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RELATIONSHIP BETWEEN WATERSHED AREA AND DISCHARGE OF WEST PRONG ROARING RIVER, WILKES COUNTY, NC

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Abstract: Watershed area and discharge were calculated for five sites along the West Prong Roaring River, a third-order tributary in Wilkes County, North Carolina for which discharge data was previously unavailable. A nearly linear relationship was found such that $Q = 6.8945A^{1.1496}$ ($R^2 = 0.9902$), where Q is discharge (Ls^{-1}) and A is watershed area (km^2), which is consistent with every unit increase in watershed area contributing a unit increase in water volume.

Key Words: rivers; hydrology; discharge; tributaries; Wilkes; Roaring River.

INTRODUCTION

The Roaring River in Wilkes County, North Carolina is a three-pronged southeast-trending tributary of the Yadkin River in the Yadkin Pee-Dee River Basin. The West Prong runs for ~20 km before joining with the Middle Prong, which then runs for ~8 km before joining with the East Prong to form the Roaring River main stem. The West and Middle Prongs have been the focus of few studies compared to the East Prong, which runs through Stone Mountain State Park and has undergone restoration efforts (Wise-Frederick et al. 2001). The U.S. Geological Survey (USGS) maintains a stream gage (USGS gage 02112120; discontinued in October 2014) along the main stem (USGS 2013).

The West Prong, which commands 13% of the watershed area of the Roaring River, begins in the Thurmond Chatham Gameland along the Blue Ridge Front. Elevation ranges from 550 to 1040 m, bedrock consists of fine-grained mica gneiss and schist, and vegetation is a secondary oak-hickory forest with a dense understory of mountain laurel (Graham et al. 1990). The climate is humid temperate with an average of 1,400 mm in annual precipitation (mostly as rain) and a mean annual temperature of 10°C (Graham et al. 1990). Soil consists predominantly of well-draining clay loams, sandy loams, and stony slopes (USDA 2013). The majority of the watershed's land cover is forest, containing less than 10% pastures and less than 5% pavement based on 2011 National Land Cover Database data (TNM 2013). The West Prong has not been subjected to any significant anthropomorphic modifications of streamflow (e.g. farm irrigation) as of the time of this study, although some riverfront property owners have created small natural rock dams and vehicles sometimes cross sandy, shallow portions of the river. General climatic, geological, and hydrological characteristics of the Yadkin Pee-Dee River Basin are available in Fish et al. 1957, Wallace et al. 1992, and Krishnaswamy et al. 2000.

METHODS

On 16 November 2013, Discharge was measured at five sites along the West Prong using the current-meter method (Rantz 1982). Sites were selected for straight, symmetrical, and flat streambeds and were measured within a three hour period in order to minimize possible changes in flow conditions. In the two weeks preceeding the study, the site received less than 3 mm in total precipitation (USGS 2013).

Site locations were as follows (Table 1): Site 1, near Longbottom Road; Site 2, near the northern end of Cabin Creek Road; Site 3, near the southern end of Cabin Creek Road; Site 4, near Riverbend Lane; and Site 5, near the southern end of Shumate Mountain Road.

Using USGS topography maps (2013) for the Whitehead, Glade Valley, McGrady, and Traphill quads (http://store.usgs.gov), each site's watershed was delineated and its area calculated manually and with ArcGIS. The average discharge rate for the main stem of the Roaring River on the day of the study was obtained from the USGS (USGS 2013).

RESULTS

At each site, the West Prong's watershed area and discharge were calculated as follows (Table 1): Site 1, watershed area of 2.6 km^2 and discharge of 19 Ls^{-1} and; Site 2, watershed area of 14.1 km^2 and discharge of 176.03 Ls^{-1}; Site 3, watershed area of 35.7 km^2 and discharge of 35.7 Ls^{-1}; Site 4, watershed area of 57.5 km^2 and discharge of 602.2 Ls^{-1}; and Site 5, watershed area of 61.7 km^2 and discharge of 865.9 Ls^{-1} (the USGS reports an area of 59.7

Table 1. Watershed area (km^2) and discharge (Ls^{-1}) for sites measured along the West Prong Roaring River, Wilkes, NC.

Site	Coordinates	Watershed Area	Discharge
1	36°21'17" N 81°11'26" W	2.6	19
2	36°21'20" N 81°10'35" W	14.1	176.0
3	36°18'50" N 81°7'52" W	35.7	412.4
4	36°17'40" N 81°7'19" W	57.5	602.2
5	36°17'39" N 81°5'48" W	61.7	865.9

km^2 for site 5). At the USGS stream gage, the discharge for the main stem of the Roaring River was 4105.0 Ls^{-1}, compared to its 49-year mean of 4955.5 Ls^{-1} and median of 3596.2 Ls^{-1} (USGS 2013).

DISCUSSION

Discharge of a river can be calculated using the generalized formula

$$Q = kA^c,$$

where Q equals the discharge, k equals the baseflow (volume per time), A represents the upstream drainage area ($length^2$), and c is the scaling power (Galster et al. 2006). A value of 1 is usually employed for c under the assumption that every unit increase in area provides an additional unit volume of water to the stream, resulting in linear relationship between watershed area and discharge (Galster et al. 2006). The data obtained for the West Prong are consistent with this relationship, with a regression line calculated at $Q = 6.8945A^{1.1496}$ ($R^2 = 0.9902$), where Q is measured in Ls^{-1} and A is measured in km^2 (Fig. 1).

This study represents the first discharge values reported for the West Prong. However, further research is needed in order to better characterize the West Prong, which remains poorly understood despite its vicinity to a gameland and state park. Streamflow modeling would provide a valuable baseline with which to compare the data collected in this study. Future studies should focus on longterm monitoring of discharge and its response to precipitation events, stage-discharge relationships, drainage density, sediment transport, and contamination levels.

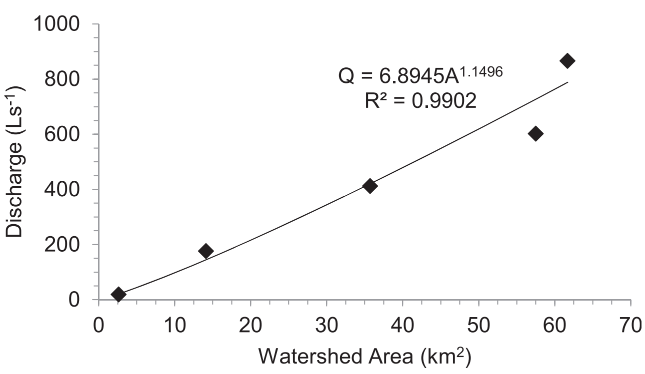

FIG. 1. Relationship between watershed area (km^2) and discharge (Ls^{-1}) of the West Prong Roaring River, Wilkes County, NC. Regression line: $Q = 6.8945A^{1.1496}$ ($R^2 = 0.9902$).

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