Hydrogeomorphic processes influencing ephemeral streams in forested watersheds of the southeastern Piedmont U.S.A.

by

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ABSTRACT

The extent of headwater channel networks are poorly represented on United States Geologic Survey topography maps. These maps are often used to delineate watersheds for management strategies and policies regarding the protection of waterways and wetlands. First and second order streams are often identified on these maps as thin blue lines that grade into dotted lines that are meant to estimate the extent of intermittent reaches of the network. Ephemeral creeks are generally left unmarked and are subsequently disregarded by policy makers when developing management strategies. Together ephemeral, intermittent, and first order perennial streams are important members of the larger stream system as they are the connection between hillslope processes and the valley. The conversion of forests and farmland into urban land uses has caused impairment and increased the level of degradation to many of the streams in the Piedmont. Public concern for the health and function of these waterways has heightened in recent decades, as demonstrated by the increased restoration efforts in many communities. Despite increasing attention to management of water quality, stream function, and ecologic health of headwater streams, no studies have quantified hydrologic processes in ephemeral channels that feed headwater streams in the Piedmont region of the southeastern United States.

This study reports field mapping of 102 forested ephemeral channel heads at five sites with varying soil types and underlying rock type. Drainage area and slope for each mapped channel head were derived using publically available six meter LIDAR surveys in conjunction with map grade Global Positioning Systems (GPS) in the field. Ephemeral channel heads have source areas that average 1.0 ha (range: 0.1 – 3.0 ha) and local slopes that average 0.13 (range:

0.04 - 0.36). As described in steeper landscapes, there is an inverse relationship between local slope and contributing area at Piedmont channel heads. Similarity of slope-area relationships for channel heads at all sites suggests that there is no prominent lithological or soil type control on the position of ephemeral channel heads in the region. Historic agricultural practices, such as extensive timber harvesting and row crop ploughing that occurred in the area, may be partly responsible for the shape of this relationship as these types of changes to the landscape are known to increase erosion and infiltration excess overland flow that can cause alterations to the hydrologic function of channelized networks. Further research is needed to constrain the effects of these legacy land uses on the position of channel heads in the region.

From July 2010 to April 2011, six ephemeral streams with an average length of 173 m (range: 91–290 m) and average cross sectional area of 0.33 m^2 (range = 0.17-0.66 m^2), were instrumented with 41 crest stage gauges (6 – 7 gauges per creek). Over the course of this study, eight precipitation events with accumulation depths ranging from 2.3 cm to 10.8 cm, generated discharge in one or more crest stage gauge in the monitored creeks. Regardless of antecedent soil moisture conditions in the watersheds or season, events producing ≥0.60 cm/hr rainfall intensity initiated flow over significant portion of the flowpath from ridgeline to perennial channel. However, based on analysis of the crest stage data and field observations during and immediately after rain events, it has been determined that ponding in the channels occurs during more moderate rain events. During these events, there is not always complete connection and coalescence between the ponded water creating flow across the channels from ridgeline to perennial flow. High intensity rainfall or saturated soil conditions previous to events accumulating ≥2.3 cm rain do result in flow over significant portions of the channel.

Disturbances to the ephemeral channel network, such as occur during urbanization, may have an under-appreciated impact on larger streams. Headwater streams represent a significant portion of the landscape and are vital sources of water, sediment, and detritus to the down valley system. Here I have quantified frequency and magnitude of response by ephemeral channels to a variety of meteorological events. Continued research is needed to better understand the nutrient and sediment delivery processes of these forested systems.