Geophysical Research Abstracts
Vol. 15, EGU2013-5642, 2013
EGU General Assembly 2013

Effects of Wildfire Disturbances on Multi-scale Connectivity

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Eco-geomorphic systems are characterized by interactions between system components which operate at various spatial and temporal scales. Many processes in these systems are scale-dependent (point-plot-slope-basin), and vary over different spatial extents. Within any landscape unit the magnitude and nature of interactions between system elements and processes vary, suggesting that variables and processes that are interdependent at one scale may be independent at another. Disturbances can have profound effects on scale-dependent processes, 'reframing' spatial boundaries between the various functional-geomorphic units. Wildfires, for example, result in the removal of woody patches, which might be translated to displacement of patch boundaries, essentially homogenizing land cover and facilitating hydrological connectivity between the burnt patches and consequently among the nested scales (patch-slope-basin). Further, processes such as fire-induced hydrophobicity which have important hydrological implications at the point scale, do not necessarily translate to significant increase in runoff at larger scales. Accordingly, structural and mechanical changes caused by wildfires, might alter both the boundaries as well as the role of scale-dependent processes, resulting in increased connectivity between the spatial units and consequently an overall intensification of post-fire hydrological response of the system. Accordingly we try to statistically identify what are the threshold values at which processes operating at one scale are replaced by processes operating at other scales, in contrast to the arbitrarily defined scales.

To identify such thresholds we compiled data from over 60 published studies which addressed sediment yield following fire events at various spatial scales (2 m^2 plots - 1660 ha basin). The data were ranked from the smallest scale to the largest, and we incrementally calculated the coefficient determination (R^2) of the data by successively adding each observed data point. We demonstrate that a sinusoidal response exists, and that a sharp decrease in R^2 values represents an introduction or replacement of processes in the geomorphic system. As more data points accumulate R^2 values increase, representing the increasing explanatory power of the model, until another process is introduced into the system resulting in a consequent drop of R^2. This approach enables us to estimate sub-scales which are characterized by high connectivity and the transition thresholds, which represent values of fragmented connectivity.

Following the identification of the transition thresholds we partitioned the data to the subgroups associated with each of the scales, and analyzed specific regression models for each of the subgroups. In this case the emerging transition thresholds were at scales of 0.05ha, 2.5ha, and 1660ha. Evaluating the best fitting regression curve for each of the data subsets suggests that within each scale different driving forces dictate the response of the disturbed systems, as different regression models performed best at each scale. Fire effects on scale-dependent sediment yields reveal a clear partitioning into three spatial scales.