Santa Fe, NM. June 13th 2013

Ecosystem organisation and climate resilience (in the context of fire)

Rosie Fisher (NCAR)

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MODIS active fire counts (are mostly in savanna)

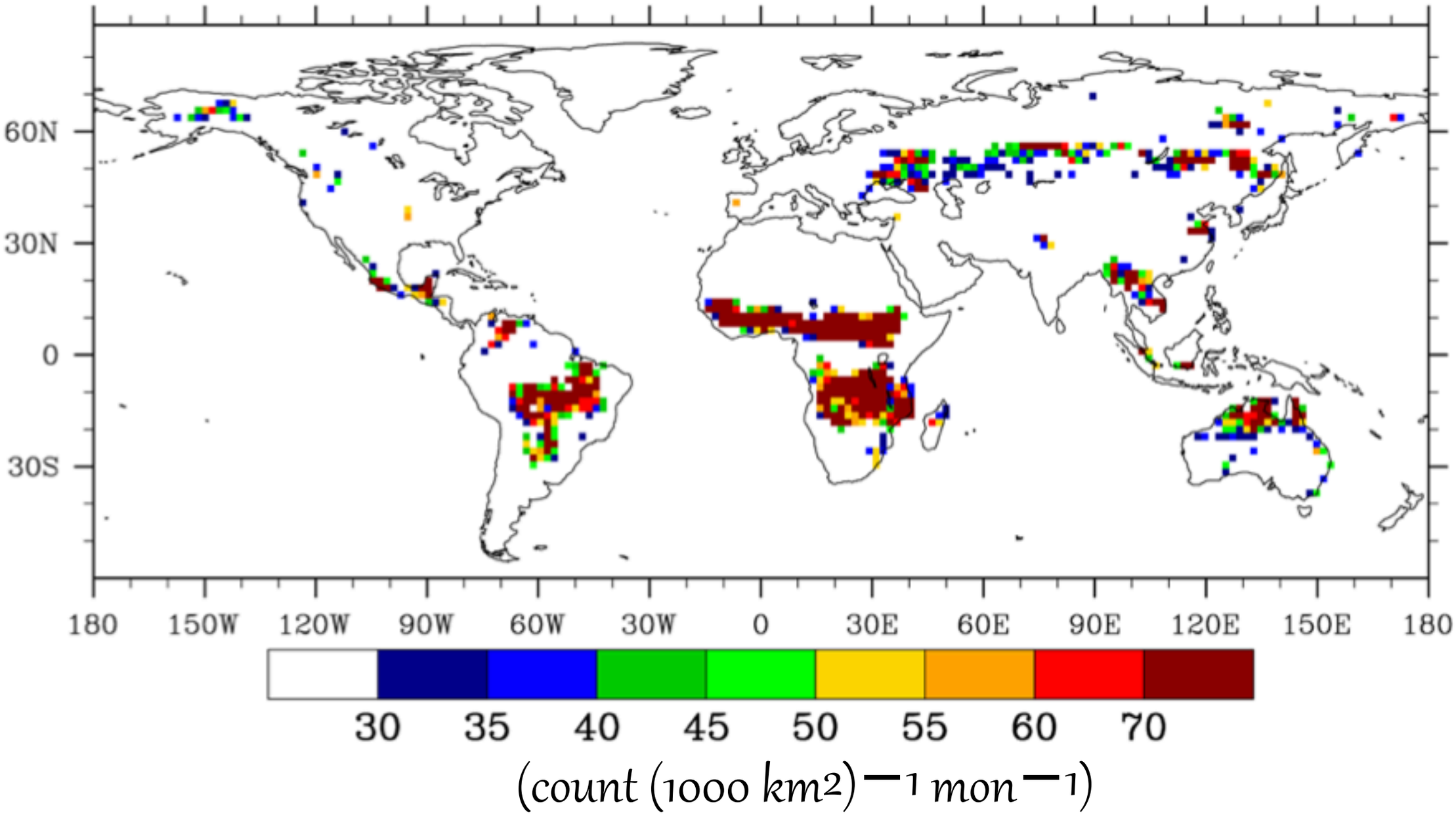
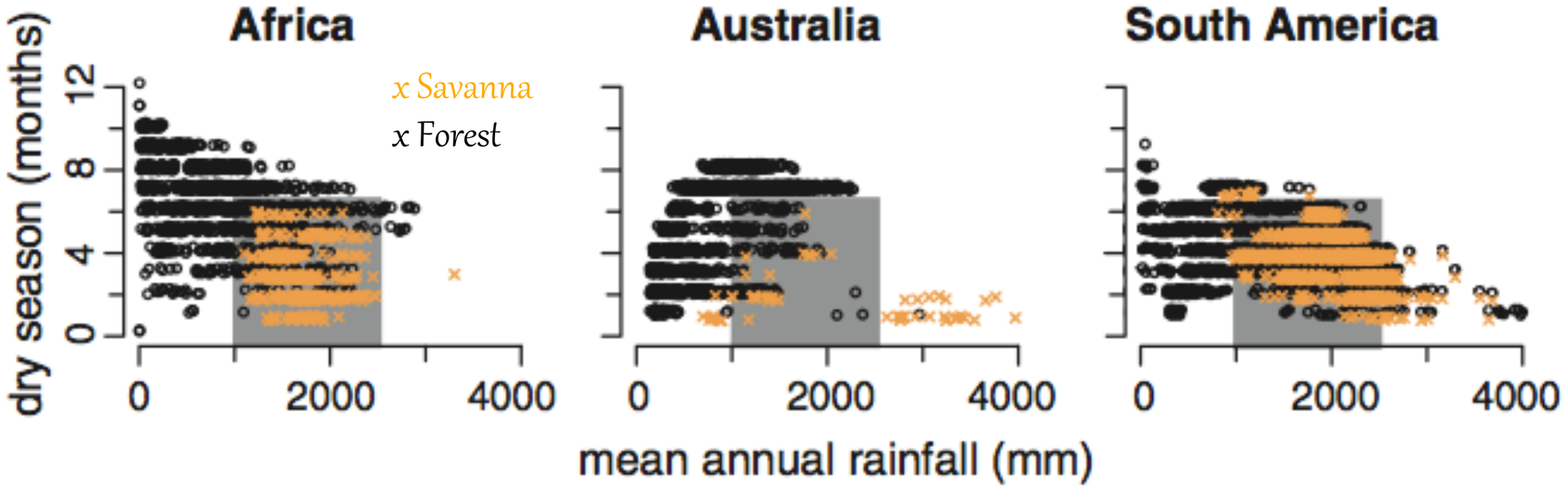
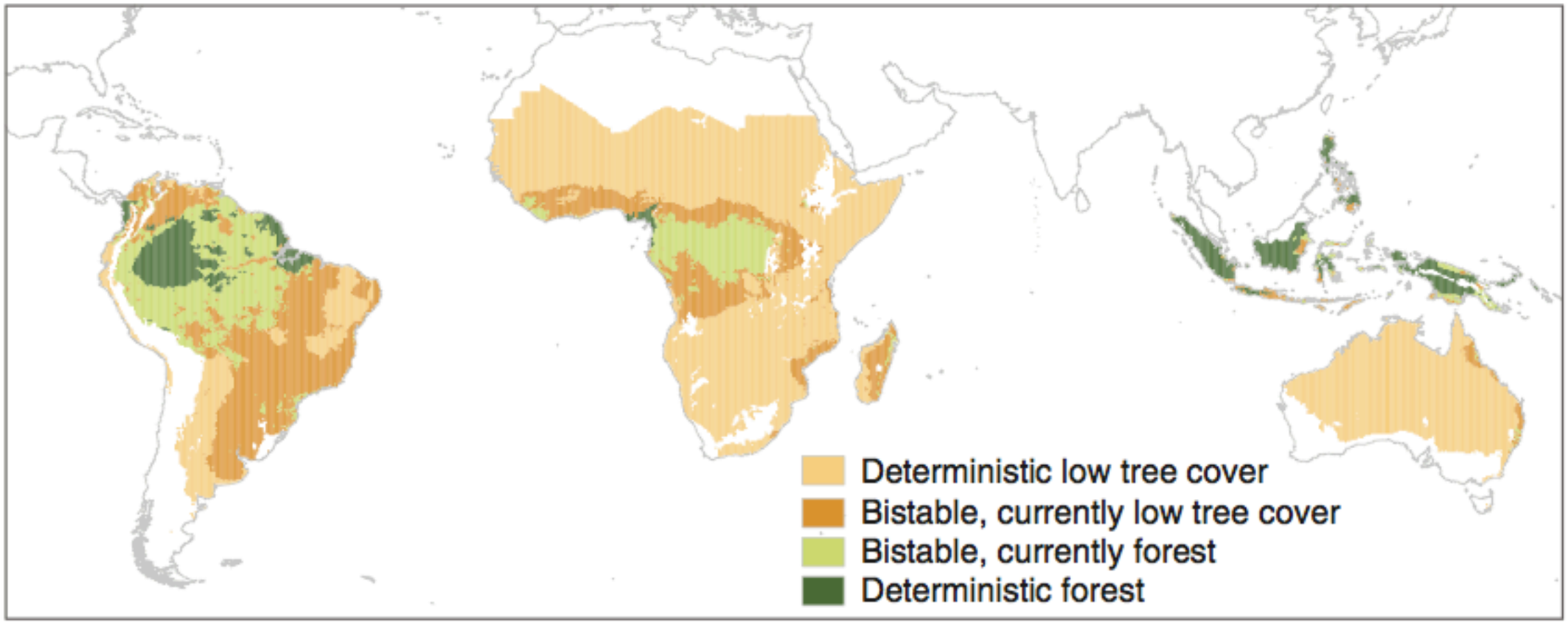


Figure from Li et al. 2012

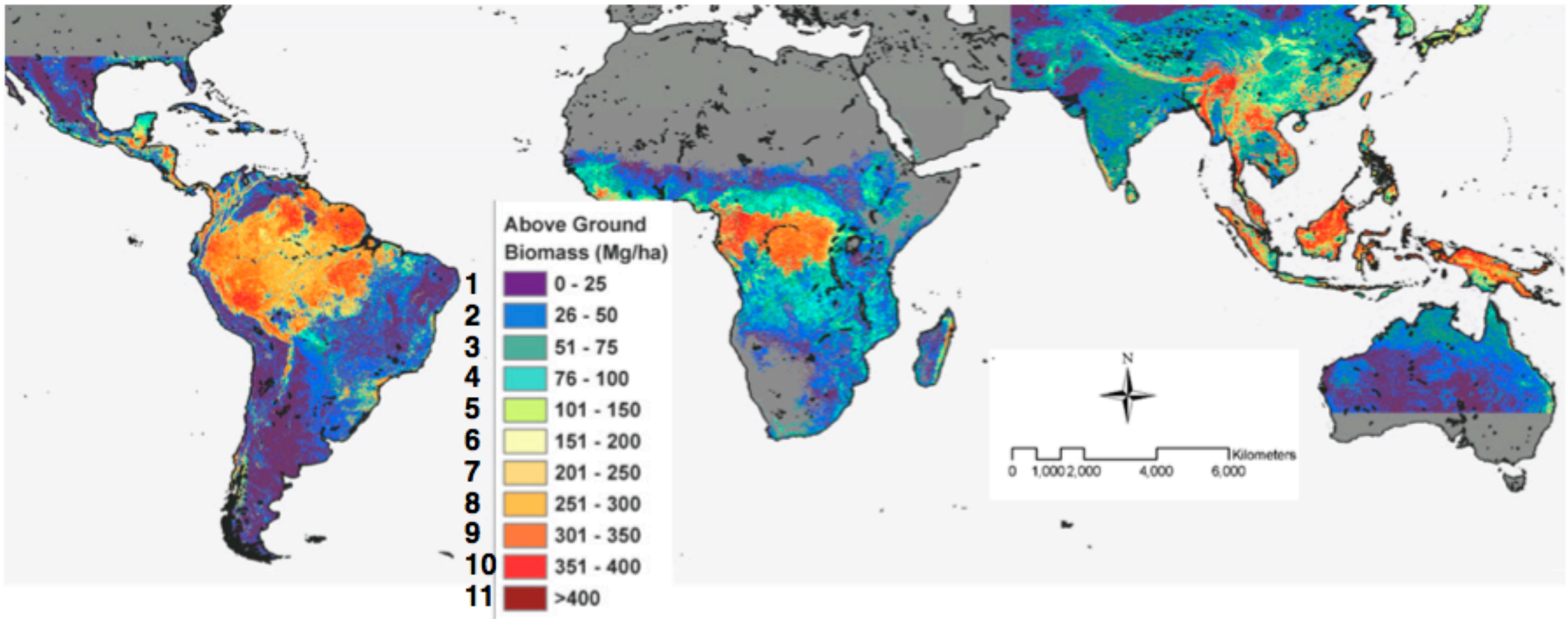
Bistable climate zones





Staver et al. Science 2011

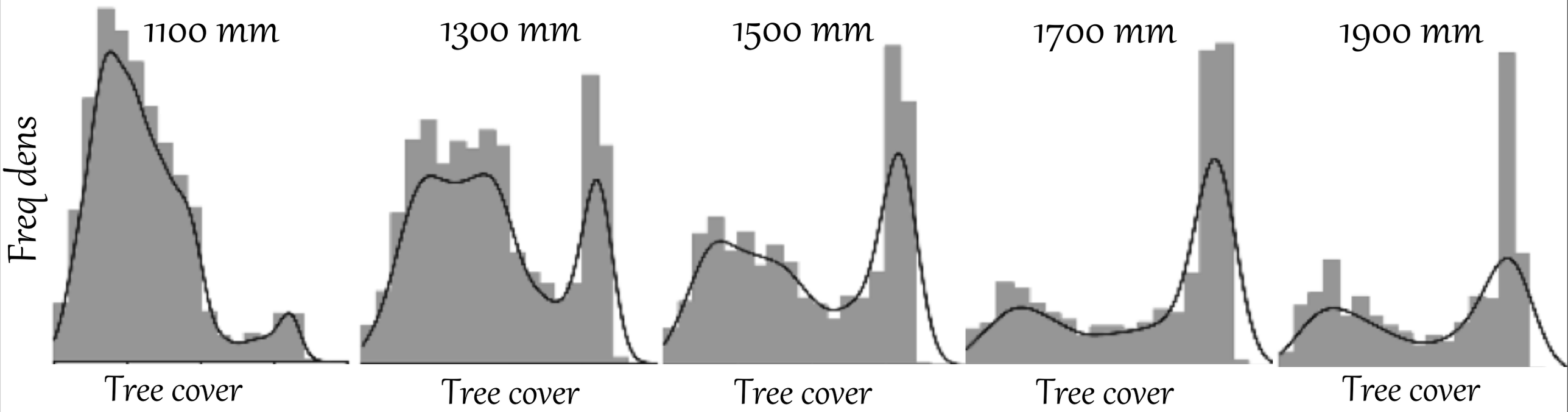
This is a big deal, because forest -> savanna transition implies a massive reduction in biomass



Saatchi et al. 2011

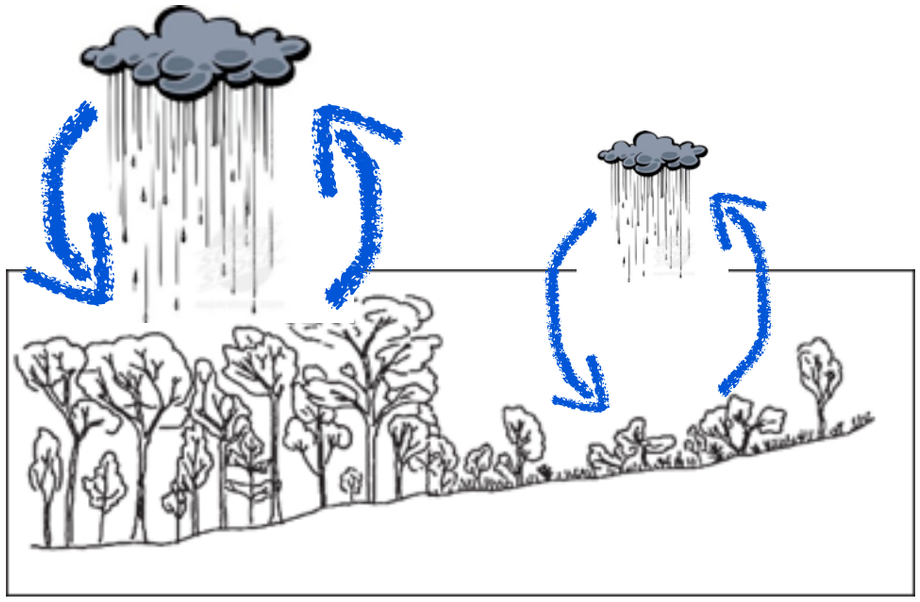
Staver et al. 2011

Bistability in mid-rainfall range



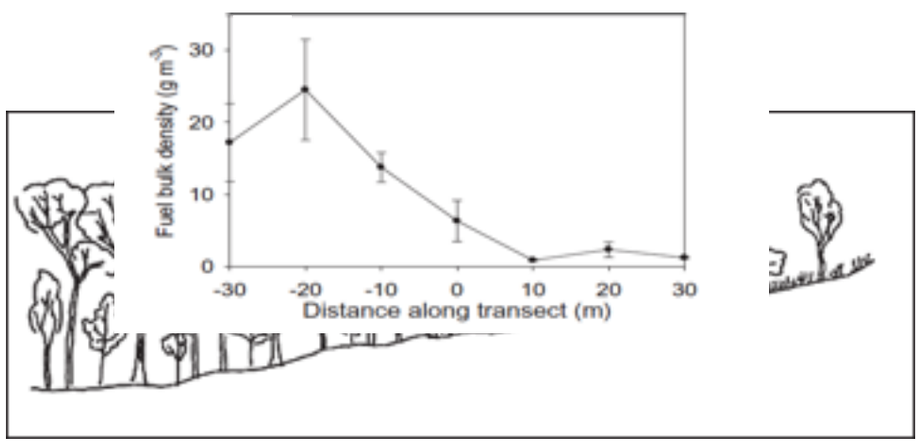
Vegetation cover is not a simple function of climate

Multiple scales of feedback

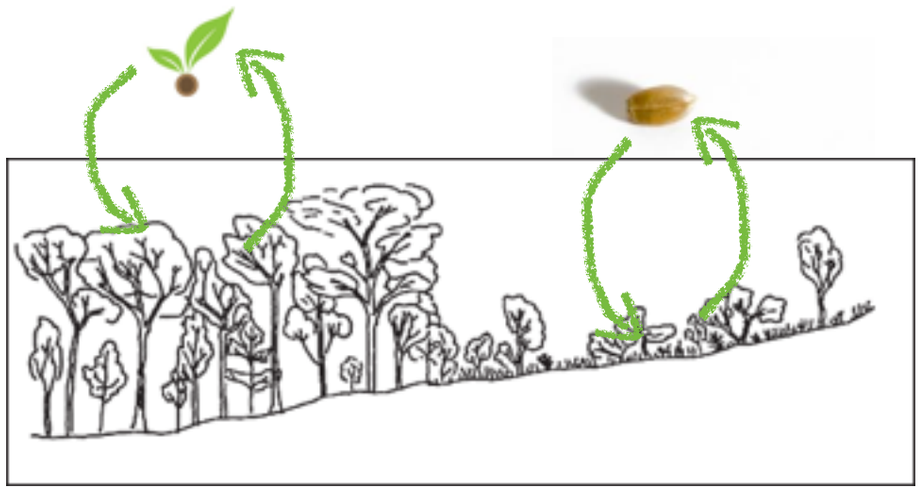


Land-atmosphere feedback

Wind speed feedback



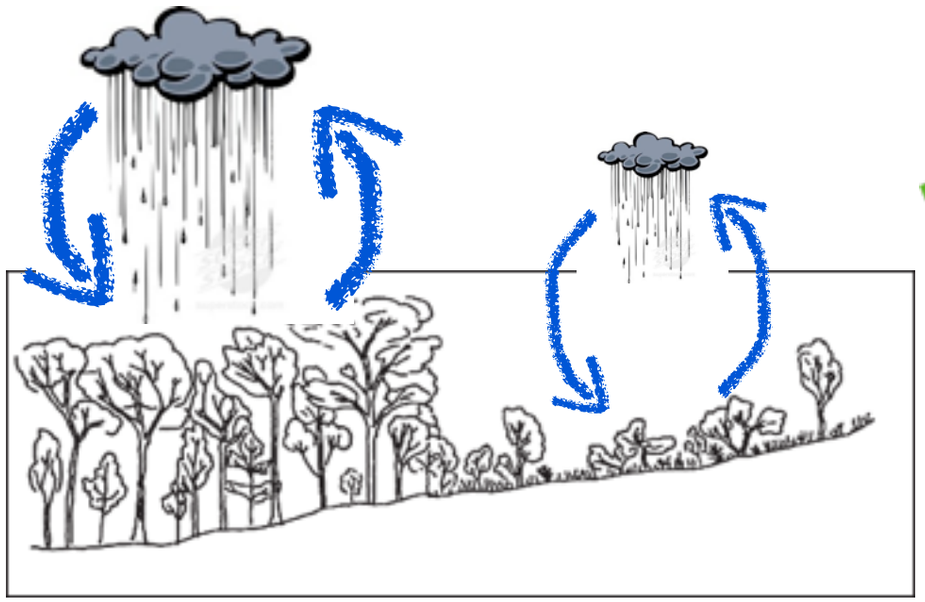
Flammability feedback



Demographic feedback

adapted from concepts in Hoffman et al., 2012, 2013

Do models understand the different scales of feedback?

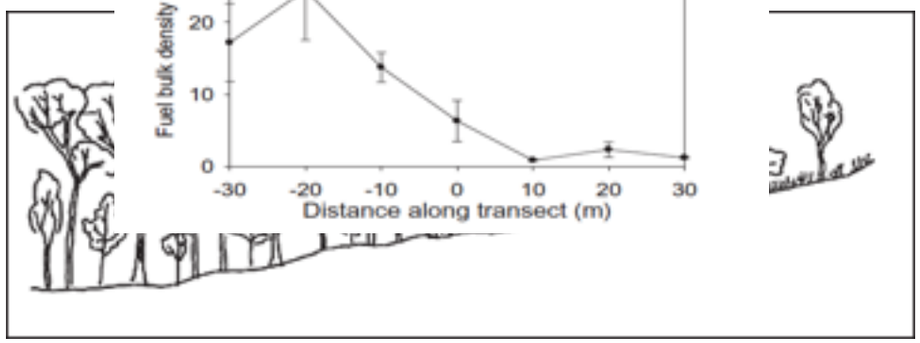


CLM-CESM ✓

Land-atmosphere feedback

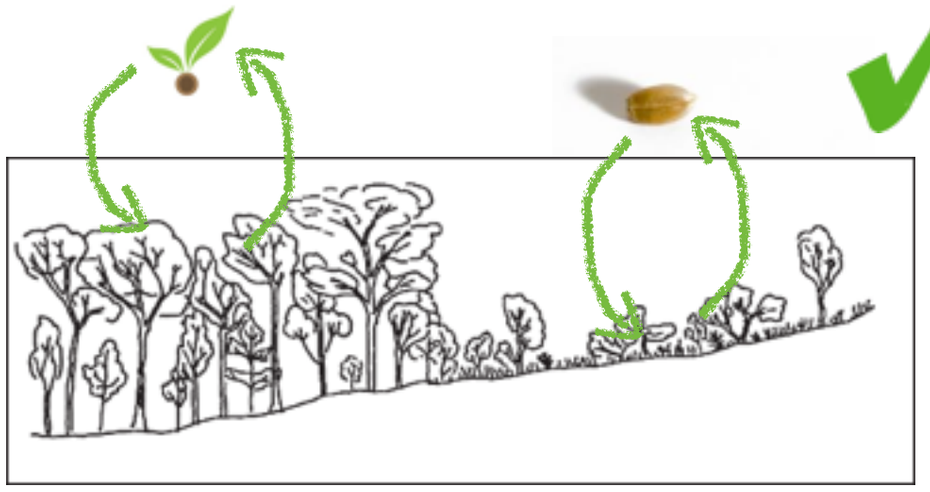
CLM-4.5 fire ✓

Wind speed feedback



CLM-4.5 fire ✓

Flammability feedback

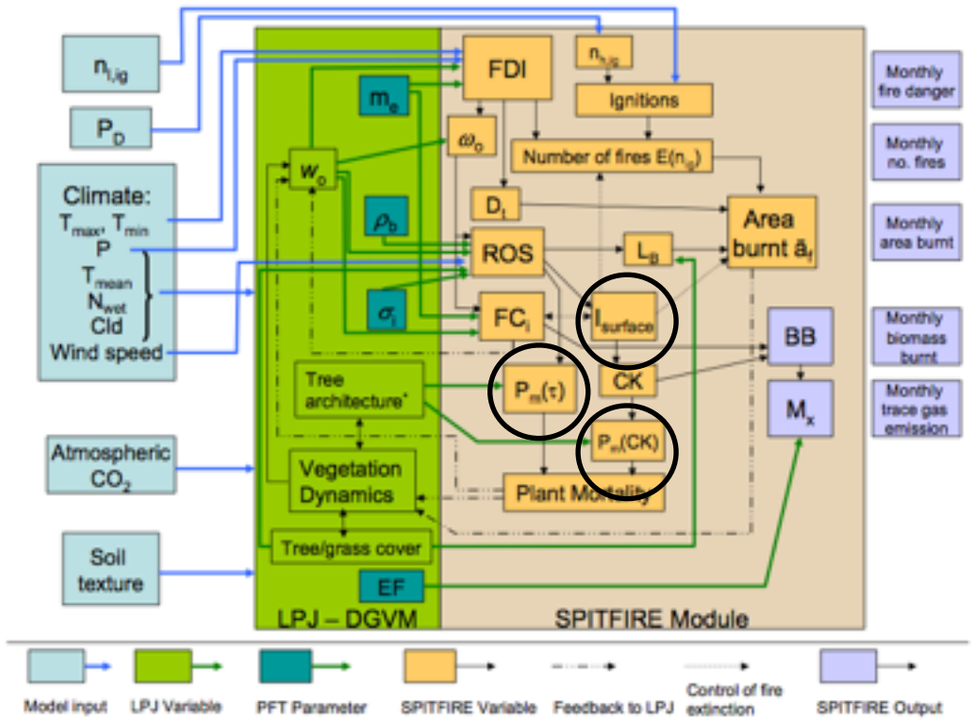


CLM(ED-SPITFIRE) ✓

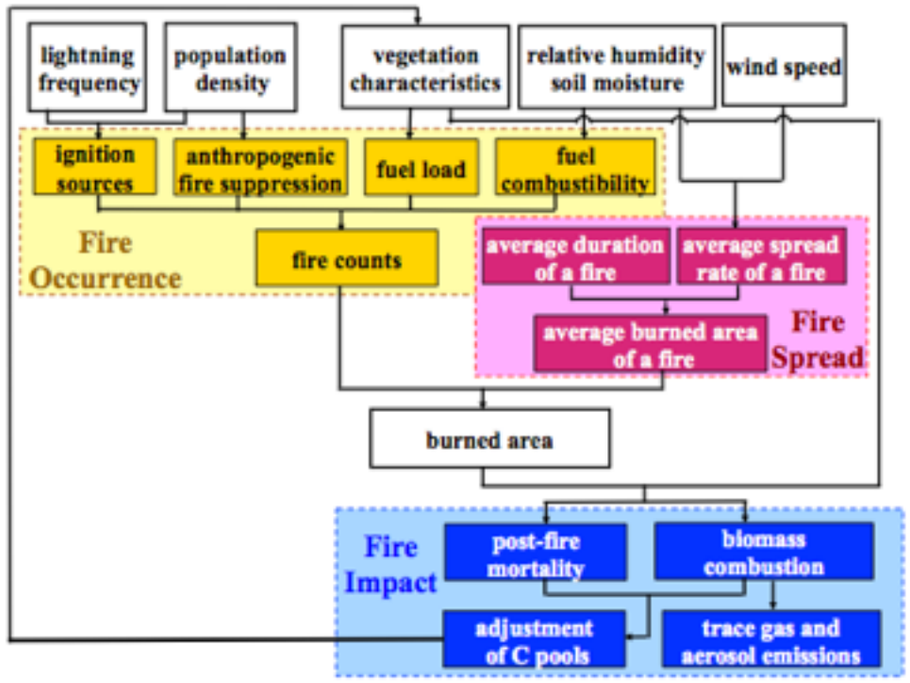
Demographic feedback

adapted from concepts in Hoffman et al., 2012, 2013

Fire-vegetation models

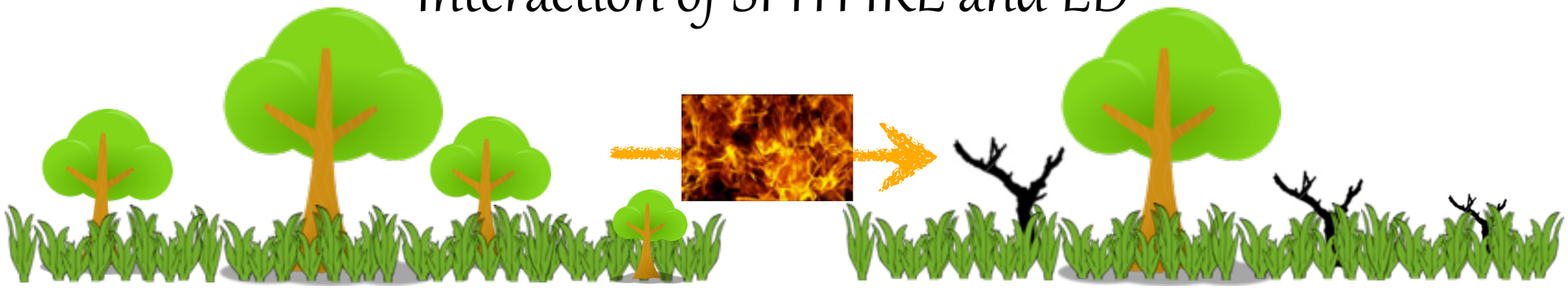


SPITFIRE: Thonicke et al. 2010



CLM4.5 fire: Li et al. 2012

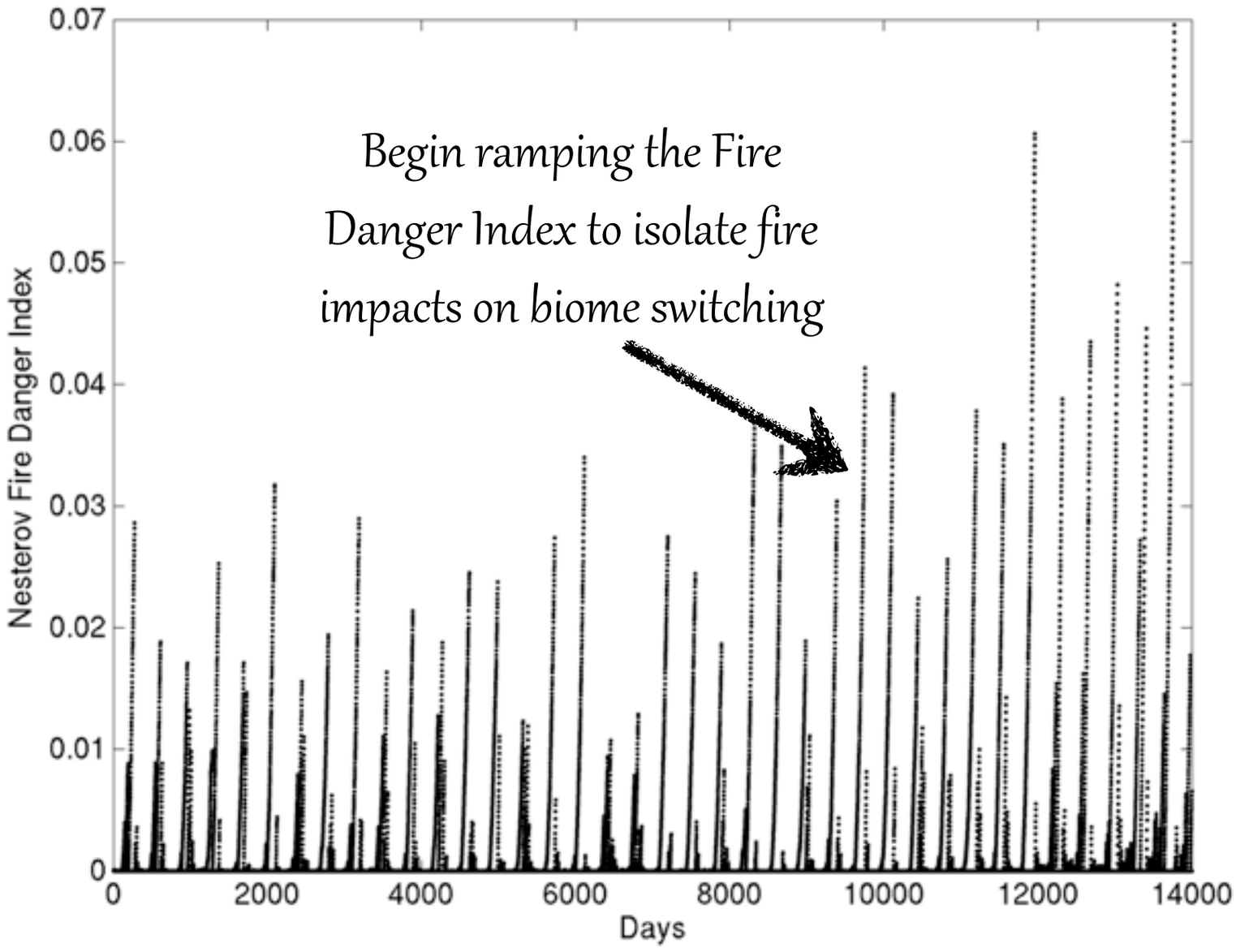
Interaction of SPITFIRE and ED



- Models -already- include many hypotheses for what controls forest/savanna stabilizing feedbacks

- We need to understand what conditions allow biome transition

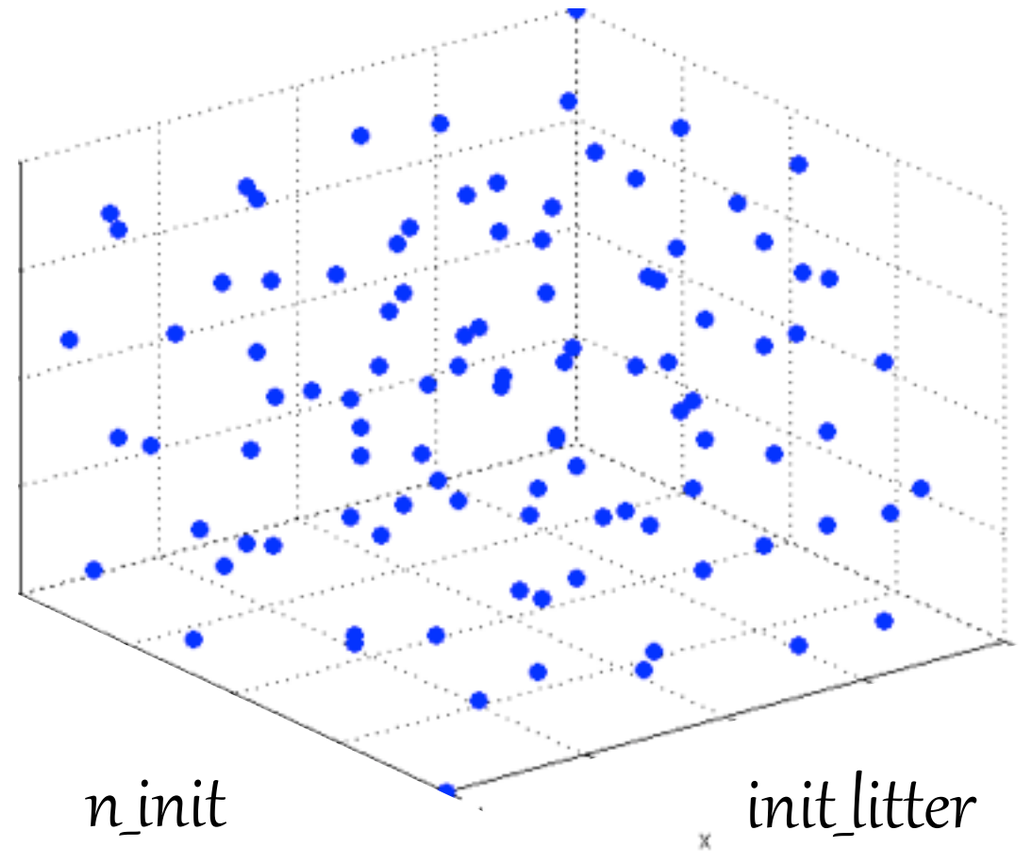
Impose conditions to induce forest switching



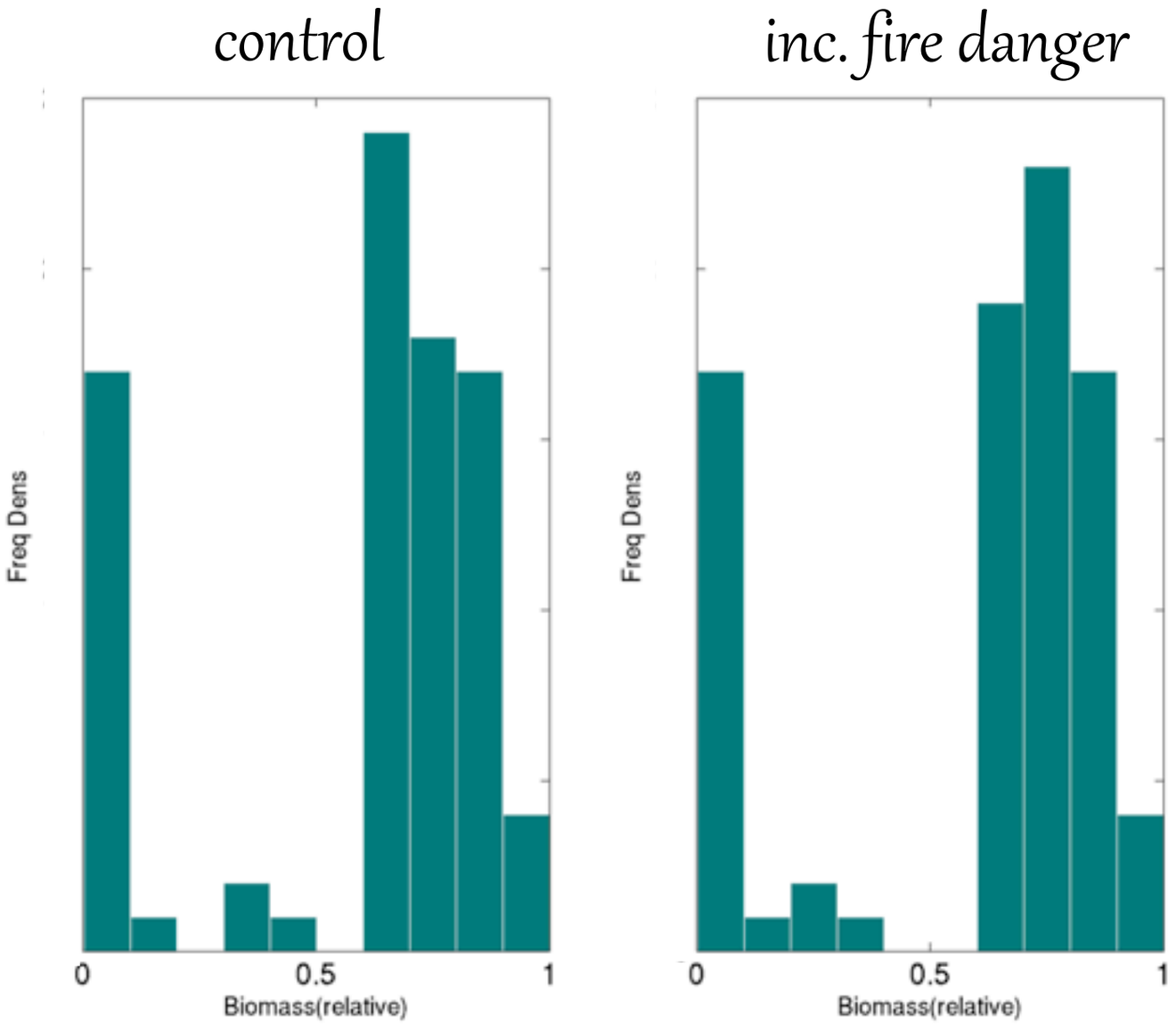
Nesterov fire index= climatological driver of fire danger model...

Sensitivity Analysis

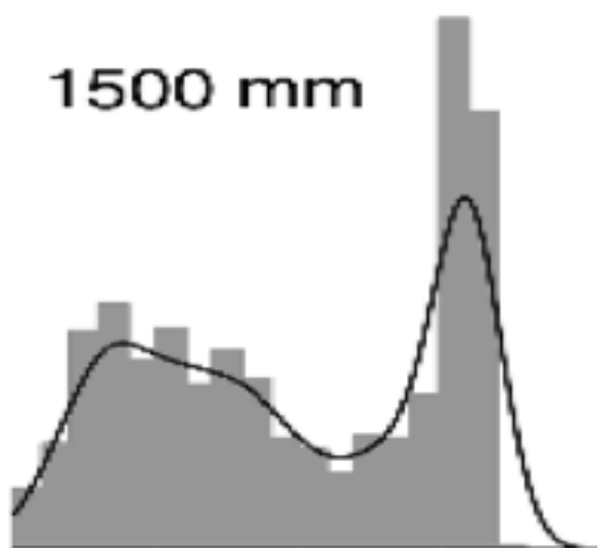
- 150 x Latin Hypercube perturbation of:
  - Initial sapling height
  - Initial litter pool size
  - Number of trees
  - Number of grasses



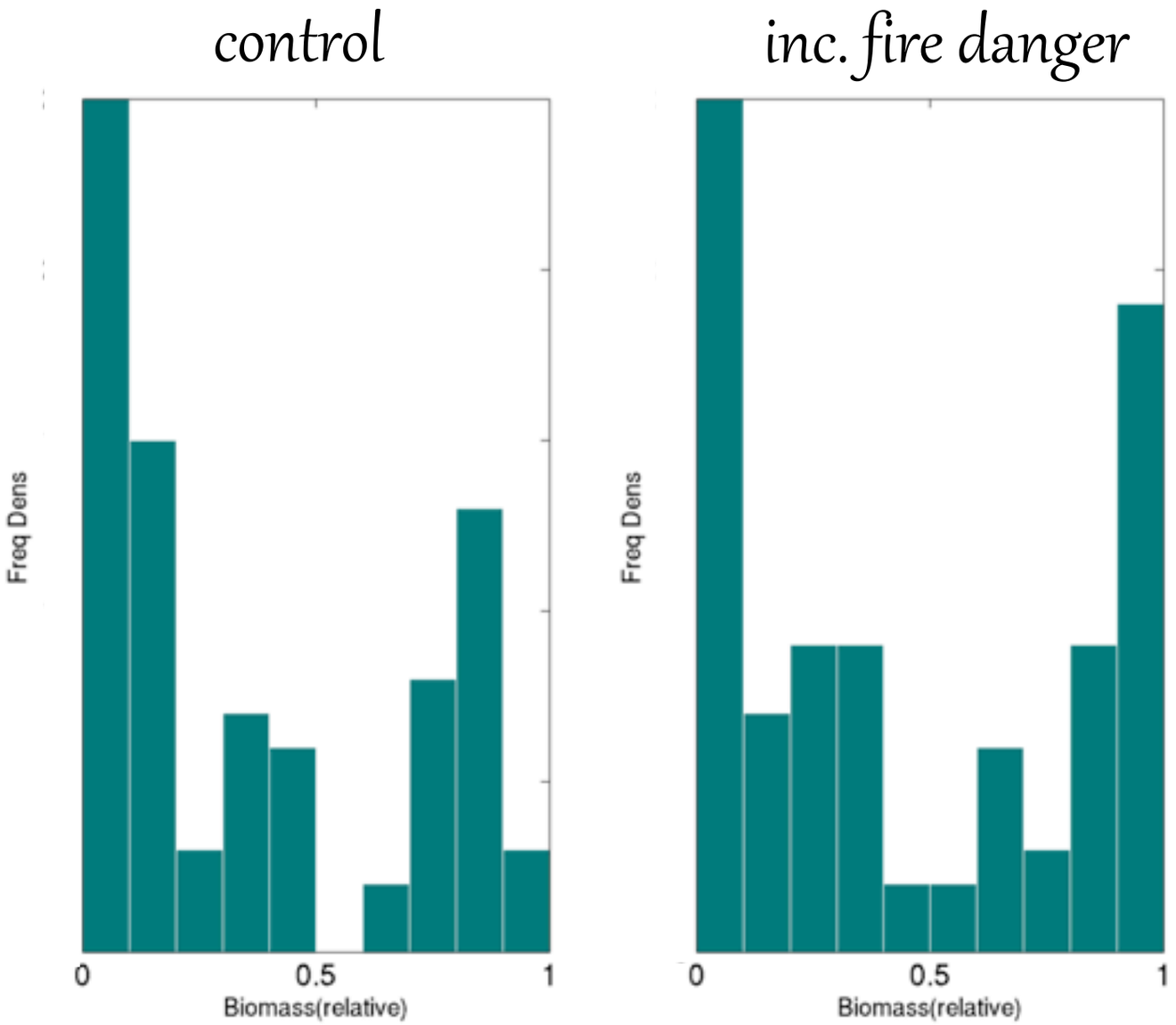
standard model



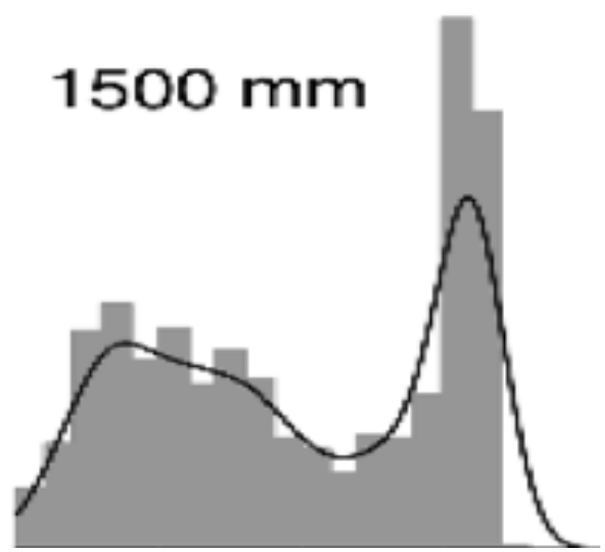
- Forest cover is too high
- There is no response to doubled fire danger



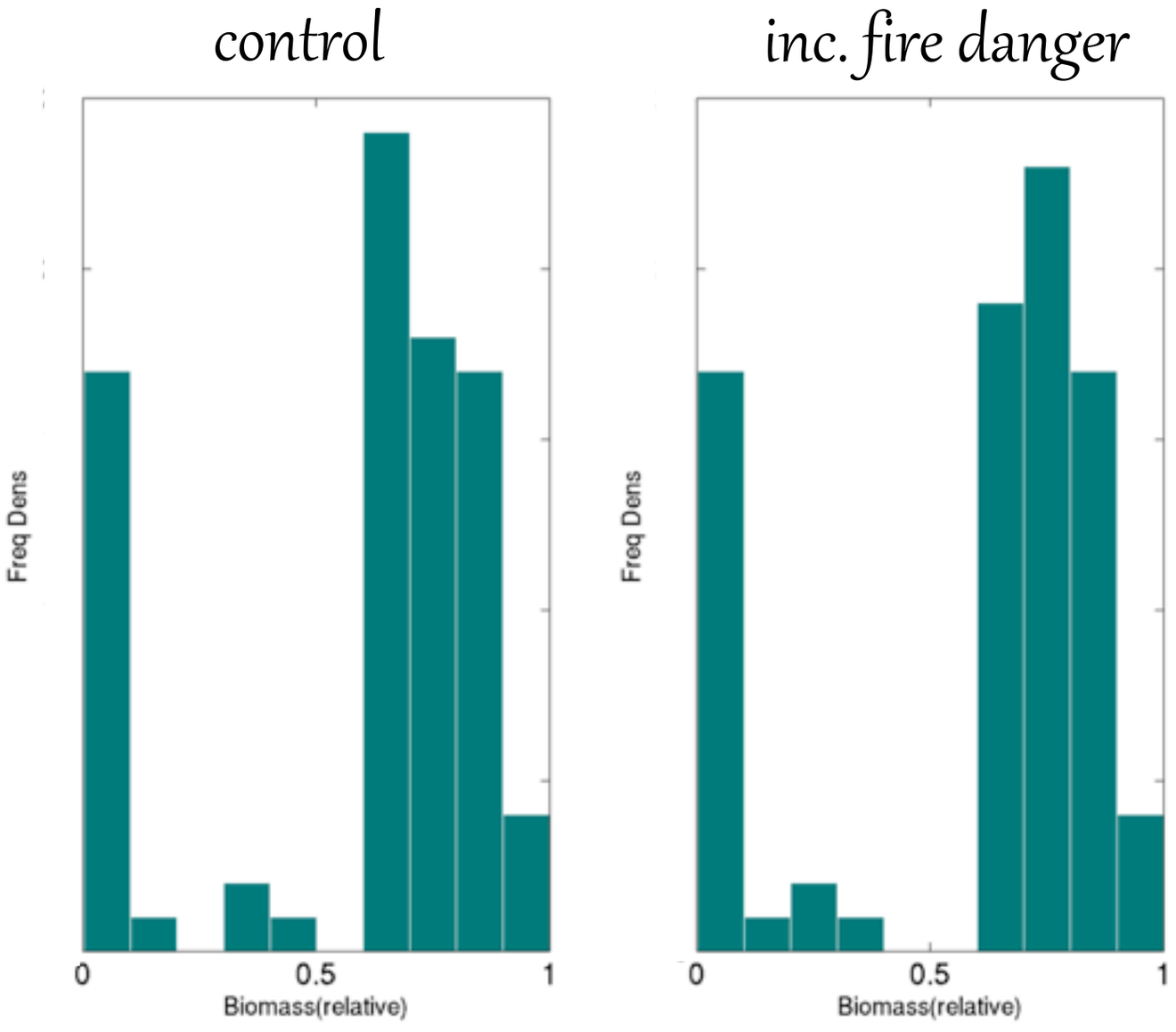
no windspeed feedback



- Grass fires are smaller
- Grass cover is higher
- There is a very slight response to doubled fire danger



standard model



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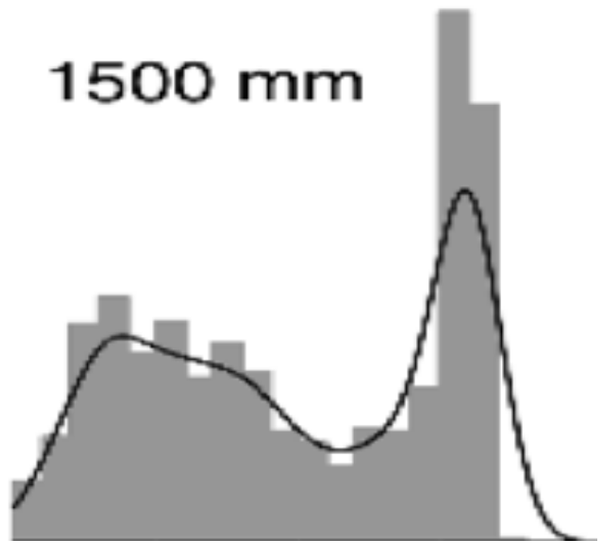
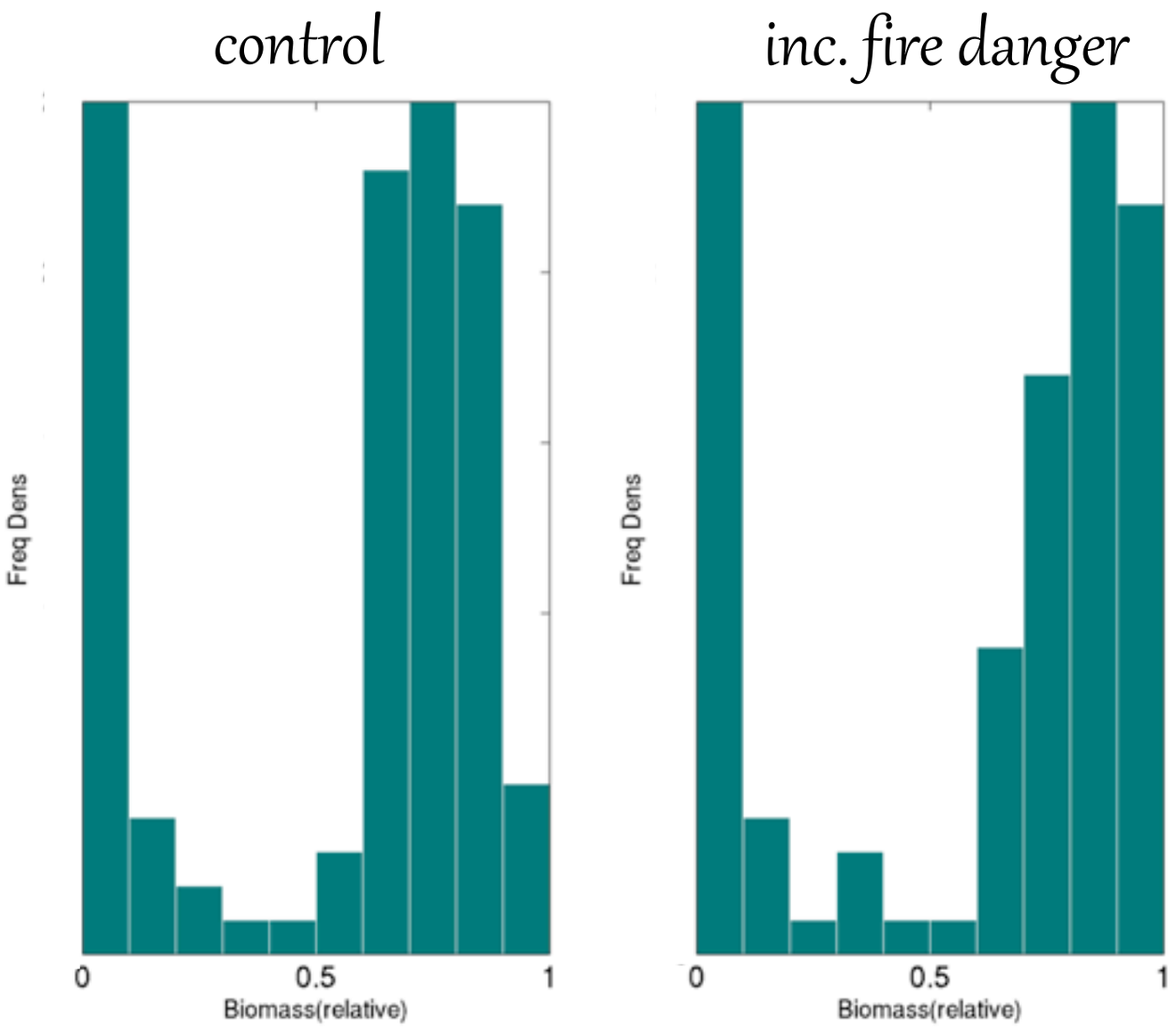
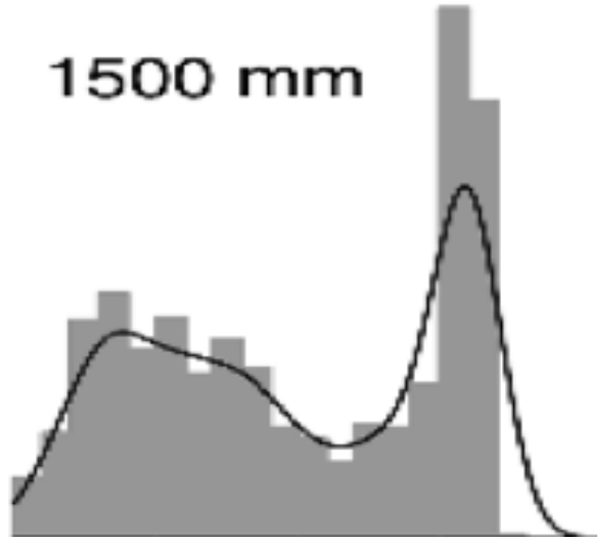


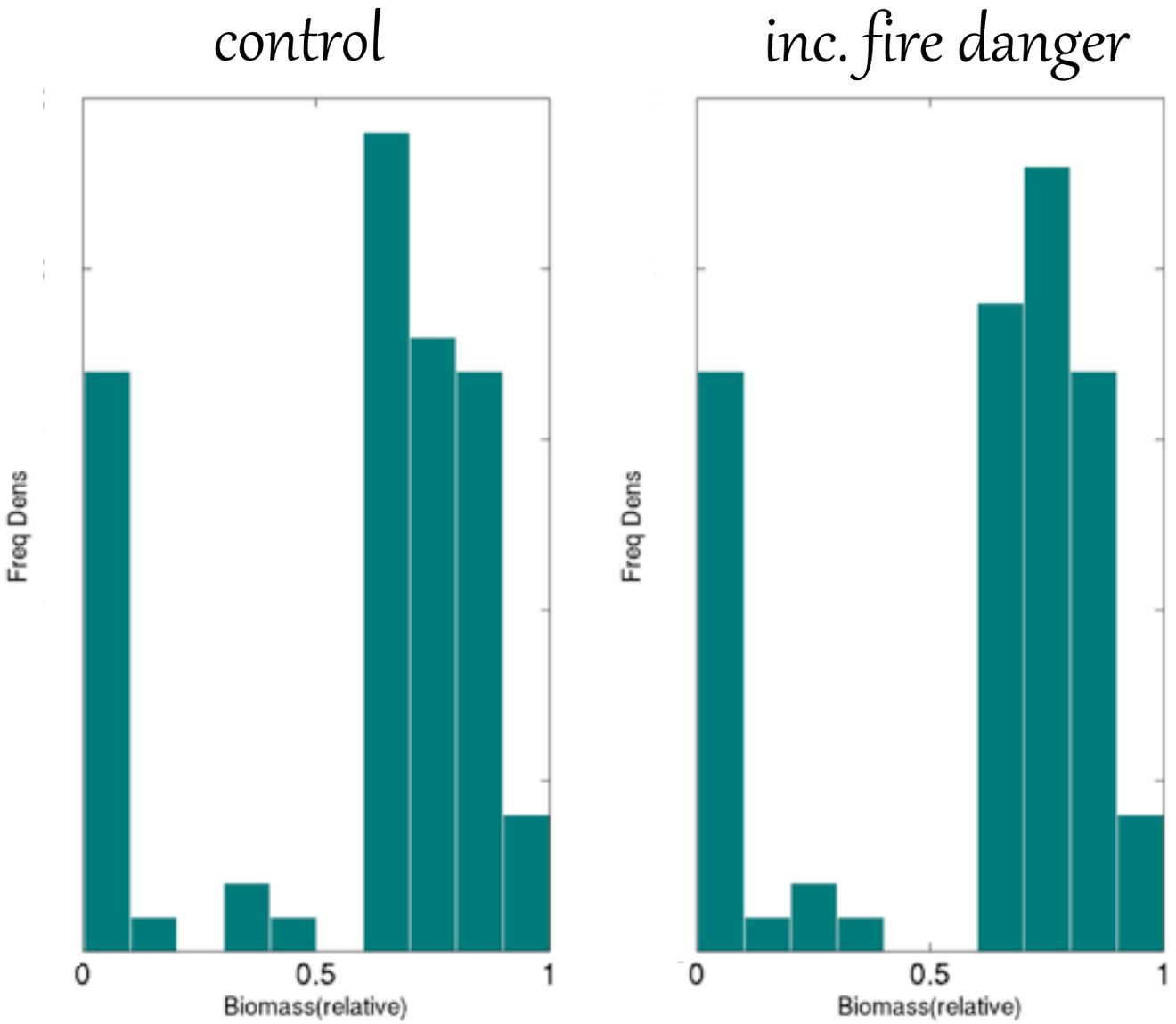
reduced flammability feedback



- Grass leaves are less flammable
- Smaller fires = tree survival.
- Very slight response to doubled fire danger



standard model



- Forest cover is too high
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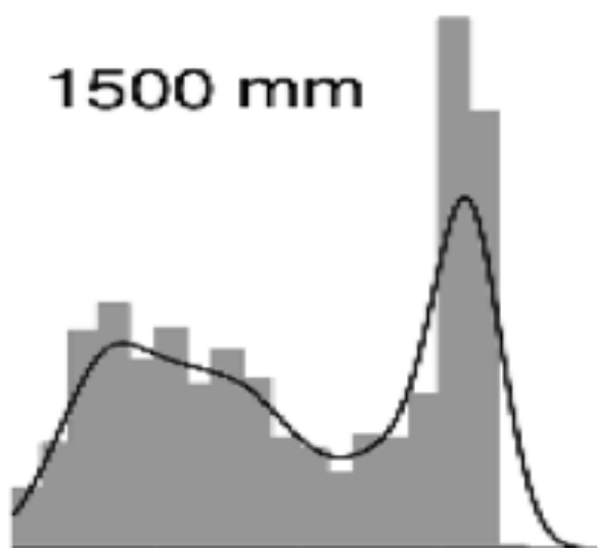
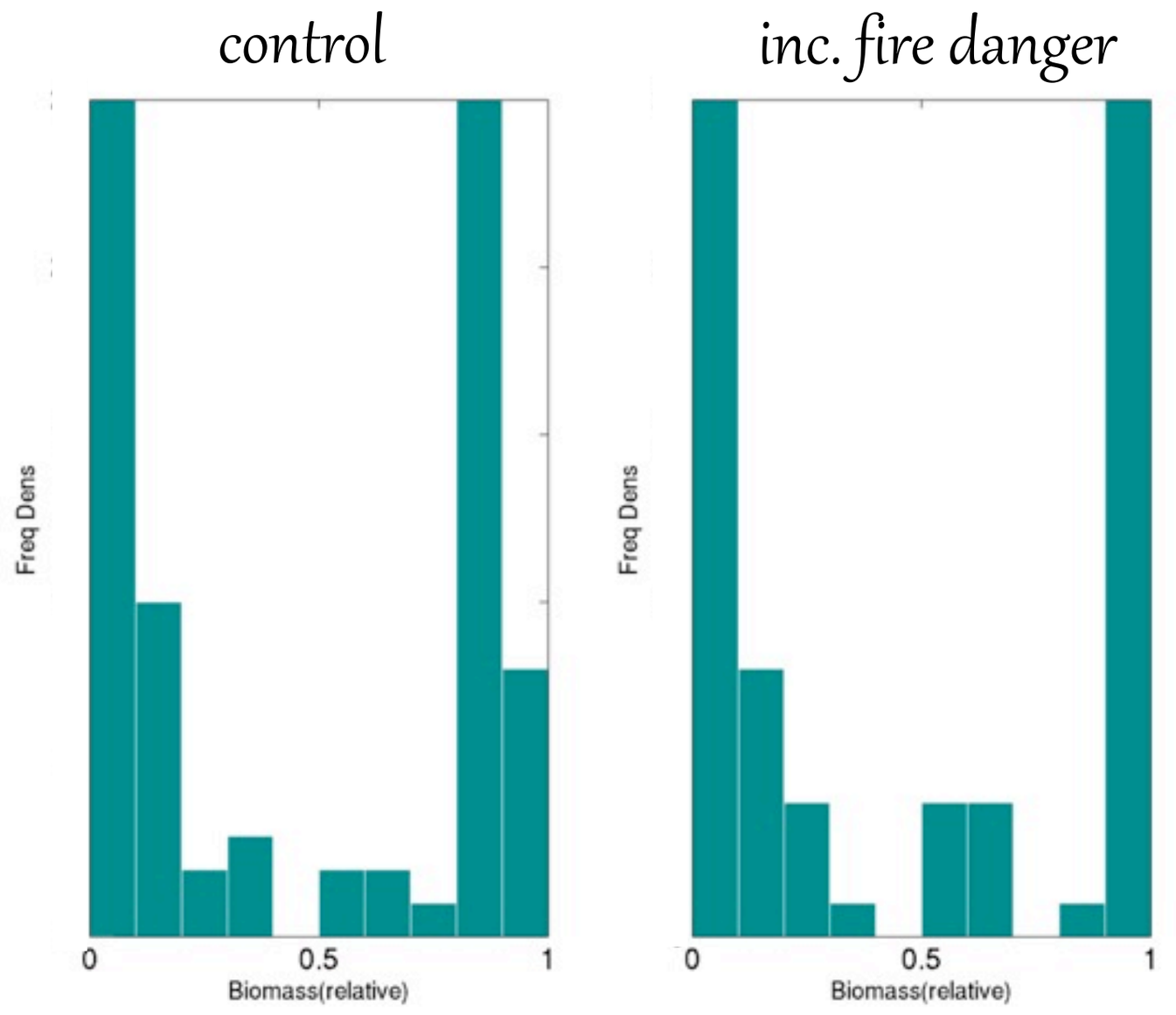
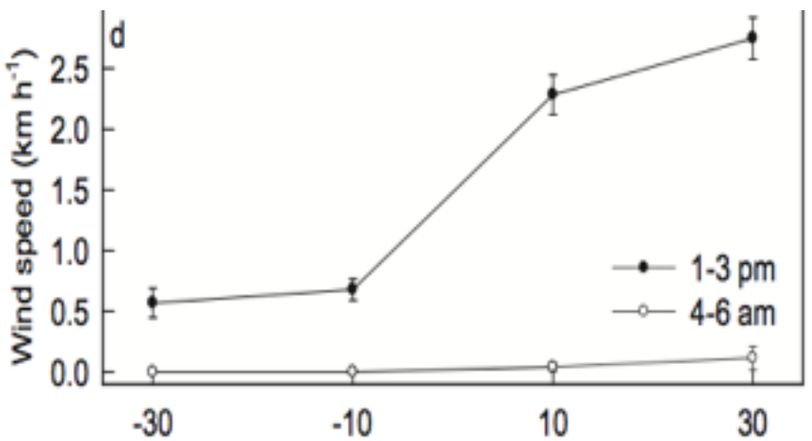


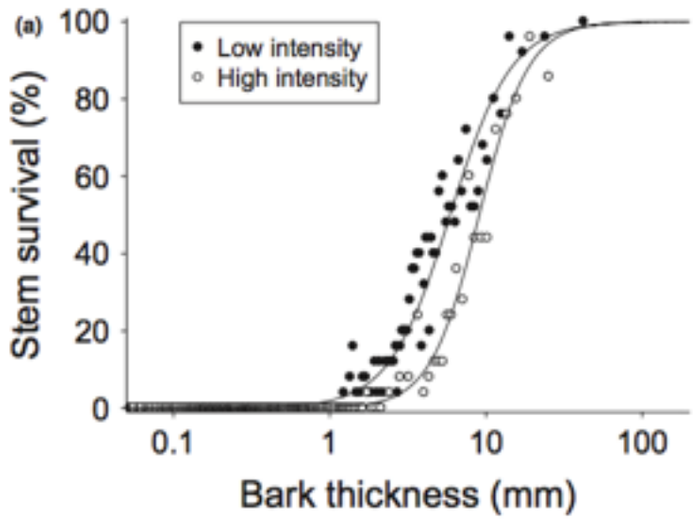
reduced demographic feedback

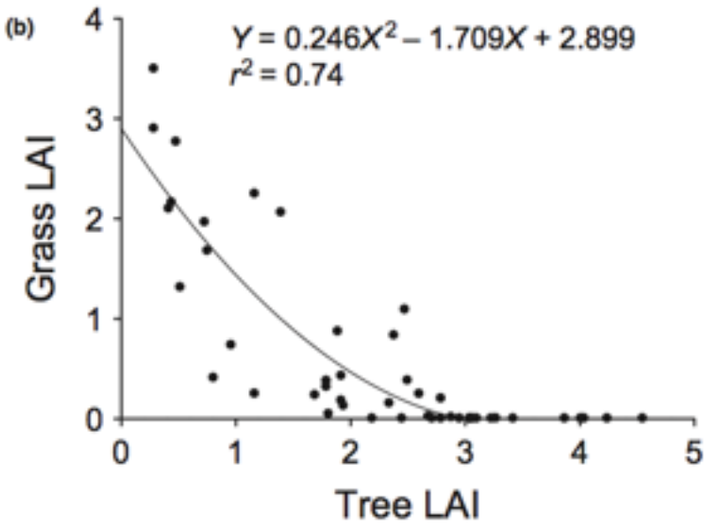


- Trees are less resilient to fire (10x lower bark allocation)
- Causes death of trees
- Still only a slight response to doubled fire danger

- The standard fire-vegetation model is extraordinarily resilience to shifts in climatic fire danger
- These hypotheses are typically parametrized for non-savanna systems (Arizona, Wyoming & China)
- The new model will be developed in tandem with recently collected data, and a new experimental burning system in Brazil.

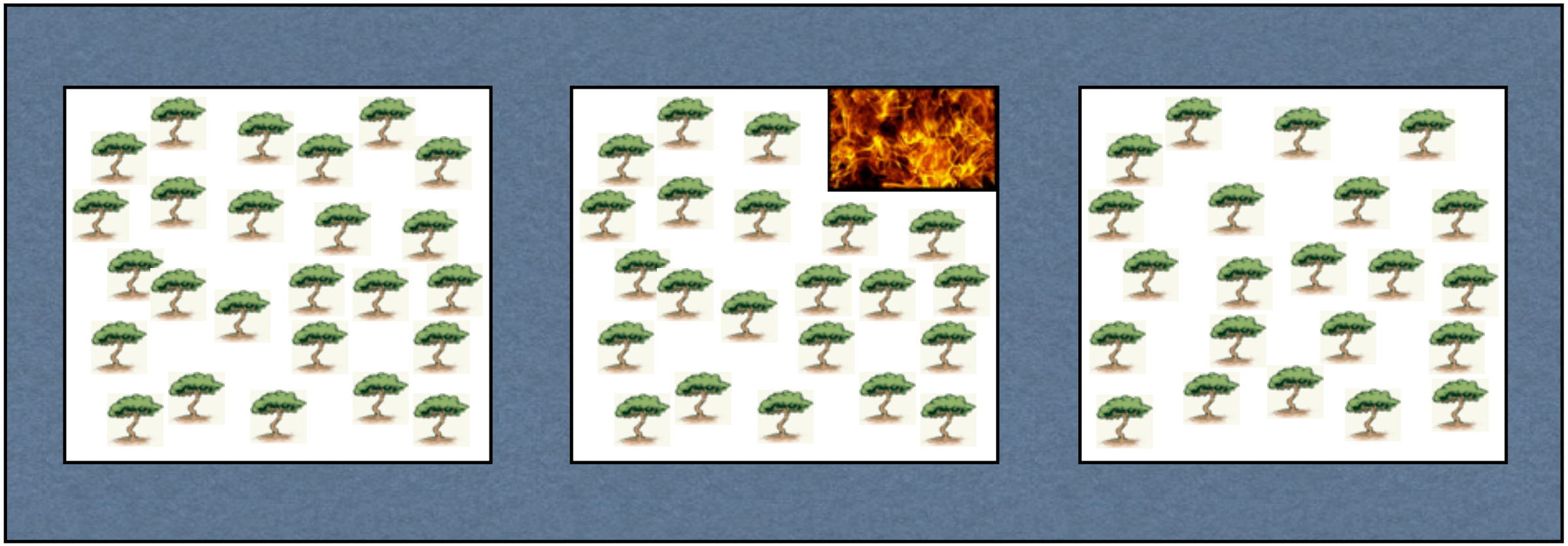




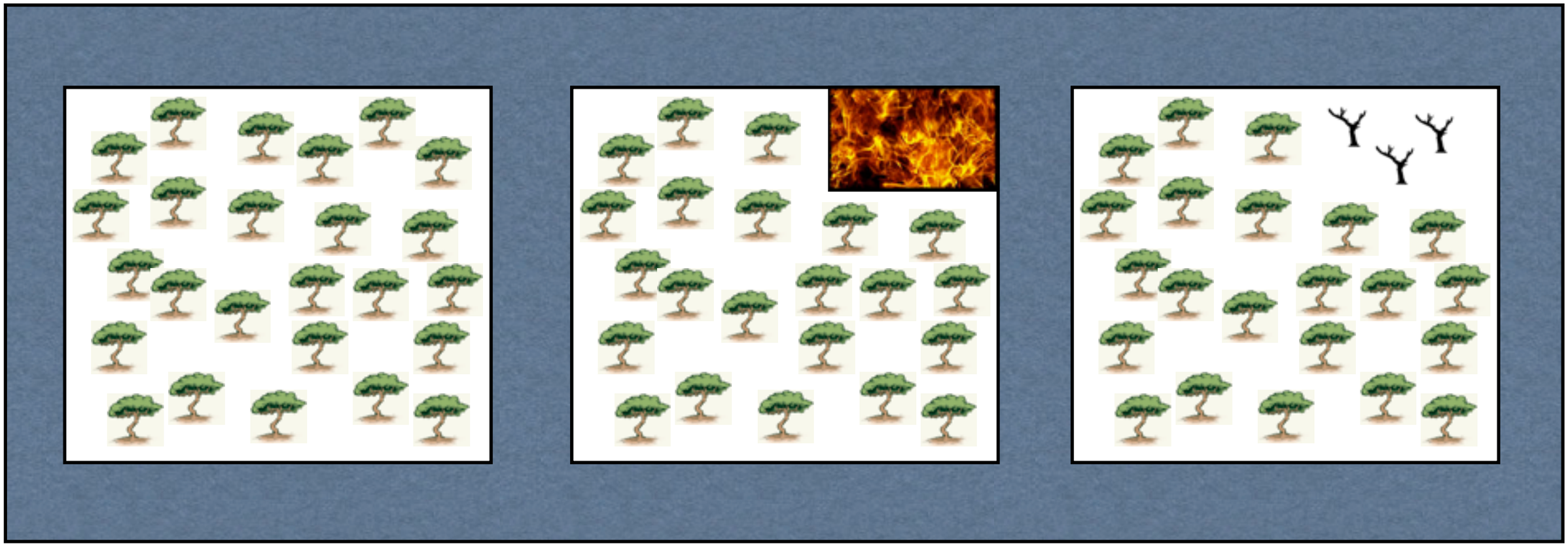


Hoffman et al. 2011, 2012, 2013

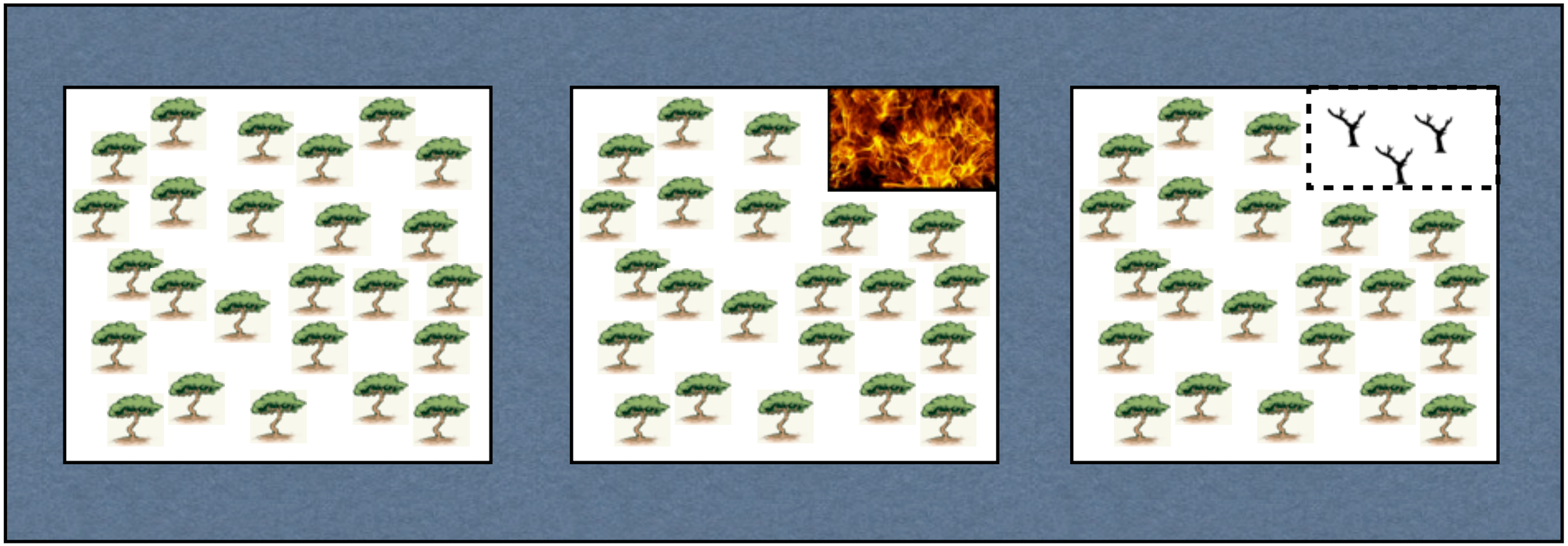
Fire models and area averaging



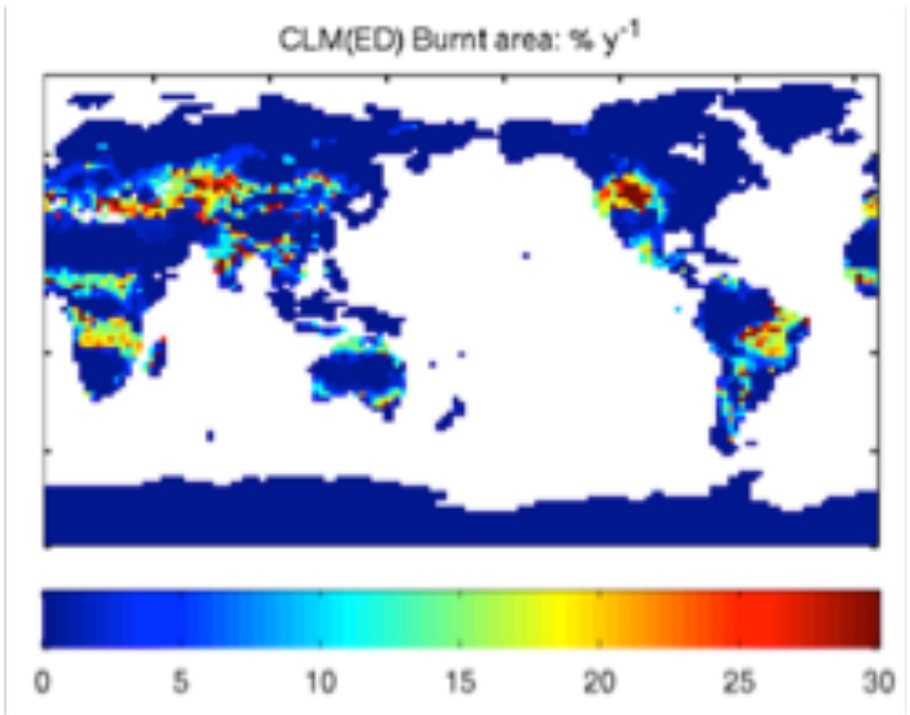
In the real world...

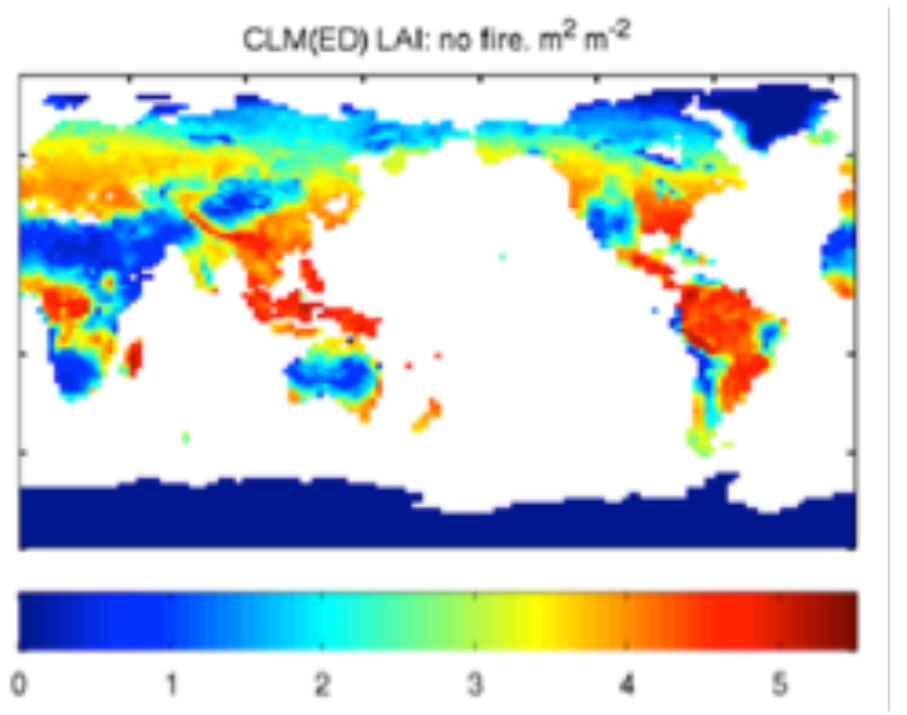


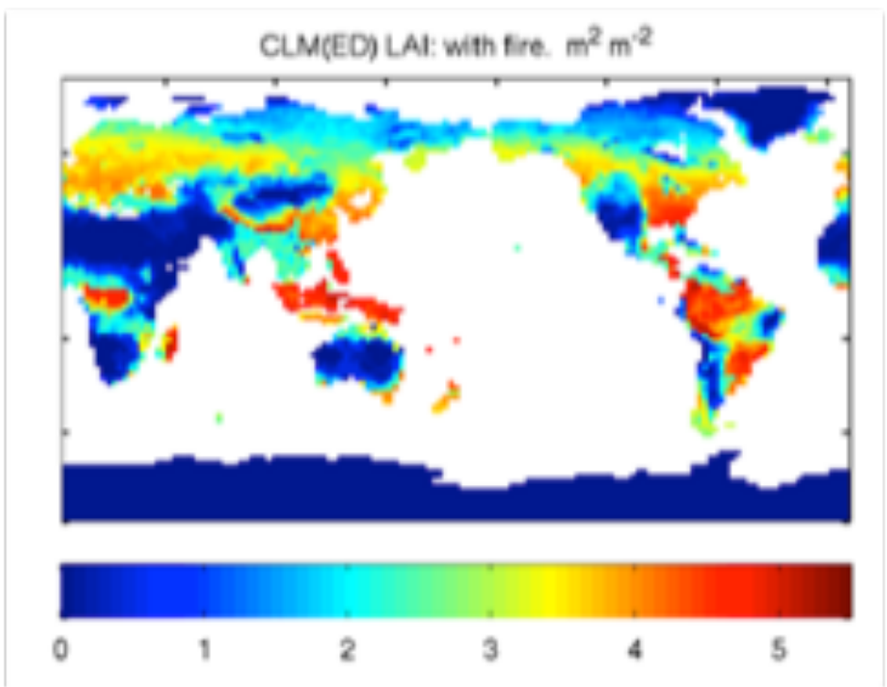
In the Ecosystem Demography world...

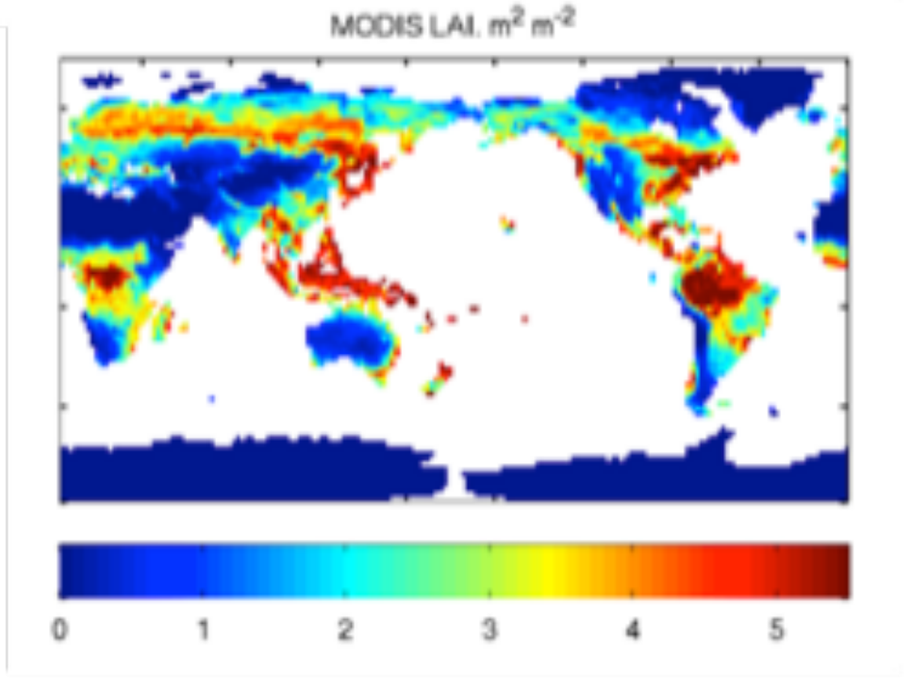


Impacts of global fire

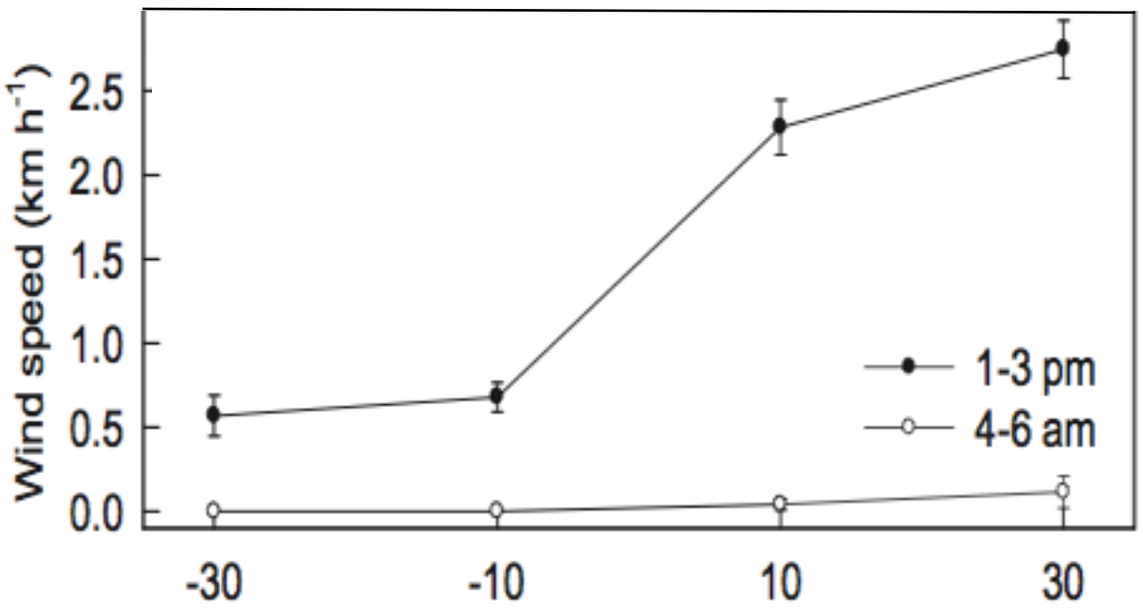




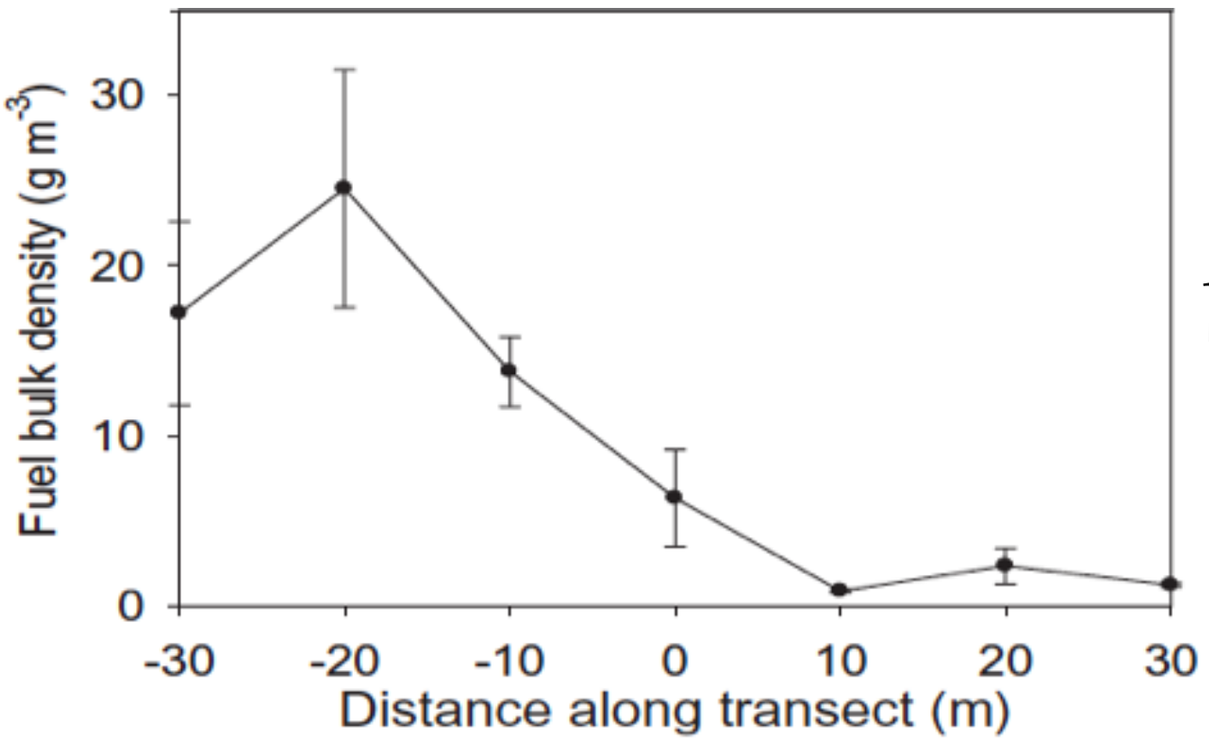




Observations from Brazilian savanna



Wind feedback



Flammability feedback

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Fire theory says that forest boundaries are subject to positive reinforcement