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Relating hydrologic recovery to changes in post-wildfire debris flow activity as a function of time since burning

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Debris flows and flash floods pose well known hazards downstream of burned areas. Post-wildfire debris flows can move substantial amounts of sediment, leading to downstream threats to life, infrastructure, and water quality. Debris-flow likelihood following wildfire is commonly estimated using rainfall intensity-duration (ID) thresholds. These thresholds are derived from paired observations of debris flow occurrence and the estimated triggering rainfall intensity in the first year following wildfires when wildfire-induced changes are the most extreme and debris flows are the most common. However, there is currently little guidance related to how (or why) rainfall ID thresholds and debris flow magnitude change with time since burning. In this study, we use a combination of numerical modeling and repeated infiltration measurements following wildfire to quantify how recovery of wildfire-induced hydrologic changes translate into recovery from a geomorphic perspective. More specifically, we report on measurements of soil hydraulic properties as a function of time since burning for three different burned areas in the western United States. Results suggest an increase in soil sorptivity (the metric that governs water infiltration due to capillary suction) within the burned areas as a function of time. We performed model simulations of runoff and sediment transport to quantify how temporal variations in soil hydraulic properties translate into changes in debris-flow volume and rainfall ID thresholds for debris-flow initiation. Recovery of soil hydraulic properties appears to have a greater effect on both debris-flow volume and ID thresholds relative to other factors, such as changes in rainfall interception. Results identify common trends in the recovery of soil hydraulic properties among the burned areas and provide a framework for quantifying temporal changes in rainfall ID thresholds, and thus debris-flow hazards, as a function of time since burning.