



Interactions among hydrology, geomorphology and vegetation on dryland hillslopes

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On dryland hillslopes vegetation is typically patchy, and areas bare of vegetation are likely to be either stony or crusted. These bare areas promote Hortonian runoff, the pathways of which interact with the patchy vegetation. This interaction leads to a characteristic microrelief. On hillslopes dominated by woody shrubs there is a pronounced across-slope microrelief in which shrubs sit atop mounds and intershrub areas form swales. This microrelief concentrates runoff into the swales resulting in relatively efficient, connected runoff pathways which concentrates erosion and sediment transport within the swales. On hillslopes dominated by grass there is a pronounced downslope microrelief of small steps and risers. These steps create a disconnected pattern of runoff that traps runoff and sediment behind clumps of grass providing both water and nutrients to the grass. Both ecosystems are dominated by positive feedbacks implying stability; yet records show that locations may switch from one ecosystem to the other. To understand the conditions under which such switches may occur we have developed a modelling framework for the analysis of ecosystem change in drylands that is rooted in the concept of connectivity and is derived from a detailed process-based understanding of interactions among hydrology, geomorphology and vegetation. The model has been implemented in the deserts of the American Southwest both to test hypotheses of the causes of the invasion of woody shrubs, and to test its ability to reproduce observed spatial differences in response to drought in the 20th century. The modelling results show the importance of local conditions in determining the susceptibility of a location to ecosystem change and the significance of grazing in causing such changes.