Hillslope and Low-order Channel Changes after a High-severity Fire: Differences in Processes and Recovery Rates

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Abstract. High-severity wildfires in the Colorado Front Range increase runoff and surface erosion rates by several orders of magnitude, and these changes can severely degrade downstream water quality and aquatic habitat. A critical question for resource managers is the relative duration of these effects at both the hillslope and watershed scales. The objectives of this study were to: (1) quantify the effects of the 2002 Hayman fire on hillslope and channel conditions relative to adjacent unburned areas; (2) determine the rate of recovery for hillslopes and low-order channels; and (3) determine the key controls on post-fire recovery in two burned watersheds with different valley morphology.

The study area is southwest of Denver in the northwestern portion of the 2002 Hayman fire. Hillslope and channel monitoring fortuitously began the summer before burning, and the hillslope-scale measurements have continued through summer 2007. Channel conditions and cross-sectional change was most intensively studied from May 2004 to November 2005.

In areas burned at high severity there was a nearly complete loss of surface cover. Summer rainfall intensities of 8-10 mm hr^{-1} generated Horton overland flow, and the resulting rilling generated most of the 20 Mg ha^{-1} of sediment measured at the hillslope scale in the first three years after burning. At larger scales these rills converged to form incising gullies, and the gullies transitioned to aggrading ephemeral channels where the mean channel slope decreased from about 16% to 10%. Up to 1.3 m of aggradation was measured, and the channels in the burned watersheds were significantly wider and had more unstable banks, knickpoints, and fine bed material than the channels in unburned watersheds.

By summer 2005 vegetative regrowth had greatly reduced hillslope runoff and erosion rates, and we project a relatively rapid filling of the rills and gullies by bank collapse and colluvial processes. The extensive aggradation in the unconfined channels means that nearly all of the flow is subsurface, and the low sediment transport capacity means that the post-fire deposits are a nearly permanent change in channel and valley morphology. In the more confined reaches flow is perennial and exceeds the critical stream power needed to transport the fine bed material, but several decades will probably be required for the channel to re-incise its original channel and transport most of the post-fire sediment to the South Platte River. These results emphasize the different rates of post-fire recovery at different spatial scales and between watersheds, and indicate that the 2002 Hayman fire will continue to have persistent, adverse effects on coldwater fisheries, reservoir storage, and other downstream resources.