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Effects of Forest Fires on the Strength and Persistence of Soil Water Repellency in the Colorado Front Range

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Post-fire soil water repellency is often cited as a primary cause of the large increases in runoff and erosion observed after high-severity wildfires. The problem is that few studies have simultaneously measured soil water repellency, runoff and erosion, or documented the decline in soil water repellency over time. The objectives of this study were to: (1) measure soil water repellency in burned and unburned areas in ponderosa pine forests in the central Colorado Front Range; (2) assess the persistence of post-fire soil water repellency in two wildfires; and (3) determine whether soil water repellency is correlated with runoff and erosion rates from rainfall simulations at the plot scale, or with sediment yields at the hillslope scale.

Direct comparisons between pre- and post-fire conditions are possible because of the fortuitous establishment of 36 study sites in summer 2001, which was one year before the 530 km^2 Hayman wildfire. Another 18 sites were established in summer 2002 after the May 2002 Schoonover wildfire, and these data are compared to earlier data from an adjacent unburned area. At all sites the soil water repellency was measured at 3-cm intervals using the critical surface tension (CST) procedure. Post-fire measurements were made in the summers of 2002, 2003, and 2004.

In the unburned areas the mean soil water repellency was 55 dynes cm-1 at the soil surface. Soil water repellency weakened to 59 dynes cm^{-1} at 3 cm and 64 dynes cm^{-1} at 6 and 9 cm. At 12 cm there was little evidence of soil water repellency. Soil water repellency was stronger under the tree canopy than in the intercanopy areas. After burning the mean soil water repellency was significantly stronger at the soil surface (41 dynes cm^{-1}). Burning also increased the soil water repellency at 3 and 6 cm,

but the magnitude of the differences between burned and unburned areas decreased with increasing depth. Soil water repellency rapidly weakened at the soil surface, and by summer 2004, which was two years after the fires, there was little evidence of soil water repellency at either the soil surface or at 9 cm. In summer 2004 the strongest soil water repellency was 57 dynes cm^{-1} at 3 cm. These indicate a more rapid breakdown of soil water repellency at the soil surface than at 3 or 6 cm below the surface. The variations in the decay rate of post-fire soil water repellency with soil depth may help identify the primary cause(s) of the observed declines in soil water repellency.

Soil water repellency values in the burned areas were only weakly correlated with the runoff rates measured from rainfall simulations on 1 m^2 plots. Soil water repellency also was poorly correlated with sediment production rates at both the plot and hillslope scales. We conclude that forest fires in the Colorado Front Range induce soil water repellency, but this is relatively short-lived and is not a primary cause of the flooding and erosion that is commonly observed after high-severity wildfires.