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CLM(ED) and the end of `vegetation dynamics'

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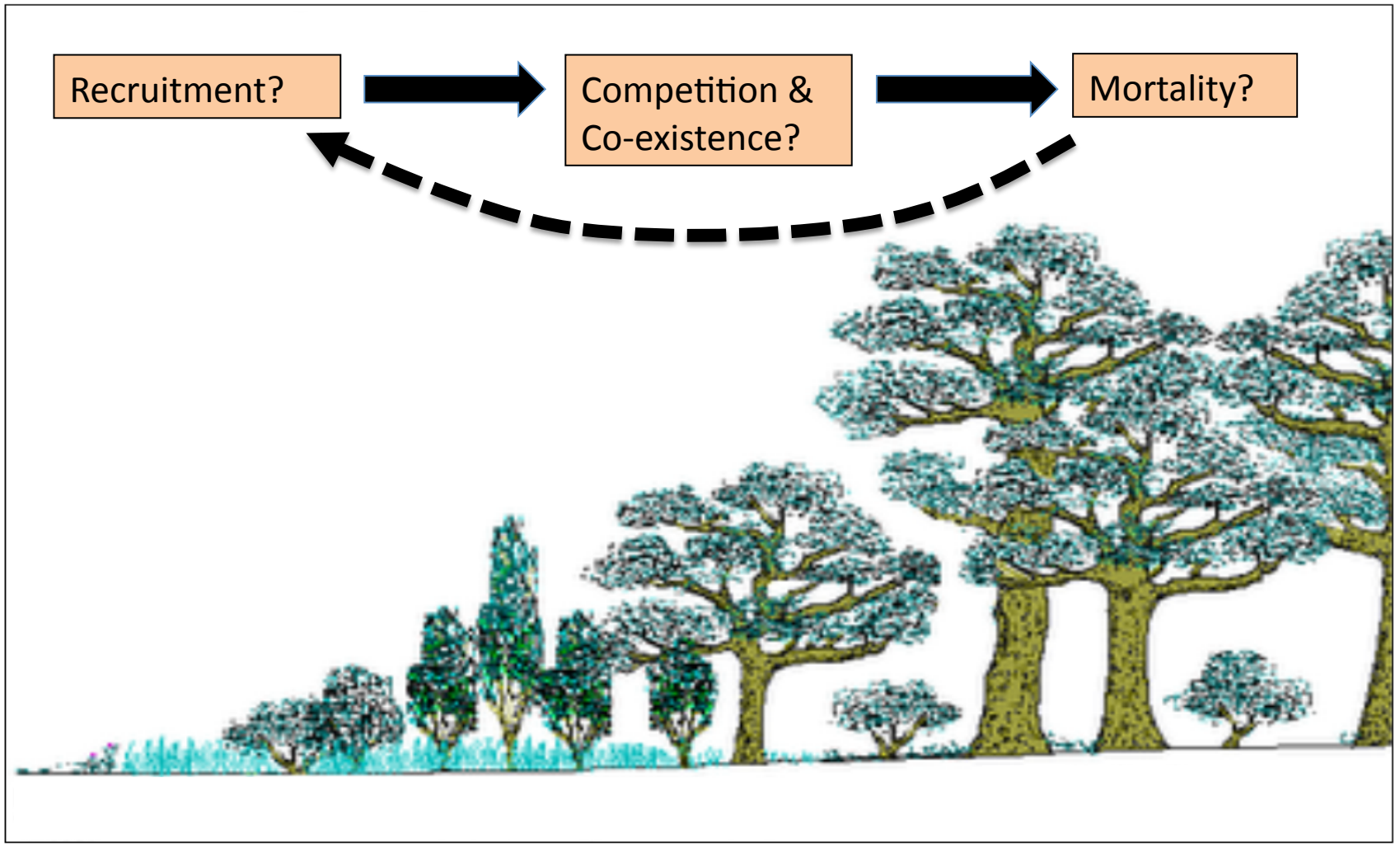
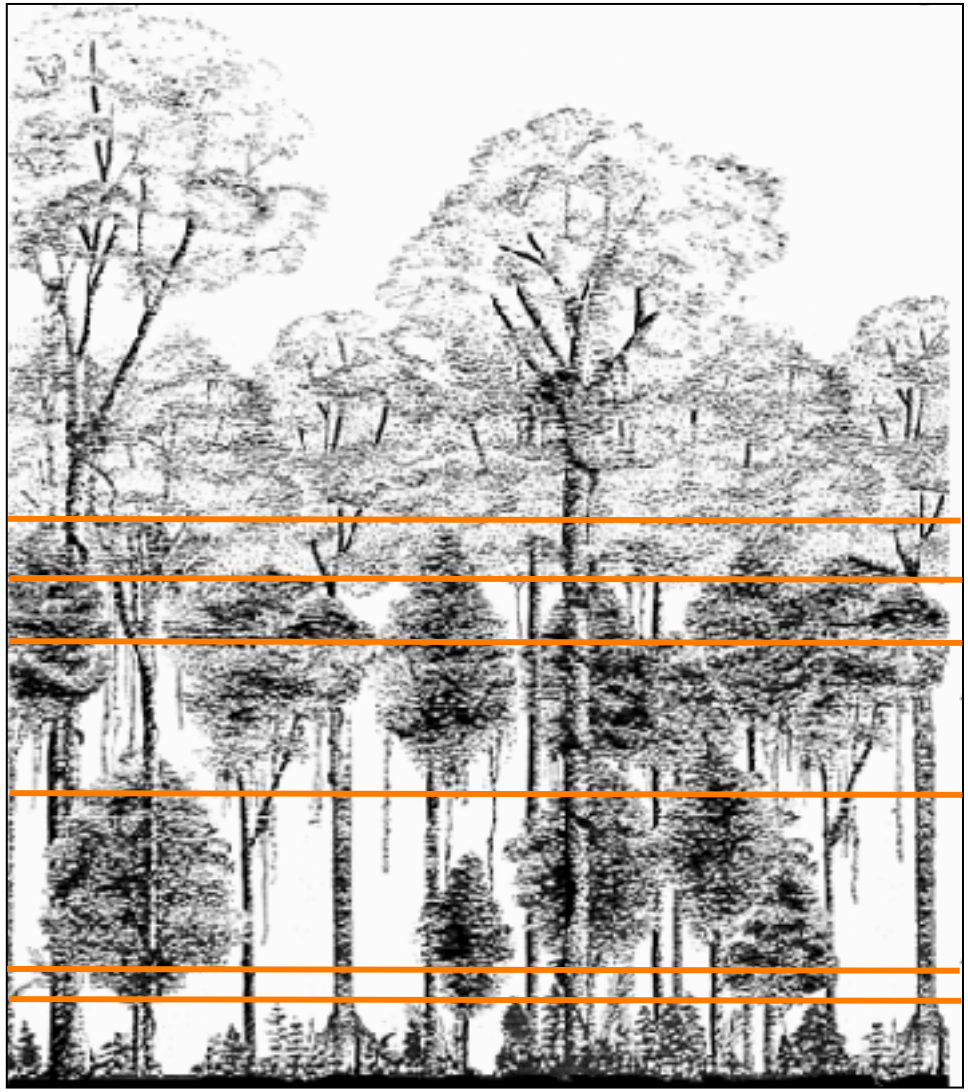
What is vegetation dynamics?



Ecosystem Demography Model (ED)

Moorcroft, Hurtt and Pacala (2001)

Plant competition as an emergent property of plant physiology…



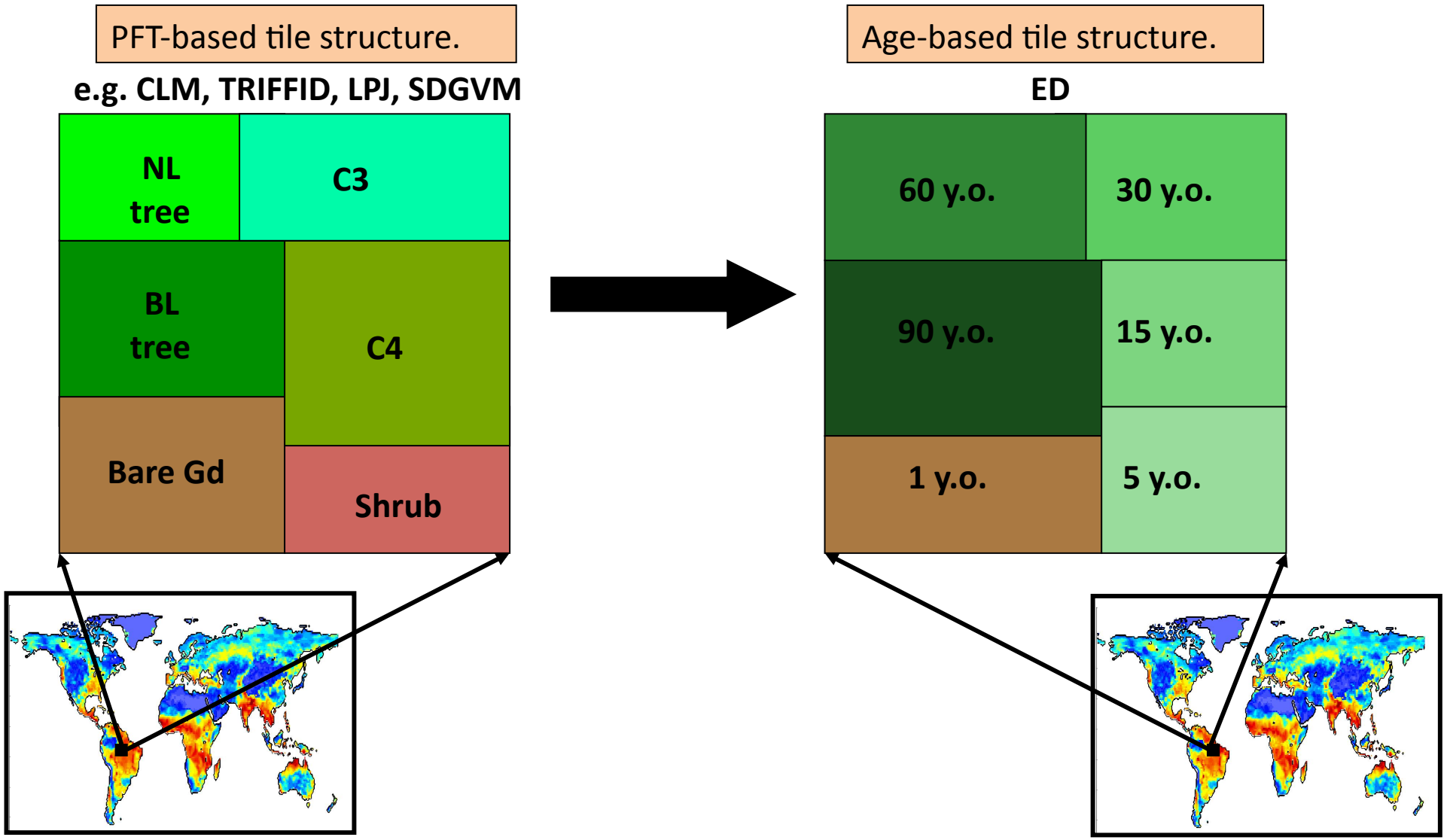
'Cohorts' of plants,
Binned according to:

1. Successional stage of land
2. Functional type of plant
3. Height class of plant

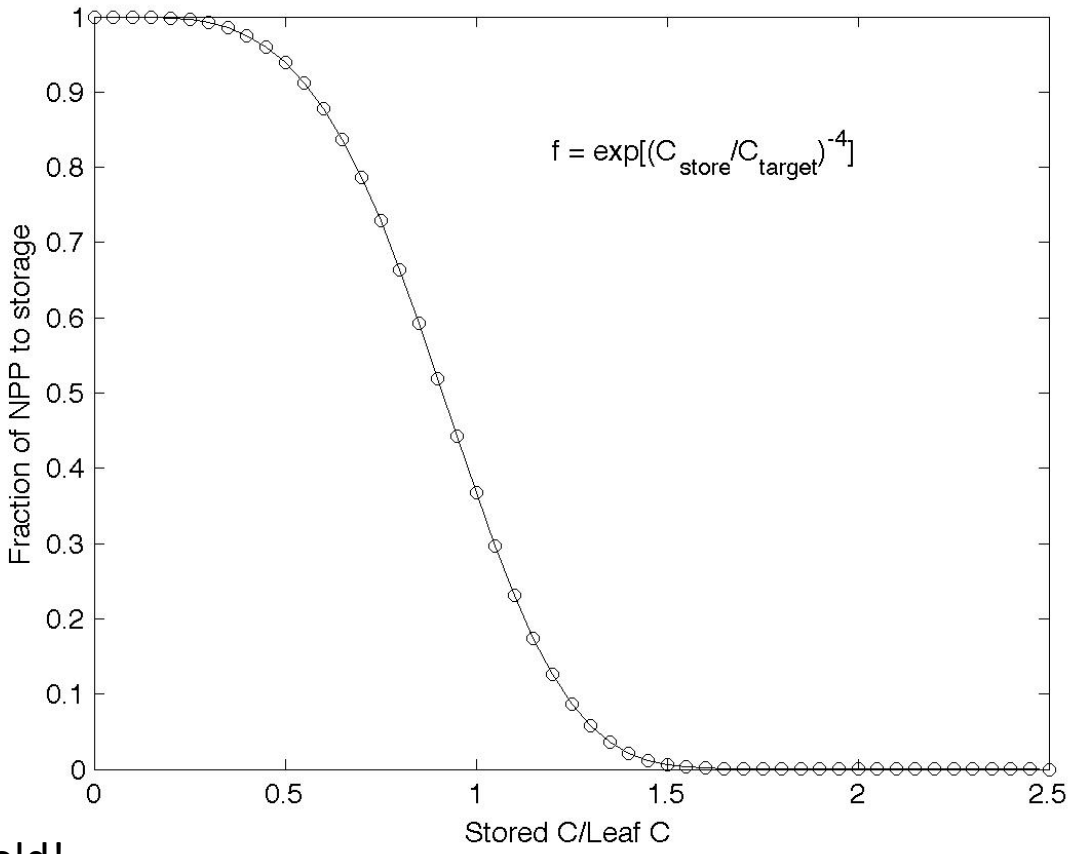
Provides a framework to simulate

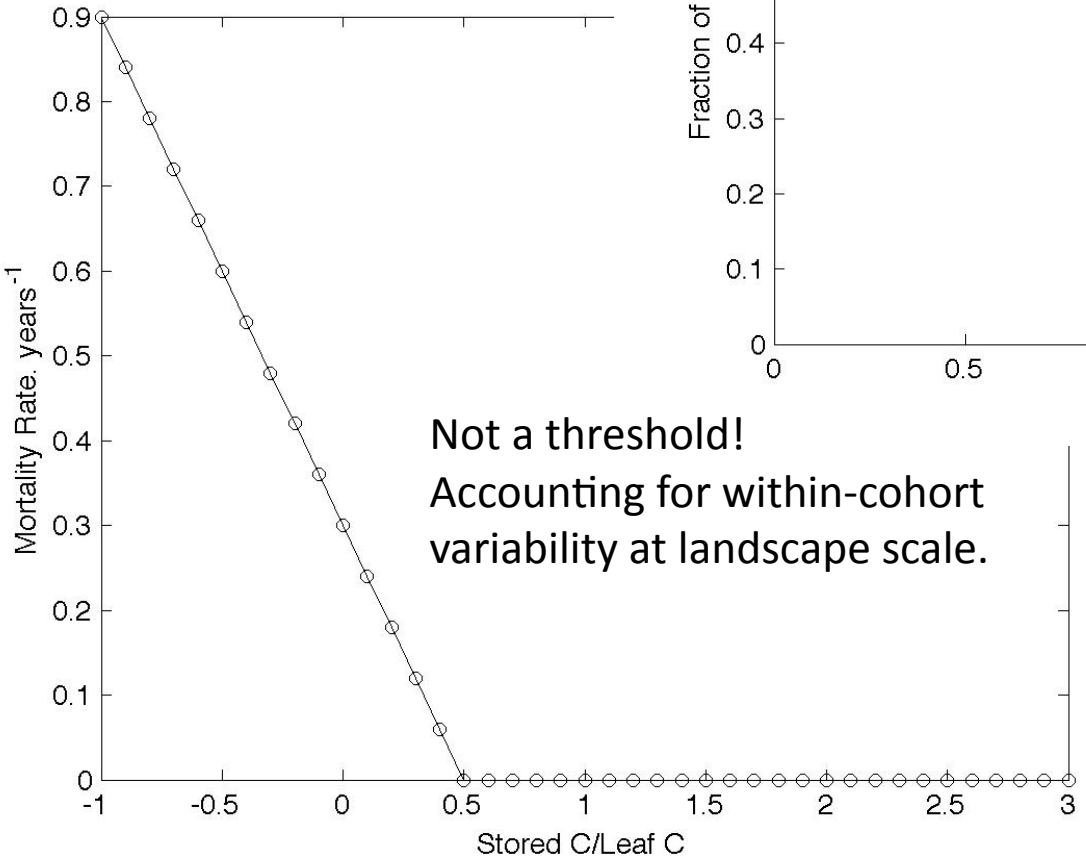
1. Competition for light
2. Coexistence between plant types...
3. Post-disturbance succession
4. Variable vegetation complexity

CLM(ED) changes to tiling structure



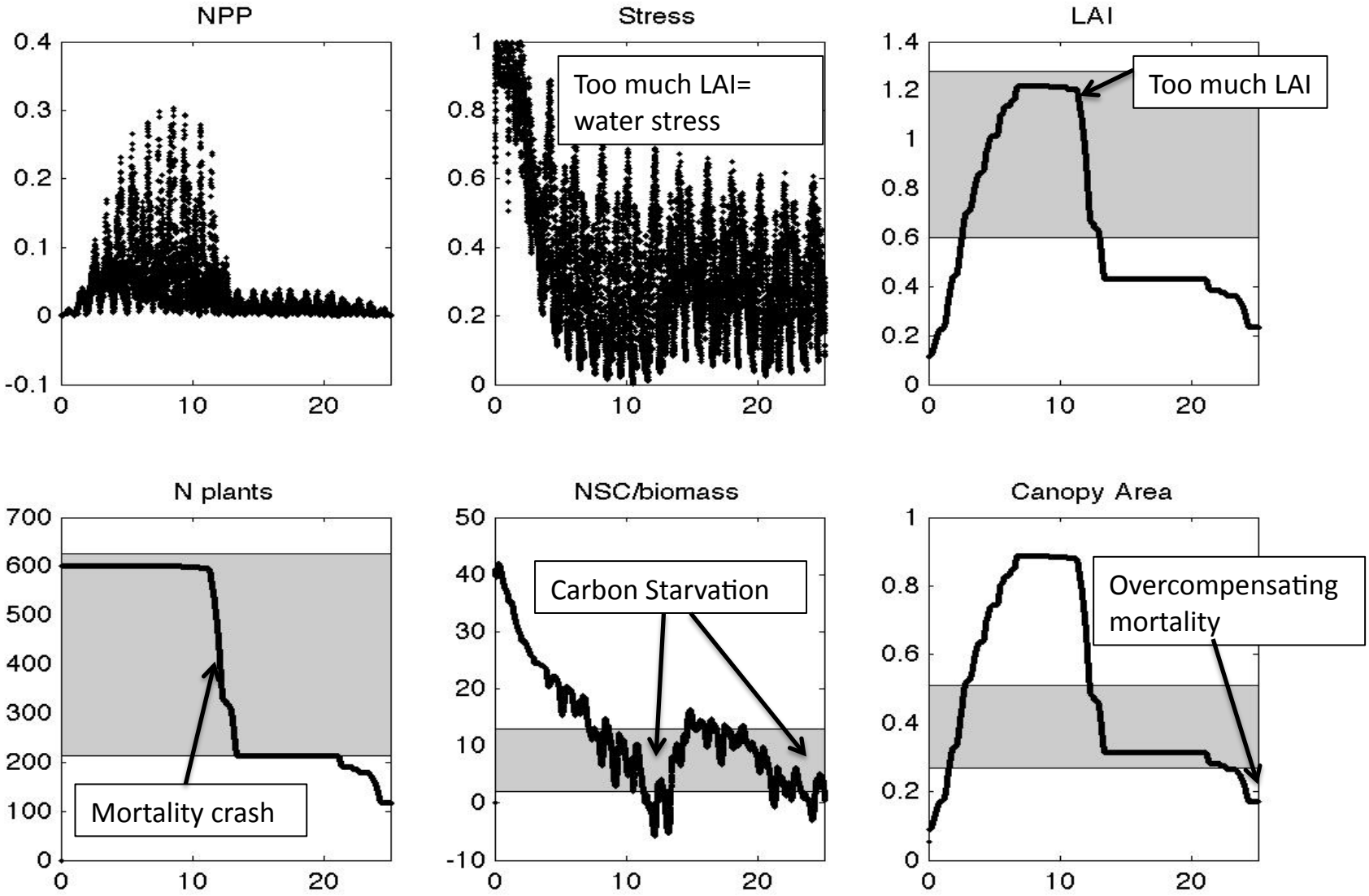
Mortality as a function of plant physiology v1.0: Carbon starvation





Not a threshold!
Accounting for within-cohort variability at landscape scale.

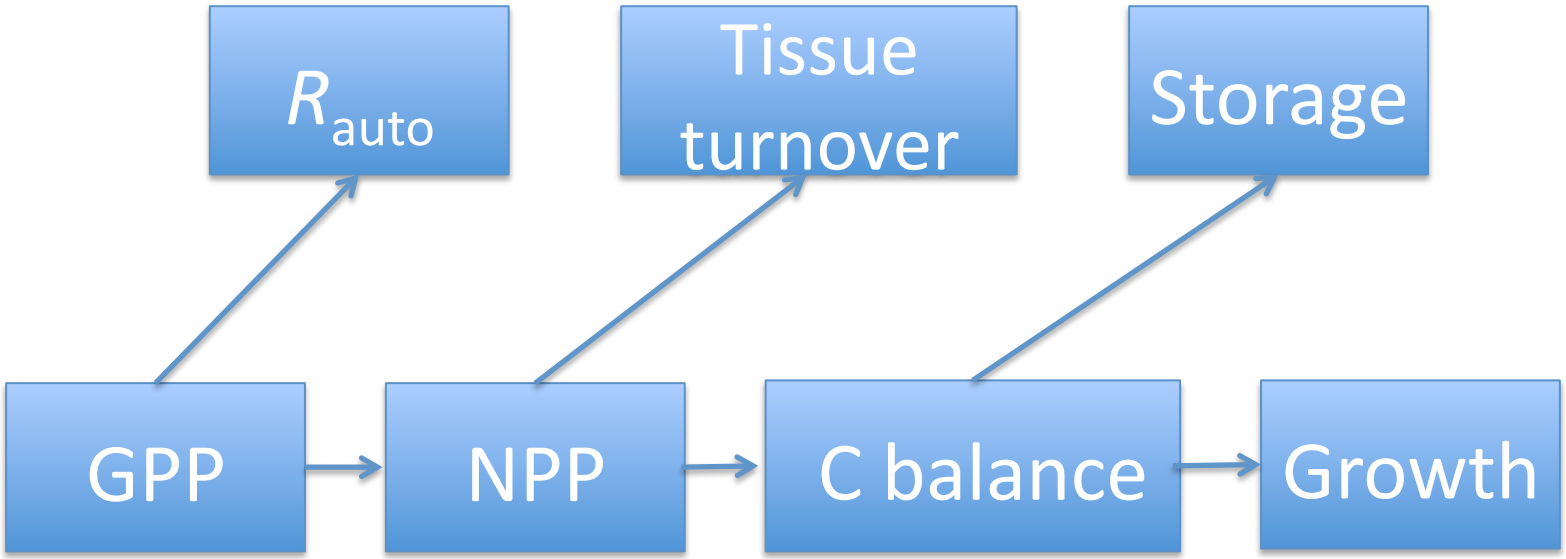
Trying to grow semi-arid plants in New Mexico….



Grey shaded areas are the range of observations from the Sevilleta Pinon-Juniper throughfall exclusion in Central New Mexico
Pangle R, Plaut J, Pockman W, Lemarc JF, Pockman W, McDowell N in prep.

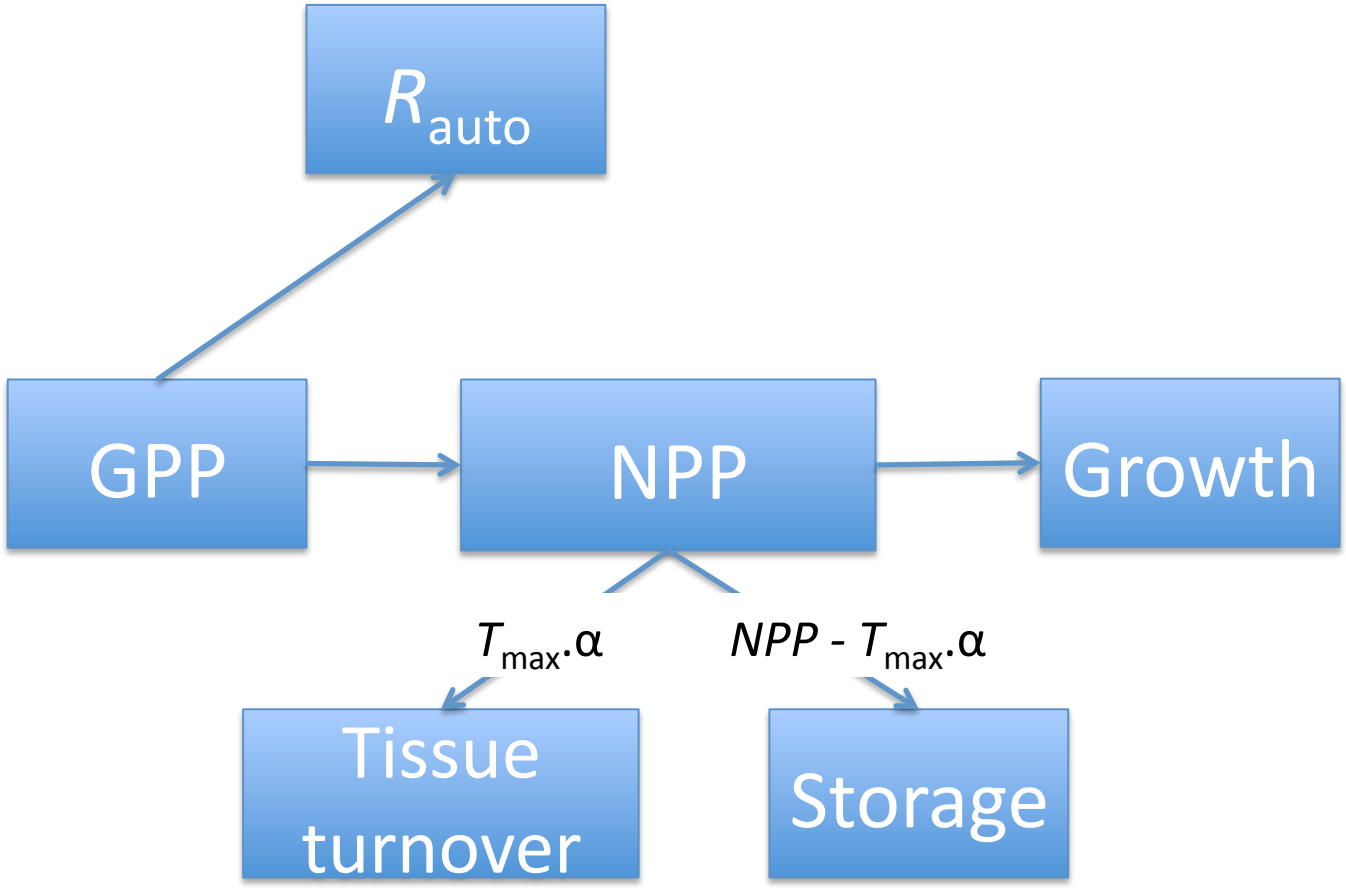
Existing CLM4(ED) evergreen allocation

Why are plants starving so catastrophically?



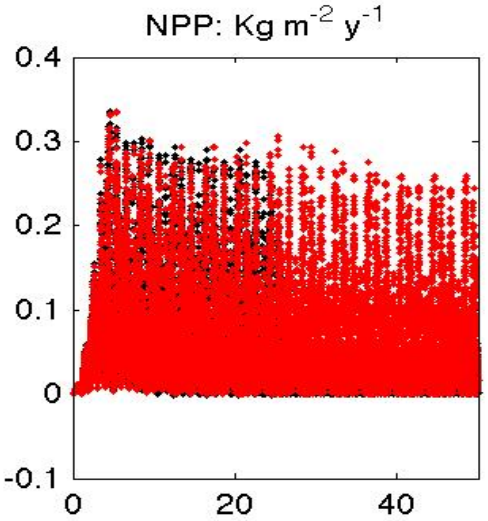
-Priority given to tissue turnover at the expense of storage
-Extra leaf area uses up both carbon and water during drought (RISK).
-Keeping leaf area is advantageous after drought (GROWTH).

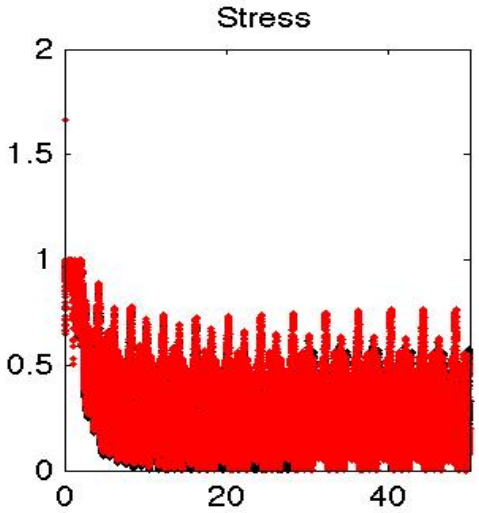
New CLM4(ED) evergreen allocation

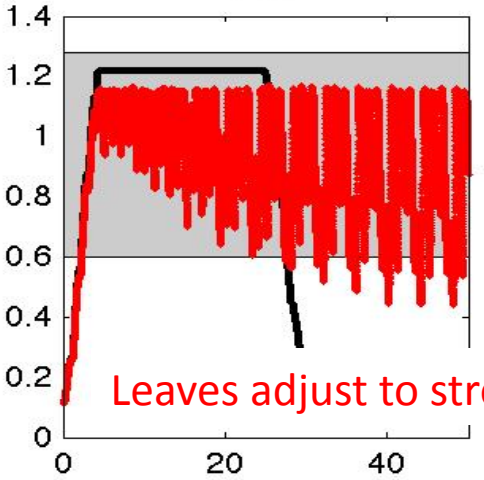


Do plants a) lose leaves or b) use up carbon stores during stress?

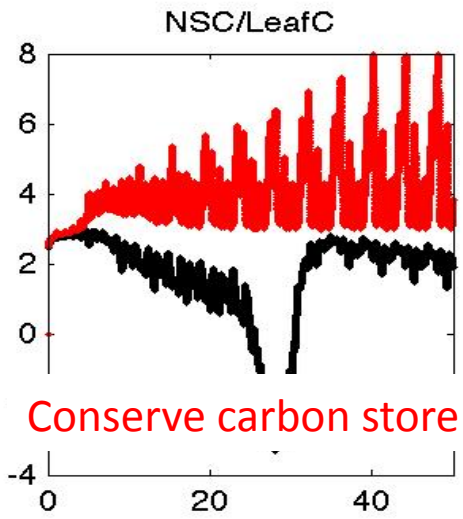
What if storage gets priority over tissue turnover?



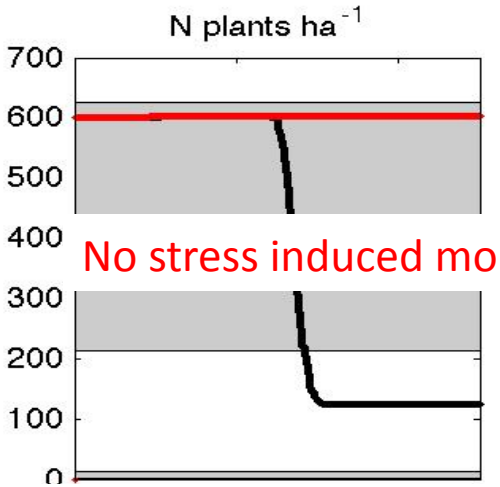




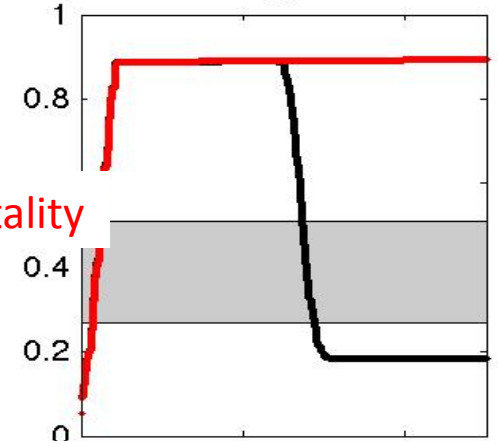
Leaves adjust to stress



Conserve carbon store



No stress induced mortality



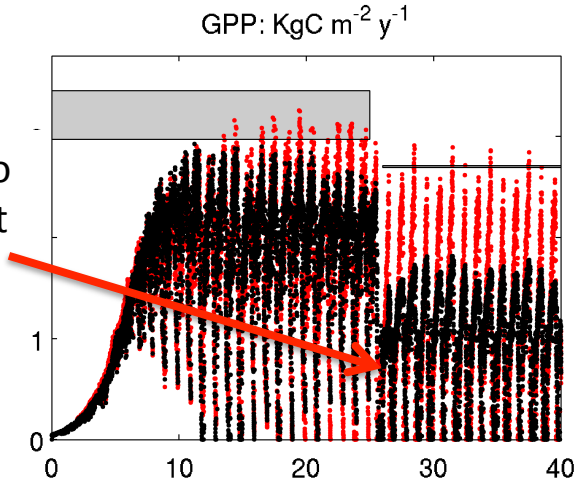
Allocation to tissue turnover under stress = 50% of demand

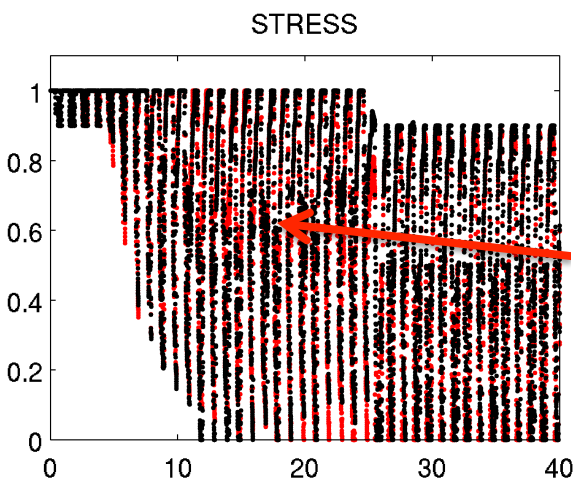
Allocation to tissue turnover under stress = 100% of demand

Grey bars = data from Caxiuana rainforest through-fall experiment: Fisher et al. 2007, Metcalfe et al. 2010

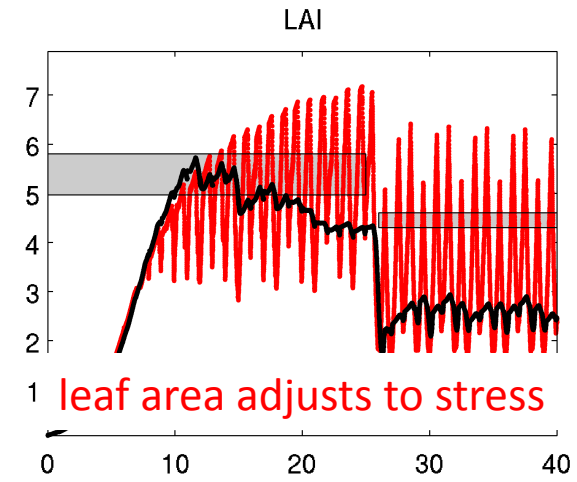
Application to rainforest drought experiment

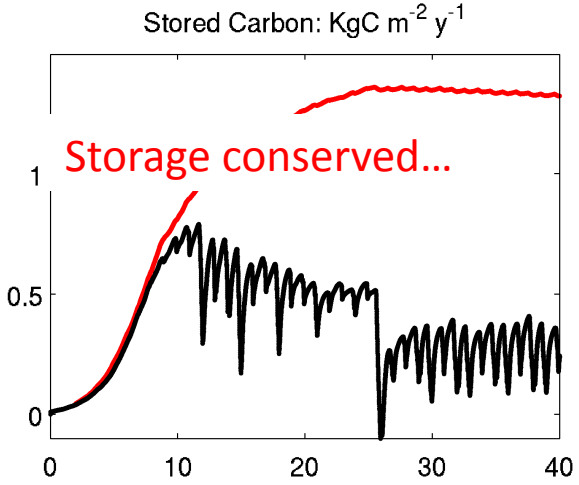
Rainfall halved to simulate drought treatment





Too much dry season stress?

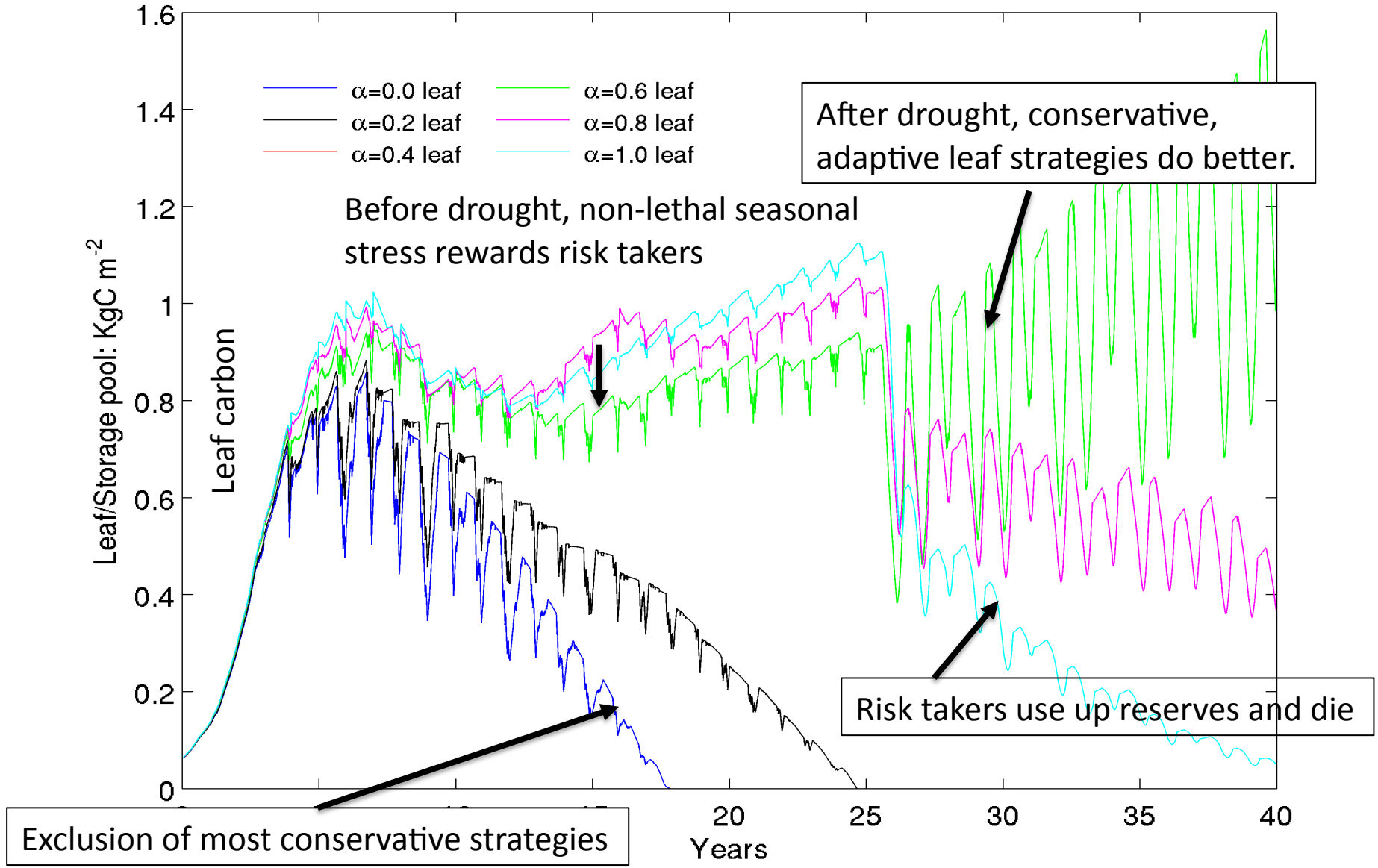


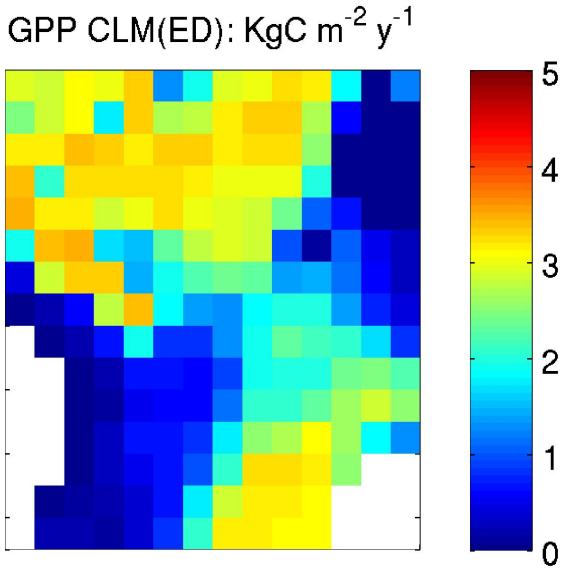


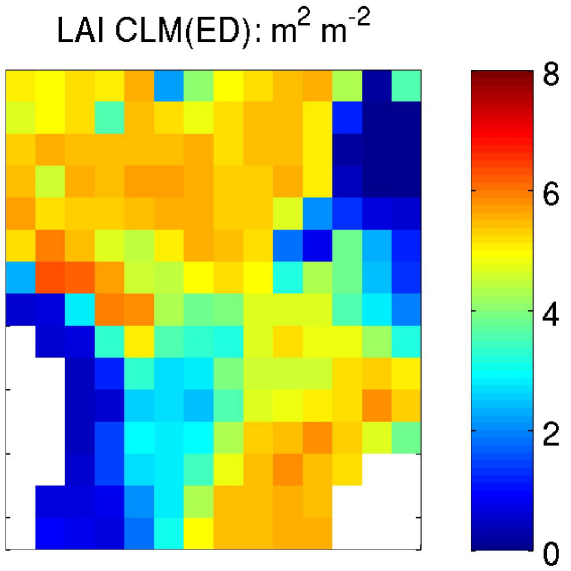
Allocation to tissue turnover under stress (α) = 0% of demand

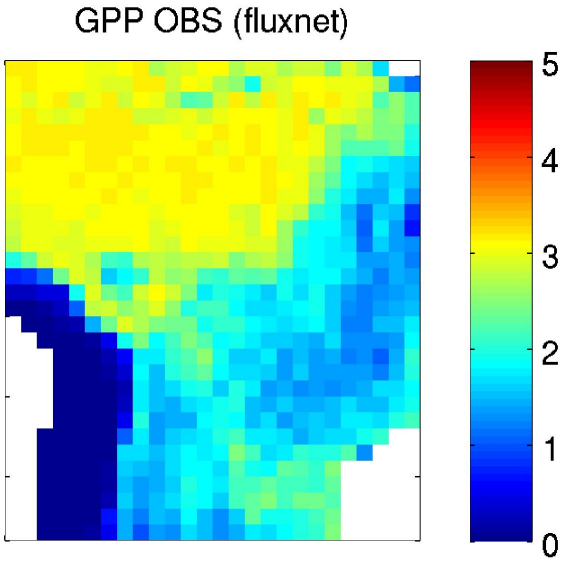
Allocation to tissue turnover under stress (α) = 100% of demand

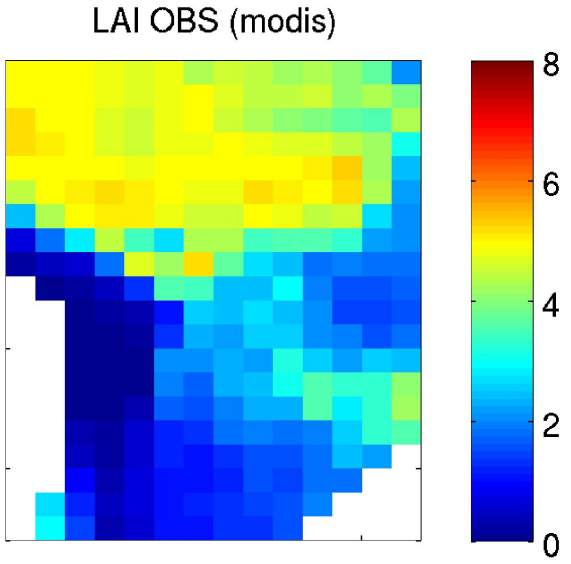
Community interactions and competition





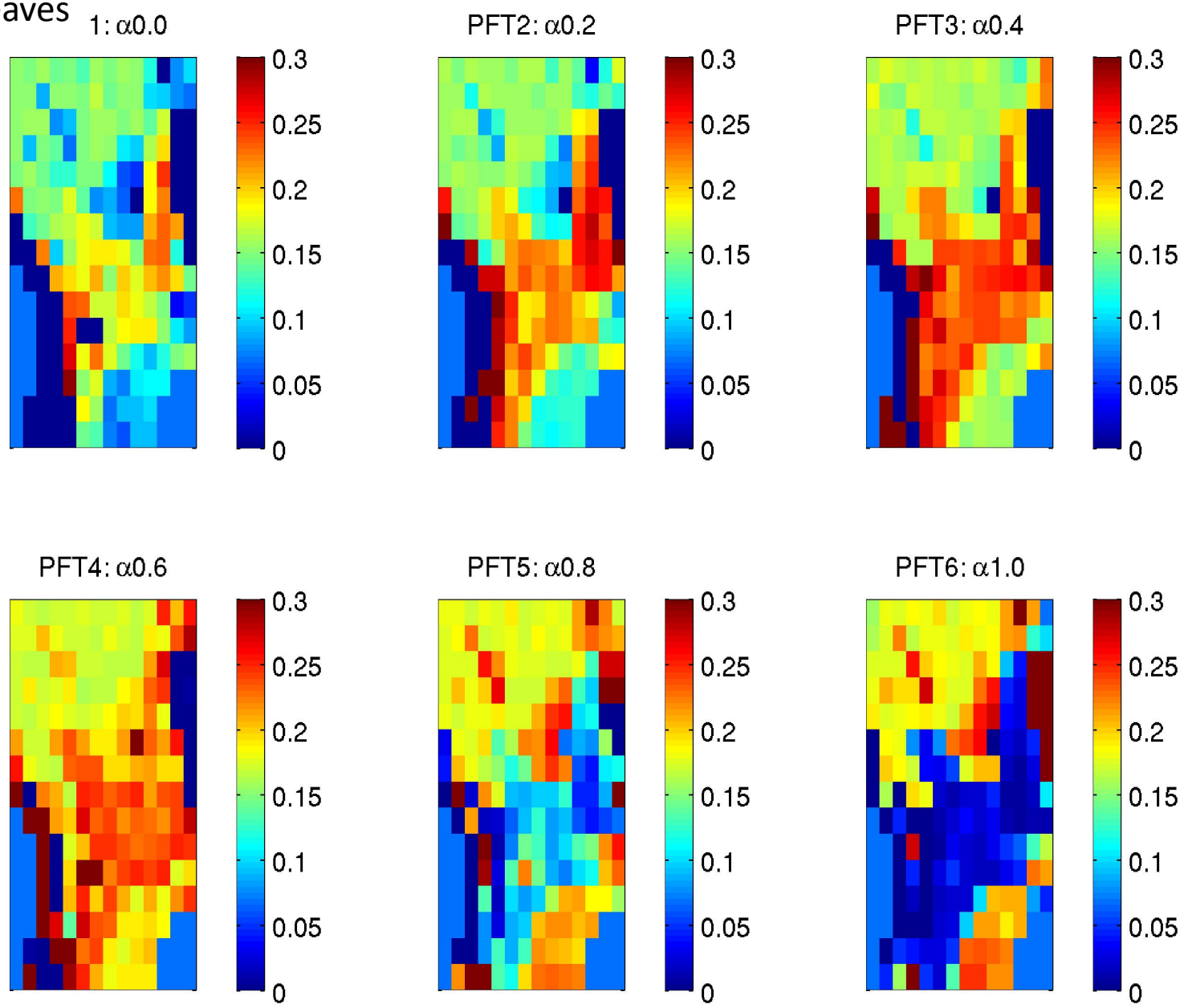






Benchmarking of CLM(ED) canopy physiology

Maintain leaves



Maintain stores

Fractional cover of 6 PFT's with differing allocation strategies

Summary

- Plant allocation strategies have implications for mortality
- Under 'good' climate conditions, risk-taking strategies (leaves staying on) are advantageous
- Under more stressful conditions, conservative strategies are more appropriate
- In ED, vegetation growth, competition and mortality all **emerge** from vegetation physiology
- …but, once we link plant demography and physiology together, we need to be even more confident that our plant physiology models are accurate.

CLM(ED) to-do list

- Data structure
- Radiation transfer scheme (Norman)
- Energy balance closure
- Photosynthesis code (CLM4)
- Water stress update
- Cold Phenology (Botta et al. 2001)
- Drought Phenology (?)
- Restarts
- Parameter fusion
- Allometry priorities
- Carbon starvation mortality (NM)
- Flexible canopy architecture
- Canopy closure/space filling (PPA)
- Timestep/numerics
- Leaf Optimization
- Point tests
- Parallelization Tests
- Regional Tests
- Global Tests
- PFT reclassification (TRY database)
- Snow interactions (DL,SS)
- Stem area index
- Grass allometry (AS)
- Fire & Insects & Windthrow
- Nitrogen Cycle (CN+CX,RQT,SZ)
- Migration (MIT)
- Land Use/Harvest/Crops (CX,PL,SL,AS)
- Benchmark, Publish, Coupled runs, etc...

GOAL:
Develop a model to investigate physiological hypotheses for why-plants-live-where-they-do.
Investigate their behaviour in future climate systems