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Assessing the relevance of drought duration on dryland rangelands: an experimental and modelling study

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Abstract

Dryland rangelands contribute to the livelihoods of numerous people in southern Africa by providing ecosystem services such as forage for livestock. While the demand for ecosystem services (ESS) is growing, climate change effects such as droughts reduce ESS provision and cause degradation of drylands. Yet there are still knowledge gaps regarding the effects of drought duration and the interaction with grazing on dryland rangelands. We hence asked: (1) How resistant is herbaceous savannah vegetation to a two- and a six-year extreme drought under both grazed and rested conditions? (2) How do the different drought lengths influence the recovery after drought release?

To answer these questions, we used data from a field experiment in a semi-arid savannah region in Limpopo, South Africa. In this "DroughtAct"-experiment, treatments of drought (66%-reduction of ambient rainfall) were implemented for two and six years and contrasted by non-drought control treatments. All treatments were combined with both moderate grazing and resting. We annually collected data on ANPP (aboveground net primary production) and plant species composition over a period of seven growing seasons including one post-drought season. The experimental treatments were also simulated using vegetation modelling (aDGVM2), where we additionally simulated a ten-year recovery period.

Our results indicated minor impacts and a fast recovery after two drought years. The reduction of ANPP did not exceed the rainfall reduction. However, this changed from the third drought year leading to ANPP in drought treatments of only about 20 % as compared to non-drought control plots in the sixth drought year. While grazing initially improved drought resistance, it increased the harmful effects of a long-term drought. Species composition showed as well a strong response to the different treatment combinations. The model results matched during the first two drought years, while effects of a continuing drought were underestimated. Still, the model results supported faster recovery after a two-year drought.

Our results stress the relevance of drought duration for vegetation resistance and resilience. Rangeland management strategies must consider a declining forage provision,

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an increasing vulnerability of the vegetation, and longer recovery time after prolonged droughts.

Keywords: Climate change, drought experiment, resilience, resistance, South Africa, vegetation modelling