

# Does fire reinforce or dilute discontinuities in woody cover?\*

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# Abrupt transitions in tree cover are often observed across the savanna domain



Kroonenberg & Noordam (2017)



Bernardino *et al.* (2022)



<https://jgpausas.blogs.uv.es/tag/brazil/>



Rietkerk *et al.* (2021)

# How does this work? The **fire feedback model**

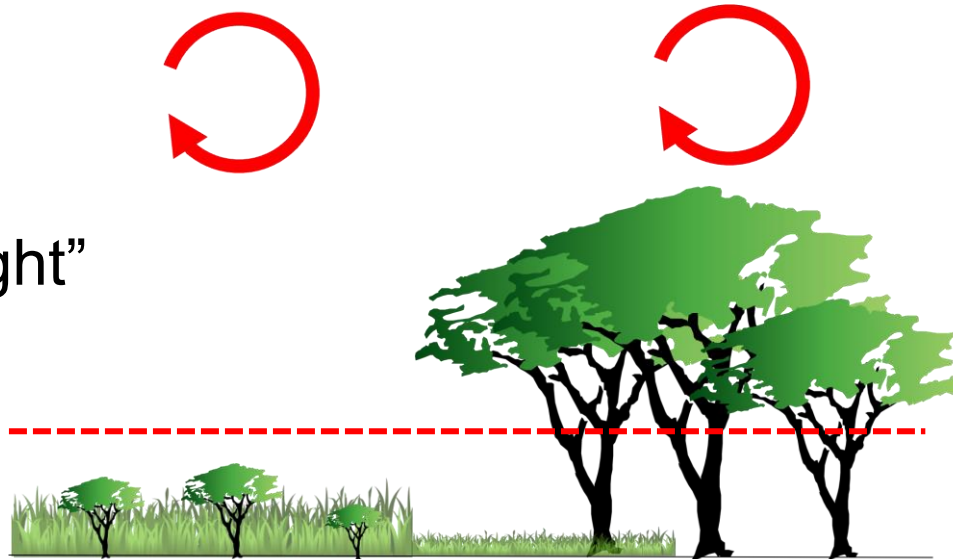
## **Low tree cover (= grassy)**

High grass biomass  
High grass competition  
Low fuel moisture  
Lower RH  
Higher wind speed  
High ignition probability  
Intense fire  
**High topkill**

## **High tree cover (= woody)**

Low grass biomass  
Low grass competition  
High fuel moisture  
Higher RH  
Lower wind speed  
Low ignition probability  
Low-intensity fire  
**Low topkill**

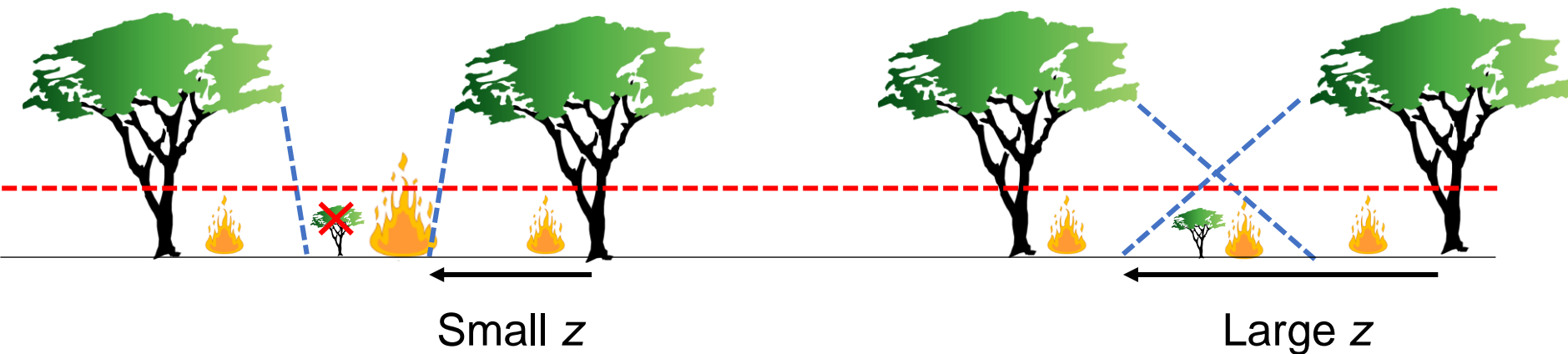
“Escape height”



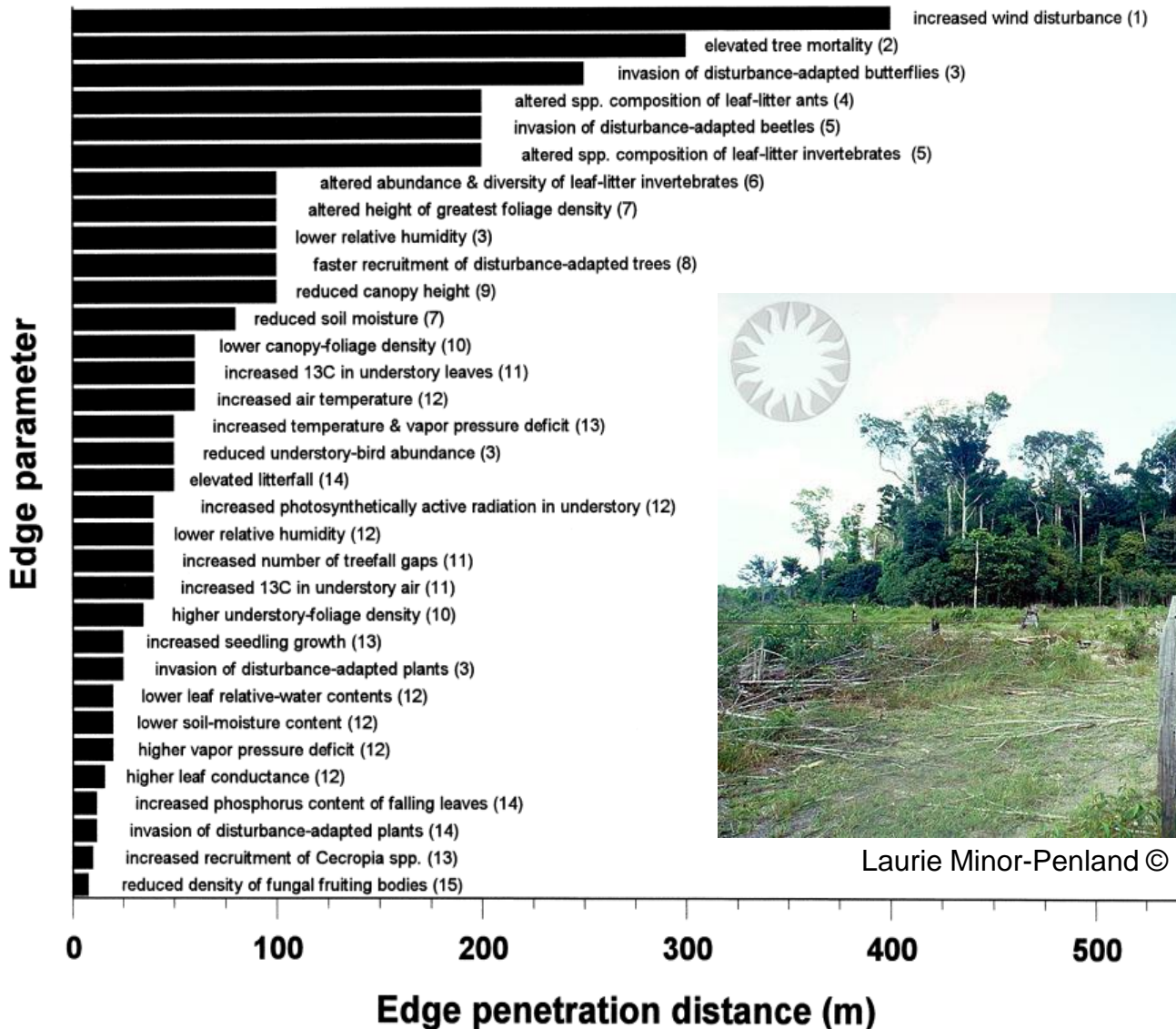
# Neighborhood effects

Tree canopies exert effects on grass (and fire) over a certain neighborhood (e.g., a circle of radius  $z$ )

How large is  $z$ ? Canopy feedbacks on fire regimes need to benefit nearby saplings to sustain the woody state. Small zones of influence might **lower the stability of the woody state.**

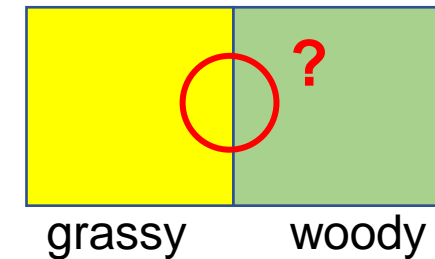
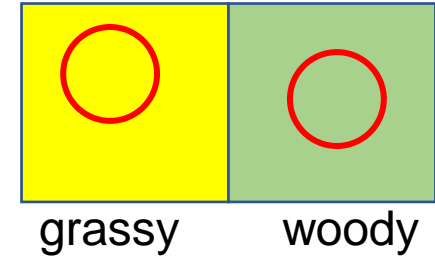
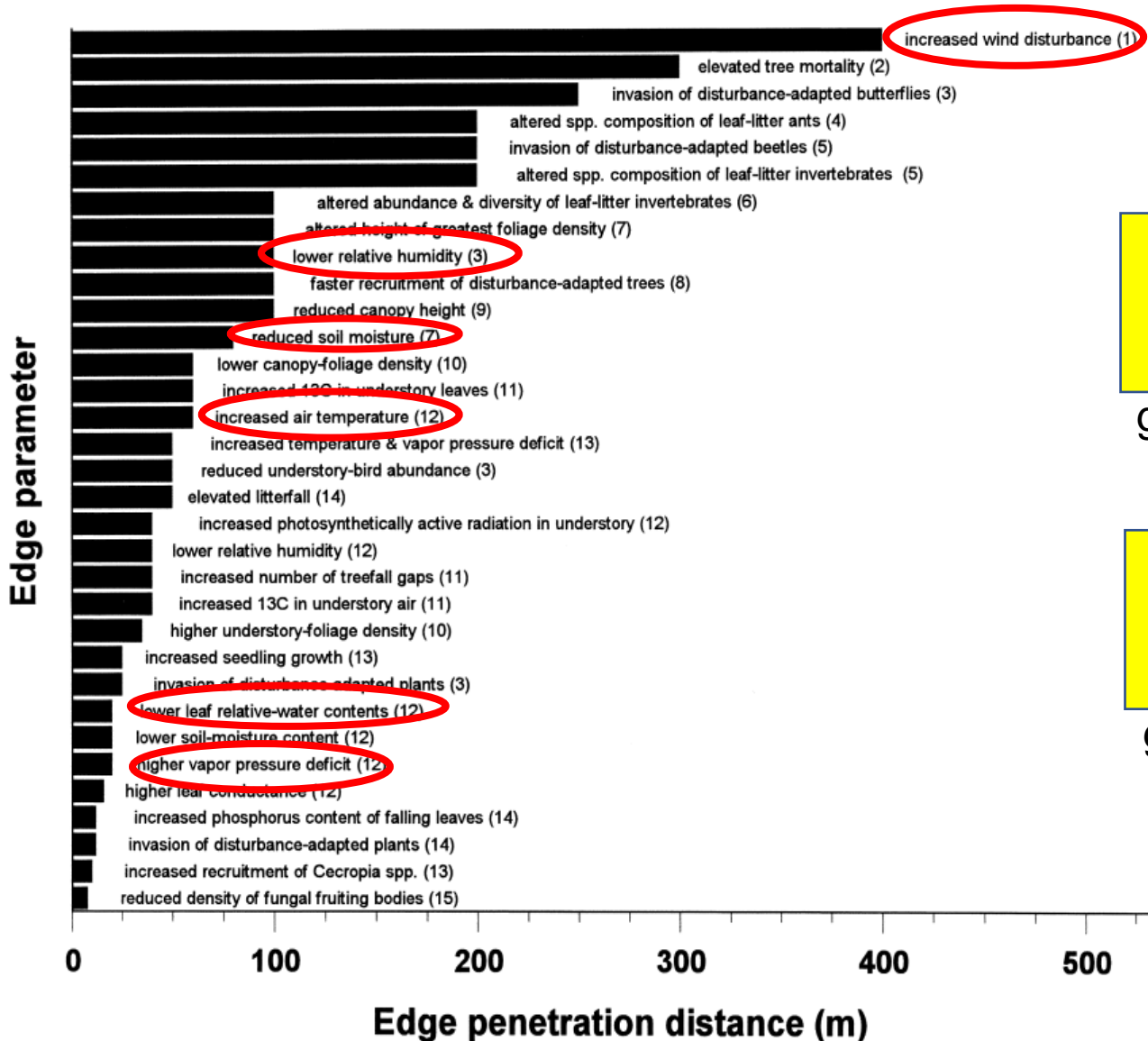


# The importance of edge effects



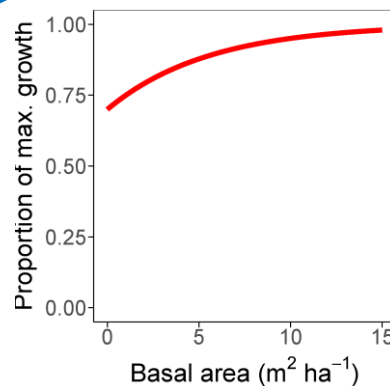
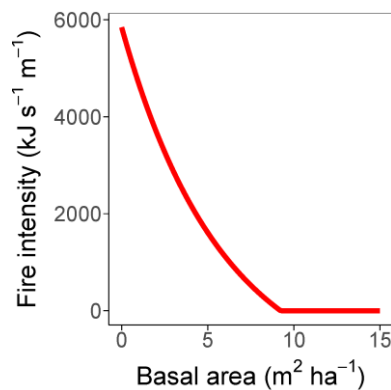
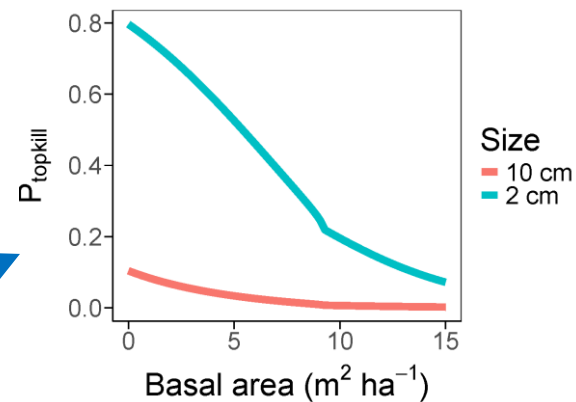
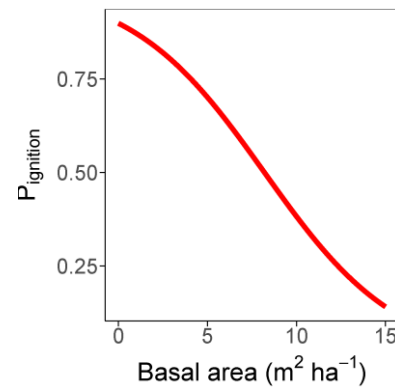
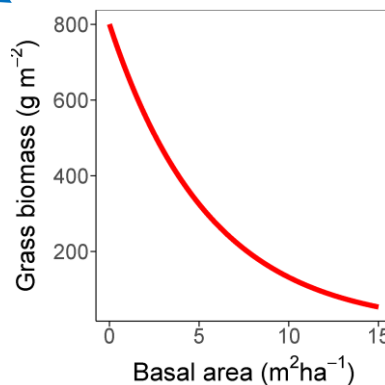
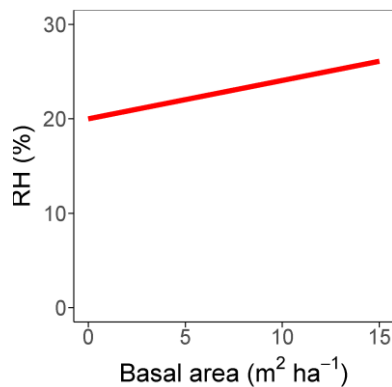
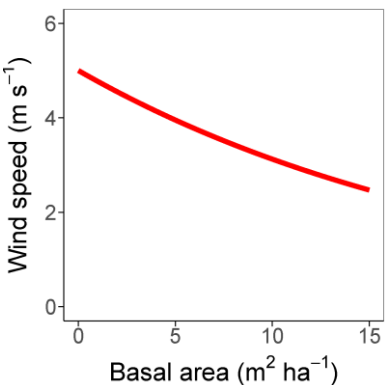
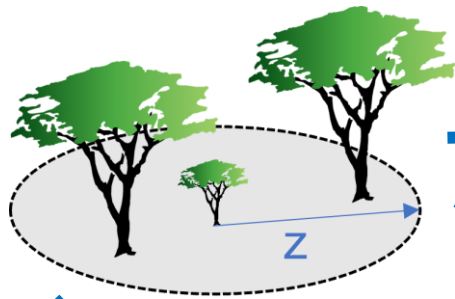
Laurie Minor-Penland © 2004 Smithsonian Institution

# The importance of edge effects



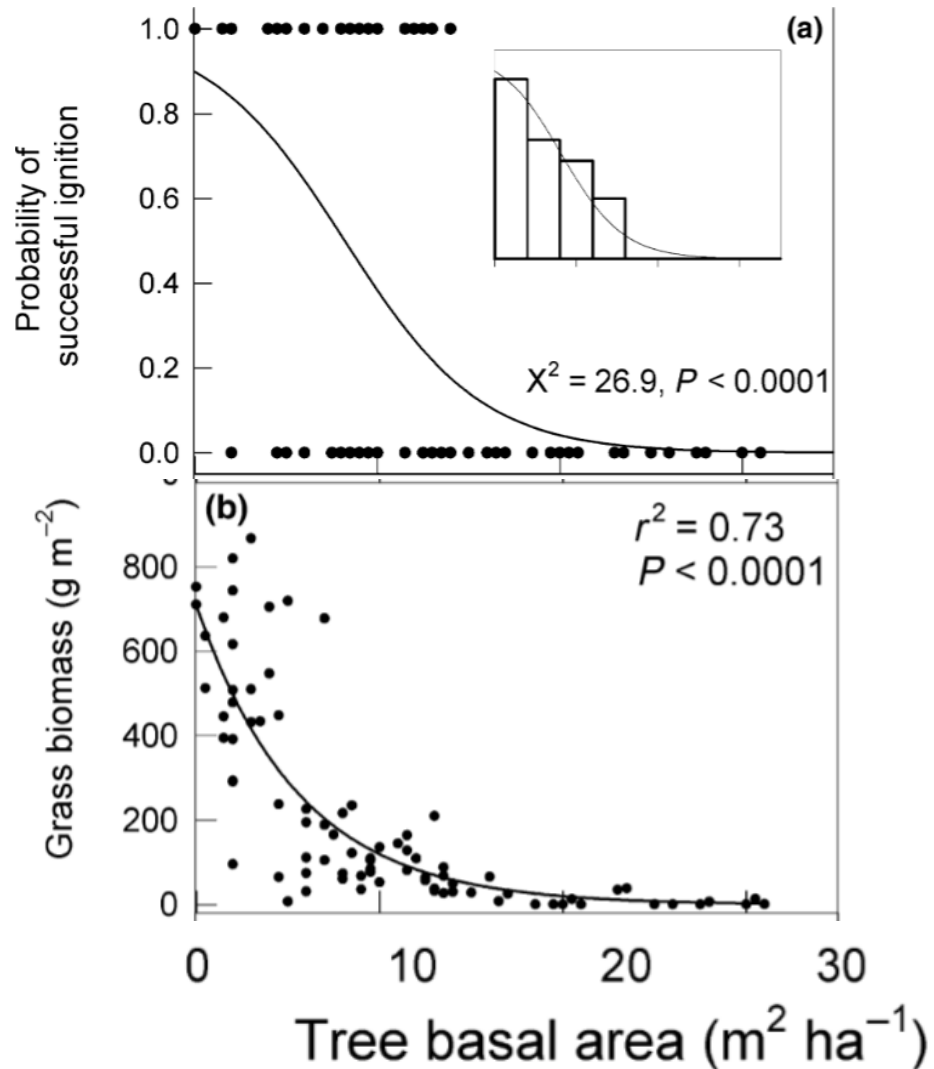
# Simulation model

- 1-ha torus-shaped habitat with fixed tree density and  $xy$  locations random
- Variable fire frequency ( $f$ )
- Size (=diameter) growth has individual ( $\sigma_{ind}$ ) and residual ( $\sigma_{res}$ ), stochastic and localized grass competition components
- Tree neighborhood ( $\mathbf{z}$ ) affects grass biomass and microclimate, and therefore ignition, fire intensity and topkill
- Both topkill and whole-tree background mortality ( $m$ ) occur



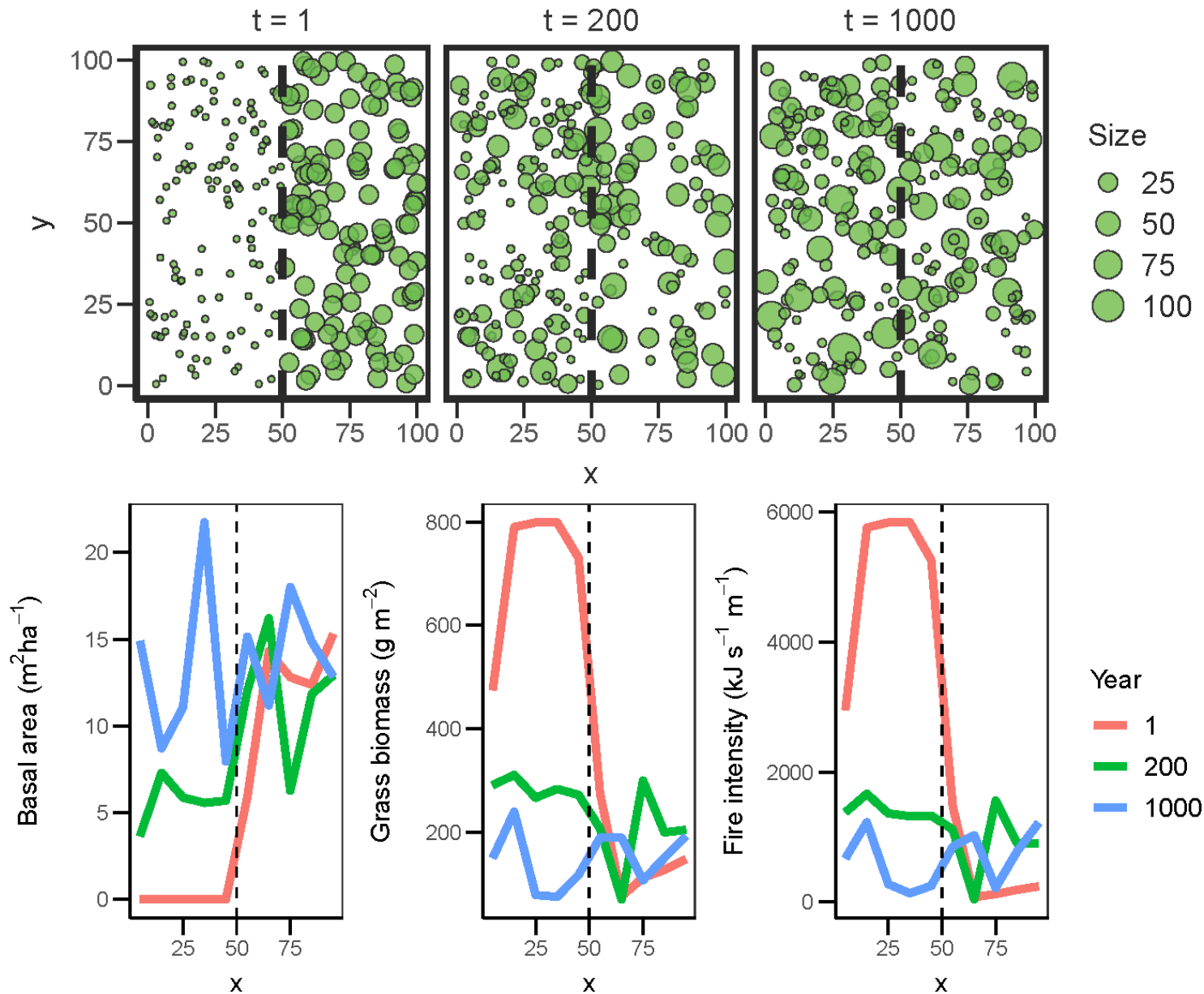
**ESCAPE**

# Model parameters (example)



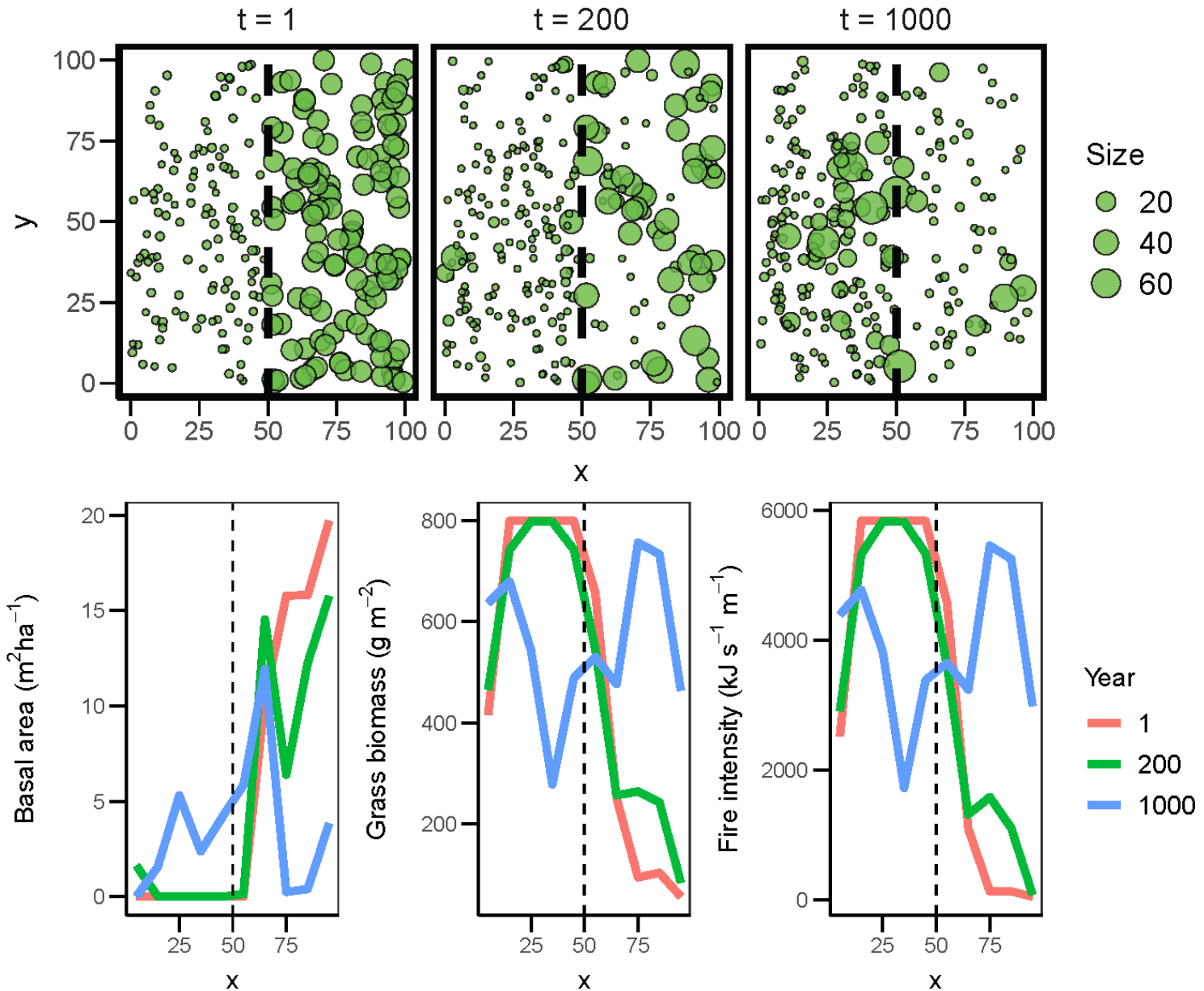
# Sharp boundaries always break down over time...

$$f = 0.2 \text{ y}^{-1}$$

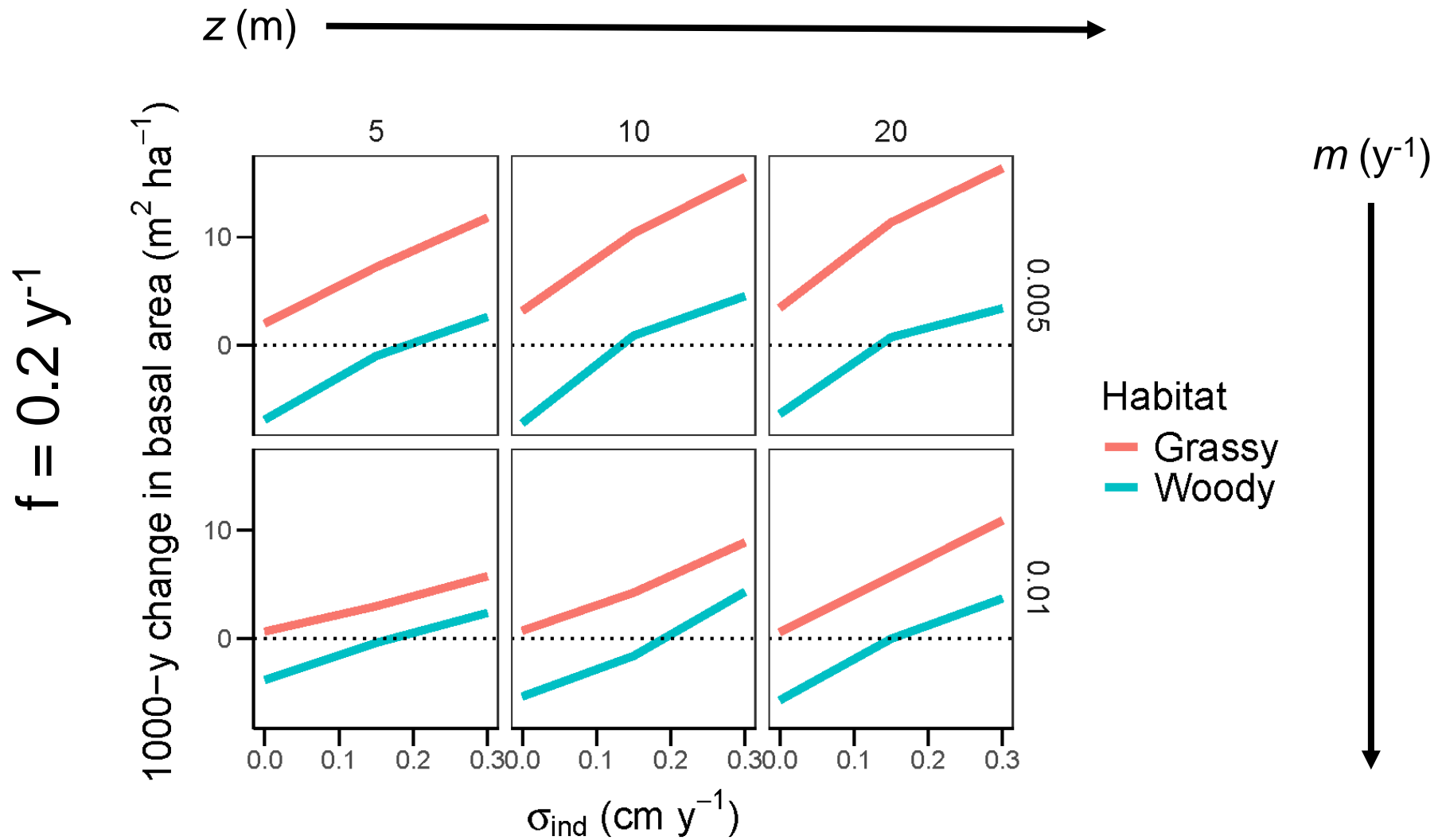


# Sharp boundaries always break down over time...

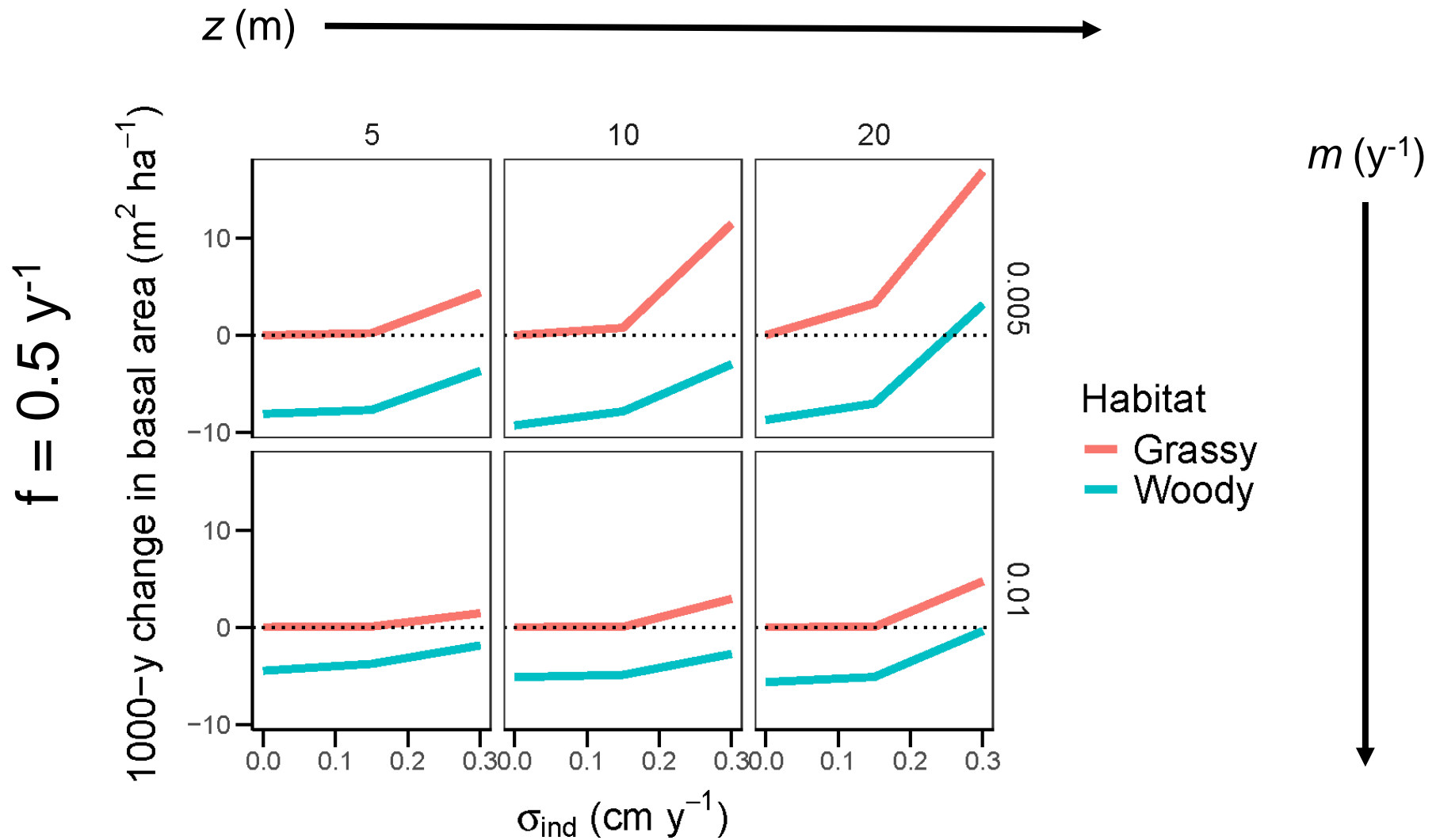
$$f = 0.5 \text{ y}^{-1}$$



And biome differences always disappear...



And biome differences always disappear...



## The take-home

Fire seems unlikely to generate or maintain sharp tree cover discontinuities in the absence of underlying variation in other factors. In fact, over time **fire tends to break down** such sharp transitions and homogenize vegetation.

# Acknowledgements

## People

S. Higgins and W. Hoffmann (data/parameter estimation)

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National Science Foundation  
WHERE DISCOVERIES BEGIN