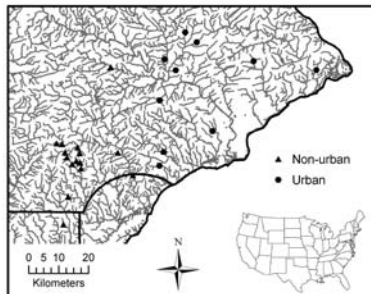


Figure 1. Location of paired study reaches.

Methods

Sampling Design: The sampling design was based on direct comparisons of morphologic attributes in forested and nonforested sections of 26 streams (Fig. 2). Each site was composed of nearly contiguous, forested and nonforested stream reaches with different amounts of urban development within their watersheds. The paired reaches were selected based on several additional criteria: (1) no major tributaries could enter within or between reaches, (2) no major disturbances were ongoing, such as livestock access or grazing, and (3) they could not directly abut each other.



Figure 2. Example paired-reach sites.

Statistical Analysis: The paired-reach design means watershed characteristics are virtually identical for the two riparian types within each stream. For any channel characteristic, the difference between paired reaches can be used to test for riparian effects and interactions of riparian effects with other factors. Riparian effects were tested using Wilcoxon Signed Ranks test, while more complicated effects were tested using ANCOVA.



Figure 3. Streams surveyed using laser levels, tapes and GPS.

Field Surveys: We measured the morphologic characteristics of all study reaches during base-flow periods between 1997 and 1999 (Fig. 3). The thalweg of each sample reach is ~100–200 m long. Longitudinal profiles were surveyed at important features (top of riffle, top of pool, deep point in pool), as were five to six detailed cross sections orthogonal to flow. The reach averaged grain-size distribution was determined by using a modification of the Wolman (1954) method (Pizzuto et al., 2000). The extent of each reach was sampled using a differential global positioning system (GPS) and imported into our geographic information system (GIS) to determine contributing watershed characteristics and percent imperviousness.

Results

Influence of Riparian Vegetation: There are significant differences in the stream characteristics of the paired forested and nonforested reaches (Fig. 4). Bankfull channels in forested streams are wider and have greater cross-sectional areas. No significant differences between forested and nonforested bankfull depth, sinuosity, slope, or median bed particle size (D_{50}) were found.

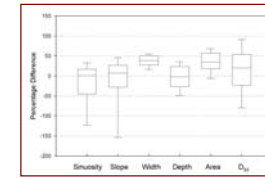


Figure 4. Comparison between important morphological measures of forested and nonforested pairs. Significant differences were found for bankfull width and cross-sectional area.

Influence of Urbanization: Channel width and cross-sectional area are larger in urban watersheds. We documented a significant ($p < 0.001$) urban effect and significant urban drainage-area interactions for channel widths and cross-sectional areas, but not depths. The regression lines relating morphologic characteristics to drainage area for urban and nonurban watersheds have significantly different slopes and intercepts (Fig. 5).

Combined Influence of Vegetation and Urbanization: Forested sites, whether urban or nonurban, have larger widths than nonforested sites (Fig. 5). The differences in width between forested and nonforested sites persist despite the effects of urbanization.

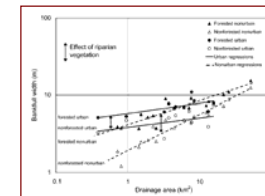


Figure 5. Bankfull width as function of drainage basin area. Separation between forested and nonforested regression lines, as illustrated by vertical arrows, indicates effect of riparian vegetation on bankfull width in urban and nonurban categories.

Conclusions

This is the first demonstration that both riparian vegetation type and watershed-level land use are equal influences on the downstream hydraulic geometry of alluvial rivers. Forested channels are wider than nonforested channels, and the magnitude of this difference is not influenced by the degree of urbanization within the contributing watersheds. These results have important implications for river restoration design practice around the country. Many restoration designs rely on regression curves that relate bankfull stream dimensions to drainage area. These curves do not separate streams based on riparian vegetation type or level of watershed urbanization. More localized regional curves should be developed that take into account riparian condition, watershed land use, and natural variability.

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Hession, W.C., J.E. Pizzuto, T.E. Johnson, and R.J. Horwitz, 2003. Influence of Bank Vegetation on Channel Morphology in Rural and Urban Watersheds. *Geology* 31(2):147-150.

References:

Pizzuto, J.E., W.C. Hession, and M. Midville, 2000. Comparing Gravel-Bed Rivers in Paired Urban and Rural Catchments of Southeastern Pennsylvania. *Geology* 28(1):79-82.

Wolman, M.G. and A.P. Schuck, 1967. Effects of Construction on Fluvial Sediment. *Urban and Suburban Areas of Maryland*. *Water Resources Research* 3(2):451-464.