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Predicting Post-fire Flooding and Sediment Delivery at the Watershed Scale: An Urgent Need for Upscaling

Lee MacDonald (1), Joe Wagenbrenner (2), Peter Nelson (3), and Dan Brogan (3)

(1) Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO, USA (lee.macdonald@colostate.edu, 970-215-5311), (2) USDA Forest Service Rocky Mountain Research Station, Moscow, ID, USA (joe_wagenbrenner@yahoo.com, 208-301-1408), (3) Dept. of Civil Engineering, Colorado State University, Fort Collins, CO, USA

Over the past 10-15 years tremendous advances have been made in understanding the effects of fires on runoff and erosion processes, the effectiveness of various post-fire rehabilitation treatments, and the prediction of these changes. The problem is that nearly all of this work has been done at the plot and hillslope scale, while it is the larger-scale issues of flooding, water quality, and sedimentation that are of primary concern to resource managers and the public. In most cases these larger-scale changes are predicted either by simple lumped models, such as the curve number technique, or by summing up the hillslope-scale responses. These approaches can greatly overestimate the downstream effects because they do not account for the spatial variability of rainfall or the complexities of routing and storage. While post-fire stormflows may be efficiently routed downstream, our observations from fires across the western US indicate very large differences in the amount of sediment delivered to downstream areas. As one example, a large storm after the 2012 High Park fire near Fort Collins generated huge amounts of sediment, but relatively little of this was delivered to the Cache la Poudre River; in the case of the 2002 Hayman fire near Denver even moderate-sized storms delivered enough sand and fine gravel to temporarily dam up the South Platte River and over time around 750,000 m^3 of sediment was deposited into Strontia Springs Reservoir.

In this paper we hypothesize that relatively simple set of tools can greatly improve our ability to predict post-fire runoff and sediment delivery at the watershed scale (5-100 km^2). In areas dominated by convective storms post-fire flood risks should be modified according to the size of those storms relative to the upslope contributing area and extent of high or moderate burn severity. The potential delivery of post-fire sediment can be improved by combining the predicted flood risk with empirical adjustments based on valley confinement, valley slope, and the density of the residual riparian vegetation. Particle size is hypothesized to be a lesser control because most of the deposited post-fire sediment is easily transported. Valley slope can be estimated from existing DEMs, while the accurate characterization of valley confinement and riparian vegetation requires higher-resolution imagery such as lidar and Quickbird or SPOT. The development of such tools should greatly improve our ability to predict the larger-scale risks of flooding and sedimentation, and more efficiently allocate post-fire treatments to watersheds that have the highest sediment delivery potential.