Impacts of climate change on the vegetation of Africa: an adaptive dynamic vegetation modelling approach

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world of biodiversity

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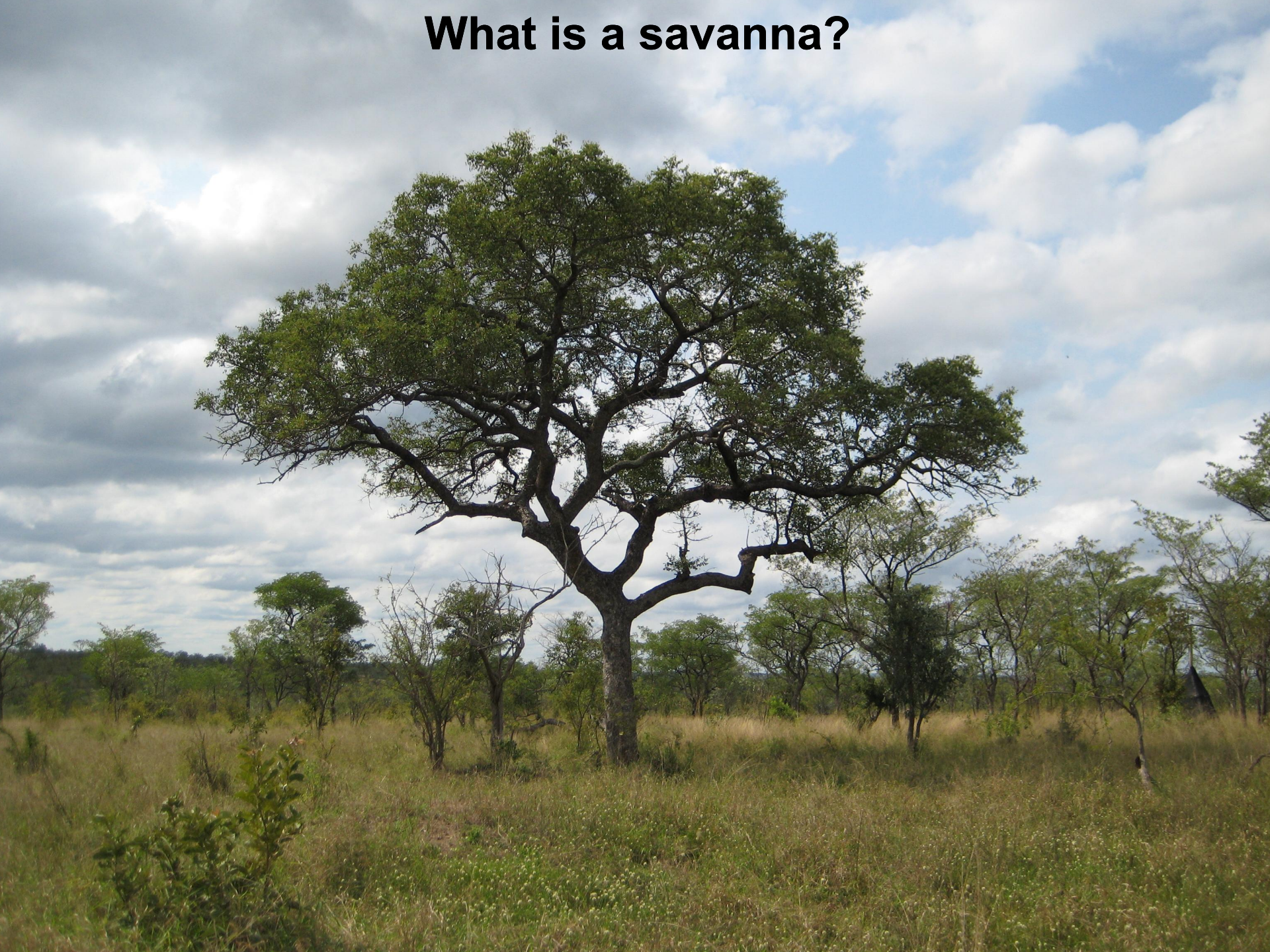
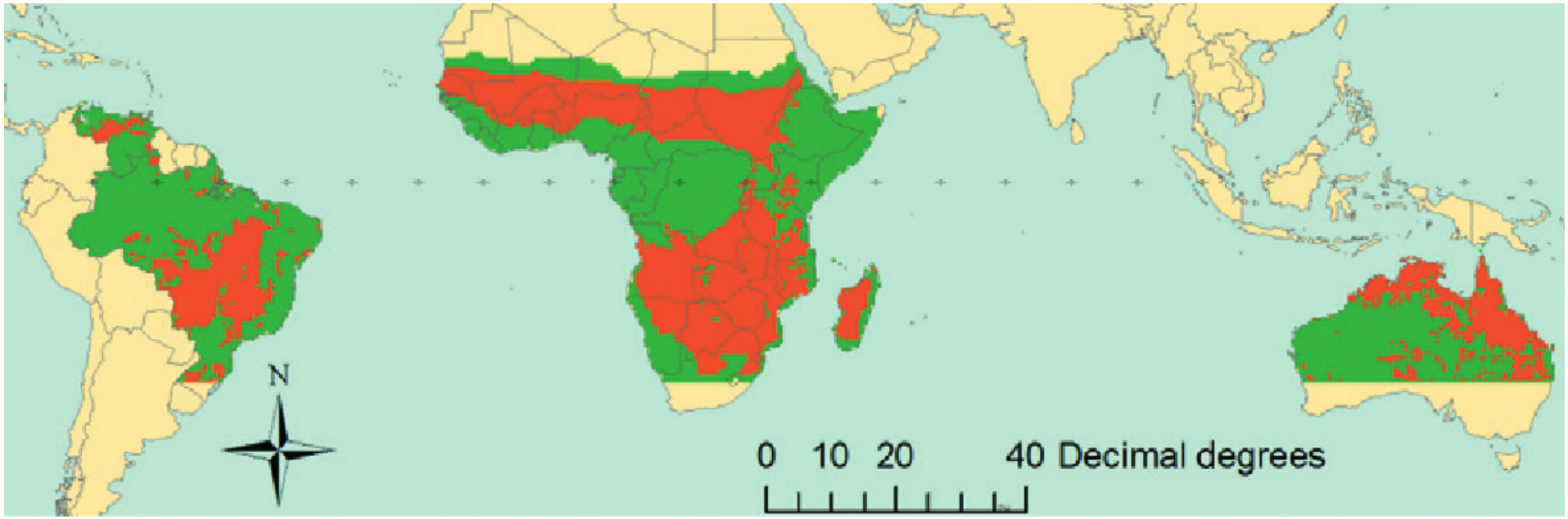
What is a savanna?



Global distribution of savannas



Savanna
No savanna

Lehmann et al. (2011) New Phytologist

The aDGVM: scaling from leaf level to ecosystem level

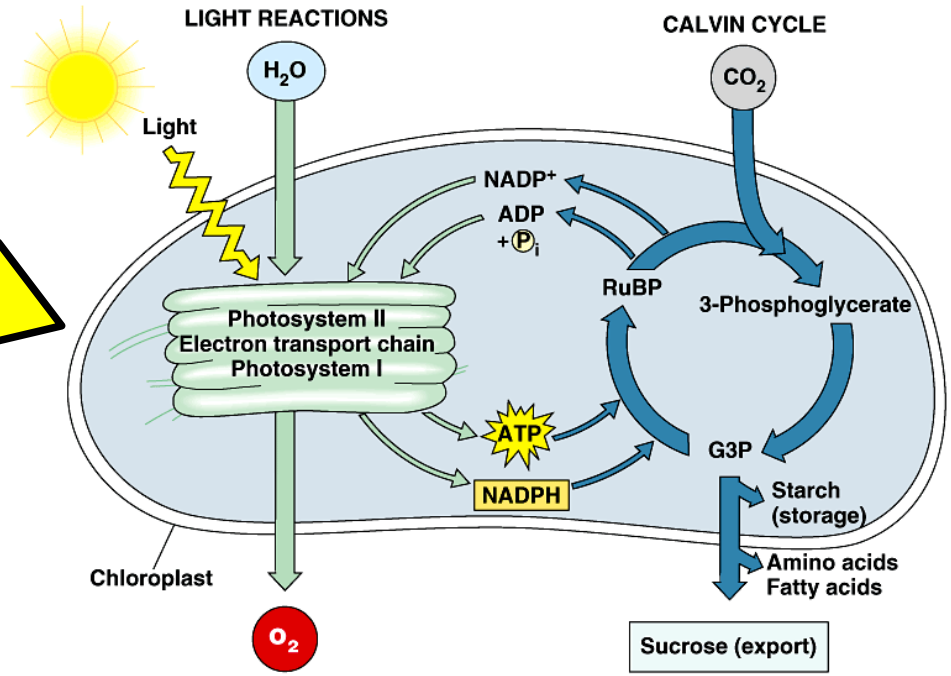
Soil hydraulic properties

Solar radiation

Precipitation

Temperature

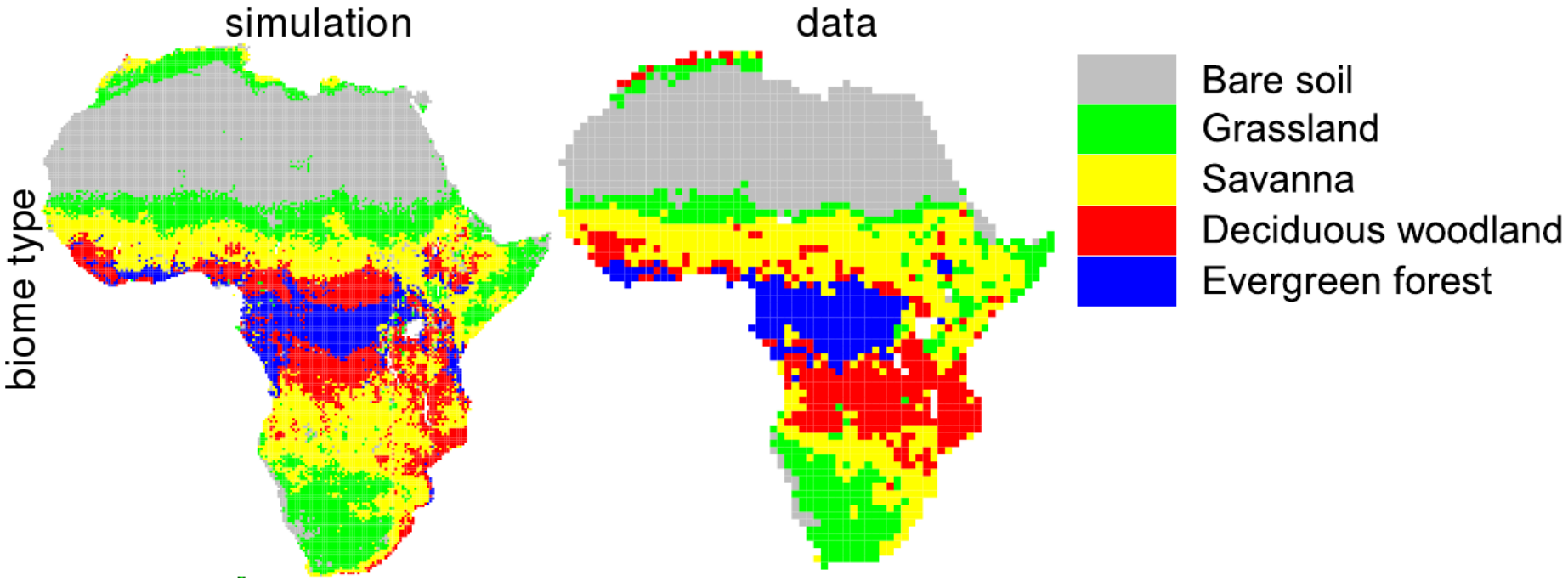
$[CO_2]$



The aDGVM: scaling from leaf level to ecosystem level

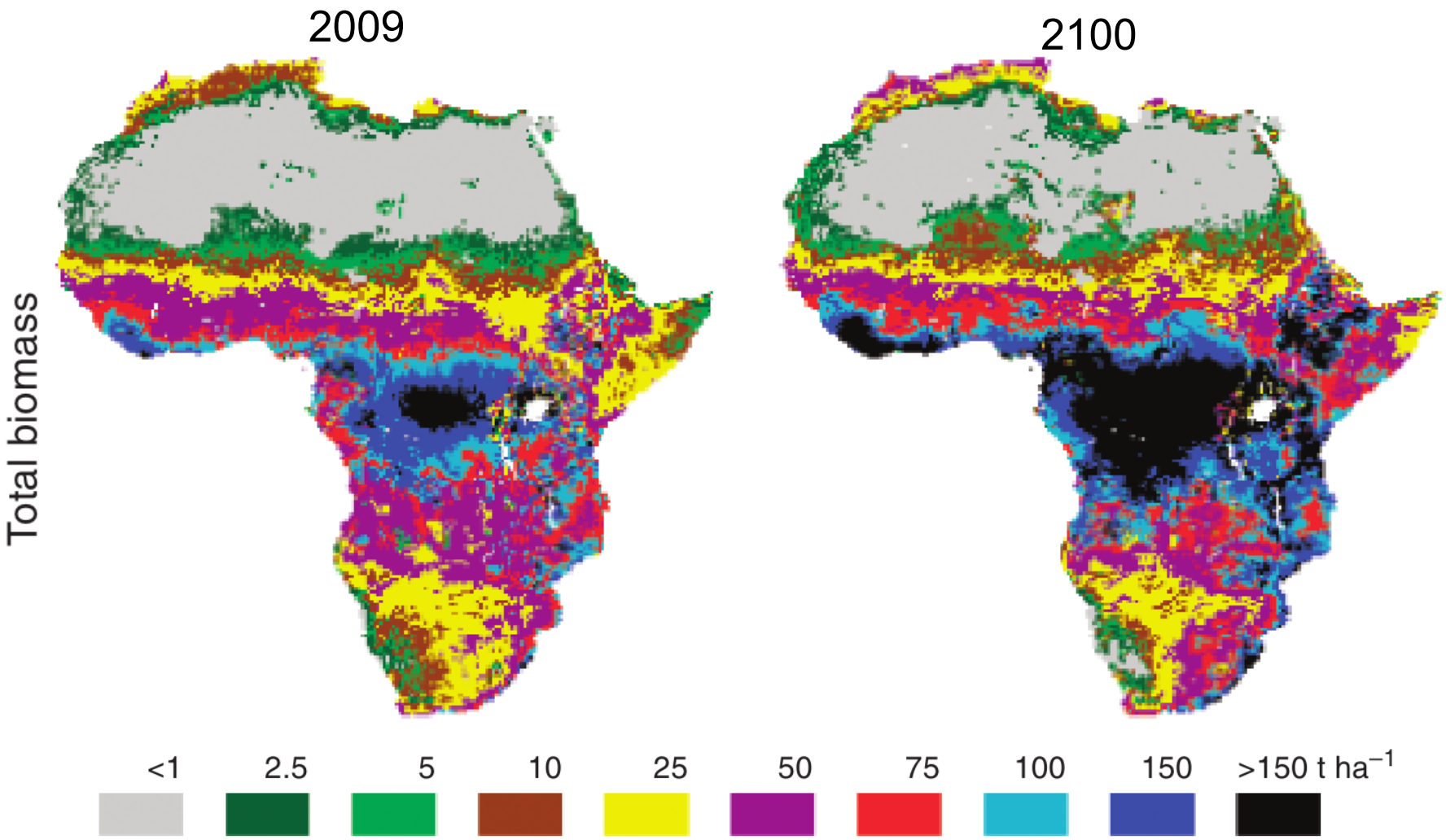
- Model builds on existing bio-physical models
- Individual-based approach
- Vegetation responds flexibly to climate conditions
  → based on leaf-level physiology
  → process-based allocation model
  → process-based phenology model
- Simulates light and root competition
- Fire impacts depend on tree height

Model benchmarking at continental scale



Scheiter and Higgins (2009) GCB

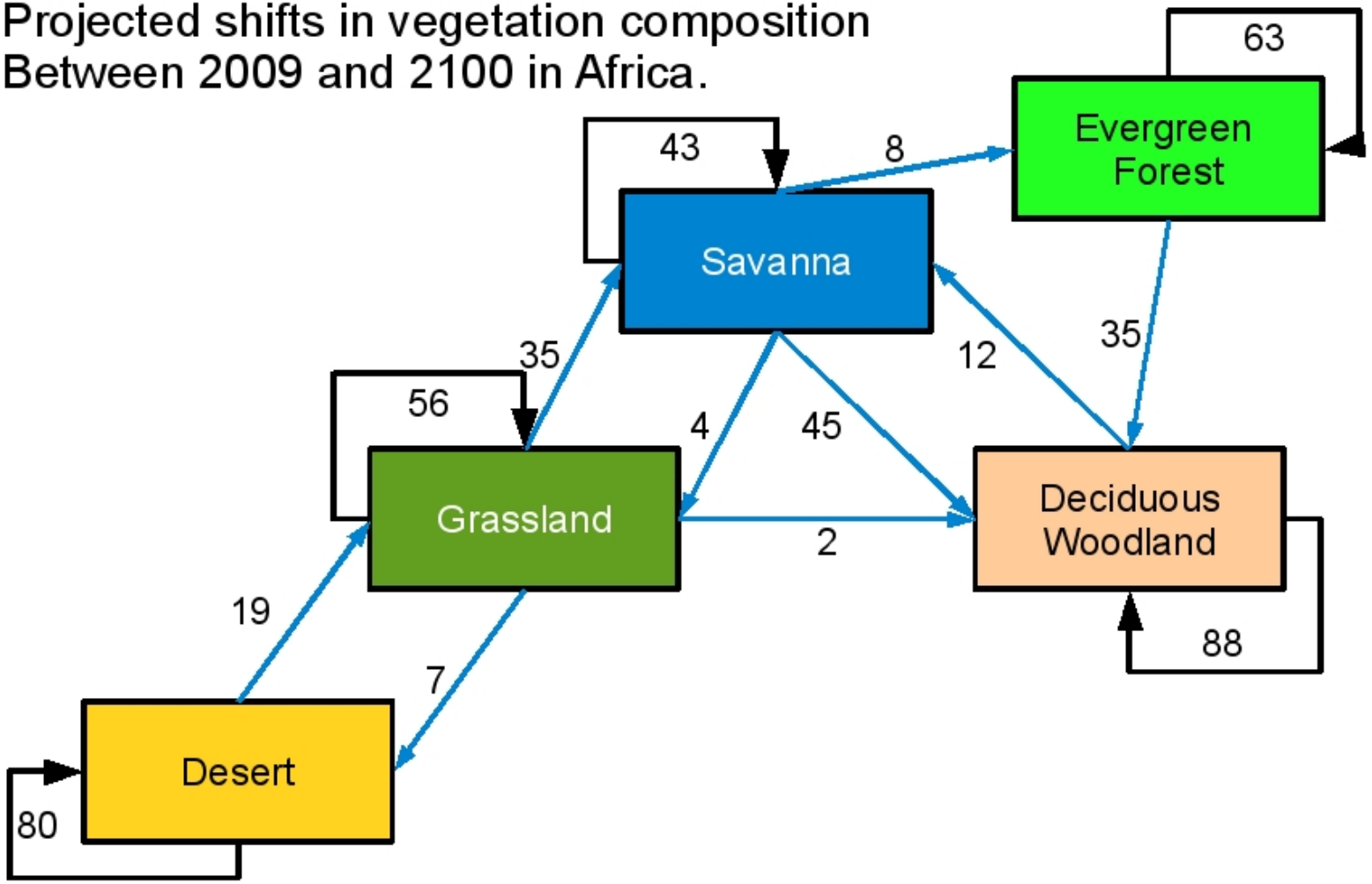
Climate change increases carbon sequestration



Simulations conducted for IPCC SRES A1B, MPI Hamburg ECHAM model

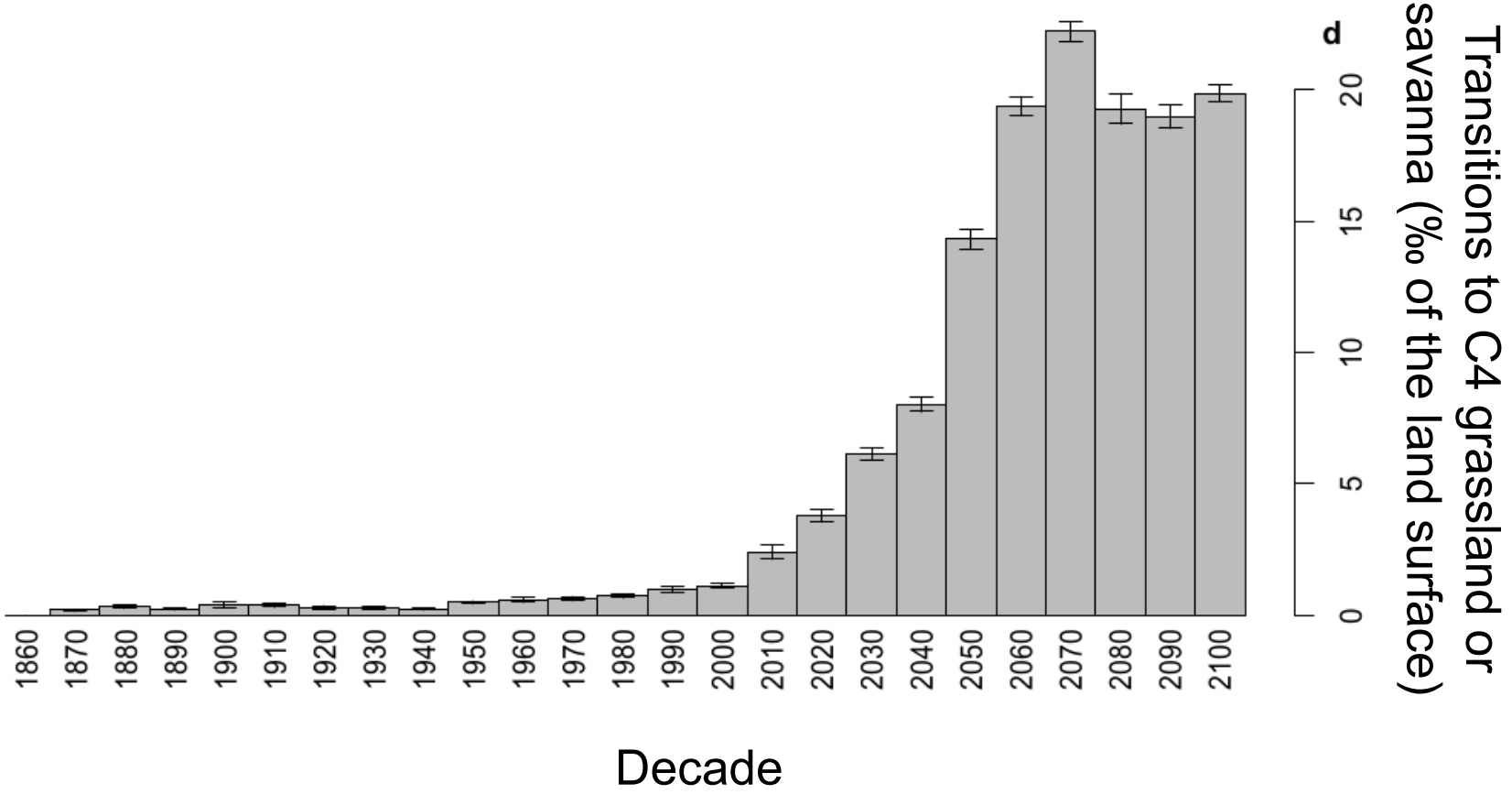
Scheiter and Higgins (2009) Global Change Biology

Climate change promotes tree dominated biomes



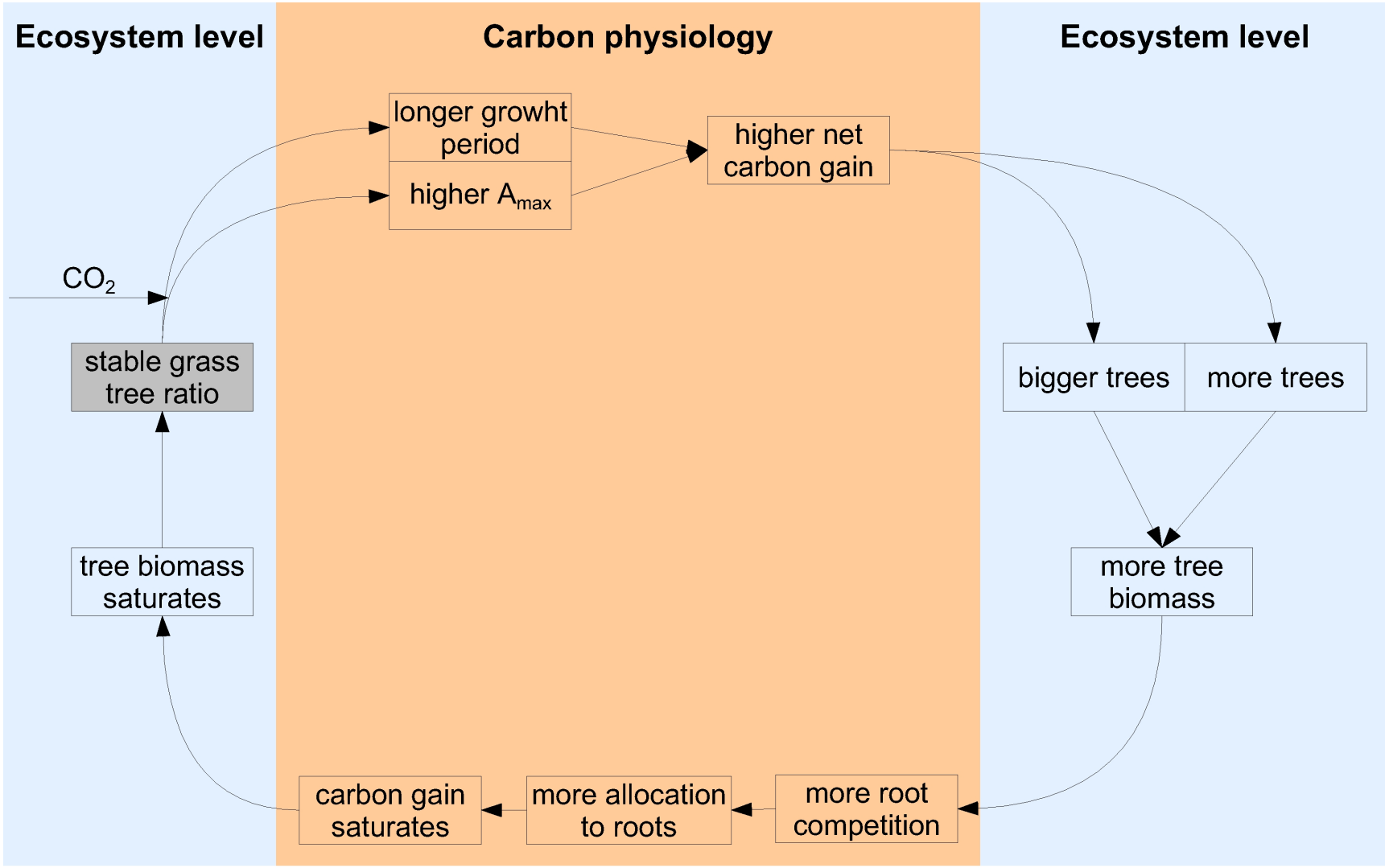
Scheiter and Higgins (2009) Global Change Biology

Climate change promotes tree dominated biomes

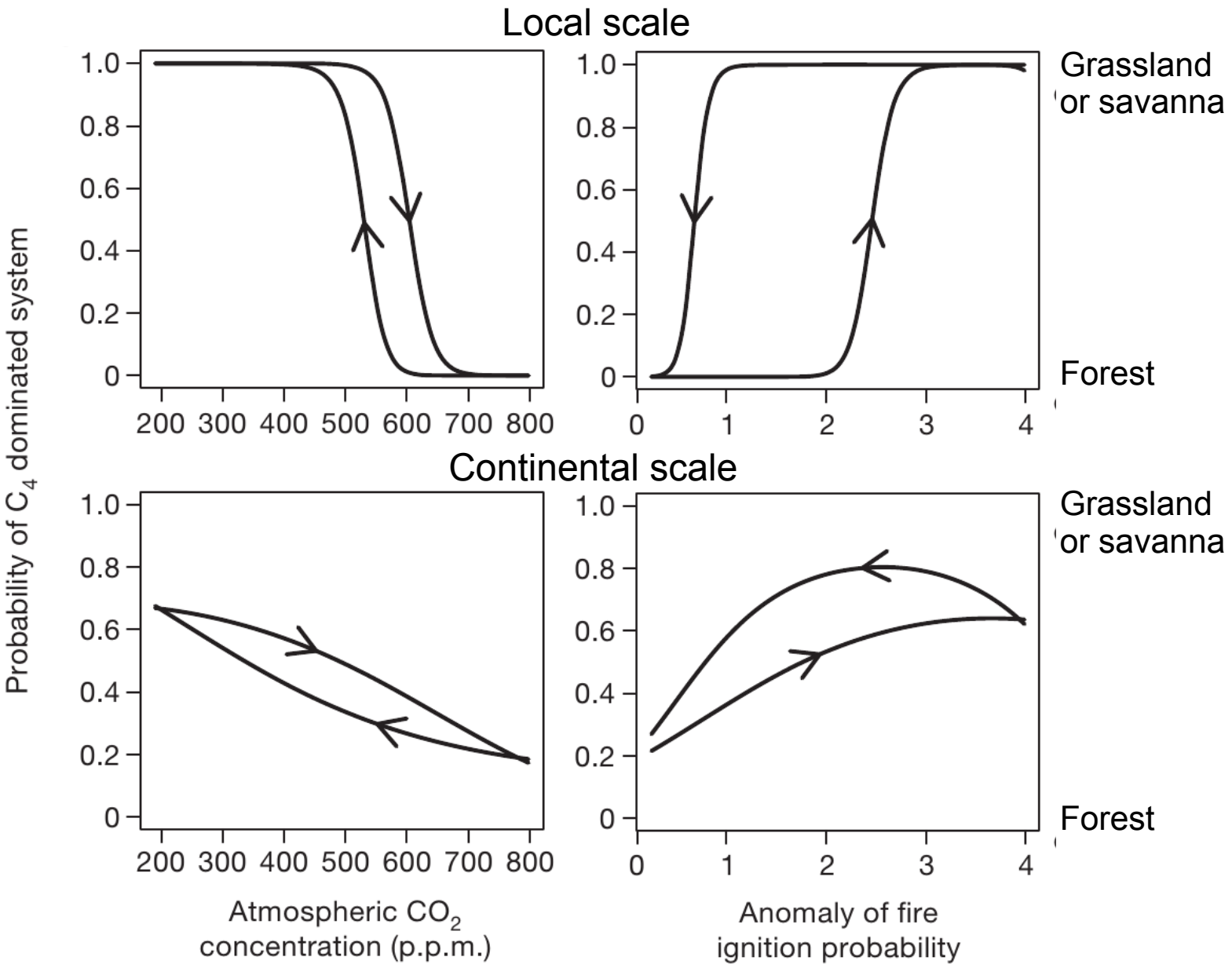


Higgins and Scheiter (2012) Nature

CO2 fertilization in aDGVM



Smooth transitions or abrupt biome shifts?



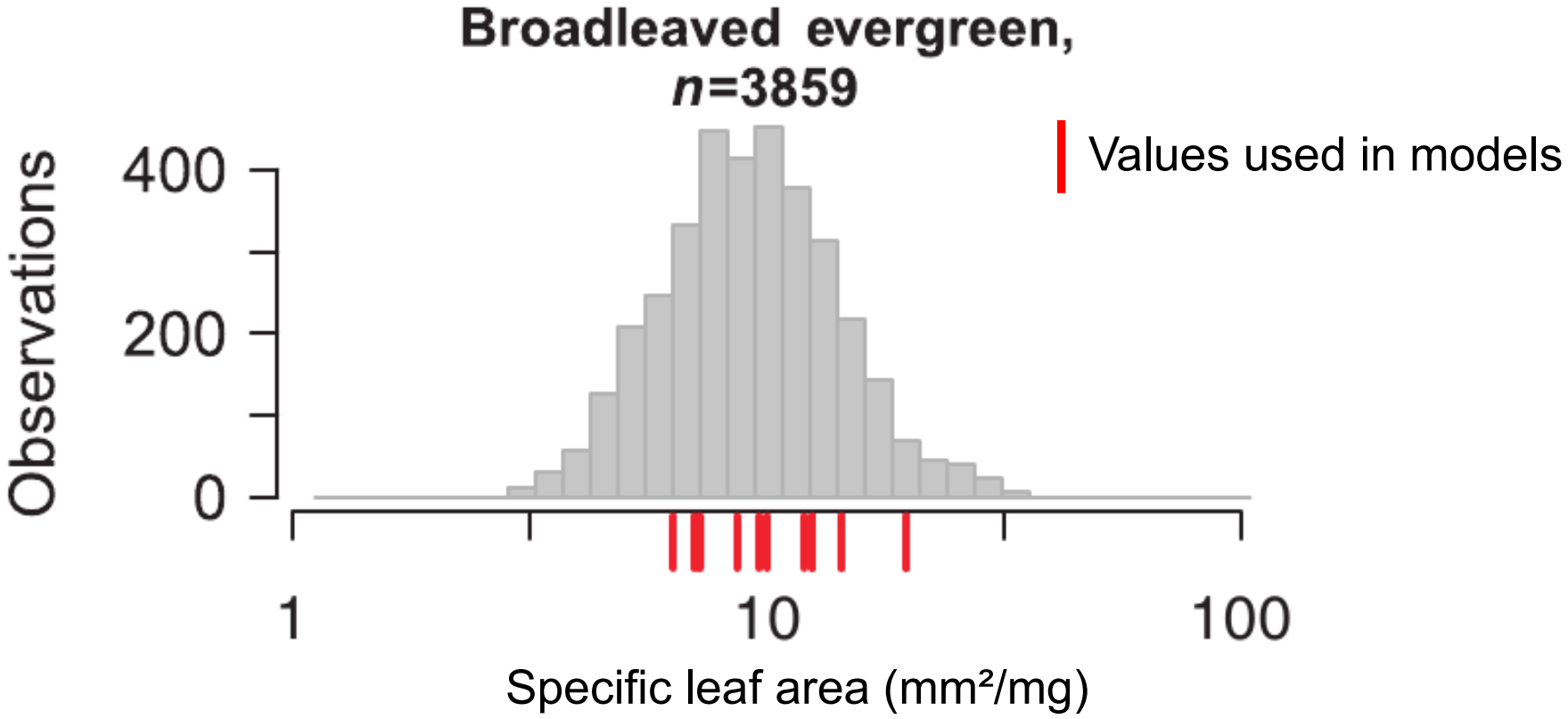
Higgins and Scheiter (2012) Nature

Plant functional types in DGVMs

PFT	W/H^*	z_1 (–)	z_2 (–)	g_{min} ($mm\,s^{-1}$)	r_{fire} (–)	a_{leaf} (yr)
Tropical broad-leaved evergreen (TrBE)	W	0.85	0.15	0.5	0.12	2.0
Tropical broad-leaved raingreen (TrBR)	W	0.70	0.30	0.5	0.50	0.5
Temperate needle-leaved evergreen (TeNE)	W	0.70	0.30	0.3	0.12	2.0
Temperate broad-leaved evergreen (TeBE)	W	0.70	0.30	0.5	0.50	1.0
Temperate broad-leaved summergreen (TeBS)	W	0.80	0.20	0.5	0.12	0.5
Boreal needle-leaved evergreen (BoNE)	W	0.90	0.10	0.3	0.12	2.0
Boreal needle-leaved summergreen (BoNS)	W	0.90	0.10	0.5	0.12	0.5
Boreal broad-leaved summergreen (BoBS)	W	0.90	0.10	0.3	0.12	0.5
Temperate herbaceous (TeH)	H	0.90	0.10	0.5	1.00	1.0
Tropical herbaceous (TrH)	H	0.90	0.10	0.5	1.00	1.0

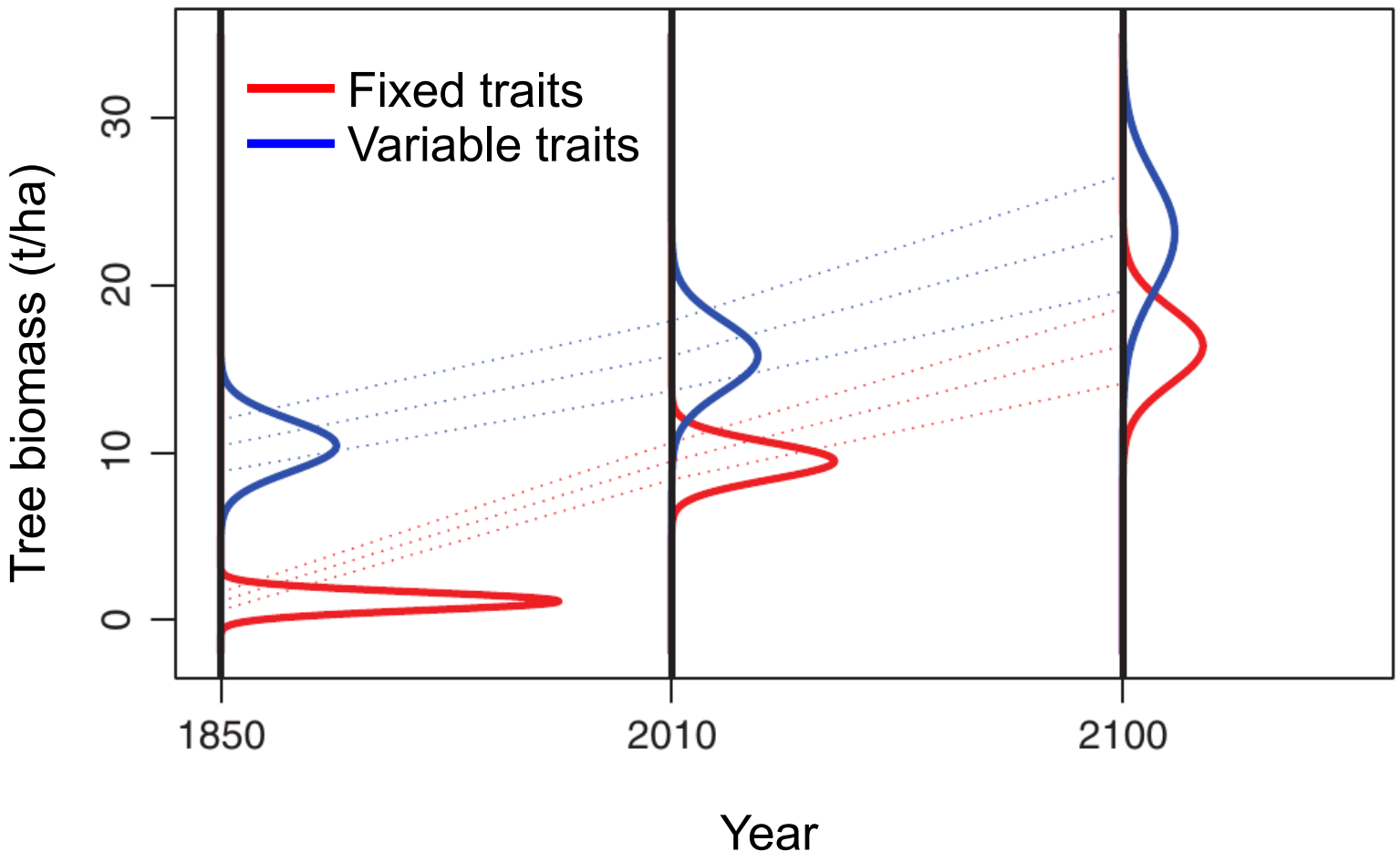
*W = Woody; H = Herbaceous.

Limitations of DGVMs: the PFT approach



TRY database, Kattge et al. (2011) Global Change Biology

Including trait variability into a DGVM



Scheiter, Langan, Higgins (2013) New Phytologist

The aDGVM2: major features

The aDGVM2 is a trait-based dynamic vegetation model:

→ Model is based on leaf-level physiology

→ Model uses an individual-based approach

→ Each individual is characterized by combination of trait values

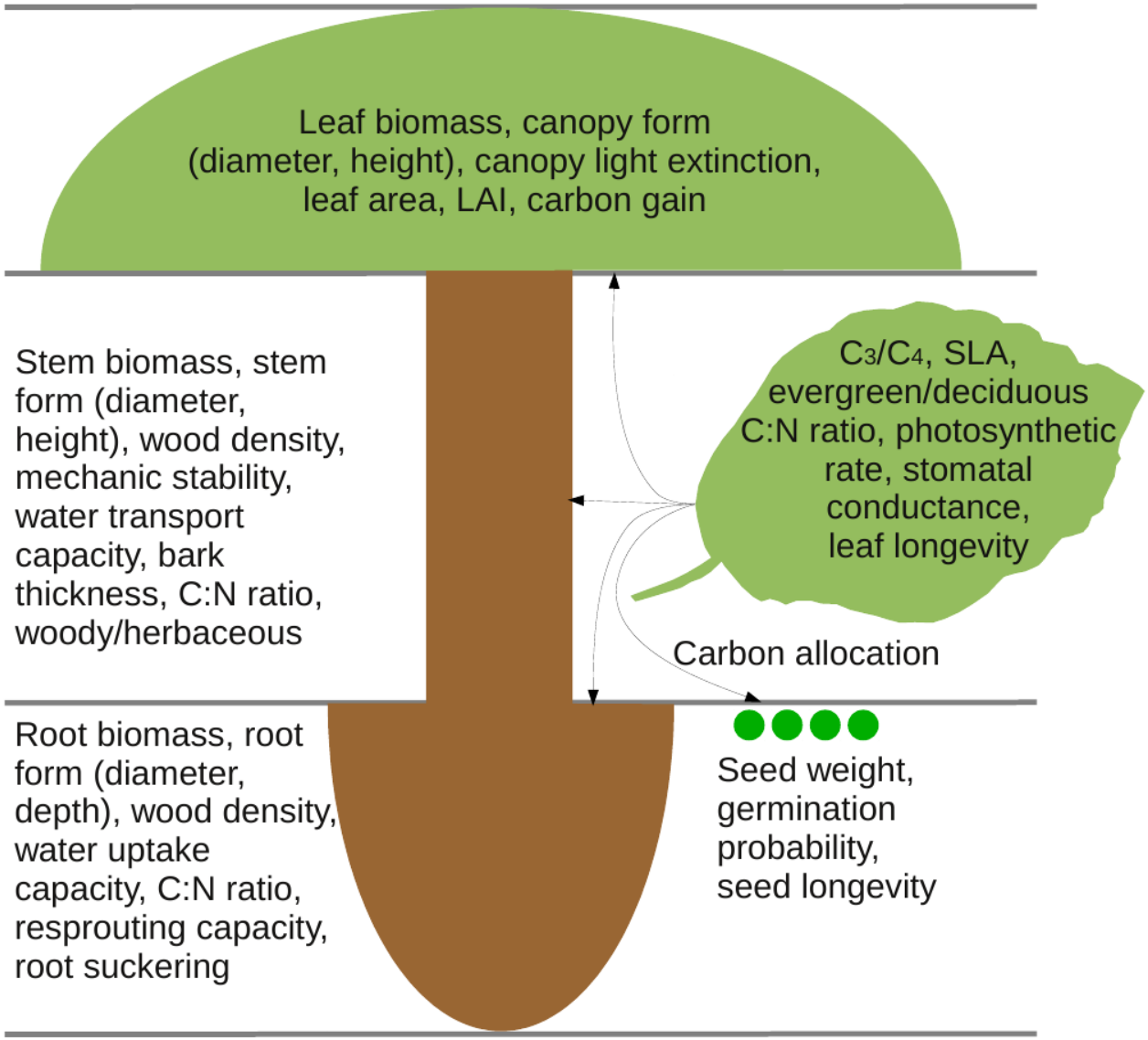
→ Growth controlled by trade-offs between traits

→ Neighboring plants compete

→ Reproduction controlled by inheritance, mutation and cross-over

→ Trait combinations that maximize fitness under given climate conditions can persist

The aDGVM2: a trait-based vegetation model



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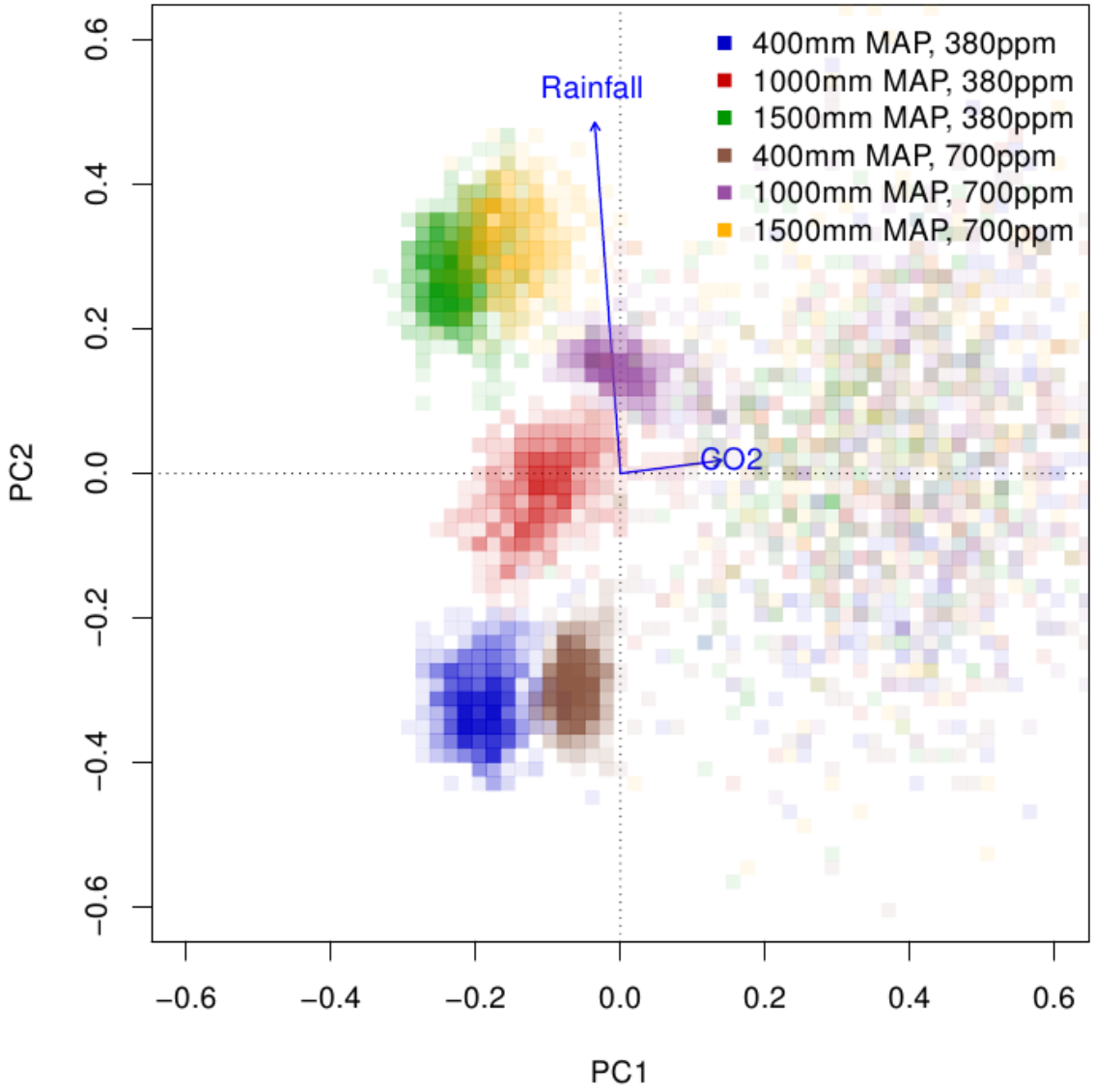
Communities respond to environmental conditions



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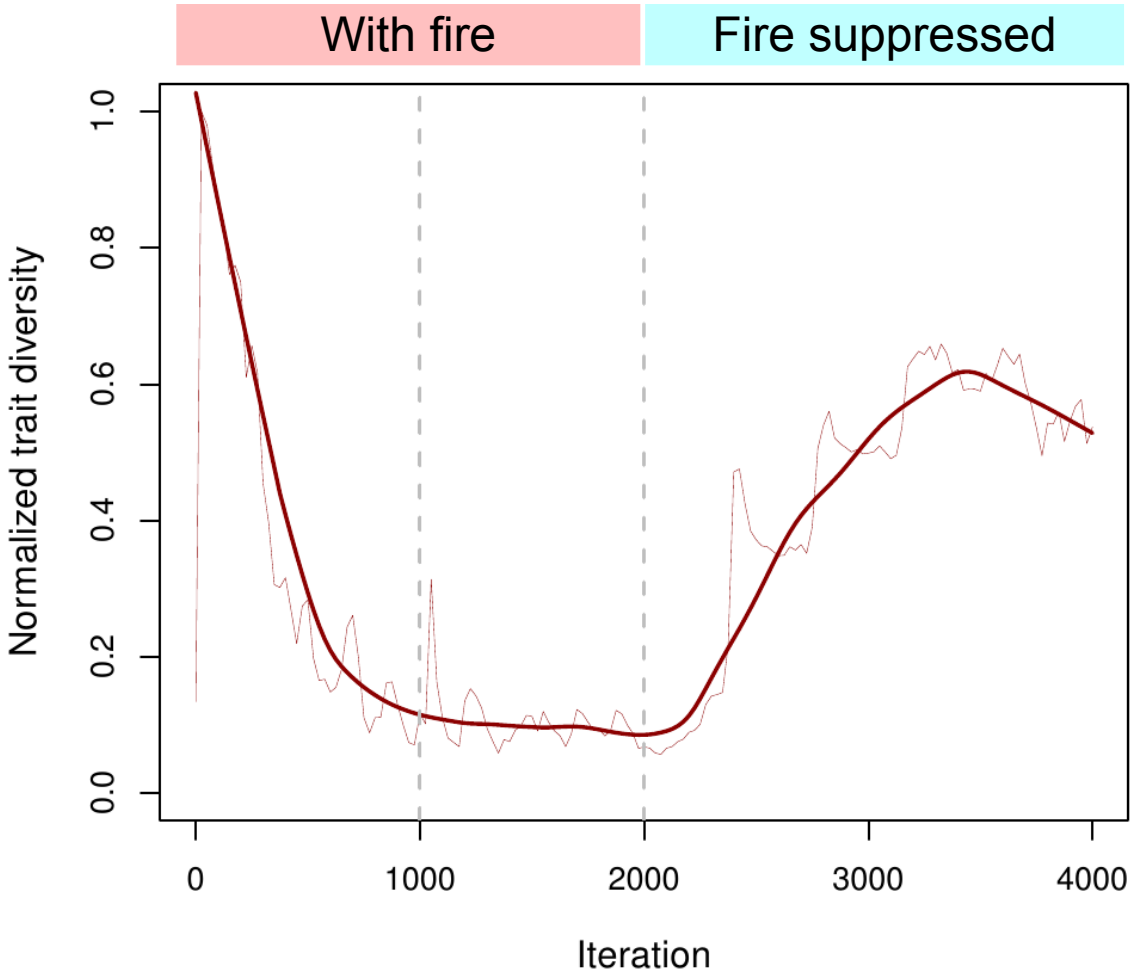
Trait diversity responds to fire suppression



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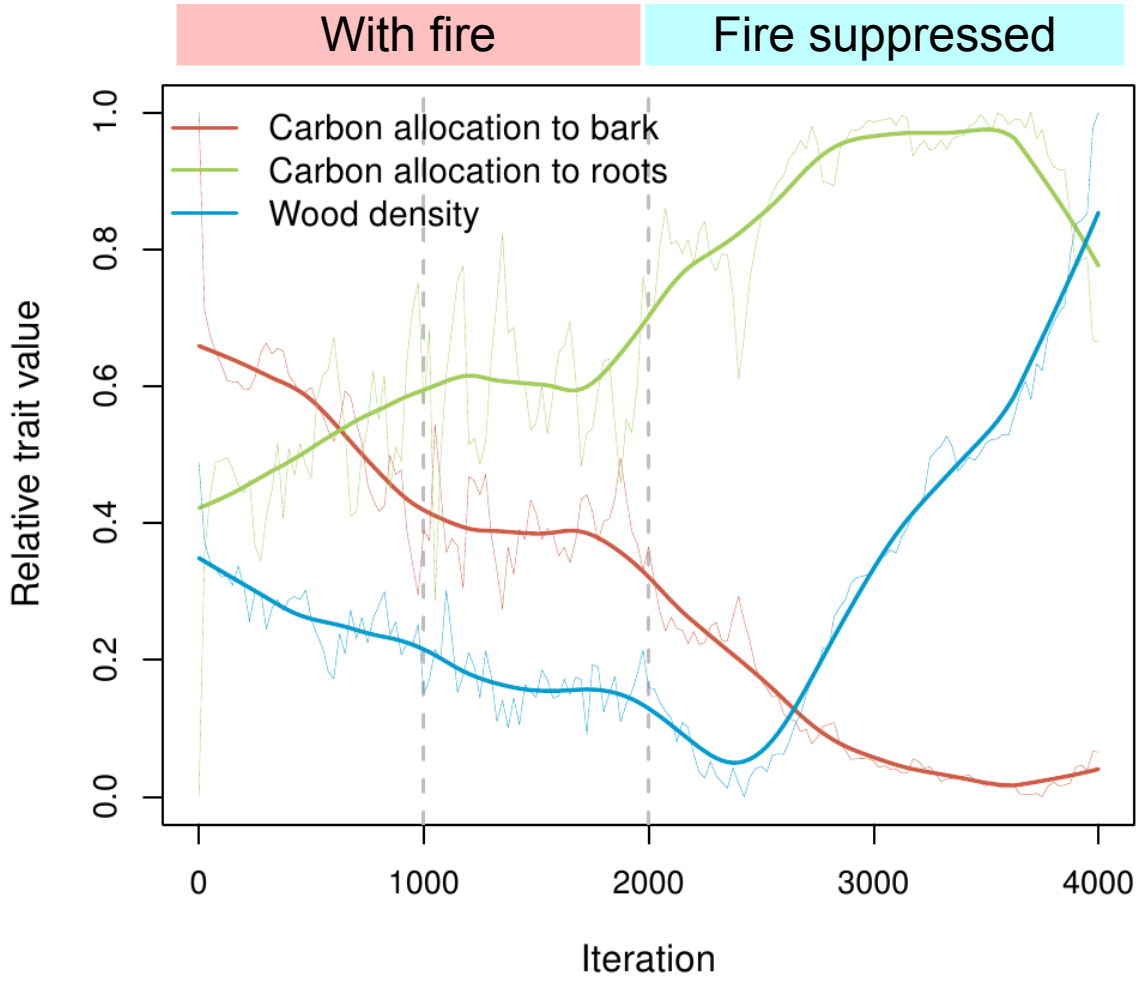
Traits respond to fire suppression



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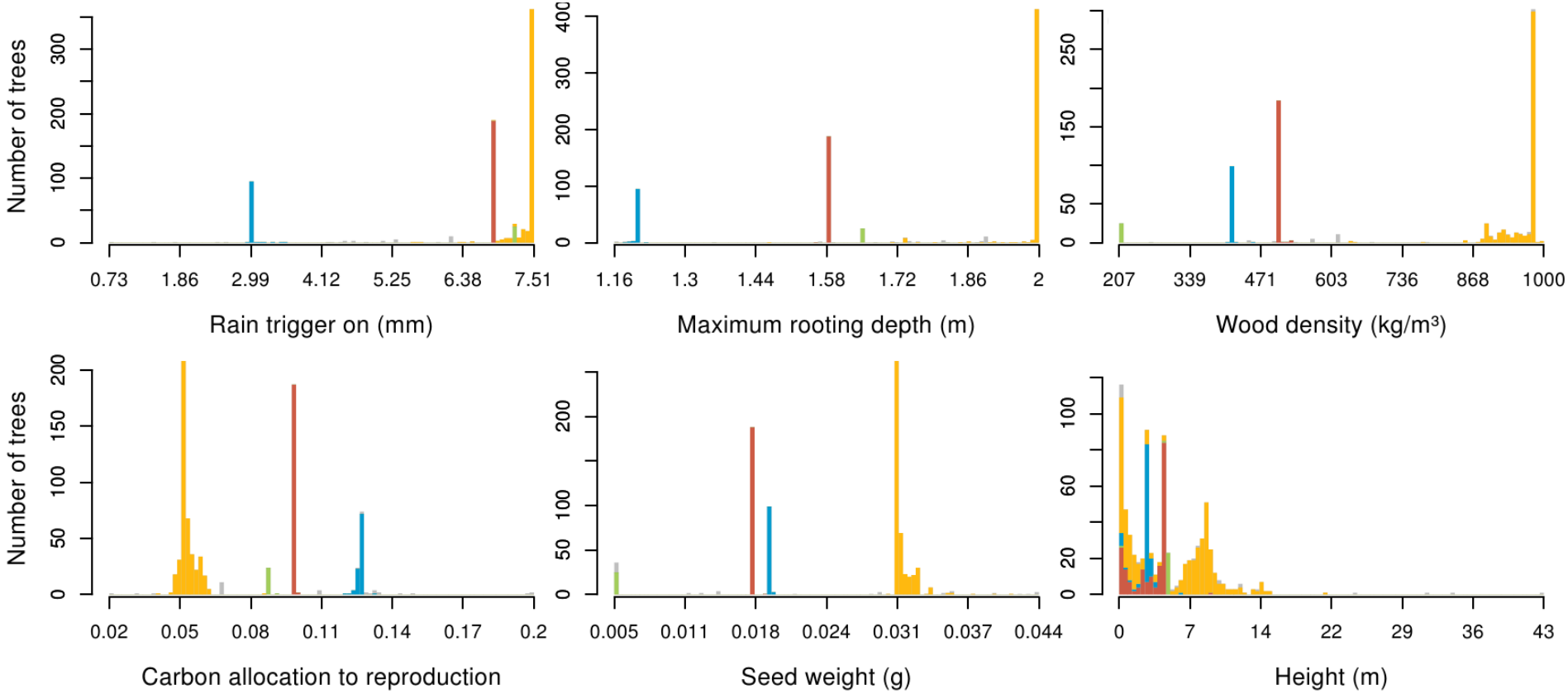
The aDGVM2 projects coexisting life history strategies



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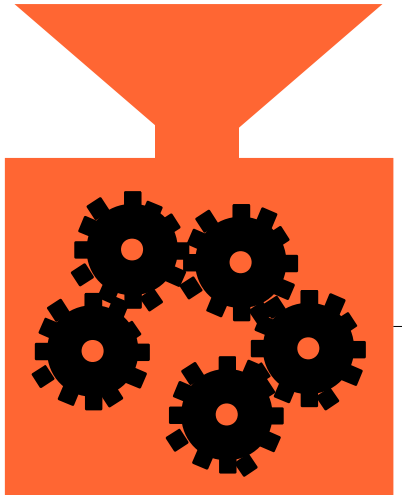
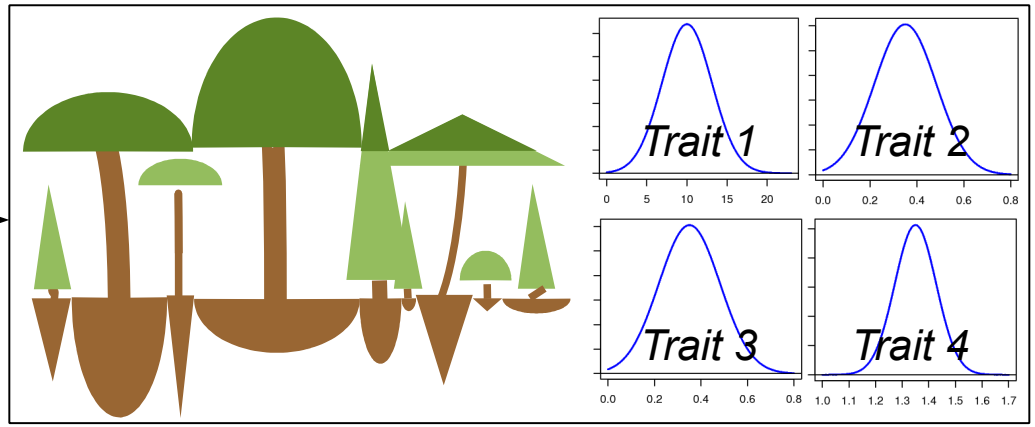
Putting pieces together

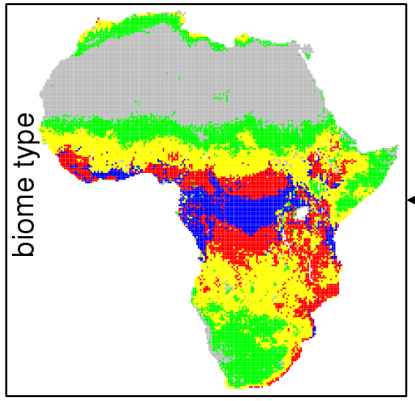
Environmental input data

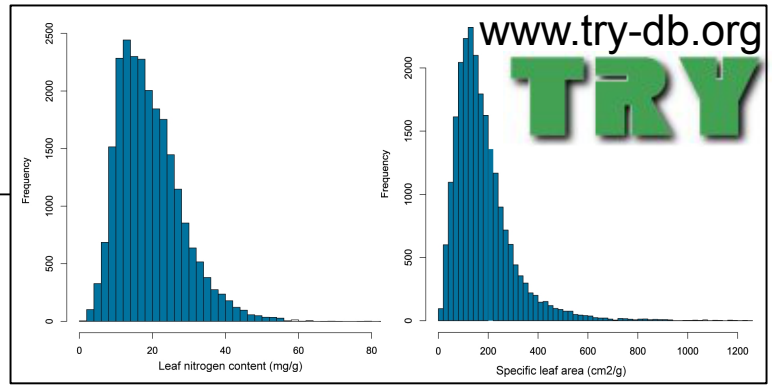


Model based on ecological knowledge (traits&tradeoffs)



PFT and biome classification by using trait databases





Thanks for your attention.

Thanks to Steven Higgins and Liam Langan

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LOEWE – Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz

DFG Deutsche Forschungsgemeinschaft