Exploring regimes of tropical forest PFT competition in FATES

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NGEE–TROPICS
NEXT-GENERATION ECOSYSTEM EXPERIMENTS

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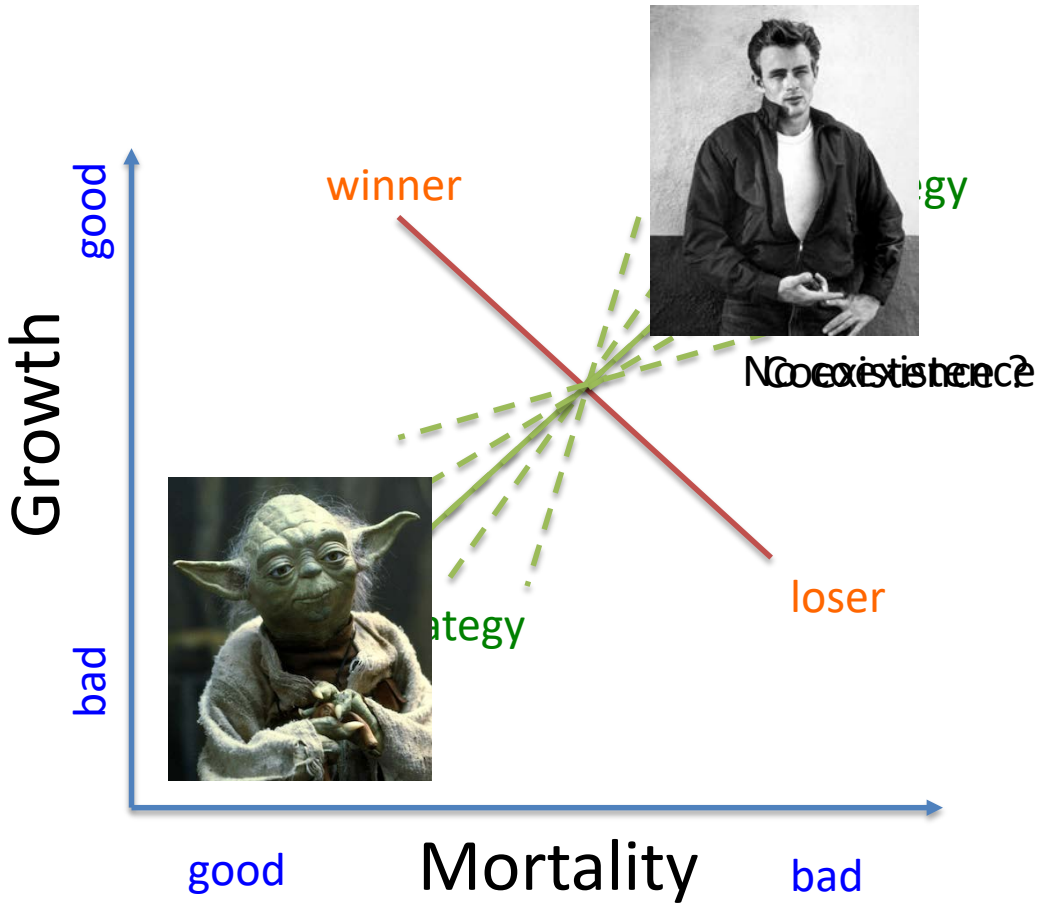
Basic goal of FATES: predict changes to plant trait distributions via trait filtering

- Competitive interactions determine distribution of PFTs at a given site.
- Need multiple PFTs at a given site so that they can compete with each other.
- Coexistence between PFTs not guaranteed, and in genera may be difficult to attain, thus we would like to know something about how to identify regimes where coexistence is possible

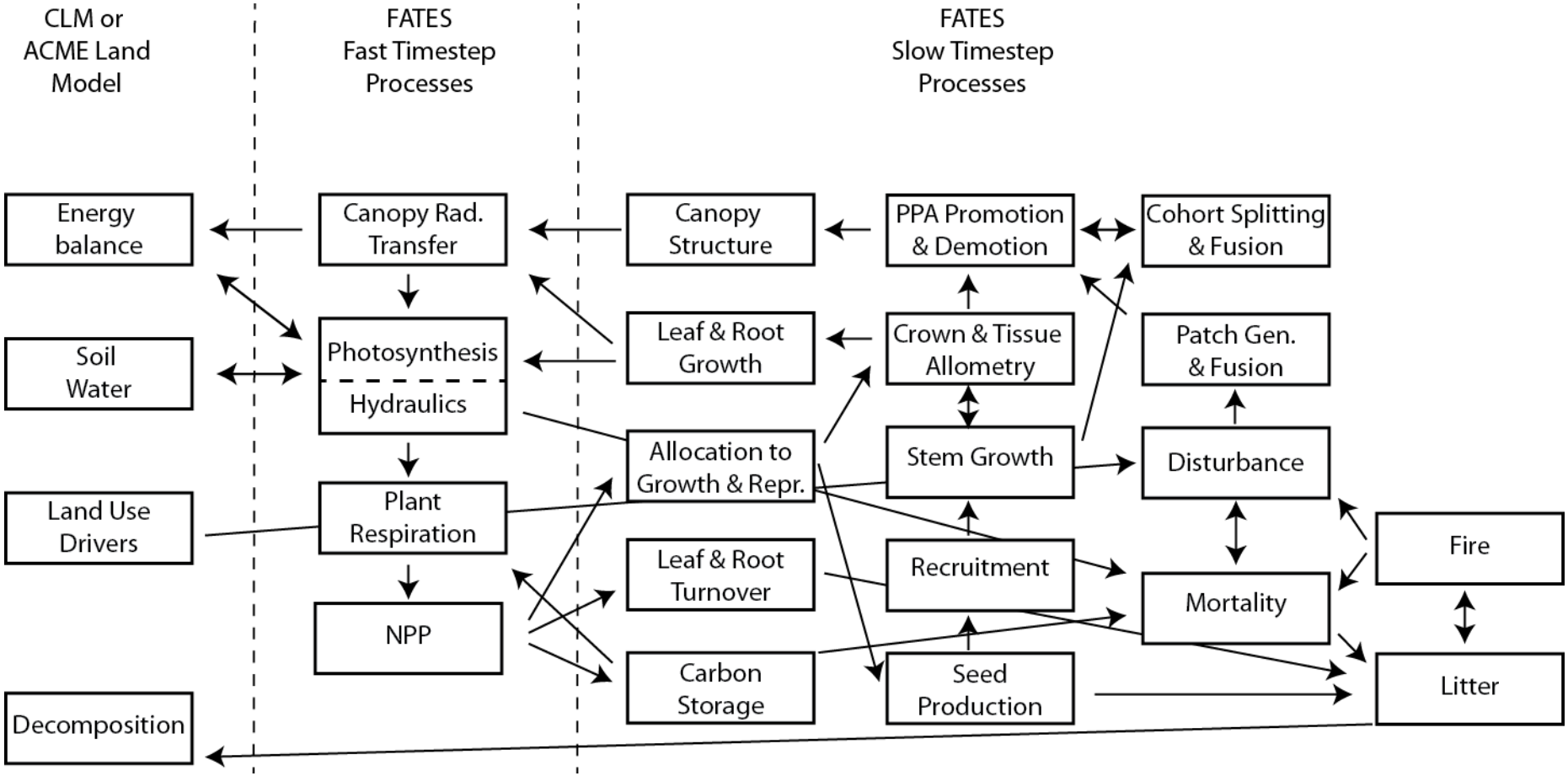
Anatomy of a tradeoff



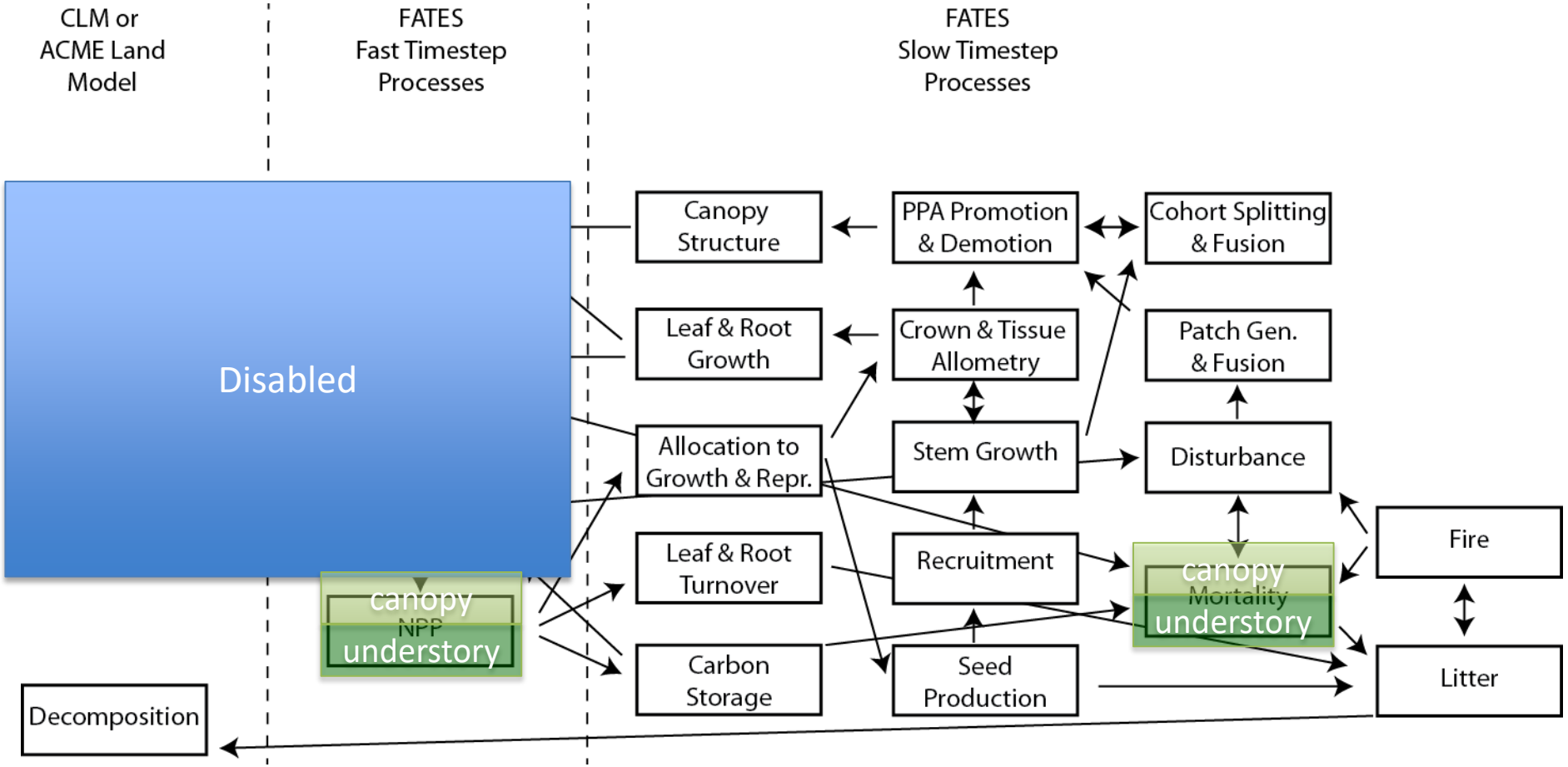
Goal here for this talk:

- Explore domains where PFTs can/can't coexist, within a parameter space relevant for closed-canopy tropical forests.
- How do structural (non-PFT) parameters shift the balance of a successful strategy or increase/decrease the size of the domain of coexistence?

FATES schematic



FATES-Prescribed Physiology Mode
Blue: disabled; Green: Prescribed

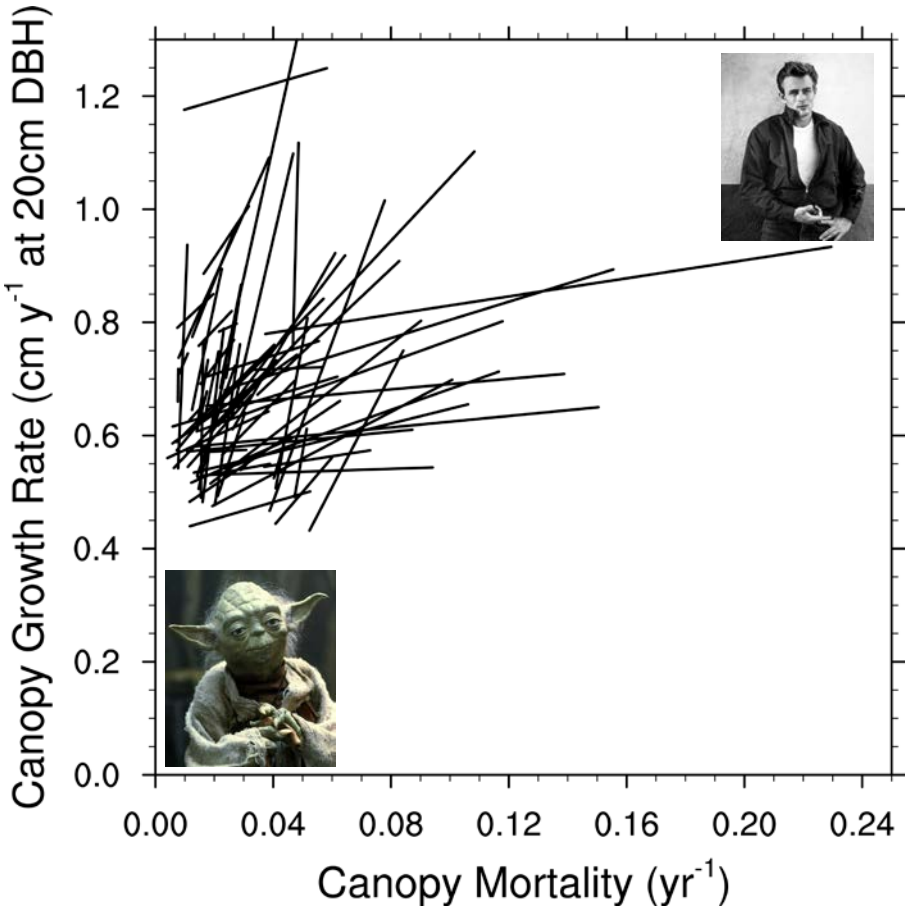


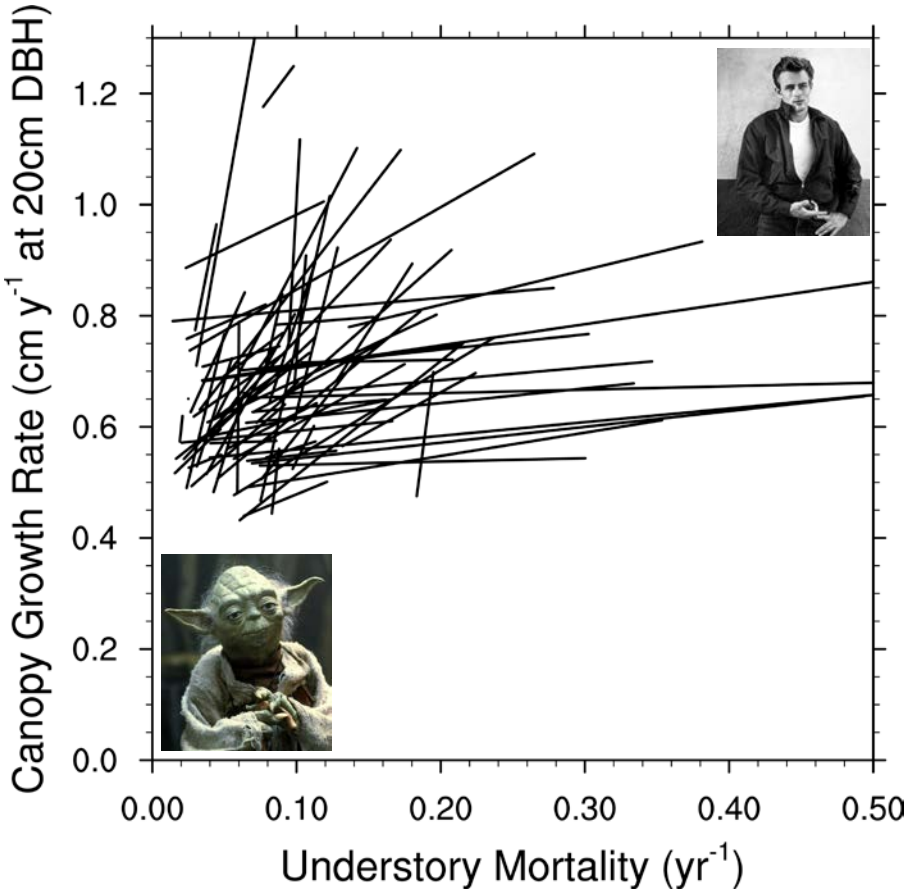
Allows efficient sampling of rates that directly govern outcomes

Experimental Setup

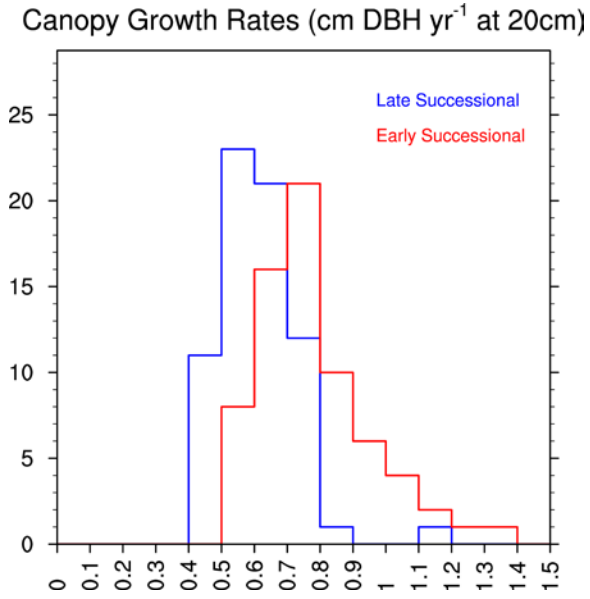
- Randomly sample a growth and mortality space as a 6-D Latin hypercube design, 68 ensemble members:
  - 2 PFTs: early successional (fast) and late successional (slow)
  - 3 traits:
    - wood density (=> growth rate)
    - canopy mortality rate
    - understory mortality rate
  - Only considering ecologically meaningful subset of trait combinations (so a Latin hyperwedge):
    - mortality(early) > mortality(late)
    - Growth(early) > growth(late)
    - Understory mortality > canopy mortality
  - Run for 1000 years. Who, if anyone, wins?

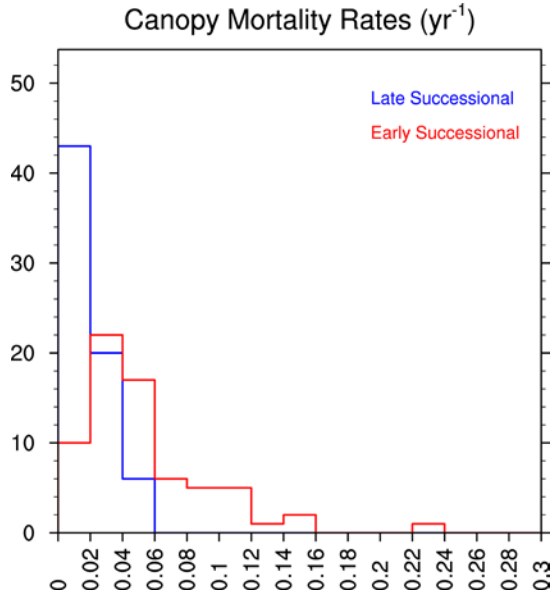
Parameter combinations

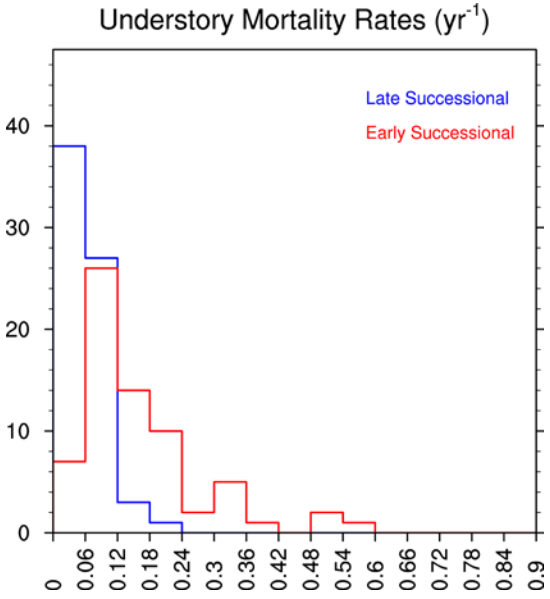




Overall parameter distributions



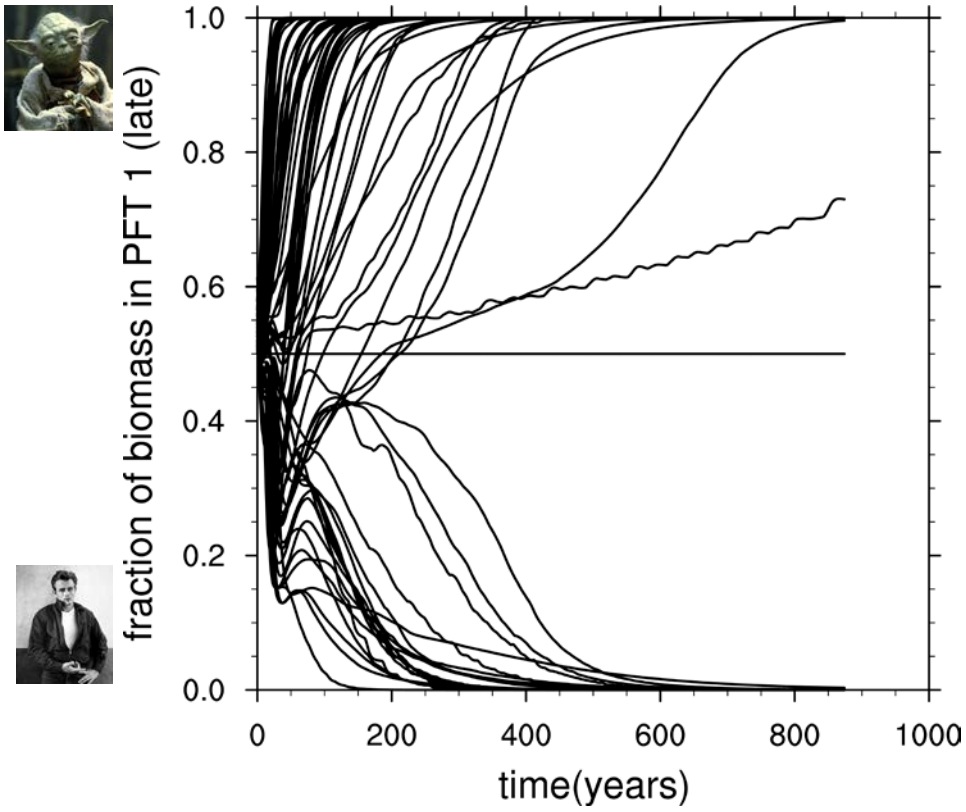


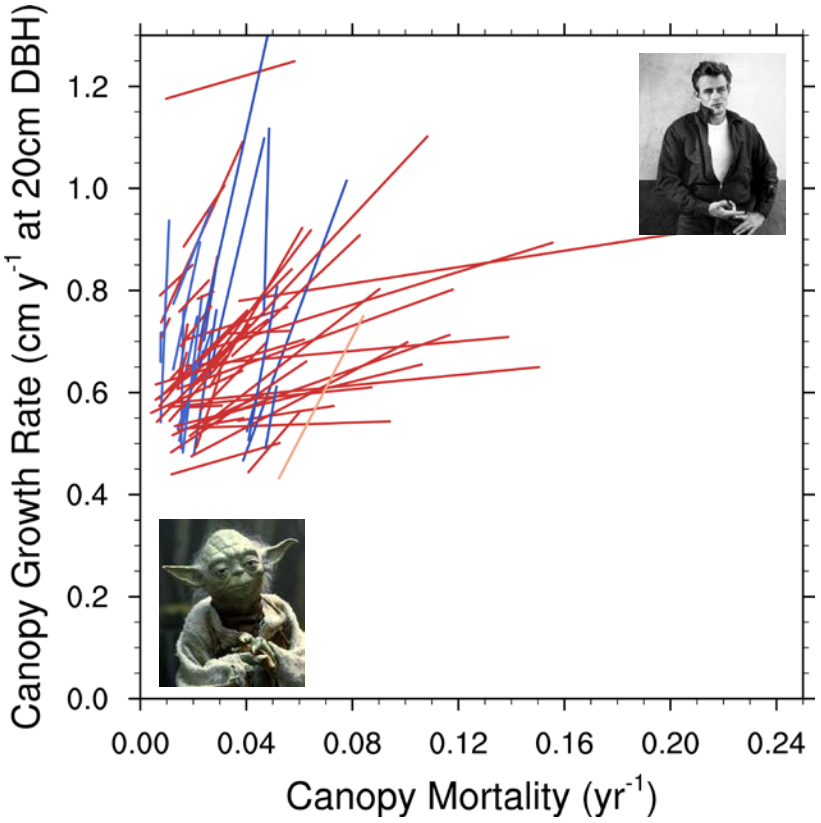


Early Successional

Late Successional

Results, base case, after 1000 years

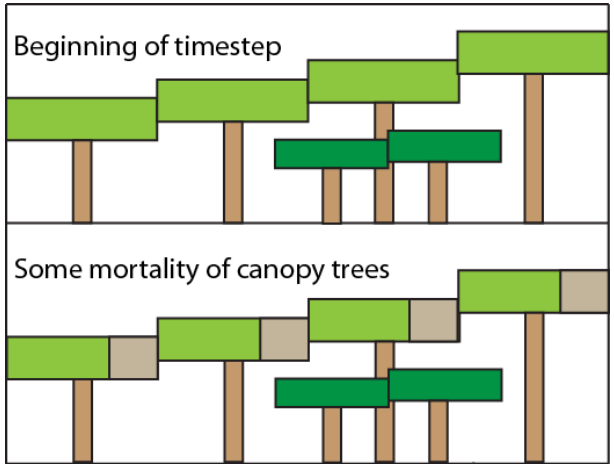




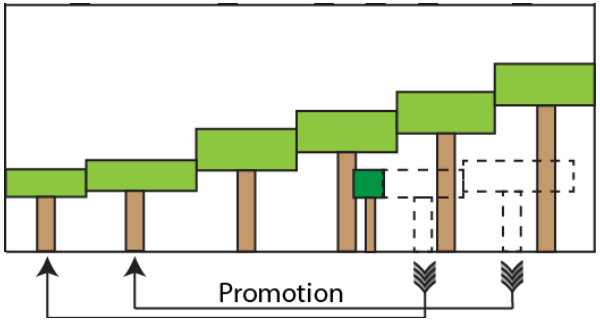
No coexistence!

(except in case where PFTs are identical)

Multiple ways of representing patch heterogeneity with disturbance

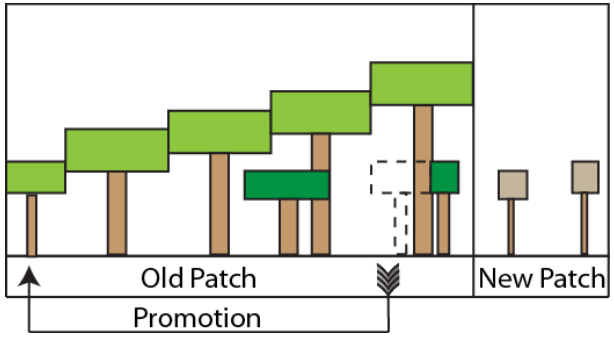


"Pure PPA Disturbance"



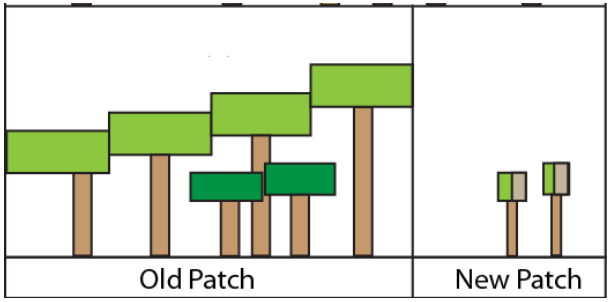
Accommodate all disturbance by rearranging within patch

"Mixed ED-PPA Disturbance"



Create smaller amount of unoccupied patch area

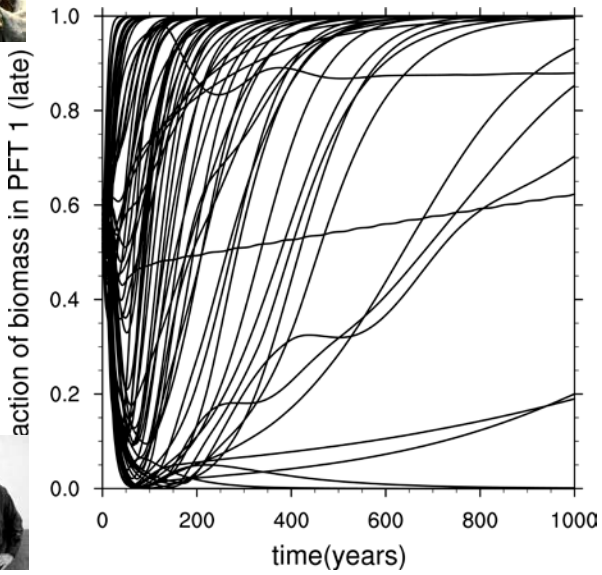
"Pure ED Disturbance"



Resolve disturbance by creating new (occupied) patch area

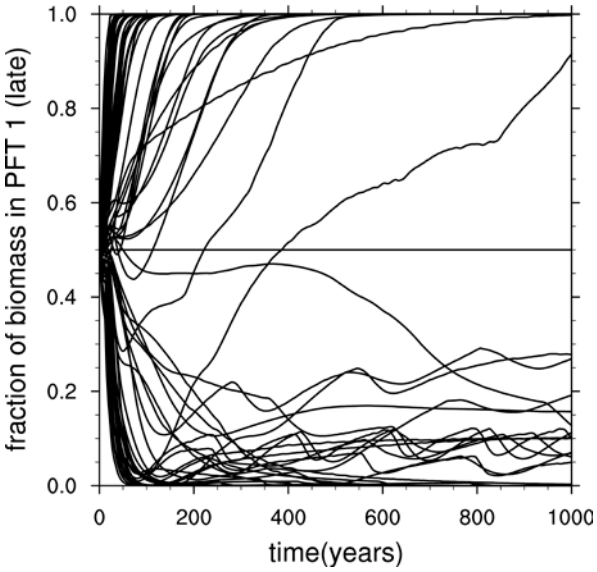
What if we vary patch heterogeneity?

"Pure PPA Disturbance"



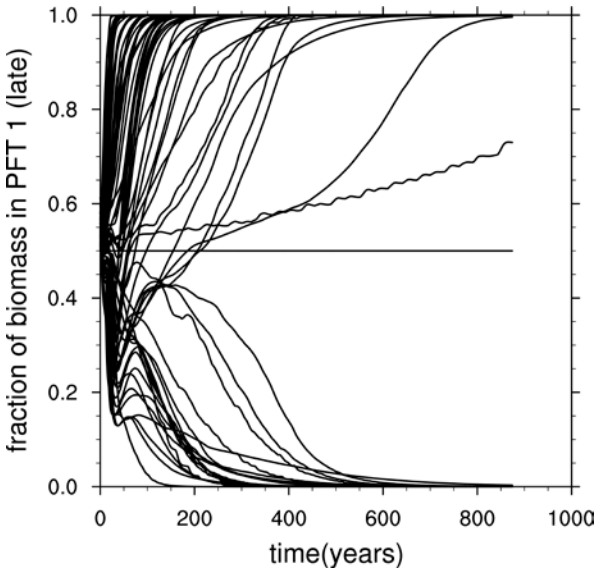
Lowest heterogeneity: Outliving your competitor is almost always the best strategy.

"Mixed ED-PPA Disturbance"



Highest heterogeneity: Coexistence is starting to seem possible here.

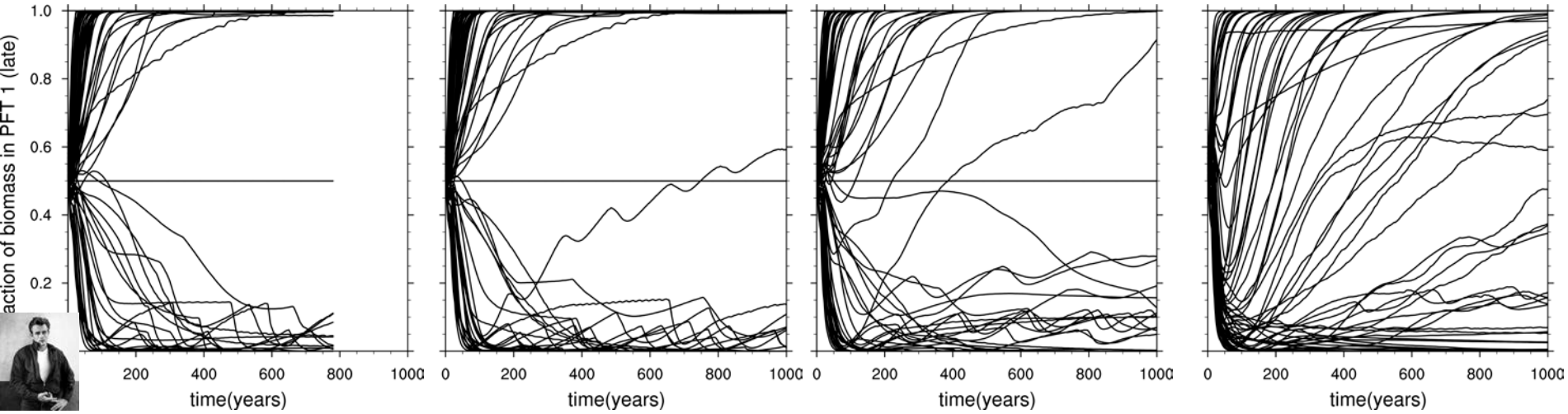
"Pure ED Disturbance"



Medium heterogeneity: Both strategies may succeed, but one always dominates.

What if we vary the efficiency of height sorting?

cmp_excln=0.5 cmp_excln=1.0 cmp_excln=3.0 Deterministic PPA



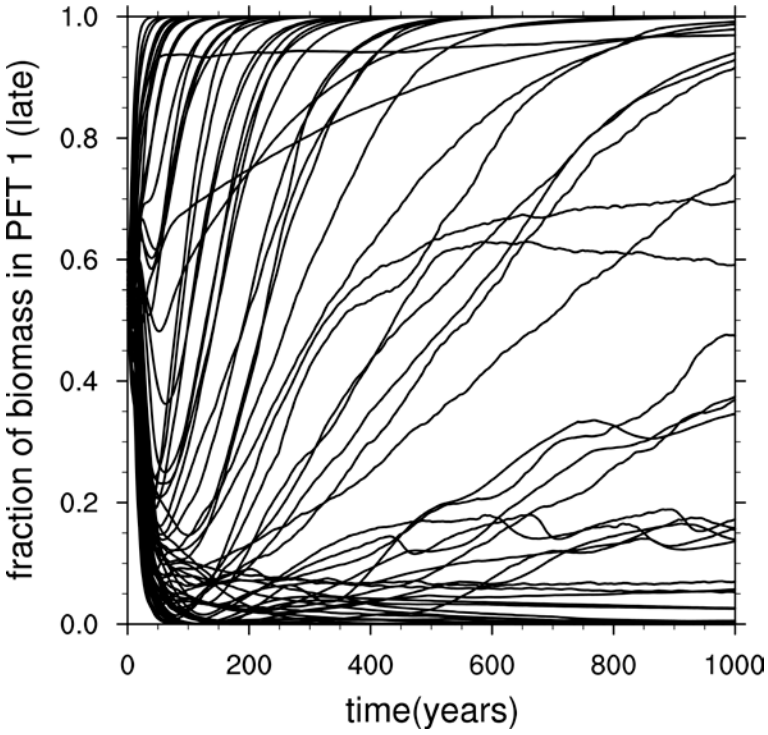
Less efficient height sorting

More efficient height sorting

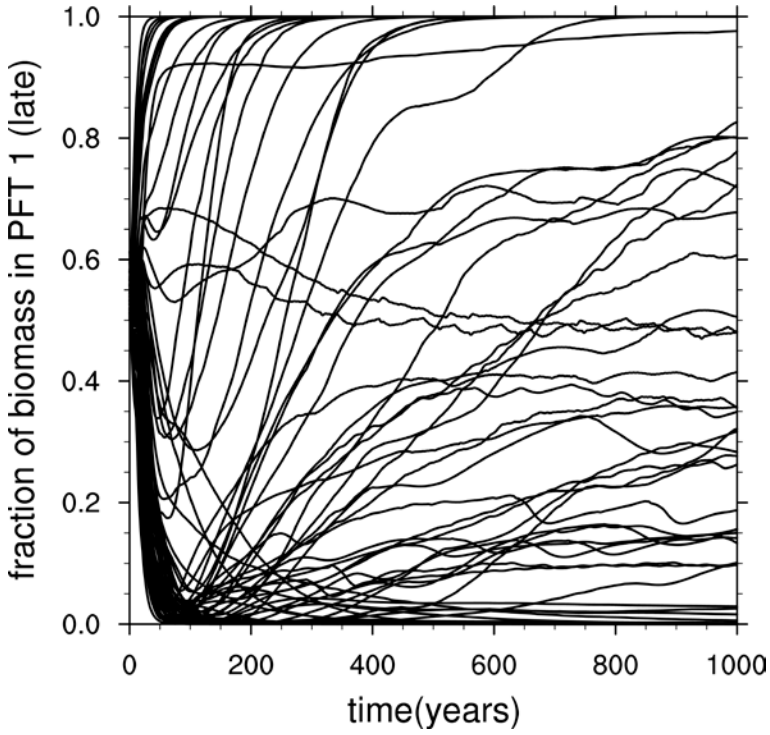
Reduced Coexistence

Increased Coexistence?

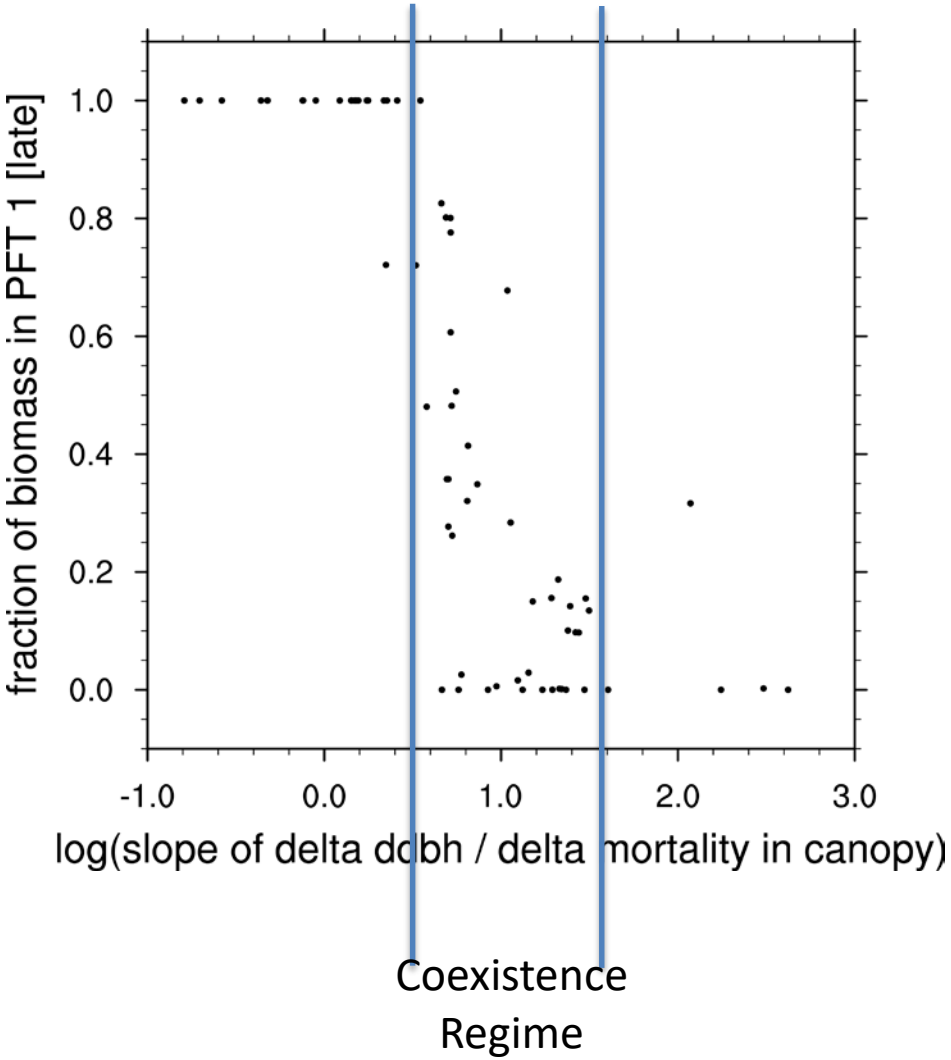
Maybe they need to invest more in the next generation?



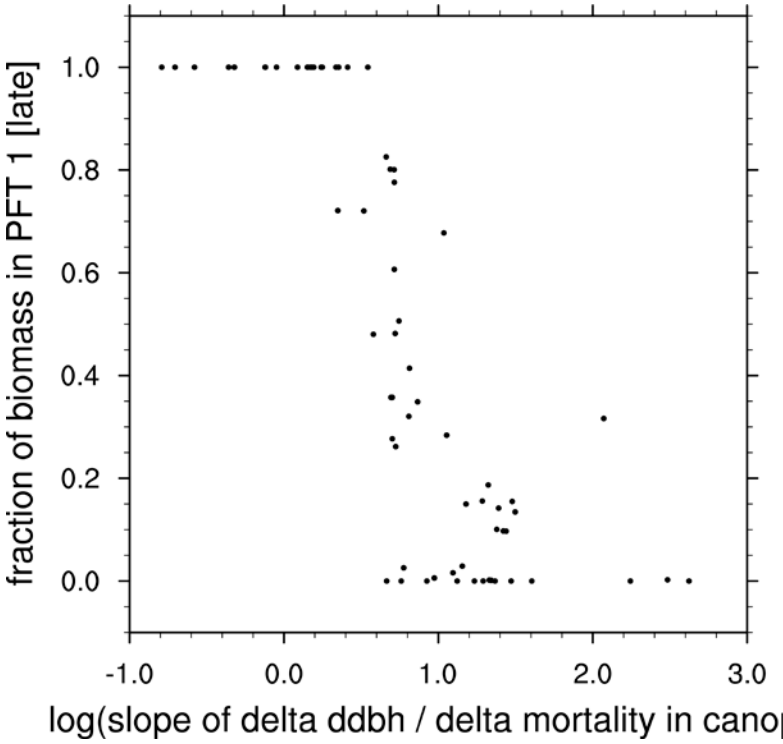
10x allocation to seeds (10% NPP)

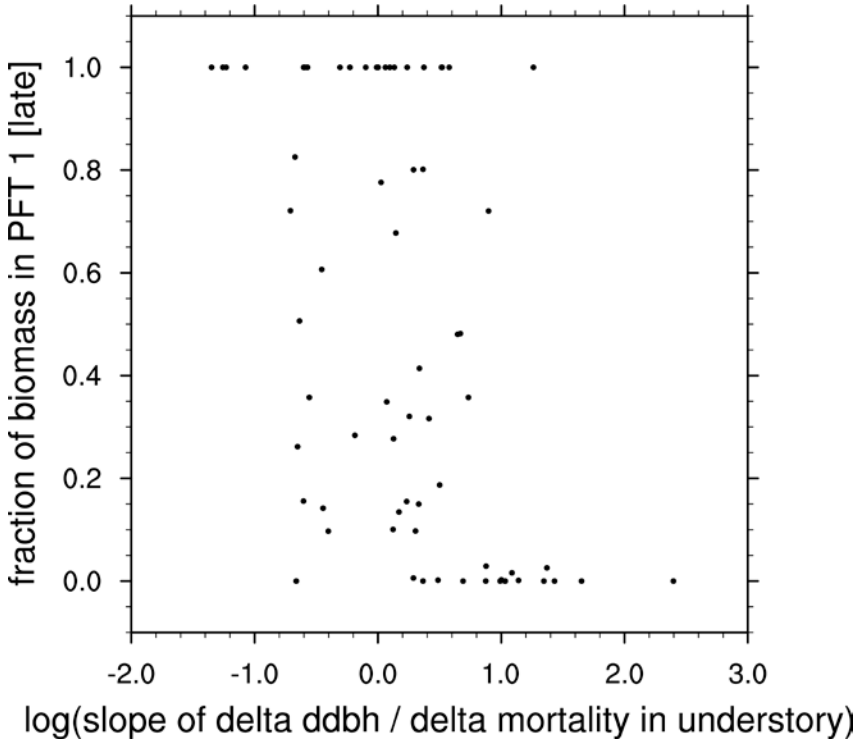


If conditions permit, we can have a reasonably broad range of coexistence



Interestingly, mortality in the canopy seems much more important than mortality in the understory





Conclusions

- Long-term (1000 year) coexistence or early-late successional PFTs is possible in FATES.
- PFT dynamics are complicated and slow!
- The range in which it is possible is a sensitive function of the rules of competition.
  - More height structure = wider coexistence
  - More patch heterogeneity = wider coexistence
  - More seed production = wider coexistence
- Canopy mortality differences more important than understory mortality differences in determining outcomes in FATES.