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Observations of drainage network change in a recently burned watershed using terrestrial laser scanning

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Wildfire enhances the geomorphic response of a watershed to precipitation events, effectively altering the form of the hillslope and channel drainage network. Typically, drainage networks expand following rainfall on a recently burned watershed. Expansion of drainage networks following wildfire increases in erosion and sediment transport rates, and the probability of flash-flooding and debris-flows at downstream locations. Observations of the response of hillslope and channel drainage to individual precipitation events are vital to unraveling the dynamics of erosion processes in recently burned watersheds. Here, we apply terrestrial laser scanning (TLS) methods to produce digital terrain models (DTMs) of a recently burned watershed at an unprecedented spatial resolution. The DTM data aid the quantification of changes in the hillslope and channel drainage networks at several spatial scales.

Two TLS surveys were conducted, one survey between 28-30 September 2008 to document pre-rainfall conditions, and one between 18-21 December 2008, three days after 52 mm of rainfall over a period of 22 hours. A Leica Geosystems ScanStation 2 TLS was used to generate 1 cm resolution DTMs, from which the hillslope and channel drainage networks were derived. The location and magnitude of erosion and deposition for each pixel within the basin was determined by calculating the topographic differences between DTMs. Changes in the drainage network morphology were identified through the analysis of bifurcation ratio, drainage density (including rills), rill length, horizontal migration of rills, width-depth ratios and upstream migration of knickpoints. Comparisons of these measures were made between morphologically distinct sub-basins within the study area, and between surveys.

Analyses of bifurcation ratios, and measures of rill position and gullyhead migration indicate an expansion of the rill network and upstream migration of knickpoints. These results suggest that expansion of the drainage network is a function of boundary conditions that exist at multiple spatial scales, including depth to bedrock, surface roughness, and contributing area. Additional predictive capability at this spatial and temporal resolution is going to require a physically-based model capable of combining high-resolution topographic changes and process information from in-situ measurements of flow dynamics.