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Influence of surface form on sediment transport in a recently burned watershed derived from multi-temporal terrestrial laser scanning data

D. Staley (1), T. Wasklewicz (2), and J. Kean (1)

(1) U.S. Geological Survey, Denver CO, USA, (2) Department of Geography, East Carolina University, Greenville NC, USA

Spatially-distributed models of erosion and sediment transport often rely upon measurements of soil properties and the hydrological characteristics of a hillslope or watershed. Collection of a sufficient quality and quantity of data to fully represent the spatial variability in these parameters is difficult and time consuming. In addition, the acquisition of such data often results in disturbances which may alter the hydrology of the surface. The difficulties of quantifying the complex patterns of soil properties and hydrological characteristics have led researchers to rely upon quantitative descriptions of surface form as surrogates for measurements. Terrain parameters such as surface curvature, compound topographic index (CTI), and the terrain characterization index (TCI) previously have been related to soil properties, hydrology, and geomorphic processes. One of the goals of establishing these relations is to include the terrain parameters in a sediment transport model for predicting the spatial location and volume of erosion, transport and deposition from runoff processes in a watershed. Given the difficulties of accurately measuring the spatial patterns of erosion and deposition over broad areas, tests of these relations between surface form and sediment transport are typically constrained to computer models, or laboratory- or plot-scale studies.
Our research focuses on measurements of erosion and deposition in a small (0.97 ha) recently burned drainage basin near Santa Barbara, CA, USA obtained from multi-temporal terrestrial laser scanning (TLS) data. We analyzed the relation between surface form and measurements of the changes in surface elevation using high-resolution (1-cm raster resolution) topographic data from two TLS surveys. Two small rainstorms occurred between the first survey in September 2008 and the second survey in mid-December 2008. In total, 132 m3 of material was transported out of the watershed during the inter-survey period. We derived the terrain parameters of surface curvature, CTI, and TCI from the TLS data to assess the influence of surface form on the type and magnitude of sediment transport.

Preliminary results indicate that the CTI and TCI parameters are better predictors of erosion in areas of increasing flow accumulation and erosion depths in excess of 2 cm. Surface curvature was a better predictor of erosion where depth was less than 2 cm. The relation between deposition and slope form was less clear than that of erosion. Deposition was largely constrained to a relatively small number of areas, which had a large range of TCI and CTI values. Some evidence of preferential deposition in areas of planform concavity and profile convexity was identified, but additional analysis is necessary to verify this finding. We conclude that for our dataset, the topographic parameters of CTI, TCI and surface curvature are useful for predicting the extent and magnitude of erosion for our particular sequence of meteorological conditions. Additional analysis is necessary to determine the utility of these parameters for predicting the extent and magnitude of deposition, and the extent and magnitude of erosion during different rainfall conditions and over varying timescales.