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Experimental Investigation of climate change effects on plant available water on rocky desert slopes

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Deserts and semi-deserts cover more than one-third of the global land surface, affecting about 49 million km^2 with aridity. In many arid regions, slopes are characterized by sparse and patchy soil and vegetation cover, forming so called “fertility islands”. The mosaic of soil and vegetation is dynamically interdependent, controlled by adaption of the ecosystem to limited and spatially as well as temporarily variable precipitation. Commonly, the role of the pattern of rocks and soil is considered to act as a natural water harvesting system. In an ideal system, the rocky area supplying water matches the soil’s infiltration capacity for the given rainfall magnitude. This approach limits the assessment of plant water supply to the amount and intensity of rainfall events, i.e. the supply of water. In reality, the demand of water by the plants also requires consideration. Therefore, the volume of soil storing water is equally important to the ration of soil to rock. Soil volume determines the absolute amount of water stored in the soil and is thus indicative of the time period during which plants do not experience drought related stress between rainfall events. With climate change likely affecting the temporal pattern of rainfall events, a detailed understanding of soil-water interaction, including the storage capacity of patchy soils on rocky slopes, is required.

The aim of the study is to examine the relationship between climate change and plant available water on patchy soils in the Negev desert. Thirteen micro-catchments near Sede Boqer were examined. For each micro-catchment, soil volume and distribution was estimated by laser scanning before and after soil excavation. Porosity was estimated by weighing the excavated soil. Before excavation, sprinkling experiments were conducted. Rainfall of 18mm/h was applied to an area of $1m^2$ each. The experiments lasted 25 to 40 minutes, until equilibrium runoff rates were achieved. Based on these data, rainfall required for soil saturation and soil water storage was calculated. The results of the sprinkling indicate that the minimum rainfall amount to saturate a median soil patch with water is only 2.5 mm. Such low rainfall event magnitudes have a high frequency in the Negev, indicating that the soil storage space is filled frequently. Consequently, the storage capacity of the soil is of great relevance for plant water supply during periods without rain. Rainfall records for the period of 1976-2008 show a significant variability of the average duration of periods without rainfall during the wet winter season. Depending on the size of a soil patch, serious drought stress can develop, indicating that only an understanding of soil and rainfall interaction enables a full understanding of the impacts of climate change on hillslope ecohydrology. The study also illustrates how rainfall simulation experiments and the analysis of meteorological records can be combined as a tool for the assessment of environmental change.