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"Reconcile land system changes
with planetary health"

Land-use history mediates responses to global change drivers in a semi-arid rangeland

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Abstract

Increasing drought frequency and land-use intensification are key global change drivers threatening dryland ecosystems, with significant implications for forage provision and livelihoods, particularly in the Global South. However, the combined effects of drought and grazing on rangeland productivity remain poorly understood.

We investigated (1) how drought and consecutive grazing affect aboveground net primary productivity (ANPP), and (2) whether land-use history mediates these effects. To address these questions, we established a full-factorial field experiment in a semi-arid rangeland in Namibia. Rainfall reduction was simulated using passive rain-out shelters (–66 % of ambient rainfall), while grazing was mimicked through repeated clipping at three intensities (low, moderate, high). Land-use history was represented by two sites differing in grazing pressure due to their proximity to a watering point and consequently different levels of degradation. We quantified ANPP through biomass harvests and assessed vegetation composition to estimate functional group-specific productivity (perennial/annual grasses, forbs, legumes).

Our results from the 2021/22 vegetative season demonstrate that the effects of one-year drought and two years of grazing were strongly mediated by land-use history. At the more degraded site, grazing significantly increased ANPP ($F = 4.37$, $p = 0.02$), but this positive effect disappeared under drought combined with moderate grazing (interaction: $F = 3.44$, $p = 0.04$) leaving ANPP unaffected compared to low grazing. In contrast, the less degraded site showed no significant changes in ANPP under any treatment. Shifts in plant functional group composition appeared to buffer productivity losses at both sites. We compared ANPP values with the ones from the previous season under ambient conditions and identical clipping treatments and found the relative year-to-year changes diverged significantly between sites: productivity increased by 40 % on average at the healthier site, while it declined by 27 % at the degraded site, despite above-average rainfall. These findings highlight not only the interactive nature of global change drivers but also the crucial role of past land-use in shaping ecosystem responses. Understanding such dynamics is vital for sustainable rangeland management under increasing environmental stress.

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