Introduction Fluvial Processes in Small Southeastern Watersheds

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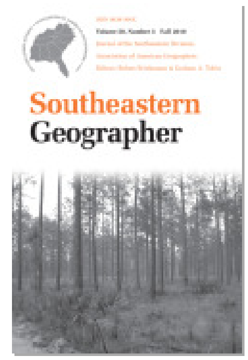

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Introduction

Fluvial Processes in Small Southeastern Watersheds

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The seven papers in this special issue resulted from two special sessions by the same name, at the Southeastern Division of the Association of American Geographers (SEDAAG) in Knoxville, Tennessee, in November 2009. The sessions were convened to address research involving fluvial processes and form in small headwater streams, and the papers represent a subset of the authors that were invited to present at those sessions. The sessions were well attended and stimulating, and we were delighted at the large number and high quality of papers that resulted. We believe that this reflects the growing importance of small watershed research and the need to apply this type of research to basins in the Southeast.

Small streams drain most of the land surface in the United States and are strongly coupled to adjacent hillslopes and catchment surfaces, so they drive runoff generation, sediment production, and the cycling of organic materials and nutrients. Yet, until recently, most research on fluvial systems has been focused on relatively large rivers. The study of small watersheds is of growing importance for many reasons. Regulations of water quality and aquatic ecosystems arising from legislation such as the Clean Water and Endangered Species Acts have provided incentives for state and local governments to study headwater streams. Improved flood hazard analyses and flood forecasts require physically based rainfall-runoff models that include realistic channel morphologies and network maps. Restoration and rehabilitation of small streams will only be successful over the long term with an accurate scientific understanding of the watershed processes that control the rivers. Better quantification of terrestrial carbon and nutrient cycling, much of which involves small streams, is becoming increasingly important to an improved understanding of global cycling of carbon and nutrients. Finally, the application and testing of conventional fluvial geomorphology theory to small watersheds is at a critical stage. Most fluvial theory has been developed in much larger systems, so many of the assumed processes and relationships depend upon extrapolations up into smaller drainage areas than where most data have been available. In addition, many of these relationships were developed elsewhere in the United States, so testing and refining these relationships in the Southeast is a logical extension of the present state of knowledge. We do not claim that the seven papers in this issue can accomplish these challenges by themselves, but we hope that they inspire further study along these lines of research.

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PAPERS IN THIS ISSUE

This issue is divided into three sections concerned with fluvial processes and features in small watersheds. Part One contains four papers concerned with the morphology of channels, Part Two consists of two papers on bank erosion and historical sedimentation, and Part Three has one paper on automated mapping of headwater channel networks.

Part One, Channel Morphology

This section begins with a paper by David Leigh on channel morphology and evolution of small streams ($<$20 km^2) in the southern Blue Ridge Mountains in response to human impacts. Using conventional statistical analyses of channel cross-section parameters, gradients, and bed-material textures with drainage area, Leigh shows a difference in morphologies —especially channel top width—between forested and pastured or grassland reaches. A series of hydraulic geometry regression equations relate channel form to drainage area. Processes of floodplain evolution and a centennial history of floodplain formation and readjustment in the watershed are identified through the analysis of ^{137}Cs, optically stimulated luminescence (OSL), and ^{14}C dating of floodplain and terrace alluvium to distinguish between historical and pre-historical sediment.

The paper by Kristen Blanton et al. examines bankfull channel indicators at 45 sites in small Florida streams ranging in drainage area from 0.52 to 805 km^2. Flow duration curves and flood frequencies are analyzed to determine the frequency of bankfull discharge. They find that the elevation of a break in slope of the banks or of the valley flat are the most reliable indicators of bankfull stage in this region, with the latter performing best for reaches with wetland floodplains. They conclude that bankfull stage has a duration of $\sim$25 percent of the time and that the recurrence interval of bankfull flows is relatively short, ranging from $<$ 1.0 to 1.44 years. Interestingly, evaluations of flow frequency based on flow-duration curves indicate longer periods of bankfull channel inundation than implied by recurrence intervals based on an annual maximum series. This study should provide guidance to the design of channels for restoration efforts.

The paper by Dan Royall et al. examines the occurrence of in-channel, step-like bench deposits attached to river banks in small watersheds of the Southern Piedmont. Bench deposits were surveyed and their stratigraphy analyzed at 9 sites across the Piedmont and compared to observations of benches made at the same sites in 1964 by USGS personnel. They found “new” benches (i.e., benches not documented in 1964) at 50 percent of the study sites. Flood variability analyses conducted for each site using USGS gage data showed that bench elevations above the channel bed were similar to bankfull stage calculated for a recent drought interval, suggesting a connection between bench formation and hydrologic variability induced by drought. At other sites, hydroclimatic influences on in-channel depositional processes appear to be subordinate to other watershed and localized processes. Their research provides insight into in-channel sediment storage processes and possible connections between sediment dynamics and hydroclimatic processes.

The paper by Barbara Smucygz et al.

examines changes to stream hydrology and channel morphology in three watersheds that experienced varying degrees of urbanization from 1961 to 2005. Percent impervious surfaces for four periods are estimated from urbanized areas based on classifications of Landsat satellite imagery. Annual stormflow ('event runoff') is computed by baseflow separations of mean daily flows from USGS gauge data. They find that mean runoff increased in all three basins between two periods 1961–1989 and 1990–2005 but that the increases are greatest in the two urbanized basins. Channel cross-section areas enlarged in response to the degree of urbanization, but Peach Tree basin, with the longest history of urbanization, shows a recent slight decrease in channel capacity.

Part Two, Bank Erosion and Historical Sedimentation

The first paper in this section, by Carol Harden et al., documents rates of streambank erosion based on detailed field monitoring of 45 erosion pins in twelve different stream banks over a period of 2.5 years. They raise the question of two primary sources of fluvial sediment: the "land-as-source" model versus the "banks-as-source" model. Bank erosion of up to 32 cm was recorded with mean bank-erosion rates of 2.4 cm per year. These rates indicate channel widening in small streams and substantial contributions of sediment from stream banks. They recommend that modelers and watershed managers consider these in-channel sediment sources in addition to upland land use that has been the conventional focus of sediment research.

The paper by Robert Pavlowsky et al. examines contamination of active channel sediments by nineteenth century gold and copper mining in the Gold Hill mining district in the Piedmont of North Carolina. Spatial and geochemical trends were evaluated in 93 active channel samples collected from contaminated main stem and unmined, background tributary sites. They find that both watershed-scale dispersal processes (distance downstream) and reach-scale sediment transport (percent sand) are significant factors explaining 86–91 percent of the variance in mercury and copper in active channel sediments. Concentrations of mercury and copper in uncontaminated tributary sites are controlled by grain-size, geochemical substrates, and mineral weathering sources. They also found that the imprint of regional background processes is evident in mining contaminated sediments, where 20–45 percent of the variance in contaminated mercury and copper can be explained by background parameters.

Part Three, Mapping Channel Networks

The one paper in this section, by Allan James and Kirsten Hunt, is concerned with improving maps of channel networks for small watersheds in the Southeast. High-resolution remote sensing methods, based on light detection and ranging (LiDAR) data, can generate high-resolution topographic data beneath forest canopy, and standard automated methods, based on a critical accumulation threshold (drainage area), can be used to create maps of channel networks. This paper examines the potential of a multivariate approach to automated mapping based on the inclusion of slope grids. The slope-discharge product is proportional to stream power, so the product of slope and drainage area grids theoretically should approximate the power of flowing water and the potential to generate channels (assuming discharge is proportional to drainage area).

CONCLUSION

These studies exemplify the wide variety of research that is being conducted on small streams in the Southeast. Several factors facilitate and call attention to the need for increased study of headwater streams. The increasing quality and availability of dating methods, high-resolution spatial data, spatially distributed models, and other developments have increased the capability of small watershed studies and are ushering in a new generation of research. Human impacts, such as deforestation, agriculture, urbanization, or road construction, are dominantly initiated in small watersheds. Regulatory requirements based on stream order or other metrics and the need for risk assessments call for objective estimates of water and nonpoint source pollution generation in headwater systems. The vast knowledge of fluvial processes and form established by fifty years of research concentrated in large rivers is not well established in smaller systems where extrapolations from established relationships should be questioned and tested. We hope that these papers inspire further study of small watersheds in the Southeast.