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The Evolution of Wildfire Ash and Implications for Post-fire Infiltration

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Changes in the properties of an ash layer with time may affect the amount of post-fire runoff, particularly by the formation of surface crusts. The formation of depositional crusts by ash has been observed at the pore- and plot-scale, but the causes and temporal evolution of ash layers and the associated crusts have not yet been thoroughly investigated. In particular, it is uncertain whether crust formation by re-crystallization can be caused just by exposure of the ash to air, or whether rainfall is necessary to wet the ash. Increases in the density of the ash as it collapses under its own weight, compaction by raindrops, and chemical transformations within the ash may increase the potential for forming an ash crust and the associated decrease in infiltration. Furthermore, the rate and causes of the temporal evolution of the ash layer is largely unknown. Over the longer-term, however, ash crusting effects will decrease as the ash layer is removed by wind and water erosion, while in the short-term ash crusting can contribute to the observed changes in post-fire runoff.

This study addresses these topics by studying the evolution over time of highly combusted ash layers from two wildfires in the Northern Rockies. More specifically, this research is designed to assess the potential for ash crusts to form and thereby contribute to the observed decreases in infiltration after forest fires. Nine sites were established in two Montana wildfires that burned at high severity in 2011, and these were the Avalanche-Butte and West Riverside fires. The study sites had similar tree canopies and hence are presumed to have had similar amounts of mixed pine fuels prior to burning. Three plots were established in each site to track the evolution of ash properties over time with different exposure to rainfall. The control plot was exposed to natural rainfall, the second plot was completely sheltered from rainfall by a canopy, and the third plot was exposed to rainfall but protected from raindrop impact by covering the ash surface with a fine mesh screen. The ash layer in each plot was sampled weekly over a two-month period, and the data collected for the ash layer included color, thickness, bulk density, infiltration, and water repellency. Soil water repellency and surface ground cover were also measured each week. Weekly ash samples were taken and analyzed for particle size, particle density, and porosity. X-ray diffraction analysis was used to identify the minerals within the ash samples and changes in ash composition associated with hydration. This design allowed us to distinguish the effects of natural rainfall on ash properties and ash crust formation as compared to rainfall with minimal raindrop impact, and the exposure of the ash layer to moist air but no rainfall.

Preliminary results indicate that high-combustion ash does evolve due to post-fire rainfall. In the plots exposed to rain the thickness, infiltration and bulk density all decreased over time. Crust formation occurred in all plots except for the covered ones, and this indicates that direct hydration of the ash layer is needed to form an ash crust. The preliminary results indicate that post-fire rainfall is an important control on the properties of the ash layer after burning and on crust formation. The observed changes over time mean that the timing of sampling can affect whether the ash layer is affecting post-fire infiltration and runoff.