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Savanna Resilience Through Tree Stand Structure and Species Interactions

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Introduction

- Savannas shaped by tree–grass–fire–herbivory feedbacks [1]
- Stand structure underpins resilience: dense stands short, open stands taller [2,3]
- The aim of this study is to examines long-term shifts in structure, richness, and herbivory (1999–2021) in Hluhluwe-iMfolozi Park, South Africa.

Research Question

Research question: Do dense stands grow taller while open stands become shorter and become less species rich, and what role does herbivory play?

Hypothesis:
Dense stands gain height (escape the fire/browse trap), so they grow taller and maintain or increase woody-rich richness.

- Open stands remain short and species-poor under ongoing disturbance.

Discussion and conclusion

- Higher density promotes species richness but also signals shrub-dominated state shifts.
- Indicator species mark shifts between open to high density states (alt. stable states).
- Tree stands with higher herbivore damage are likely the high-biomass – stabilizing feedback?
- Dense sites (shrub-rich) are the stable woody regime, recently showing height increases. Tall trees are reduced in Open/Low sites.
- Long-term data show both persistence and vulnerability of savannas.

Species richness in increases with tree density

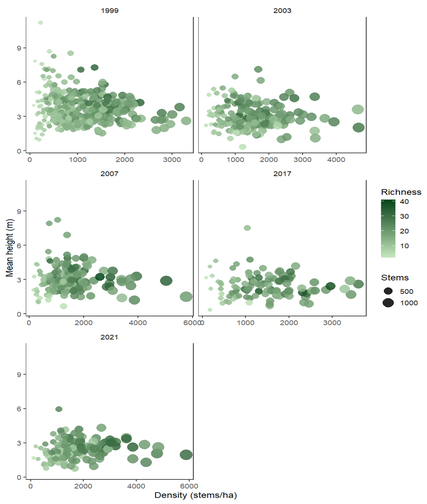

Figure 1. Relationship between tree density (log10 stems/ha + 1) and mean tree height across five surveyed years (1999 - 2021).

More tree species and shrubs became indicators of highly dense areas.

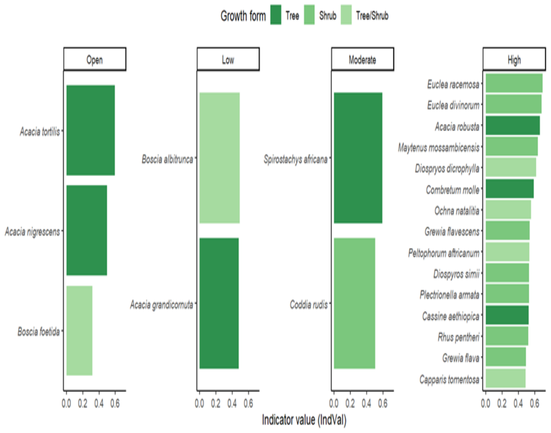

Figure 2. Horizontal bars show Indicator Value (IndVal; 0–1) indicating how strongly species are associated to each density class* in 2021.

Herbivory activity is more prevalent in higher density, larger canopy area, and volume sites.

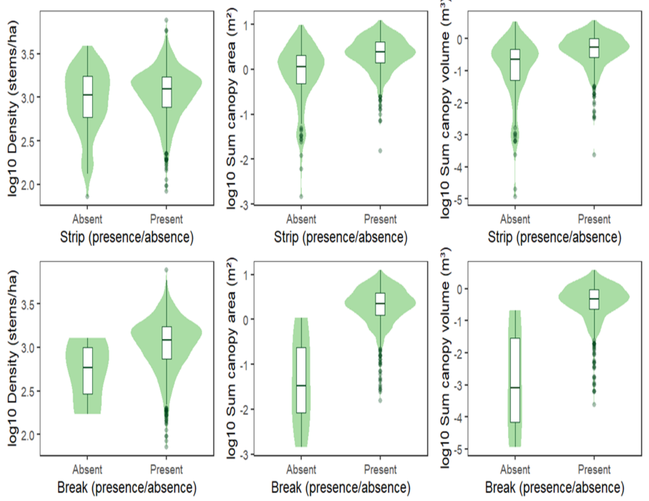

Figure 3: Violin plots of woody strips (top) and breaks (bottom) vs. log10 stem density, canopy area, and canopy volume. Boxes show medians and IQRs; violins show distributions.

Open sites decrease in tree height over the years, and high-density sites show higher tree growth rates

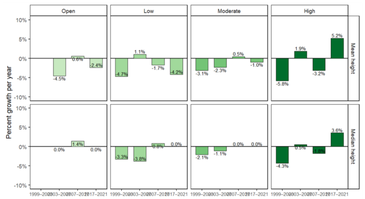

Figure 4: Median and Mean growth rates of trees in Open, Low, Moderate and High tree density classes.

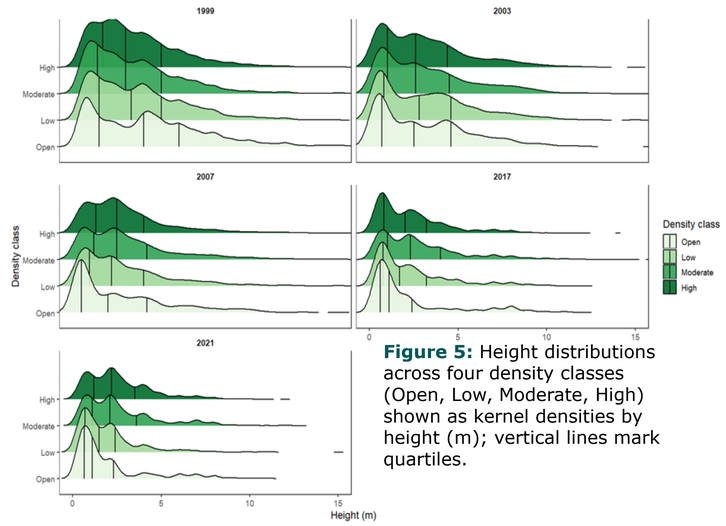

Figure 5: Height distributions across four density classes (Open, Low, Moderate, High) shown as kernel densities by height (m); vertical lines mark quartiles.

References

1.Bond, W.J. (2008) 'What limits trees in C4 grasslands and savannas?', Annual Review of Ecology, Evolution, and Systematics, 39, pp. 641–659.
2.Hirota, M., Holmgren, M., van Nes, E.H. and Scheffer, M. (2011) 'Global resilience of tropical forest and savanna to critical transitions', Science, 334(6053), pp. 232–235.
3.Sankaran, M., Ratnam, J. and Hanan, N.P. (2004) 'Tree–grass coexistence in savannas revisited', Ecology Letters, 7(6), pp. 480–490.