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Rangeland degradation in savannas of South Africa: spatial patterns of soil and vegetation

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Extensive bush encroachment by Acacia mellifera and associated woody species at semi-arid and arid sites are the most notable forms of rangeland degradation in savannas of South Africa. Concerns are growing over the threat of suppression and loss of nutritious perennial grass species. Grazing and different rangeland management systems (communal and freehold) are considered to be of major importance for degradation, but the process of encroachment is not restricted to communal land. A vegetation change is mostly accompanied by changes in soil properties, where soils in savanna systems can profit from woody species due to litter fall, root distribution, shadow and animal resting time. Savannas are very heterogeneous systems with high spatial variation of patches with wood, herbaceous species and bare ground. We hypothesized that the spatial patterns of soil properties in South Africa′s rangelands are controlled by present or past vegetation, modulated by the tenure systems with higher rangeland degradation in communal areas. To test this, we sampled soils at communal and commercial land in the Kuruman area of South Africa with the following design: three farms per tenure system, 6 randomly chosen plots (100x100m) per farm, and 25 soil samples (0-10 cm) per plot, each in a 5x5m sampling area. At every sampling point, information of overlying vegetation was recorded (species or bare soil, canopy size, height). For each sampling area, if present, trees/ shrubs were sampled and their ages estimated through the counting of annual growth rings. For each plot, high resolution UAV aerial photos were taken to evaluate the extent of bush encroachment. Analyses involved main physical and chemical soil parameters and isotopic analyses. The results of a rough aerial image classification (grass, woody species, bare ground) revealed significant differences between the tenure systems with higher coverage of bare ground and shrubs at communal farms, and higher grass cover at commercial farms. The tenure systems had no differences in main texture classes of the soils, but significant differences in the composition of the sand fraction, with higher levels of fine sand and lower levels of coarse sand in communal farms. The chemical soil properties showed a high variability both within and between the farms, with much higher variability within communal than commercial farms. Additionally, concentrations of nitrogen, carbon, calcium and pH were significant higher in communal farms. Isotopic analyses in soils showed significant differences for 15N with higher levels in commercial farms. Different photosynthetic pathways are responsible for differences found in 13C values, with higher levels (-16-18‰ in C4-grassland and lower values (-22-26‰ in soils under Acacia (C3). We found relationships between soil properties and species or bare ground, where differences in texture likely interact with both, vegetation cover and soil properties.