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Effects of patchy distribution of vegetation on infiltration, runoff generation and resources redistribution in Tengger Desert, north China

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Abstract: The spatial pattern of vegetation in desert ecosystems has been documented as a mosaic of isolated shrub patches with large patches of bare soil occupied by biological soil crusts. In these dry shrublands, an especially important interaction is that, during rainfall events, vegetation patches function to obstruct and capture runoff, sediments and nutrients generated from intershrub biological soil crust patches, mainly due to their different responses to rainfall. Consequently, shrub patches are the principal loci of productivity and diversity, primarily because of the accumulation of water and other resources. Previous research about such interactions have been mostly conducted for hot and cool desert ecosystems with apparently banded vegetation, and little is known about the ecohydrological interactions in temperate deserts with spot-structured vegetation. Our research aimed to examine (1) the influences of patchy distribution of vegetation on soil water conductivity; (2) the effects of shrub patches on runoff and erosion and related nutrients redistribution on hillslopes; (3) whether different amounts of water and nutrients are stored in the shrub patches compared to open inter-patch areas. The results showed that both saturated and unsaturated water conductivity of soil under shrub patches were greater than those of soils occupied by crusts. The times to ponding and runoff for shrub patch were typically much longer than those for crust patch, and the volume of rainfall for runoff commencement was significantly greater for shrub patch. In a simulated rainfall event with intensity at 80mm h-1 and amount at 60mm, 53% of the applied water became runoff from crust patches and 55% of this was redistributed to the shrub patches. Water penetration was significantly deeper in shrub patches than in crust patches, and more than 45% of the sediments, soil carbon, nitrogen and dissolved nutrients triggered by runoff from crust patches were delivered to shrub patches, while in the field experiment with intensity at 5.7mm h-1, amount 31.1mm, more than10% of runoff, sediment, soil carbon, nitrogen and dissolved nutrients came from crust patches were redistributed to shrub patches. In the circumstances of simulated experiment, more than 2 times of normal precipitation is available for plant growth in shrub patches, while 1.3 times under the condition of field experiments, which inevitably would enhance the ability of the vegetation to survive in an environment where water availability is notoriously erratic and lead to the increase of productivity.