Runoff and sediment production from forest fires at two scales

Juan de Dios Benavides-Solorio
Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP), Guadalajara, México

Lee H. MacDonald
Department of Forest, Rangeland, and Watershed Stewardship, Colorado State University

Abstract. Forest fires may produce large increases in runoff and sediment rates and several processes and factors control the rates. This work share the experience working two on two different scales: 1) runoff and erosion rates from small plots, and 2) sediment production rates at the hillslope scale. On the small plots 70-85 mm of mean rainfall was applied in 60 minutes, and runoff/rainfall ratios generally exceeded 45%. The high rainfall rate meant that runoff/rainfall ratios were only slightly higher from plots burned at high severity than from low severity/unburned plots. Post-fire soil water repellency was the main control on runoff/rainfall ratios. Mean sediment yields from rainfall simulations on high severity sites in the Bobcat wildfire were 1,280 g m$^{-2}$ in 2000 and 1,230 g m$^{-2}$ in 2001. Sediment yields from high severity sites in the Lower Flowers prescribed fire decreased from 850 g m$^{-2}$ in 2000 to 350 g m$^{-2}$ in 2001. High severity plots yielded 16-33 times more sediment than low severity and unburned plots. Regression analysis showed that percent bare soil was the dominant control on sediment yields, although percent silt and the runoff/rainfall ratio were significant factors for high severity sites. At the hillslope scale sediment production rates exceeded 10 Mg ha$^{-1}$ yr$^{-1}$ from sites burned at high severity in a recent wildfire, and only 0.1-4 Mg ha$^{-1}$ yr$^{-1}$ from high severity sites in recent prescribed fires. High severity sites in the Bobcat wildfire produced 75 times more sediment than moderate severity sites. Summer rainstorms generated at least 73% of the sediment at all sites. Sediment production rates from swales or small drainages were 2-3 times higher than planar hillslopes. Multivariate modeling showed that sediment production rates were a function of fire severity, percent bare soil, rainfall erosivity, soil water repellency, and soil particle size. The best model had a $R^2$ of 0.77. Areas burned at high severity are at particularly high risk for at least the first 2-3 years after burning. To be effective post-fire rehabilitation treatments must immediately provide ground cover and maintain this for at least two years.