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Effects of Overland Flow on Infiltration in Semi-arid Grassland and Shrublands

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We studied the effects of overland flow on the spatial pattern of infiltration in a semi-arid grassland and two shrublands. We hypothesized that overland flow causes the spatial redistribution of water, which can augment infiltration in excess of the rainfall amount. We investigated the relative roles of higher-infiltration mound inundation and surface water storage on redistribution using observed small-scale soil heterogeneity associated with vegetation using field observations and a rainfall/runoff model. In the presence of spatially correlated microtopography and saturated conductivity, overland flow depths and associated infiltration augmentation, vary as a function of vegetation type, landform type, soil heterogeneity, and rainfall intensity. For our sites, we found that overland flow can increase infiltration by up to 2.5 times the total rainfall. The redistribution of water via overland flow can affect up to 20 percent of an area but varies with vegetation type and landform. Infiltration augmentation tends to occur near the edges of vegetation canopies where overland flow depths are deep. Infiltration augmentation is greatest in microtopographic depressions and flow threads. We used a 16-year record of precipitation and determined redistribution for rainfall likely to generate overland flow. Both redistribution magnitude and the proportion of area affected by redistribution are sensitive to the scale and magnitude of soil heterogeneity, and to rainfall depth and intensity. The average infiltration augmentation increases with rainfall depth, and per-storm averages were up to 15 mm with maximum values up to 55 mm. Averaged over 16 years, cumulative infiltration at some locations is predicted to be in excess of the annual precipitation.
These results show that some vegetation-landform settings are efficient at trapping and concentrating the primary limiting resource, and demonstrate the importance of micro-scale soil characteristics for the ecohydrologic function of semi-arid environments. Since other essential attributes for plant ecosystem, such as nutrients, likely co-vary with water availability, further research is needed to elucidate ecosystem dynamics that may lead to self-organized behavior and determine thresholds for ecosystem stability.