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Understanding the relationship between colluvial hollow morphology and hillslope processes

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Colluvial hollows are common features of soil mantled hillslopes, accumulating sediment and and water, triggering landslides and debris flows which act as significant geomorphic agents. Their geometry and volume controls how quickly sediment may re-accumulate after landslide evacuation and how quickly water, and subsequently pore pressure, is delivered to hollow axes. Thus, hollow geometry plays a fundamental role in the sediment dynamics of catchments, yet little analysis on catchment-scale hollow geometry has been conducted. We present a method to identify every hollow in a landscape and subsequently quantify their geometric properties using Elliptical Fourier analysis and deploy this method across the Coweeta Hydrologic Laboratory, USA. Surprisingly, in a landscape with an orographic gradient in precipitation and large hillslope to channel relief, we observe no correlation between elevation or spatial location and hollow geometry. However, we find that two physiographic units in Coweeta have different hollow morphologies. The two units are the steep, thin soiled, high elevation Nantahala Escarpment and the lower gradient, lower elevation, thick soiled remainder of the basin. Our results indicate that hollow slope and area negatively covary, producing the distinct hollow forms observed between the two physiographic units, which we suggest arise through competition between spatially variable creep-like sediment transport and stochastic landsliding, acting to smooth and roughen topography, respectively.