Factsheet # 03

Soil characteristics as indicators of rangeland health

Soil-vegetation feedback loops in rangeland degradation and restoration

Challenge

Soils have a significant influence on rangeland potential by storing water and nutrients, acting as a buffer during droughts, and supporting vegetation growth through processes such as nutrient cycling and water retention. In turn, vegetation influences soil, for example through organic litter inputs that affect nutrient availability. Soil fertility, often linked to soil organic carbon (SOC) content, is critical for water retention and vegetation resilience. Even small differences in SOC and soil texture (e.g., clay content) can have large effects, particularly in sandy soils, where low SOC and poor water-holding capacity increase the vulnerability to drought and unsustainable grazing.

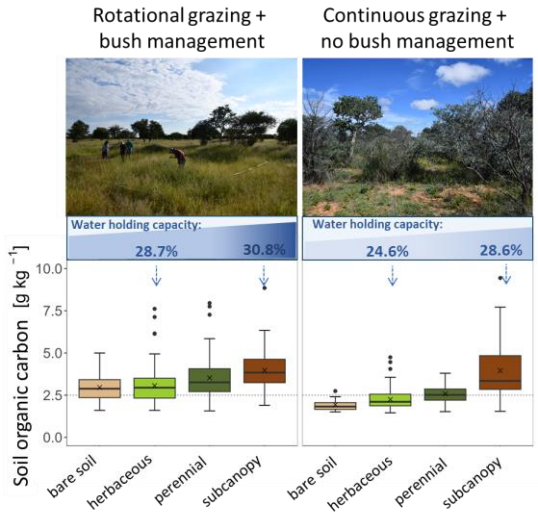
Studying soil provides essential insights into the long-term stability and productivity of rangelands. Understanding the complex interactions between soil, vegetation, grazing, and overall rangeland performance is essential to prevent degradation, sustain livestock production, and guide sustainable land management decisions.

Approach

To evaluate soil fertility in respect to rangeland degradation, we compared soil organic carbon and the water holding capacity in soils from different management systems (rotational vs. continuous grazing & different bush management practices), and stratified the samples between vegetation cover (bare soil, herbaceous plants, perennial grass, woody plant) in rangelands of the Greater Waterberg Landscape in Namibia.

Soil organic carbon (SOC) across vegetation patches

- Vegetation cover with perennial grasses increased SOC levels and reduced spatial variability between vegetation patches. Higher SOC improved water holding capacity, with patches containing more SOC holding up to 4% more water, thereby supporting vegetation growth.
- Herbaceous vegetation was better established in rangelands with rotational grazing systems likely due to recovery periods after grazing.

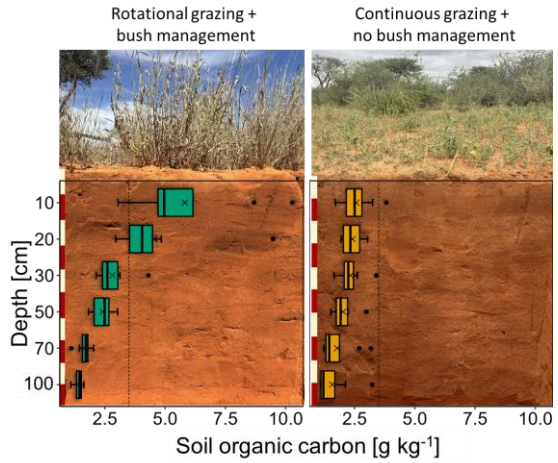


Soil organic carbon shown as boxplots and water holding capacity as blue area in different management systems and different vegetation patch types. The box shows the middle 50% of data, the line in the middle indicates the median, the cross shows the mean value, the 'whiskers' stretch to the smallest and largest typical value, points outside the whiskers represent unusually high or low values. Credit: Zimmer et al. (2024).

Credit photos: Katrin Zimmer

Soil organic carbon in 1m soil depth

- Differences in SOC are particularly evident in the topsoil (20 cm). Topsoil conditions reflect rangeland conditions well and can be 'modified' by managing rangeland vegetation.



Soil organic carbon in different management systems and soil depth shown as green and orange boxplots. The box shows the middle 50% of data, the line in the middle indicates the median, the cross shows the mean value, the 'whiskers' stretch to the smallest and largest typical value, points outside the whiskers represent unusually high or low values. Credit: Zimmer et al. (2024).

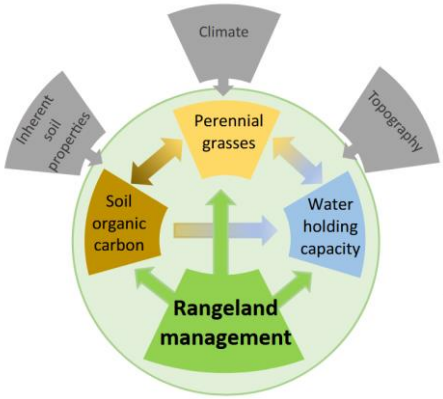
Practical Implications

To improve soil health…

- maintain or improve (herbaceous) vegetation cover, with focus on the presence of perennial grasses.
- promote rangeland management systems with recovery periods for rangeland vegetation.
- implement continuous monitoring of rangeland performance.
- encourage/ prioritize funding for research on soil-vegetation interactions and long-term monitoring programs.

Key Findings

- **Vegetation patch type distribution matters**. Soil fertility is highest under woody plants and perennial grasses, followed by other herbaceous plants and bare soil.
- **Good rangeland management,** including the promotion of perennial grasses, enhances soil fertility, and water retention, creating **a positive feedback loop** that **strengthens savanna resilience** to drought and human use**.**



Rangeland health: Interactions between soils, vegetation, and rangeland management highlighting modifiable factors within the green circle and fixed factors (outside). Credit: own work.

References

Zimmer, K., Amputu, V., Schwarz, L.-M., Linstädter, A., Sandhage-Hofmann, A. 2024. Soil characteristics within vegetation patches are sensitive indicators of savanna rangeland degradation in central Namibia. *Geoderma Regional* 36.

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The NamTip Project

The collaborative German-Namibian research project "NamTip – A Namibian Perspective on Desertification Tipping Points in the Face of Climate Change" aims to better understand the development of ecological tipping points in dryland rangelands by assessing desertification and woody plant encroachment processes. It also explores management options for preventing such tipping points and restoring degraded rangeland ecosystems.

www.uni-potsdam.de/en/namtip

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