EGU2020-16130
https://doi.org/10.5194/egusphere-egu2020-16130
EGU General Assembly 2020

Alpha- and beta- diversity of woody species across environmental gradients in African and Australian tropical savannas

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Patterns of woody plant diversity in the tropical savanna biome has received little research attention but is relevant to understanding the complex vegetation dynamics of a biome that have remained contentious for almost a century. Tropical savannas of Africa and Australia are defined by the co-existence of woody plants and grasses, and the evolution and assembly of the savanna biome trace back 3-10 million years. Here, we explored patterns of local (alpha-) diversity and species turnover (beta-diversity) of woody plant species across African and Australian savannas. We aimed test the relative role of the environmental gradients of rainfall, temperature, fire and soil in shaping the relative abundance of all of woody species, genera, and families. Using generalized additive models (GAMs) and generalised dissimilarity models (GDMs) of field inventory data from vegetation plots across sub-Saharan Africa and Northern Australia we analysed changes in alpha- and beta-diversity. Environmental gradients were characterised as effective rainfall (ER), rainfall seasonality (coefficient of variation of monthly rainfall), mean annual temperature (MAT), temperature seasonality, fire frequency, and cation exchange capacity (CEC) in soils.

Savannas in Australia are on average drier and hotter than in Africa likely as a product of lower altitude. Crucially, diversity across all taxonomic levels is approximately two to three times greater in Africa compared with Australia. Within each continent, rainfall seasonality was the strongest environmental correlate of both alpha- and beta-diversity. In Africa, there is a strongly negative relationship between alpha-diversity at all taxonomic levels and rainfall seasonality. In contrast, in Australia, the relationship between alpha-diversity and rainfall seasonality while relevant is non-linear. Surprisingly within continents, rainfall, temperature, soils and fire had little bearing in these data on patterns of alpha diversity.

In terms of beta-diversity, and likely linked to the overall differences in diversity between continents, the geographic distance equalling total species turnover is greater in Australia than in Africa. Effective rainfall was the only additional significant correlate of woody species turnover in Australia, but only in arid regions. In Australia, at higher taxonomic levels the capacity of GDMs to explain variation in the data diminished substantially as a product of low diversity in genera and families. When compared to Australia, species turnover in Africa increases when geographic

distance, rainfall seasonality and mean annual temperature are relatively low.

Our findings highlight that with ongoing climate change specifically with shifts in rainfall distribution that will also affect local drought regimes, rainfall seasonality could substantially alter patterns of diversity, specifically in Africa. There have been persistent attempts to explain ecosystem dynamics in savannas with respect to climate, soils and fire with emphasis often on total rainfall, but our findings suggest that rainfall seasonality can have strong effects on diversity that may interact with other environmental correlates such as fire.

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