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Landscape aridity, fire severity and rainfall intensity as controls on debris flow frequency after the 2009 Black Saturday Wildfires in Victoria

Petter Nyman, Christopher Sherwin, Gary Sheridan, and Patrick Lane
School of Ecosystem and Forest Science, The University of Melbourne, Parkville, Australia (nymanp@unimelb.edu.au)

This study uses aerial imagery and field surveys to develop a statistical model for determining debris flow susceptibility in a landscape with variable terrain, soil and vegetation properties. A measure of landscape scale debris flow response was obtained by recording all debris flow affected drainage lines in the first year after fire in a ∼258 000 ha forested area that was burned by the 2009 Black Saturday Wildfire in Victoria. A total of 12 500 points along the drainage network were sampled from catchments ranging in size from 0.0001 $km^2$to 75 km^2. Local slope and the attributes of the drainage areas (including the spatially averaged peak intensity) were extracted for each sample point. A logistic regression was used to model how debris flow susceptibility varies with the normalised burn ratio (dNBR, from Landsat imagery), rainfall intensity (from rainfall radar), slope (from DEM) and aridity (from long-term radiation, temperature and rainfall data).The model of debris flow susceptibility produced a good fit with the observed debris flow response of drainage networks within the burned area and was reliable in distinguishing between drainage lines which produced debris flows and those which didn't. The performance of the models was tested through multiple iterations of fitting and testing using unseen data. The local channel slope captured the effect of scale on debris flow susceptibility with debris flow probability approaching zero as the channel slope decreased with increasing drainage area. Aridity emerged as an important predictor of debris flow susceptibility, with increased likelihood of debris flows in drier parts of the landscape, thus reinforcing previous research in the region showing that post-fire surface runoff from wet Eucalypt forests is insufficient for initiating debris flows. Fire severity, measured as dNBR, was also a very important predictor. The inclusion of local channel slope as a predictor of debris flow susceptibility proved to be an effective approach for implicitly incorporating scale and relief as parameters. When combined with models of debris flow magnitude the results from this study can be used obtain continuous probability-magnitude relations of sediment flux from debris flows for drainage networks across entire burned areas.