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Modelling runoff connectivity for semi-arid hillslopes using percolation theory: The sensitivity of different vegetation patterns to changes in total vegetation cover

A. J. Hearman (1) , P. Lehmann (2) , **C. Hinz** (1)

(1) School of Earth and Geographical Sciences, The Univ. of Western Australia, Australia (christoph.hinz@uwa.edu.au, +61 8 6488 1050)

Runoff-runon processes on semi-arid hillslopes with limited vegetation cover affect the structuring of runoff and make the relationship between runoff and increasing amounts of total vegetation cover complex. Vegetation patterns affect the connectivity of runoff down the hillslope and induce threshold like behavior. In this presentation we use percolation theory as a means of predicting this hillslope connectivity of runoff and the rainfall thresholds required before runoff will connect from the top to the bottom of the hillslope. We test the sensitivity of changing percentage plant covers on this rainfall threshold and rainfall runoff relationship for firstly a hillslope where bare soil and vegetation patterns are not specified and infiltration rates are taken from a single distribution and secondly where bare soil and vegetation are specified and infiltration rates are taken from separate infiltration rate distributions for bare soil and vegetation patches. Using these separate infiltration rate distributions for bare soil and vegetation we test the effects of different vegetation patterns such as bands, labyrinth, patches and randomly distributed vegetation. Using separate bare soil and vegetation infiltration distributions results in a hillslope that can undergo a dramatic increase in the amount of rainfall required to produce hillslope runoff with only a small change in total vegetation cover. In comparison, using a single distribution for infiltration rates gives a gradual (linear) change in the rainfall threshold for hillslope runoff connectivity with increasing percentage plant cover. The testing of different vegetation patterns shows that the percentage plant cover where this distinct change in the rainfall required to produce hillslope runoff occurs depends on the structure of the vegetation. Banded structures are the most effective at trapping water resources at low vegetation percentages. With only 15% vegetation, the banded structure is still able to

effectively trap runoff generated from bare soil areas so that high rainfall intensities (above the vegetation infiltration rates) are required before runoff is able to connect from the top to the bottom of the hillslope. These differences in banded vegetation to other vegetation patterns are most pronounced between vegetation covers of 15-40% and during storms of intermediate intensities. These model predictions improve our understanding of the ecosystem functioning of such systems and could prove very useful in managing semi-arid hillslopes especially in regards to predicting the potential impacts of land use and climate changes.