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Effect of stone cover on rainfall-driven soil erosion with negligible surface roughness

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Numerous studies have shown that, for soils with sparse vegetation cover, stones/rock fragments are an important factor controlling the hydrological response and soil erosion yields. Additionally, it has been observed that this effect is complex and ambivalent depending on the features of the stones (fraction of soil surface covered, stone size, shape and emplacement, i.e. resting on the soil surface, partially or totally embedded in the soil). The aim of this study was to ascertain whether cumulative soil erosion is proportional to the area of soil exposed under the condition of constant and uniform precipitation onto an initially smooth soil surface. Precipitation-driven soil erosion with surface stone cover and negligible roughness was tested in laboratory flume experiments under controlled conditions. The surface coverage was adjusted by placing stones onto identically prepared surfaces in laboratory flumes. Three experiments were carried out with different stone coverage (20 and 40%), rainfall intensity (28 and 74 mm/h) and initial moisture content (6.52-24.30%), but with a fixed slope (2.2%). The laboratory results showed that the cumulative mass eroded depends on the cumulative runoff, and that soil erosion is proportional to the soil surface area exposed to raindrops. Additionally, the results showed that this relationship is controlled to a smaller extent by the soil's initial moisture content and bulk density. Three sets of previously published field data on precipitation-driven soil erosion were analyzed to ascertain whether the same behavior occurs under field conditions. For this case it was found that precipitation-driven erosion is not proportional to the area exposed. The data sets showed consistently that prediction of cumulative eroded mass using only the stone coverage over predicts the measured eroded sediment (when plotted as a function of cumulative runoff). In contrast to the laboratory experiments, the field experiments are characterized by non-uniform initial surface roughness, and heterogeneous stone size and spatial distribution. The data are consistent with the conclusion that soil erosion is controlled by several factors including area of soil exposed, surface roughness, stone size and spatial distribution, and surface soil aging. However, the presented laboratory results show clearly that, for soils with negligible surface roughness, erosion depends on (i) the area of soil exposed to rainfall and (ii) the cumulative runoff, and (iii) that it is only slightly dependent on other soil variables.