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Fire effects on soil structure and hydraulic conductivity

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Fire-induced changes in soil structure and hydraulic conductivity reduce infiltration and increase the likelihood for post-fire flooding and debris flows. Current post-fire hydrology models, however, cannot take fire-induced soil structure changes into account. The goal of this study was to review current understanding of fire-induced changes in soil structure and their post-fire persistence. Specifically, we seek to quantify how fire-induced soil structure changes affect soil hydraulic conductivity.

Changes in soil structure vary widely with the definition of structure. We focused on literature describing fire-induced changes to soil aggregate stability and onset of loss of aggregation followed by formation of surface crust. Generally, aggregate stability tends to increase with increasing soil temperature up to approximately 200°C. Beyond 200˚C, aggregate stability decreases due to changes or loss of soil organic matter (the main binding agent). Evidence suggests that aggregate stability may decrease for soil temperatures as low as 100˚C due to rupture doe to rapid water evaporation within the aggregates. The loss of soil aggregation can promote erosion or formation of surface crust from fine soil particles. Often, fire-induced soil crusts are related to high soil surface temperatures. Literature data show that fire-induced changes in soil structure may persist for a decade after the burn. We developed a conceptual model to describe soil surface structure life cycle in fire-prone ecosystems.

The effects of aggregate deterioration (and recovery) on saturated hydraulic conductivity (K_s) of the soil can be captured by the model of Bonetti *et al.* (2021). Calculations show that aggregate deterioration leads to a decrease in K_s by a few orders of magnitude (depending on soil texture). Additionally, post-fire soil crusting effects on infiltration were captured by calculating an effective hydraulic conductivity (Rawls *et al.,*1990) showing a decrease in hydraulic conductivity by one to two orders of magnitude. Moreover, results suggest that fire-induced aggregate deterioration combined with crust formation can reduce the hydraulic conductivity of a soil surface by three to

four orders of magnitude. Even without explicit consideration of documented effects of wildfire on soil hydrophobicity, we illustrate the important impact of fire-induced changes in soil structure on infiltration, flooding and debris flow.