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Water-depth dependent infiltration into burnt forest soils

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Infiltration into severely burnt forest soils in South Eastern Australia exhibits a behaviour that is at odds with traditional infiltration theories that assumes a coherent soil matrix, which has important implications for upscaling from plot to hillslope.
Infiltration patterns were studied at three severely burnt sites with different soils by applying a blue dye solution during rainfall and runon experiments, and subsequent profile excavation. Rainfall and runon rates were varied on each plot, runoff measured, and orthogonal photos taken during quasi-steady states. From transects on these photos average inundation fractions of the surface were measured, and 1.5 mm horizontal resolution DEMs were generated with image-based software. This information was combined in a DEM inundation algorithm that calculated water depth maps for each plot and rainfall and runon rate.
At all three sites, nearly 100% of infiltration occurred through macropores that bypass the matrix of a water repellent layer. Average fractions of subsoil dye staining were 3% in shallow soils with a northerly aspect and low trees, 60% in deep soils with southerly aspects and high trees, and 20% in an intermediate soil. This was consistent with runoff coefficients of 0.94 for the shallow soil, 0.08 for the deep soil, and 0.71 for the intermediate soil. Irrespective of the runoff coefficient or dyed fraction there was a positive relationship between average water depth and infiltration rates on a given plot.
Functions of water depth vs. bypass infiltration were derived inversely for each plot by matching average infiltration rates with the rates derived from sampling the water depth distributions. Additionally, characteristic bypass infiltration rates for all sites as function of runon and rainfall intensity were derived, normalized by the maximum infiltration rate at full inundation. These infiltration functions represent the water depth-dependent dynamics of runoff generation in bypass infiltration-dominated soils much better than traditional wetting front models. They are therefore more appropriate for upscaling plot scale runoff generation to the entire hillslope in those soils.