DISSERTATION

POST-FIRE RUNOFF AND EROSION AT THE PLOT AND HILLSLOPE SCALE, COLORADO FRONT RANGE

Submitted by

JUAN DE DIOS BENAVIDES-SOLORIO

Department of Earth Resources

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Colorado State University

Fort Collins, Colorado

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ABSTRACT OF DISSERTATION

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Forest ecosystems in the Colorado Front Range are at very high risk for large increases in runoff and erosion after wildfires. This research was proposed because there is very limited data on post-fire runoff and erosion rates and the factors that control these rates. This research focussed on two different scales: 1) runoff and erosion rates from small plots subjected to high-intensity artificial rainfall, and 2) sediment production rates at the hillslope scale from prescribed and wild fires of different ages. The results will help predict the effect of future fires and design more effective rehabilitation treatments.

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. Mean runoff/rainfall ratios in recently-burned, high-severity plots decreased by 15-30% from the first to second years after burning, but were still high relative to runoff rates from simulations on the 1994 Hourglass wildfire. 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. Simulations on high severity plots in the 1994 Hourglass wildfire yielded only slightly more sediment than unburned plots, indicating that recovery was nearly complete after 6 years. Univariate and multivariate 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. Four to six years are required for sediment production rates to approach the values from sites burned at low severity. 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, and this declined to 0.62 for a two-parameter model using percent bare soil and rainfall erosivity. Model validation was satisfactory, but more data are needed for complete testing.

The runoff and erosion rates measured in this study are high relative to the results from most other studies in burned areas. 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. Rehabilitation efforts also should focus on reducing flow velocities in swales and small drainages to reduce channel erosion.

Juan de Dios Benavides-Solorio
Department of Earth Resources
Colorado State University
Fort Collins, CO 80523
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