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Basal stem area is a better measure of woodiness than canopy cover in the savannas of the Kruger National Park

Water availability, soil nutrient availability, fire and herbivory are all known to affect the abundance of trees in savannas; yet the strength of each factor is often puzzlingly variable between sites.[1-3] Woody cover in African savannas, for example, varies from <1% to >80% under similar rainfall regimes.[4] We hypothesised that part of the problem in determining how environmental factors affect woodiness in savannas relates to the difficulty of quantifying woodiness effectively.

One of the most common ways of measuring woodiness is by estimating the extent to which the canopy of woody plants covers the ground in a plot.[5] We have found, however, that canopy cover estimates frequently differ by up to 25% amongst observers in the same plot. Another method of measuring woodiness is allometry. This method is also, unfortunately, fraught with difficulty, mainly because obtaining a sufficient sample size to develop accurate allometric equations for all woody plant species in a landscape is usually not practical.[6]

In a recent study on the effects of soil nutrients on woodiness in the savannas of the Kruger National Park of South Africa, we examined two ways of measuring woodiness in 10 m by 10 m plots: firstly by visual estimation of canopy cover (%), and secondly by measuring the basal stem diameter (cm) of each woody stem. Basal stem diameter measurements were used to calculate basal stem area (πr^2) and then summed for each plot to provide a cumulative measure of total woody area (cm^2). The methods of soil sampling and analysis are described in Mills et al.[7]. All data were analysed using R statistical software.[8]

Relationships between the two different methods of quantifying woodiness and soil nutrients are shown in Figure 1 and Table 1. Both measures of woodiness were positively correlated with a wide range of soil nutrients, with the strength of correlations varying between sampling sites. Such positive correlations have been attributed to effects of nutrient availability on the growth rate, and therefore establishment, of trees.[9,10] Where growth rates are faster, it is more likely that trees will establish and not succumb to pressures such as fire or herbivory. Assuming that such causal mechanisms are taking place, it is noteworthy that there were more, as well as stronger, correlations between basal stem area and soil nutrients than between canopy cover and soil nutrients. This finding suggests that basal stem area is more appropriate than canopy cover as an index of woodiness at our study sites in the Kruger National Park. If the same applies in other savannas, measurements of basal stem diameter could be of considerable value for isolating which environmental factors have the greatest influence on tree abundance. Such information is likely to be of practical value for land managers wanting to alter the ratio of trees versus grass in a savanna environment.

Table 1: Correlation coefficients (S), *p*-values and rho estimates for relationships between basal stem area (cm^2) and soil nutrients, and canopy cover (%) and soil nutrients at the Phalaborwa (n=32) and Skukuza (n=20) study sites in the Kruger National Park, South Africa

		Basal stem area (cm^2)			Canopy cover (%)		
Nutrient	**Site**	**S**	***p***	**Estimate (rho)**	**S**	***p***	**Estimate (rho)**
Ca	Phalaborwa	3041	0.011	0.44	3484	0.042	0.36
	Skukuza	848	0.117	0.36	915	0.181	0.31
Mg	Phalaborwa	2397	0.001	0.56	3166	0.017	0.42
	Skukuza	671	0.027	0.49	1340	0.974	-0.01
Na	Phalaborwa	4698	0.448	0.14	6653	0.227	-0.22
	Skukuza	645	0.02	0.51	1550	0.484	-0.17
K	Phalaborwa	3212	0.02	0.41	4088	0.167	0.25
	Skukuza	736	0.05	0.45	1537	0.511	-0.16
P	Phalaborwa	2805	0.005	0.49	2907	0.007	0.47
	Skukuza	1063	0.396	0.20	1061	0.394	0.20
Cu	Phalaborwa	2681	0.003	0.51	2565	0.002	0.53
	Skukuza	591	0.011	0.56	1192	0.665	0.10
Zn	Phalaborwa	2779	0.004	0.49	3969	0.131	0.27
	Skukuza	882	0.147	0.34	1100	0.467	0.17
Mn	Phalaborwa	3474	0.042	0.36	3694	0.072	0.32
	Skukuza	564	0.009	0.58	1027	0.334	0.23
B	Phalaborwa	3604	0.057	0.34	4125	0.179	0.24
	Skukuza	652	0.022	0.51	1353	0.941	-0.02
S	Phalaborwa	4589	0.385	0.16	4326	0.256	0.21
	Skukuza	631	0.018	0.52	1839	0.096	-0.38
C	Phalaborwa	3299	0.025	0.40	4687	0.442	0.14
	Skukuza	840	0.11	0.37	1314	0.962	0.01

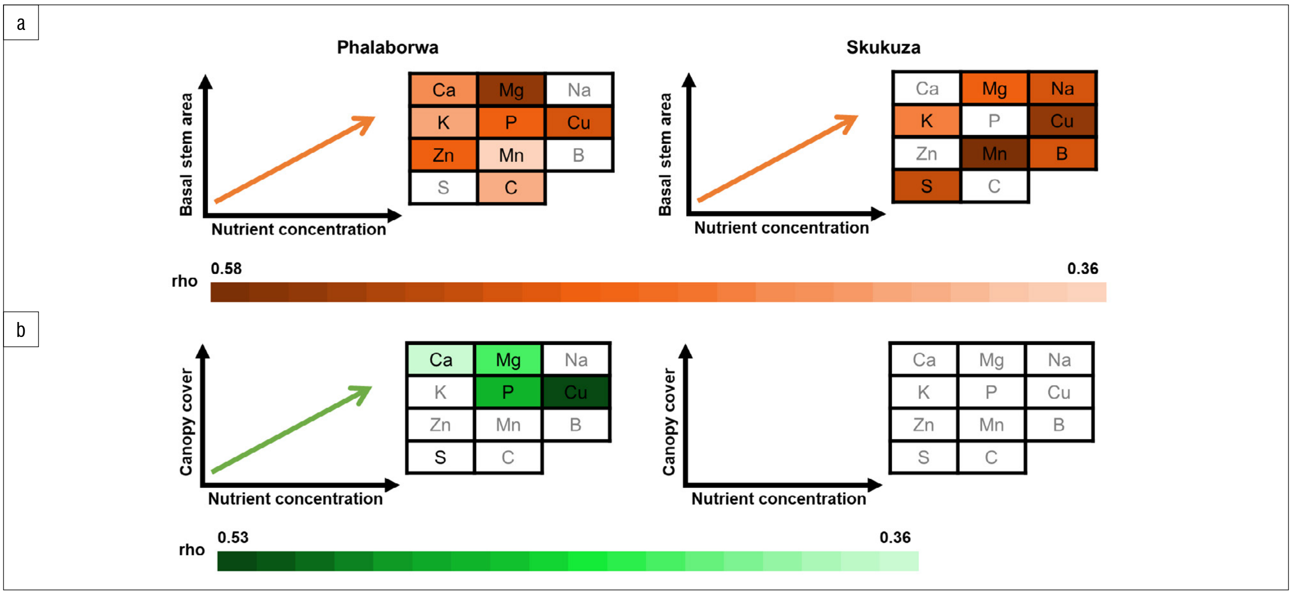

Figure 1: Significant correlations between (a) basal stem area and soil nutrients and (b) canopy cover and soil nutrients at the Phalaborwa (n=32) and Skukuza (n=20) study sites in the Kruger National Park, South Africa. Colour intensity reflects the relative strengths of the significant correlations as per the rho values.

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References

1. Sankaran M, Ratnam J, Hanan N. Woody cover in African savannas: The role of resources, fire and herbivory. Glob Ecol Biogeogr. 2008;17(2):236–245. https://doi.org/10.1111/j.1466-8238.2007.00360.x

2. Leeuwis T, Peel M, De Boer WF. Complexity in African savannas: Direct, indirect, and cascading effects of animal densities, rainfall and vegetation availability. PLoS ONE. 2018;13(5), e0197149, 14 pages. https://doi.org/10.1371/journal.pone.0197149

3. Marchant R. Understanding complexity in savannas: Climate, biodiversity and people. Curr Opin Environ Sustain. 2010;2(1–2):101–108. https://doi.org/10.1016/j.cosust.2010.03.001

4. Sankaran M, Hanan NP, Scholes RJ, Ratnam J, Augustine DJ, Cade BS, et al. Determinants of woody cover in African savannas. Nature. 2005;438(7069):846–849. https://doi.org/10.1038/nature04070

5. Pote J, Shackleton C, Cocks M, Lubke R. Fuelwood harvesting and selection in Valley Thicket, South Africa. J Arid Environ. 2006;67(2):270–287. https://doi.org/10.1016/j.jaridenv.2006.02.011

6. Nickless A, Scholes RJ, Archibald S. A method for calculating the variance and confidence intervals for tree biomass estimates obtained from allometric equations. S Afr J Sci. 2011;107(5/6), Art. #356, 10 pages. https://doi.org/10.4102/sajs.v107i5/6.356

7. Mills AJ, Milewski AV, Snyman D, Jordaan JJ. Effects of anabolic and catabolic nutrients on woody plant encroachment after long-term experimental fertilization in a South African savanna. PLoS ONE. 2017;12(6), e0179848, 24 pages. https://doi.org/10.1371/journal.pone.0179848

8. R Core Team. R: A language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2019. Available from: https://www.r-project.org/

9. Pellegrini AFA. Nutrient limitation in tropical savannas across multiple scales and mechanisms. Ecology. 2016;97(2):313–324. https://doi.org/10.1890/15-0869.1

10. Milewski AV, Mills AJ. Why was the Highveld treeless? Looking laterally to the Pampas for global edaphic principles beyond biogeographical accidents. S Afr J Bot. 2015;101:98–106. https://doi.org/10.1016/j.sajb.2015.05.019