Geophysical Research Abstracts
Vol. 13, EGU2011-13405, 2011
EGU General Assembly 2011

Short- and Long-term Feedbacks Among Vegetation Cover, Fires, Erosion, and Topography

Lee Macdonald (1), Isaac Larsen (2), Keelin Schaffrath (3), and Matthew Welsh (4)

(1) Colorado State University, Watershed Science Program, Fort Collins, Colorado, USA (leemac@cnr.colostate.edu, 970-491-6307), (2) University of Washington, Seattle, Washington, USA, (3) US Geological Survey, Glenwood Springs, Colorado, USA, (4) Jehn Water Consultants, Denver, Colorado, USA

Under undisturbed conditions forests are noted for their production of high-quality water and low erosion rates. If done carefully, forest management should have little effect on the basic runoff and erosion processes. In contrast, roads and high-severity fires can completely remove the protective surface cover, which can then increase surface runoff and erosion rates by one or more orders of magnitude. In most cases the rapid regrowth after a fire quickly restores pre-fire erosion rates. However, in this paper we suggest that in some cases large fires can have a longer-term effect on vegetative cover, which may sustain higher erosion rates. The sustained erosion in turn may limit vegetative regrowth. The high post-fire erosion rates also can cause extensive downstream deposition, which can then result in longer-term changes in valley morphology. Hence an initial change due to some external forcing, such as high-severity wildfires, can dramatically change the short- and longer-term trajectory of the vegetative cover and landscape evolution.

The study sites are primarily in the ponderosa pine forests in the Colorado Front Range, USA. In summer 2001 a study began to evaluate the effect of forest thinning, and this included the establishment of 20 pairs of convergent hillslopes as well as runoff and channel morphology measurements in two small watersheds (2.3 km^2 and 6.0 km^2). Half of these hillslopes and about 60% of the two watersheds burned in the 2002 Hayman wildfire, resulting in a unique pre- and post-fire dataset. Intensive hillslope-scale monitoring also has been conducted on six other wildfires and three prescribed fires, resulting in 600 hillslope-years of post-fire sediment production and cover data. Over two hundred hillslope-years of data have been collected in unburned areas to evaluate the effects of thinning and serve as unburned controls. The development of rills has been intensively monitored in some of the burned convergent hillslopes, and cross-section measurements have been made throughout the two study watersheds.

Prior to the Hayman fire there was more than 90% surface cover, and this consisted primarily of pine litter. Measurable erosion occurred for only three of the 222 hillslope-years of data from the control and thinned sites, even when rainfall intensities exceeded 60 mm hr^{-1}. In contrast, sediment was produced from each of the severely-burned hillslopes for each of the first three years after burning, and the cumulative mean sediment yield was 32 Mg ha^{-1}. Severe armoring has developed on the burned hillslopes while there is no comparable armor layer on the unburned hillslopes, and sediment production is primarily controlled by the amount of surface cover. The large size of the Hayman fire is precluding the establishment of trees in many areas, and the very coarse-textured soils and dry, cold climate mean that forbs, grasses, and shrubs can only provide about 60% cover, which still leaves these sites susceptible to erosion from the largest storm events. The downstream deposition of post-fire sediment has changed the runoff from surface to subsurface flow in one of the two study watersheds, causing a near-permanent change in valley morphology. Continuing surface runoff in the other watershed should allow a return to near pre-fire conditions. In summary, the fire-induced changes in vegetative cover have important feedbacks to future erosion and sediment transport rates, and hence to ecosystem services and landscape evolution.