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Plant functional groups related to grazing as early warning indicators of rangeland degradation in drylands

Faith Munyebvu-Chambara[1], Anja Linstädter[2], Ildikó Orbán[3], Wellencia Nesongano[4], Lisa-Maricia Schwarz[5], Mark Bilton[6]

[1] *University of Namibia, Dept. of Environmental Science, Namibia*
[2] *University of Potsdam, Inst. of Biochemistry and Biology, Biodiversity Research / Syst. Botany, Germany*
[3] *University of Potsdam, Institute of Biochemistry and Biology, Biodiversity Research / Systematic Botany,*
[4] *University of Namibia, Environmental Science, Namibia*
[5] *University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, Germany*
[6] *Namibia University of Science and Technology, Dept. of Agriculture and Natural Resources Sciences, Namibia*

Abstract

Major parts of global semi-arid rangelands are degraded or under threat due to frequent droughts and overgrazing. Predicting ecological thresholds using reliable indicators is increasingly important as these systems risk crossing tipping points. However, reliable, easy-to-measure indicators for anticipating abrupt ecosystem shifts remain limited.

This study examined whether herbaceous species biovolume, classified by (1) classic taxonomic/life-form differences (perennial grasses, annual grasses, forbs) and (2) independently observed grazing response (sensitive, moderate, tolerant), interacting with microhabitat (open vs shrub) and grazing intensity (distance to water points), could serve as early indicators of degradation.

In East-Central Namibia, a grazing gradient approach was applied across 16 transects: eight on rotationally grazed freehold farms, and eight on continuously grazed communal areas. To determine biovolume, cover and height of 18 herbaceous species were measured in the microhabitats ($4 \times 1\text{m}^2$ quadrats) nested within $9 \times 100\text{m}^2$ plots along each transect.

As expected, summed biovolume of the 18 species was higher on freehold farms than in communal areas. This was especially true for perennial grasses; less so, but still significantly different for annual grasses; with no difference between management for forbs. Microhabitat also affected these groupings as perennial grasses and forbs had higher biovolume in open patches than under shrubs only on freehold farms, whereas for annuals, biovolume was higher under shrubs than in open patches in communal areas.

When classifying species by grazing response, additional differences were found along grazing gradients. Biovolume of "sensitive" species groups decreased towards the water points, whereas "tolerant" species increased. Microhabitat differences were revealed, as "sensitive" and "moderate" species groups had higher biovolume under shrubs than in open patches on communal areas only. Meanwhile, tolerant species had greater biovolume in open patches than under shrubs on both tenure systems.

These findings support many ecological findings of plant community response to grazing. Creating functional groups directly from grazing response enhanced the sensitivity of our

Contact Address: Faith Munyebvu-Chambara, University of Namibia, Dept. of Environmental Science, 340 Mandume Ndemufayo Ave., Private Bag 13301 Windhoek, Namibia, e-mail: rutendomunyebvu@yahoo.com

findings over classical approaches, and revealed predicted responses across gradients. Therefore, developing a generalisable system to classify grazing tolerance in plants could greatly enhance early detection of system shifts towards a degraded state and inform proactive management strategies.

Keywords: Grazing gradient, herbaceous vegetation, land management, microhabitats, thresholds