Feedbacks between fire and patches of woody vegetation in tropical grasslands and savannas

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Rapid increase in woody cover in many savannas

Roques et al. 2001, Van Langevelde et al. 2003
What mechanism can cause rapid woody increase?

- Increase in grazing intensity
- Woody biomass $\uparrow$
- Grass biomass $\downarrow$
- Impact of fire on trees $\downarrow$

Van Langevelde et al. 2003 Ecology
Argentinean savanna (Cabral et al. 2003 J. Veg. Sci.)
Feedbacks between fire and patches of woody vegetation

Effects of fire on
clustering of trees

Effects of patches of
woody vegetation on
role of fire
Simple model

![Bar chart showing frequency of small and large categories]

- **small**: Frequency 15
- **large**: Frequency 2
Effect of fire

Fraction tree cover

fire +

fire -
Feedbacks between fire and patches of woody vegetation

Effects of fire on clustering of trees
Kruger National Park: burning plots
Clustering: measuring distances between trees
Fire frequency: positive effect on clustering of tree species that are not very abundant

• Less abundant species might be less resistant to fire

• Can grow together because excluding grass fires under their canopy
Clustering reduces damaging effect of fire on trees

Simple model

- Establishment
- Small patches
- Large patches
- Fire loss
- Loss

Flow diagram showing relationships between establishment, small patches, large patches, fire loss, and loss.
Increased fire loss of small woody patches
Feedbacks between fire and patches of woody vegetation

Effects of patches of woody vegetation on role of fire
- Higher fire temperature (= effect of fire) at windward side than at leeward side
- Difference increases with patch size
Sample dates after fire (≈ every 10 days)

Van Langevelde et al. 2014 Int. J. Wildland Fire
Simple model

- Establishment
- Small patches
- Large patches
- Fire loss
- Loss
Decreasing role fire?
Decreasing role fire

Tree cover = 0.06

Tree cover = 0.72
Interpretation

Low local fire frequency

High local fire frequency

Fraction tree cover

threshold

time
Conclusion

• Fire can result in clustering of trees
• Patches can have large effect on role of fire
• Feedbacks might lead to ‘safe zone’ for seedlings at leeward side of patch
• Combination of feedbacks can promote woody vegetation expansion (e.g. Roques et al. 2001)
• Understanding of savanna functioning: which processes are relevant in distribution of savanna trees
Thanks to PE&RC, Kruger National Park, Lajuma Research Centre, Winston Trollope
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\frac{dP_S}{dt} = \text{establishment} - \text{loss}_S - \text{fire}_S - \text{growth} + \text{loss}_L + \text{fire}_L
\]

\[
\frac{dP_L}{dt} = \text{growth} - \text{loss}_L - \text{fire}_L
\]

\[
\frac{dP_S}{dt} = c_S P_S (1 - a_S P_S - a_L P_L) - e_S P_S - f_S P_S - c_L P_S + e_L P_L + f_L P_L
\]

\[
\frac{dP_L}{dt} = c_L P_S - e_L P_L - f_L P_L
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