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Modelling nutrient dynamics during runoff events over a trajectory of land degradation from semi-arid grassland to shrubland in the south-western USA

R.E. Brazier (1), L Turnbull (2), and J Wainwright (2)

(1) University of Exeter, Department of Geography, Exeter, United Kingdom (r.e.brazier@ex.ac.uk), (2) University of Sheffield, Department of Geography, Sheffield, United Kingdom

Land degradation in arid and semi-arid areas, such as the invasion of grasslands by shrubs, is often associated with an increase in runoff and erosion and a change in nutrient dynamics. Modelling of nutrient dynamics during runoff events (in particular particulate-bound nutrients), is particularly important, since the spatial redistribution of nutrients (in addition to water and sediment) can have significant implications for vegetation dynamics in these ecosystems. In this study, MAHLERAN (Model for Assessing Hillslope to Landscape Runoff, Erosion and Nutrients) is extensively evaluated against runoff and erosion data from four plots (representative of different stages of land degradation) over a transition from grassland to shrubland at the Sevilleta National Wildlife Refuge in New Mexico, USA. MAHLERAN already simulates dissolved nutrient dynamics (based on an advection-dispersion model of N and P). A new particulate-bound nutrient module was developed to include a representation of particulate-bound nutrient dynamics which is an important form of nutrient transport in these ecosystems. Understanding dynamics of both dissolved and particulate-bound nutrient dynamics during runoff events is imperative, because of their differing roles in terms of nutrient bioavailability and potential implications for plant dynamics.

MAHLERAN was evaluated against runoff, erosion and nutrient data that was collected from the four plots over the transition from grassland to shrubland. Results of the model evaluation show that the runoff and erosion components of MAHLERAN perform well, as does the new particulate-bound nutrient submodel. However, since the particulate-bound nutrient submodel is effectively a bolt-on to the erosion model, the performance of the particulate-bound nutrient model is dependent on the performance of the erosion component of MAHLERAN. The performance of the dissolved nutrient component of MAHLERAN was abysmal, which indicates that the process representation and the parameterisation of the dissolved nutrient component were inadequate. Thus, results from the model evaluation indicate that an improved understanding of dissolved nutrient dynamics during runoff events is required, in order to improve the level of process representation within modelling approaches and thus the ability to simulate dissolved nutrient dynamics and their subsequent effects on other ecosystem processes.