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Monitoring Water Repellency Effects on Post-wildfire Infiltration and Runoff

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Fire induced soil water repellency (WR) is a common characteristic of burnt soils. Nonetheless, the rates, magnitude and the persistence of this phenomenon are highly variable, spatially and temporally. Five predominant mechanisms have been described as generating water repellency in soils: a) fungal and microbial activity, b) growth of particular vegetation species, c) organic matter content, d) heating of the soils by wildfires and e) soil characteristics.
We synthesized among in situ research data and published information to present a mathematical model describing the long-term properties of WR in soils. Using non-linear regression analysis methods we compare among different variants of the model, in order to assess the relative role of vegetation on water-repellency dynamics and its effects on runoff and erosion processes. In parallel, infiltration experiments were carried out using a rainfall simulator.
An intricate type of response driven by opposing processes dictates WR: The post-wildfire short term dynamics are characterized by a rapid increase in hydrophobicity (time scale of weeks). Following this phase a long term decrease (months) in hydrophobicity occurs. Slow formation of water repellent substances in the soil (years) generated by microbial and flora activities results in a gradual increase of hydrophobicity.
Results obtained from controlled experiments suggest that a complex set of interactions exists between water repellency, ash and vegetation cover. Ultimately, vegetation cover plays the key role in determining infiltration/runoff rates. Non-burned bare soils exhibited the highest runoff rates whereas litter-covered non-burned soils exhibited the lowest. Burned soils exhibited intermediate rates relative to the non-burned soils, which depended on the presence of ash. Up to 40 mm of simulated rainfall no runoff was generated in the burned soils. Once this threshold value was achieved, runoff begun to form, and it was partially dependent on the presence of ash, but not directly correlated with water repellency properties. Ash bearing soils exhibited lower runoff rates compared to exposed burned soils.
These responses should be viewed in light of the relevant spatial and temporal scales. While water repellency may peak following a wildfire event, its spatial expression might be local. Further its effects might be offset by the presence of ash. The temporal expression of these processes is nullified by the presence of vegetation and litter cover. In the long run the response of the geomorphic system to disturbances such as wildfires depends on the capacity of vegetation recovery.