Growth/risk trade-offs and the cost of climate resilience in CLM(ED)

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Thanks to
Gordon Bonan, Chonggang Xu & Keith Oleson
Basic ecological demographics

Recruitment

Growth
Competition
Co-existence
Exclusion

Mortality

Succession
Ecosystem Demography Model (ED)
Moorcroft, Hurtt and Pacala. 2001

‘Cohorts’ of trees:, grouped according to:
- Plant type
- Plant size
- Successional stage
Global Simulations

- CLM(ED) run globally for current climate conditions.
  - New multi-layer multi-PFT canopy (radiation, photosynthesis, respiration, stom. conductance)
  - Only Evergreen Broadleaf Trees are used for simplicity...
  - No N limitation (observed Vcmax)
  - Simulations ~30 years (to conserve CPU’s)
- Does the new model generate acceptable carbon and water fluxes?
Validation against global LAI and GPP data products

n.b. these are all maximum monthly values
Validation against global ET product
Red = Obs  Black = CLM(ED)
Red = Obs  Black = CLM(ED)
Red = Obs  Black = CLM(ED)
How do we improve the representation of biodiversity?

✦ Grass/Shrub/Tree?
✦ Evergreen/Deciduous?
✦ Do these groupings tell us much about responsiveness to climate and CO$_2$ changes?
✦ What actually controls plant tolerance to climate extremes?
✦ What alternative axes of plant variation do we need to capture?
Plants typically trade growth against survival

What actually controls growth/mortality trade-offs?

We don’t specify ‘growth’ as a parameter...

What plant traits actually control this relationship?

Wright J et al., Ecology, 2010
Ecological differentiation in xylem cavitation resistance is associated with stem and leaf structural traits

LARS MARKESTEIJN, LOURENS POORTER, HORACIO PAZ, LAWREN SACK & FRANS BONGERS

Water potential at which 50% of xylem vessels are cavitated

Interpreted in CLM as $\Psi_{\text{wilt}}$

Affects both gas exchange and drought-induced mortality

Example Functional Trade off: Wood cost vs. safety

6 PFTs, spanning observational range

$r^2 = 0.70$ **

Wood density

$P_{so}$ (MPa)

Wood density

$\Psi_{\text{wilt}}$
Average wood density emerging from competition

Increasing wood density
Increasing drought tolerance
Summary

- Vegetation carbon cycle feedback depends on
  - 1. How much plants can tolerate new climate extremes
  - 2. How much they are fertilized by CO₂ and nutrients.

- Plants can already tolerate most kinds of extreme condition... (wind, drought, heat, cold, flooding)

- But insuring against extremes has a cost, and only in some places is it a good strategy to pay that cost...

- Can we generate ecosystems that are more closely adapted to their current climate, and how does that affect climate responses?
the end
Global patterns of leaf mechanical properties

Yusuke Onoda,1,2* Mark Westoby,1
Peter B. Adler,3 Amy M. F. Choong,4
Fiona J. Clissold,5
Johannes H. C. Cornelissen,6
Sandra Díaz,7 Nathaniel J. Dominy,8
Alison Elgart,9 Lucas Enrico,7
Paul V. A. Fine,10 Jerome J.
Howard,11 Adel Jalili,12 Kaoru
Kitajima,13 Hiroko Kurokawa,14
Clare McArthur,9 Peter W. Lucas,15
Lars Markesteijn,16 Natalia Pérez-Harguindeguy,7 Lourens Poorter,17
Lara Richards,3 Louis S. Santiago,18
Enio E. Sosinski Jr.,19 Sunshine A.
Van Bael,20 David L. Warton,21 Ian J.
Wright,22 S. Joseph Wright22 and
Nayuta Yamashita22
Trade off #1: Growth vs storage
Where growth is limited by stress, more storage is a successful strategy.

Where canopy is closed, fast growth is the more successful strategy.

PFT: Carbon storage target multiples of $C_{\text{leaf}}$.
Scaling of angiosperm xylem structure with safety and efficiency

UWE G. HACKE,\textsuperscript{1,3} JOHN S. SPERRY,\textsuperscript{1} JAMES K. WHEELER\textsuperscript{1} and LAURA CASTRO\textsuperscript{2}
Ecological differentiation in xylem cavitation resistance is associated with stem and leaf structural traits

LARS MARKESTEIJN, LOURENS POORTER, HORACIO PAZ, LAWREN SACK & FRANS BONGERS

Tuesday, June 19, 2012
Carbohydrate storage enhances seedling shade and stress tolerance in a neotropical forest

JONATHAN A. MYERS and KAORU KITAJIMA
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Leaf traits show different relationships with shade tolerance in moist versus dry tropical forests

Lourens Poorter$^{1,2,3}$
The importance of wood traits and hydraulic conductance for the performance and life history strategies of 42 rainforest tree species

Lourens Poorter, Imole McDonald, Alfredo Alarcón, Esther Fichler, Juan-Carlos Peña-Carlos, Frank Sterck, Zulma Villegas and Ute Sass-Klaassen