Use of a Rainfall Simulator to Assess Controls on Post-Fire Runoff and Sediment Production, Colorado Front Range

Darren J. Hughes
Watershed Science Academic Program, Forest, Rangeland, and Watershed Stewardship Dept., Colorado State University, Fort Collins 80523 970-491-2774 djhughes@cnr.colostate.edu

Juan de D. Benavides-Solorio
Centro de Investigacion Regional de Pacifico Centro, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, Guadalajara, Jalisco, Mexico 44660 33-3641-2248 jdedios@cirpac.inifap.conacyt.mx

Lee H. MacDonald
Forest, Rangeland, and Watershed Stewardship Dept., Colorado State University, Fort Collins 80523 970-491-6109 leemac@cnr.colostate.edu

Abstract. Wildfires in the Colorado Front Range cause large increases in runoff and erosion, but the variability in rainfall inputs makes it difficult to determine the role of individual site factors, or rigorously assess recovery over time. The use of a rainfall simulator provides a more uniform means for comparing post-fire runoff and erosion rates between sites and over time. The objectives of this project were to: (1) determine the effect of different site variables on runoff and sediment yields; and (2) assess the recovery of post-fire runoff and erosion rates over time. The study sites were the June 2000 Bobcat wildfire, the November 1999 Lower Flowers prescribed fire, and the July 1994 Hourglass wildfire. Twenty-six rainfall simulations were conducted on 1 m² plots in 2000, 23 simulations in 2001, and 19 simulations in 2002. For each simulation rainfall was applied at 70-80 mm hr⁻¹ for 60 minutes.

Fire severity did not significantly affect the runoff rate at either Bobcat or Lower Flowers, and this can be attributed to the relatively high rate of applied rainfall. The mean runoff ratio for sites burned at high severity in the Bobcat fire declined from 66% in 2000 to 46% in 2001 and 51% in 2002. Runoff ratios at Lower Flowers did not significantly differ between the two years of study. Soil water repellency at 1 cm was the only variable that was significantly related to runoff ratios ($R^2$=0.20).

Sediment yields at Bobcat and Lower Flowers varied significantly with fire severity. For the first two summers after the Bobcat fire, sediment yields from high severity sites averaged 1.2 kg m⁻², or 7 times the value for moderate severity sites and 24 times the value for low severity/unburned sites. For the first two summers after the Lower Flowers fire, the mean sediment yield for high severity sites was 0.5 kg m⁻², or 4 and 17 times the values for moderate and low severity/unburned sites, respectively. The differences in sediment yields with fire severity were smaller in the third summer after the Bobcat fire, as the high severity sites produced only 4 and 6 times as much sediment as moderate and low severity/unburned sites, respectively. Significant declines in sediment yields over time were evident for high severity sites between the second and third summers after burning in Bobcat (37% decrease) and between the first and second summers after burning in Lower Flowers (54% decrease). Univariate analyses showed that percent bare soil explained 67% of the variability in sediment yields for all sites, while slope explained 27% of the variability.