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Patterns of Nitrogen Limitation along the Kalahari Transect

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Globally, savannas cover $\sim$ 20% of the Earth's land area. Nutrients and soil moisture interactively control vegetation dynamics in many savannas although it is unclear how the relative importance of water and nutrient limitations (especially nitrogen) change with the mean climatic conditions. The Kalahari Transect (KT) in southern Africa traverses a dramatic aridity gradient (from $\sim$ 200 mm to more than 1000 mm of mean annual precipitation (MAP), through the Republic of South Africa, Botswana, Namibia and Zambia), on relatively homogenous soils (deep Kalahari sands). This transect offers the ideal setting to study nutrient and vegetation dynamics without confounding soil effects. To improve the understanding of nitrogen and water controls on savanna vegetation, this study tested the hypothesis that the savannas in the Kalahari switch from conditions of water limitation in the dry areas to nutrient limitation in the wet areas. To this end, we conducted a large-scale stable isotope fertilization experiment using four study sites with different MAP. The transect included sites in Mongu, Zambia (MAP $\sim$950mm), Pandamatenga, Ghanzi, and Tshane, Botswana with MAP ranging between 700 mm and 300 mm. The experimental design consisted of a randomized block design with four 21 m x 13 m plots at each site. Each plot was divided into four 10 m x 6 m subplots with 1 m buffer zone between each subplot. Four treatments (N addition, P addition, N+P addition and control) were randomly applied to the subplots. The experiment began during the dry season, in August, 2004, when 39g/m^2 of $Ca(NO_3)_2$ (3.3g-N/ m^2) was evenly applied to the N and N+P subplots, and 7.5g/m^2 of $Ca(H_2PO_4)_2$ (1.7g-P/m^2) was applied to the P and N+P subplots, while the control subplots were left with no treatment. The N and N+P additions were enriched with

^{15}N (Ca($^{15}NO_3)_2$) to a signature of 10.3 ‰. Before application, soil samples from two different layers (0cm and 50cm) outside the plots and foliar samples of the dominant species were sampled to provide the background information. In the subsequent wet season (February-March, 2005), soil samples from three layers (0cm, 30cm and 50cm) and foliar samples of both woody species and herbaceous species were taken from each treatment. The results show that soil C/N ratios in 2004 and foliar C/N ratios in both years were significantly higher at the wet sites than at the dry sites. No significant differences were seen between the control and P-addition, and between the N and N+P addition in nitrogen isotope signatures. Based on isotope signatures, the N uptake from the fertilizer in the wet area is much higher than that in the dry area, but addition of P had little effect. These results provide evidence that N is the limiting nutrient in these savanna ecosystems and suggest that, as precipitation increases, there is a switch from limitation conditions based on water to ones based on nitrogen.