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The Eco-Hydrological Role of Physical Surface Sealing in Dry Environments

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Soil surface sealing is a widespread natural process in dry environments occurring frequently in bare soil areas between vegetation patches. The low hydraulic conductivity that characterizes the seal layer reduces both infiltration and evaporation fluxes from the soil, and thus has the potential to affect local vegetation water availability and consequently transpiration rates. This effect is investigated here using two separate physically based models - a runoff model, and a root water uptake model. High resolution rainfall data is used to demonstrate the seal layer effect on runoff generation and vegetation water availability, while the seal layer effect on vegetation water uptake is studied using a long-term climatic dataset (44 years) from three dry sites presenting a climatic gradient in the Negev Desert, Israel. The Feddes water uptake parameters for the dominant shrub at the study site (Sarcopoterium spinosum) were acquired using an inverse calibration procedure using data from a lysimeter experiment. The results indicate that the presence of surface sealing increases significantly vegetation water availability through runoff generation. Following water infiltration, the shrub transpiration generally increases if the shrub is surrounded by a seal layer, but this effect can switch from positive to negative depending on initial soil water content, rainfall intensity, and the duration of the subsequent drying intervals. These factors have a marked effect on inter-annual variability of the seal layer effect on the shrub transpiration, which on average was found to be 26% higher under sealed conditions than in the case of unsealed soil surfaces. These results shed light on the importance of surface sealing on the eco-hydrology of dry environments and its contribution to the resilience of woody vegetation.