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Investigating the influence of crust and seal development on soil erosion using portable rainfall simulators

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Rainfall simulators provide researchers with a means of controlling the rate of rainfall delivery to a soil surface, thereby eliminating the problem of having to account for the inherent variability and unpredictability of natural rainfall. Although there can be difficulties associated with their application, particularly surrounding the choice of appropriate rainfall intensities and durations, rainfall simulators represent a valuable tool in soil erosion studies and have been widely used to improve our understanding of hillslope runoff and erosion processes. In the present work, portable rainfall simulators were used to examine the progressive development of soil crusts and seals and to consider their influence on sediment yields from paired small plots in southern New Mexico, USA and central New South Wales, Australia. Study results identify that raindrop impacts play an important role in the system of seal and crust development in these environments, with structural crusts (or those formed on surfaces exposed to raindrops) being approximately 40% stronger than depositional crusts (or those formed on surfaces protected from the direct impact of raindrops). In addition, the strength of the depositional crusts reached a plateau after two rainfall events whereas the structural crusts continued to strengthen for at least three rainfall events and, somewhat surprisingly, the development of crusts did not appear to directly reflect seal development. With respect to the influence of crusts and seals on erosion, study results indicate that sediment yields from covered surfaces exceeded those from uncovered surfaces, suggesting that, at this level, the system of erosion is supply-limited and dependent on raindrops dislodging and transporting source soil particles. Materials such as litter and stones lying on the ground surface, however, can confuse this relationship such that both supply-limited and transport capacity-limited controls on erosion become important. Thus, there is a complex relationship between seal and crust formation and runoff induced erosion. The enormous spatial and temporal variability of precipitation in the semiarid study sites made it virtually impossible to investigate the issue of seal and crust development using natural rainfall. The portable rainfall simulators, however, provided an opportunity to explore these complex systems in the field and in detail.