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Functional diversity as an indicator of rangeland degradation – insights from a Namibian grazing gradient study

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Abstract

Degradation of semi-arid rangelands is associated with a sharp decline in the delivery of critical ecosystem services such as forage production. Droughts and overgrazing – or a combination of both – may lead to reduced herbaceous production, the loss of palatable grass species, and bush encroachment. During the process of degradation, several ecosystem components change, such as plant community composition. Therefore, taxonomic and functional diversity might be valuable indicators of ecosystem state, as losses of species or functional strategies might strongly affect ecosystem functioning and ecosystem services. However, while the response of taxonomic diversity to rangeland degradation has been frequently evaluated, there is still limited knowledge. We therefore included the following questions in our study: (1) Are there patterns of shrinkage of functional trait spaces as grazing pressure increases? (2) How does the management regime influence the stability of taxonomic and functional diversity? (3) Can functional diversity serve as indicator of degradation?

To answer these questions, we conducted a space-for-time substitution for land-use intensification in semi-arid Namibia. We studied 16 grazing gradients (transects) starting at a livestock watering point where grazing pressure was assumed to be highest. Transects were distributed over four commercial and four communal farm areas, with commercial farms characterised by rotational grazing, and communal farms by permanent grazing. Plant community composition of the grass layer was recorded on nine (10 × 10 m) plots per transect (162 in total). For 142 dominant species contributing > 90% of the biomass, we measured a set of plant functional traits related to plants’ life-history and resource acquisition strategies, and calculated indices of taxonomic and functional diversity, and functional trait spaces.

Results indicate no clear trends along grazing gradients, but differences in taxonomic diversity and functional trait spaces between management systems. Rangelands characterised by continuous grazing, heavy bush encroachment, and low densities of palatable grass species had narrower functional trait spaces. This may indicate the loss of functional strategies in the process of rangeland degradation. We conclude that measuring functional diversity can improve understanding of degradation processes and helps in developing strategies to prevent them.

Keywords: Arid ecosystems, ecosystem services, ecosystem stability, land degradation, plant functional traits, rangeland management