

Research interests, Previous work, Ideas for GEO-TREES

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My background

- Functional ecologist
 - Biodiversity, ecosystem structure, carbon dynamics
 - Tropical woody ecosystems
 - Deep experience of tree plot networks. SEOSAW database curator.
- PhD (2021) at the University of Edinburgh
 - Biodiversity and ecosystem function in African savannas and dry forests
- (2021-Now) SECO: carbon dynamics in the dry tropics
 - Global multi-network plot analyses
 - Where and why is woody biomass changing?
 - How does biogeography affect climate responses?



Open savanna, southwest Angola



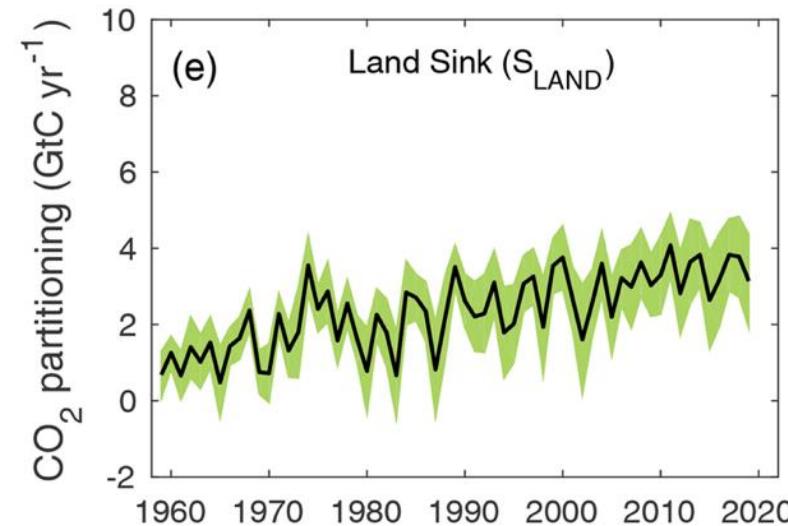
Oak woodland, northern England

Motivations and approach

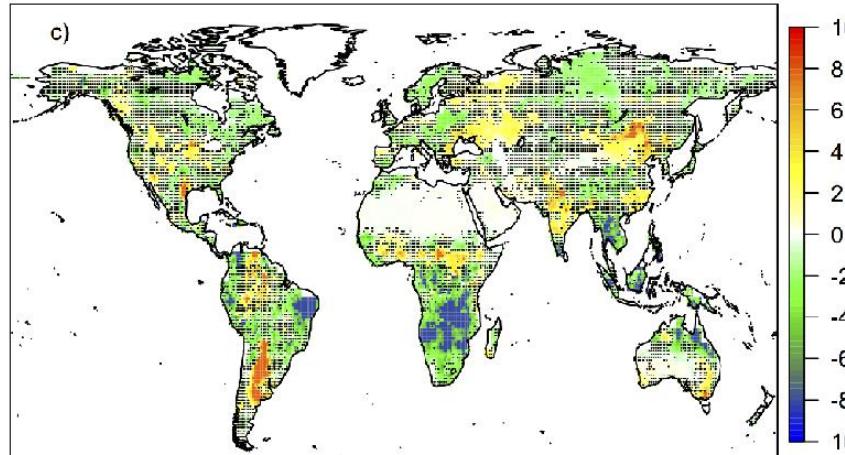
Grand challenges:

1. What is the role of terrestrial vegetation in global biogeochemical cycles?

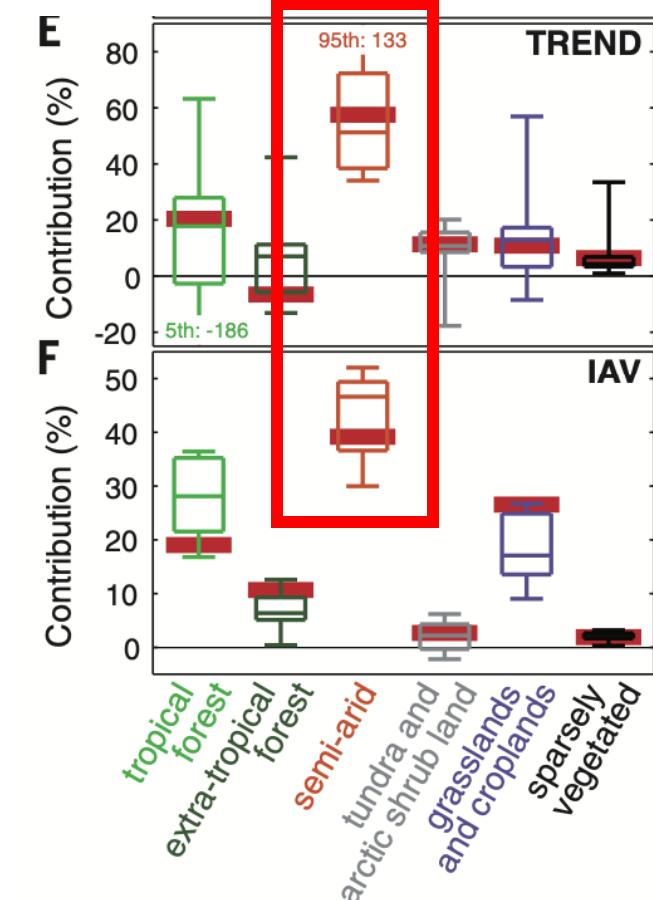
Models: increasing terrestrial carbon sink



Spatial variability in carbon flux trend



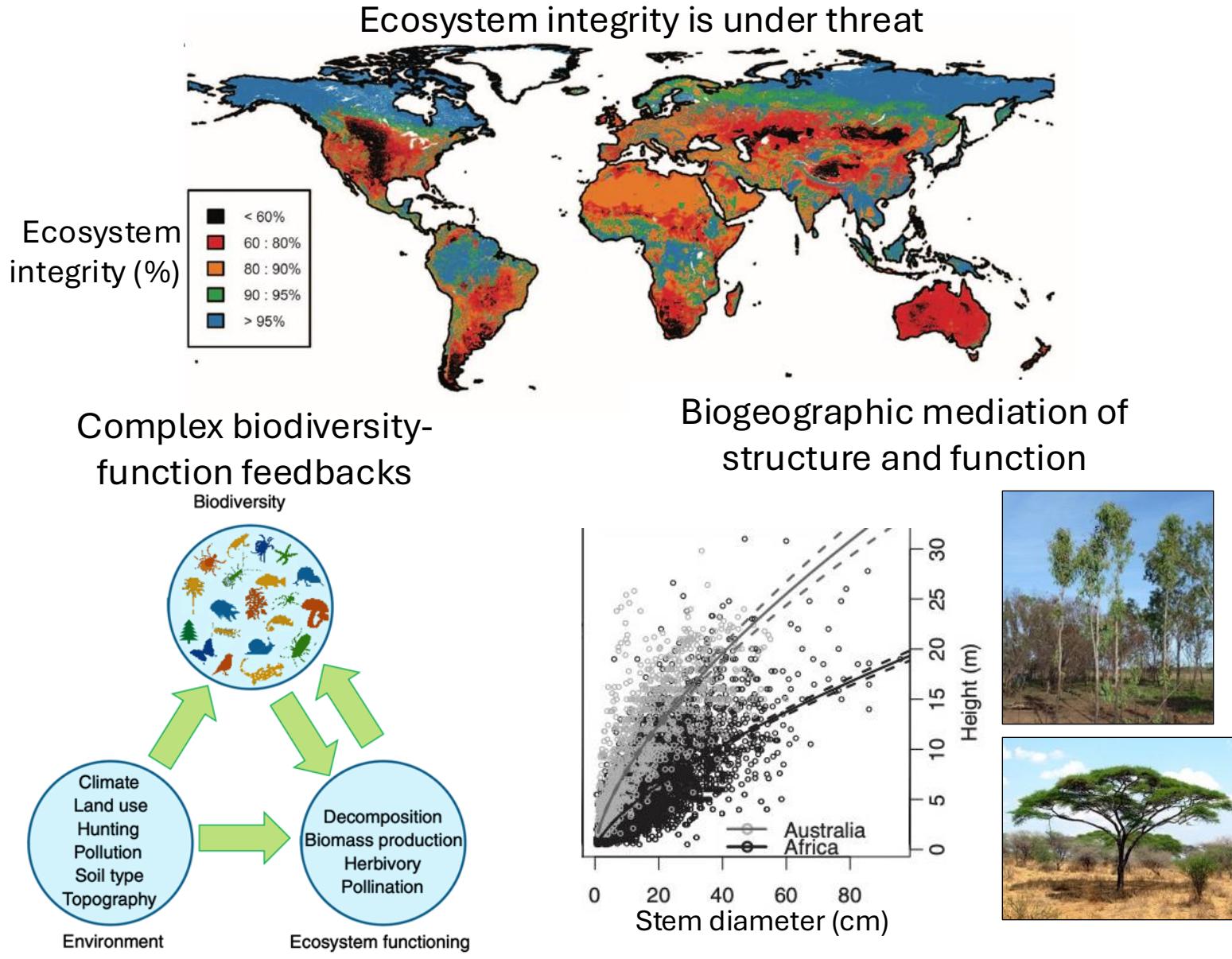
Uncertainty in trend and inter-annual variability of carbon sink



Motivations and approach

Grand challenges:

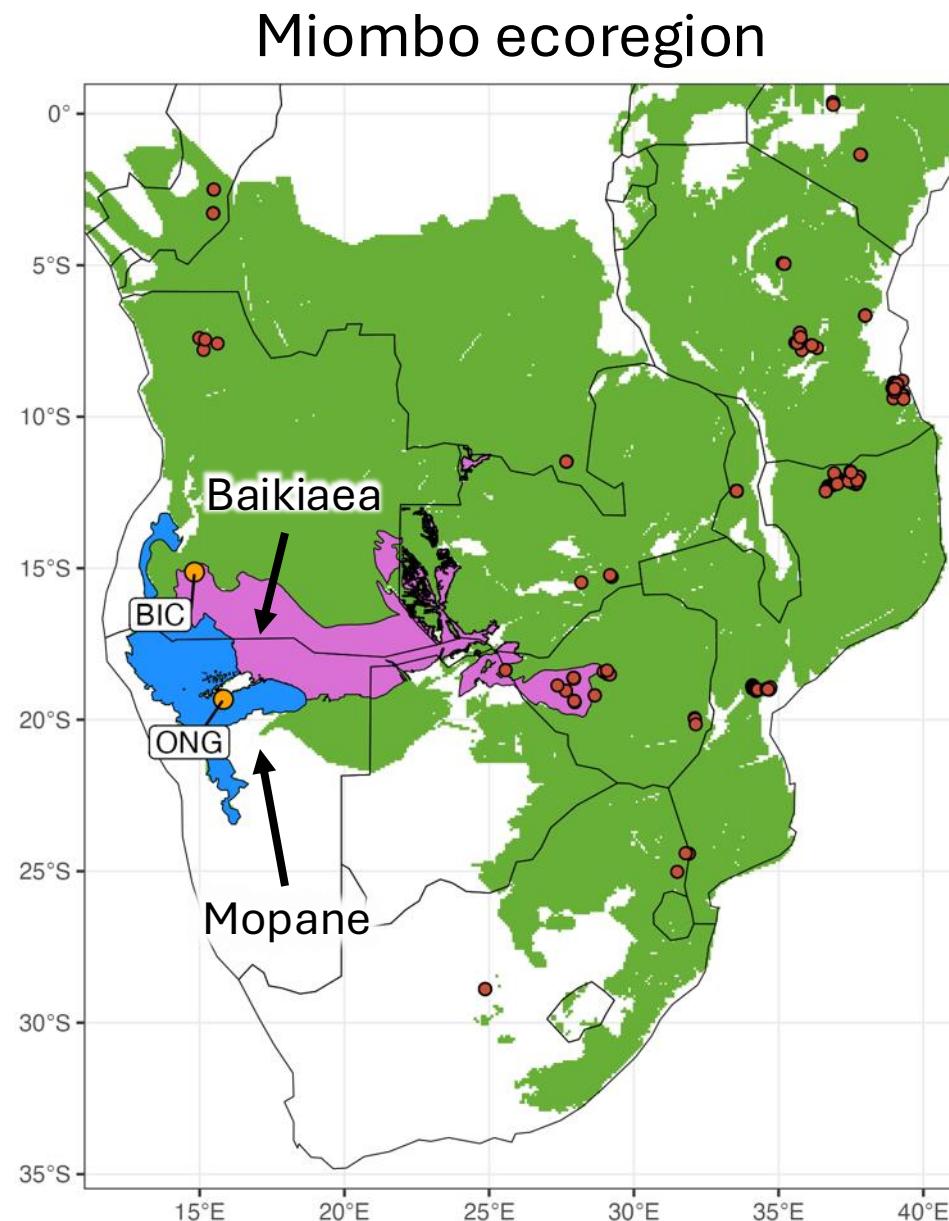
1. What is the role of terrestrial vegetation in global biogeochemical cycles?
2. How do biodiversity and environment jointly affect ecosystem structure and function?



Developing vegetation monitoring infrastructure

Building capacity for research in the global south.

Ensuring sustainable site provision.



SEOSAW



Miombo savanna,
Bicuar National Park (BIC)



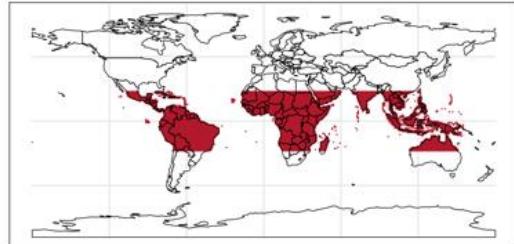
Succulent dry forest,
Ongava Reserve (ONG)

The dry tropics: Tropical savannas and dry forests

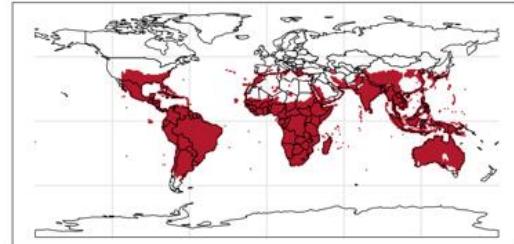


Where are the tropics?

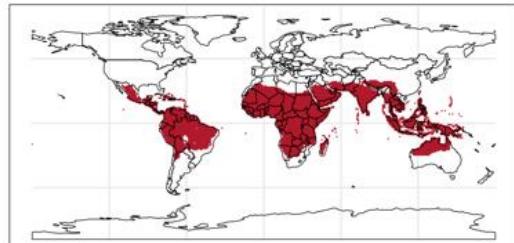
23.4° N-S



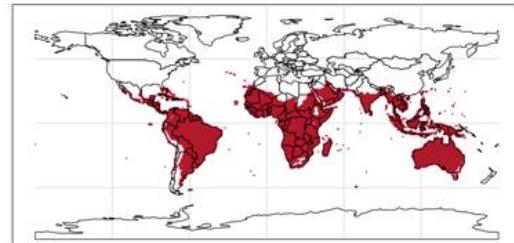
Net positive energy balance



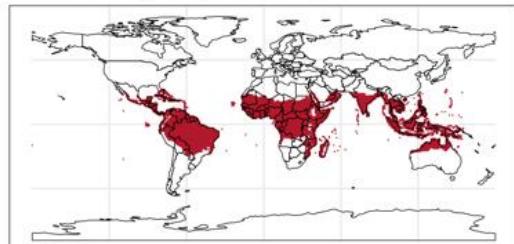
MAT does not vary by latitude



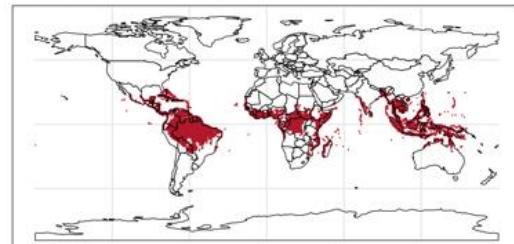
No freezing



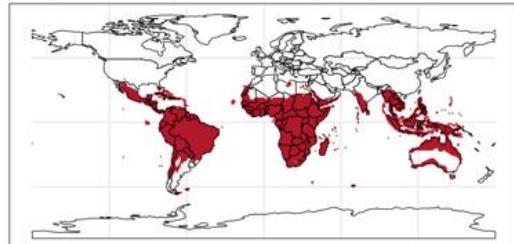
Mean monthly temperature >18 °C



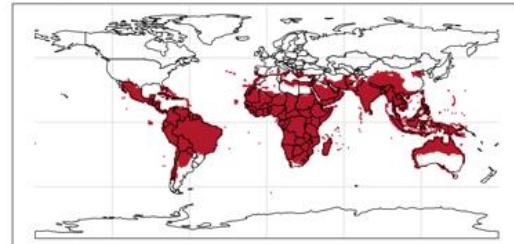
Mean annual biotemperature >24 °C



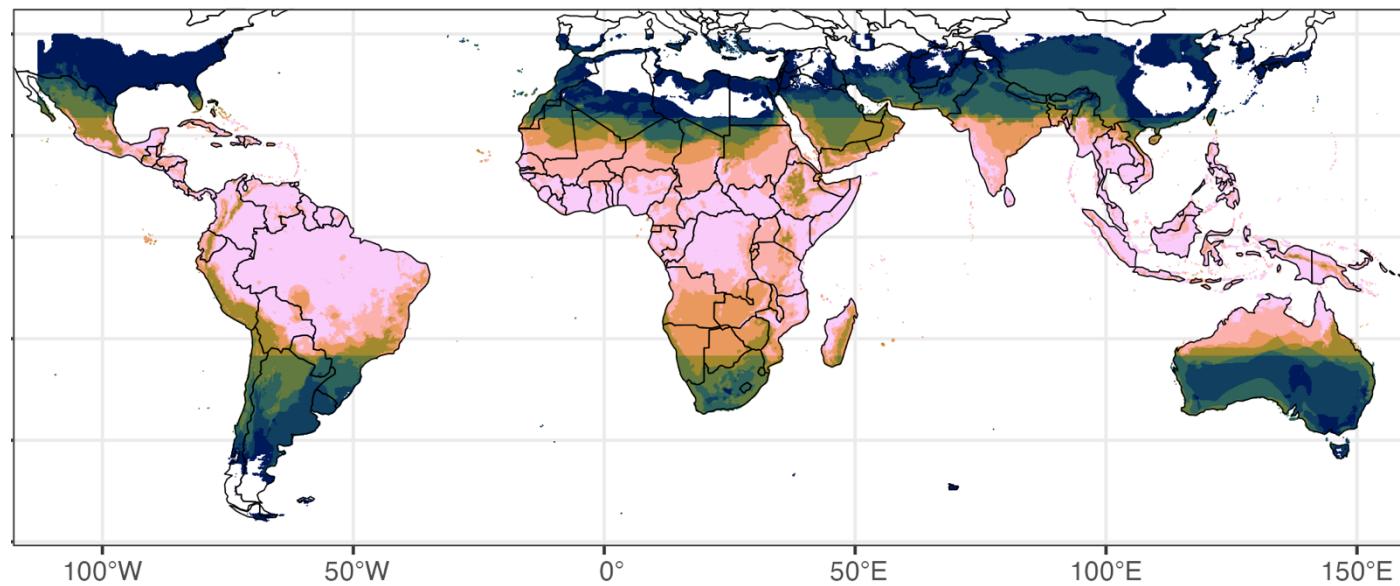
Temp. ann. range < mean daily temp. range



Precip. seas. > temp. seas.

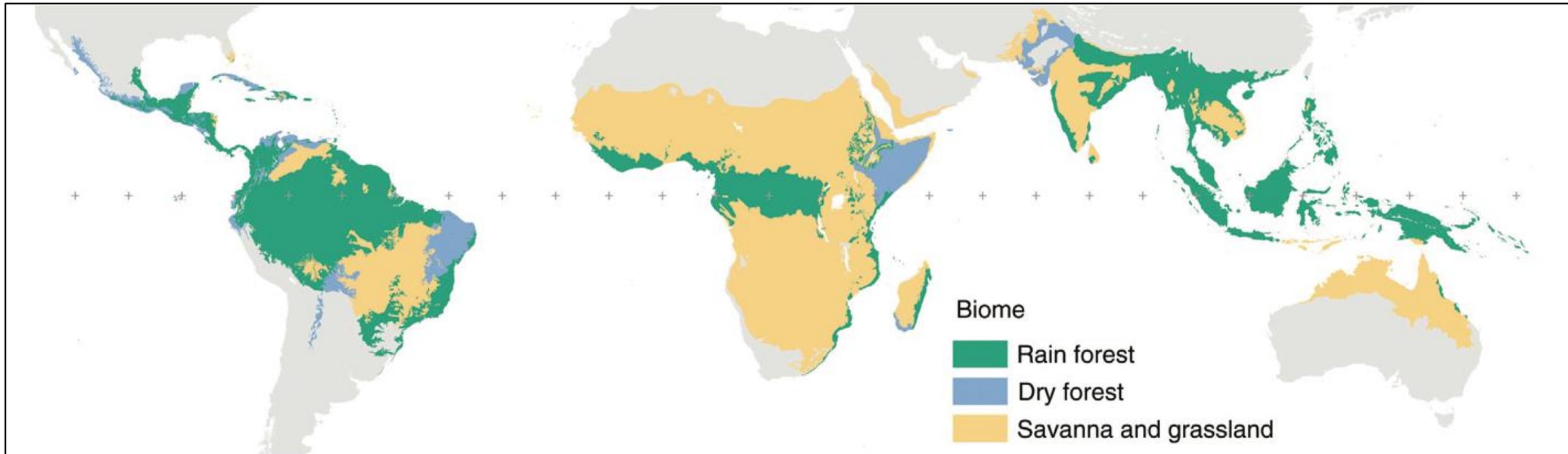


Definition is important: determines how our work will be interpreted.



Increased “tropicality”

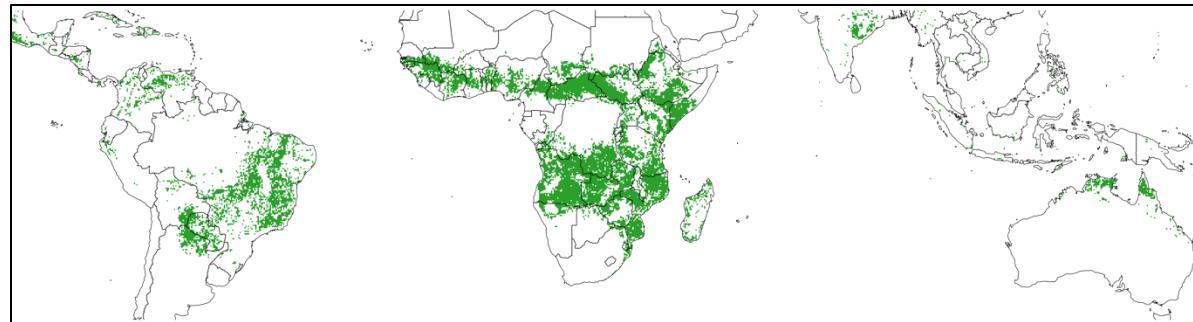
Half of the global tropics are "dry"



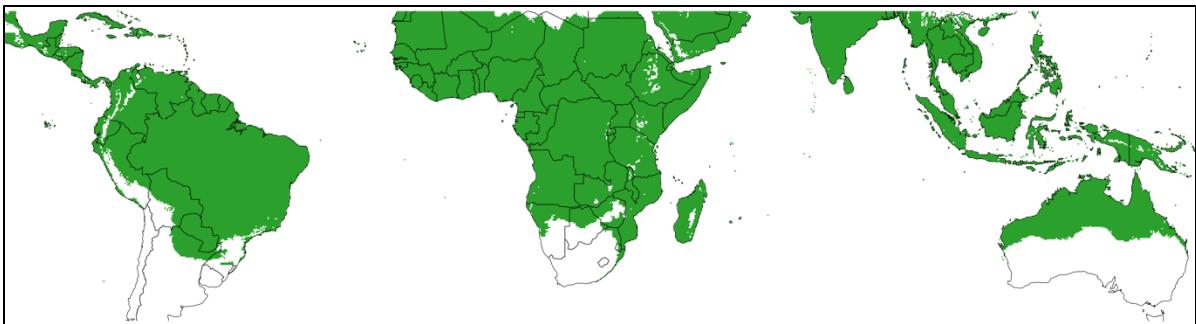
Where are the (seasonally dry) tropics?

A functional definition allows us to estimate realised extent of woody vegetation.

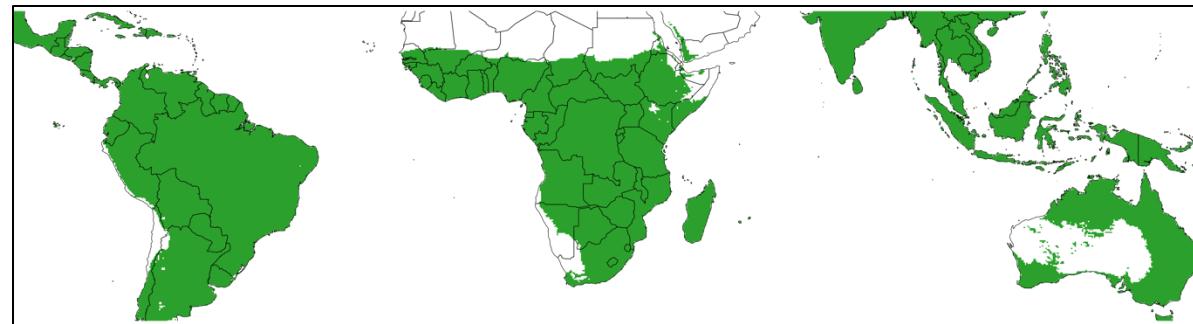
Not human-transformed landscape



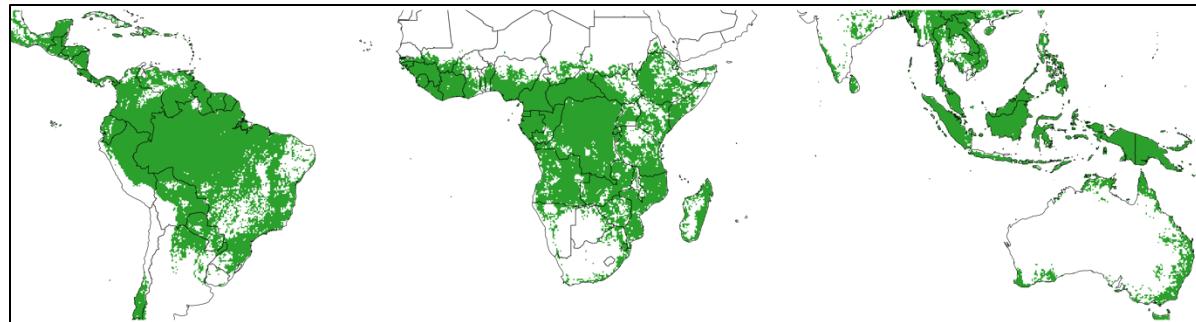
Temperature of coldest quarter $> 15^{\circ}\text{C}$



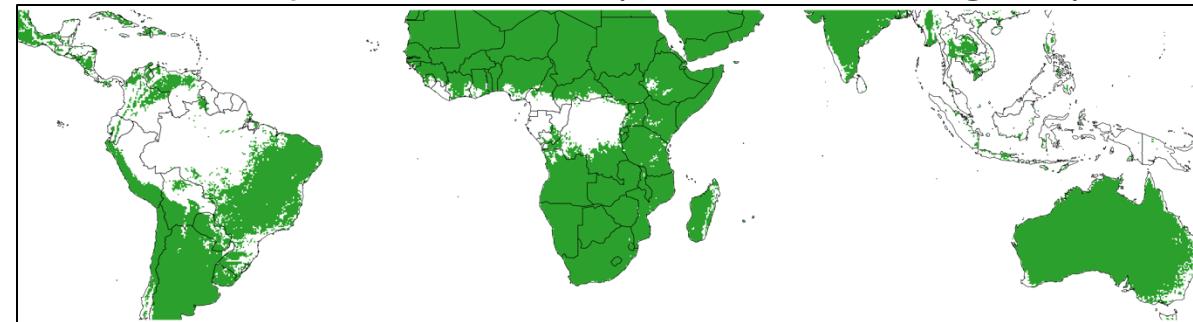
>3 wet months (>30 mm rainfall)



Woody biomass $>5 \text{ MgC ha}^{-1}$



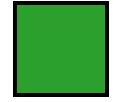
Not tropical wet forest (Terrestrial Ecoregions)



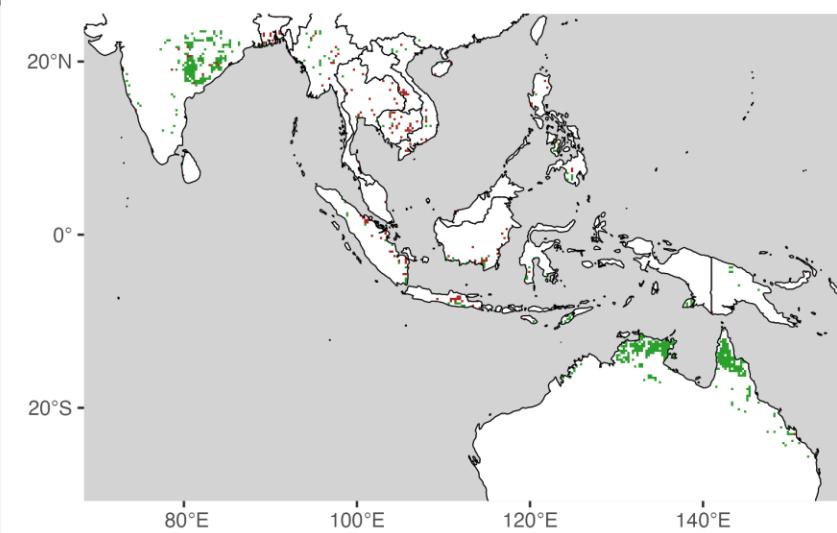
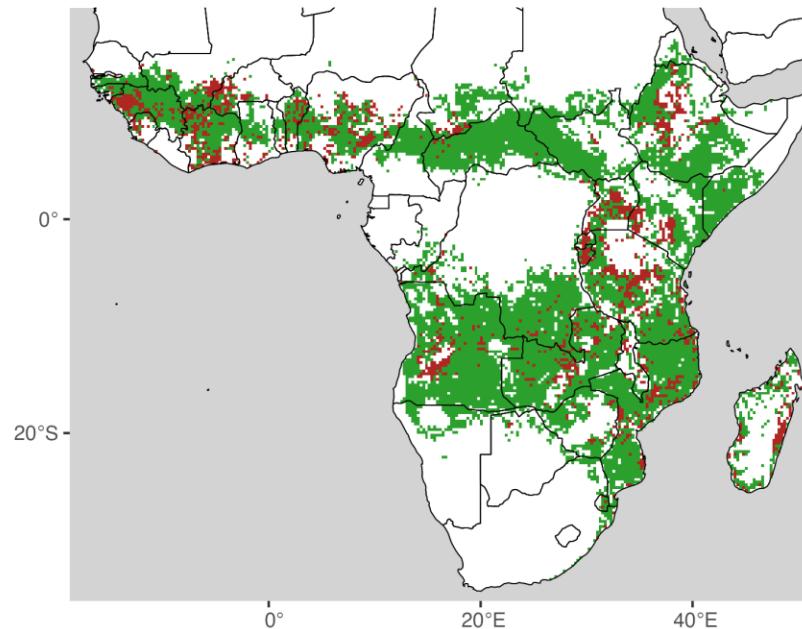
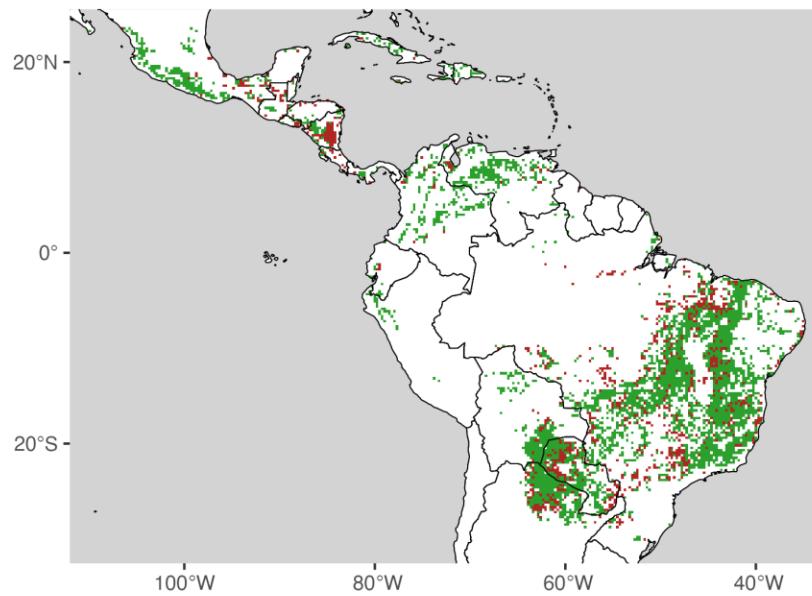
Tropical savannas and dry forests are patchy



Human-transformed landscapes



Remaining woody vegetation



The dry tropics are functionally diverse



Cerrado,
Brazil



Caatinga,
Brazil



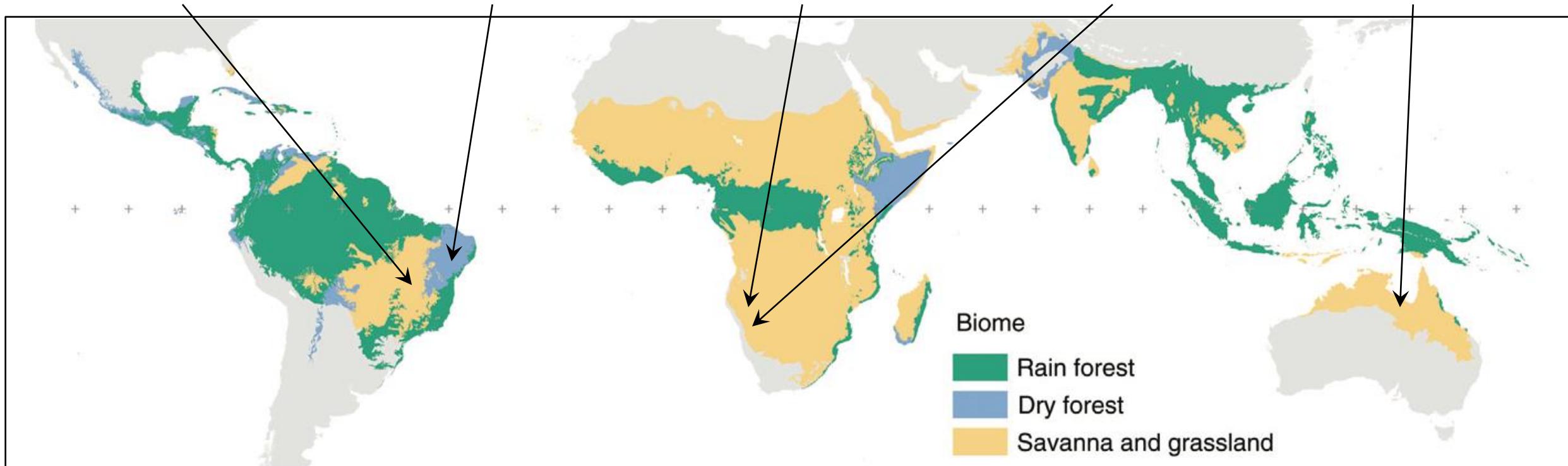
Miombo,
Angola



Mopane dry forest,
Namibia



Eucalypt savanna,
Australia

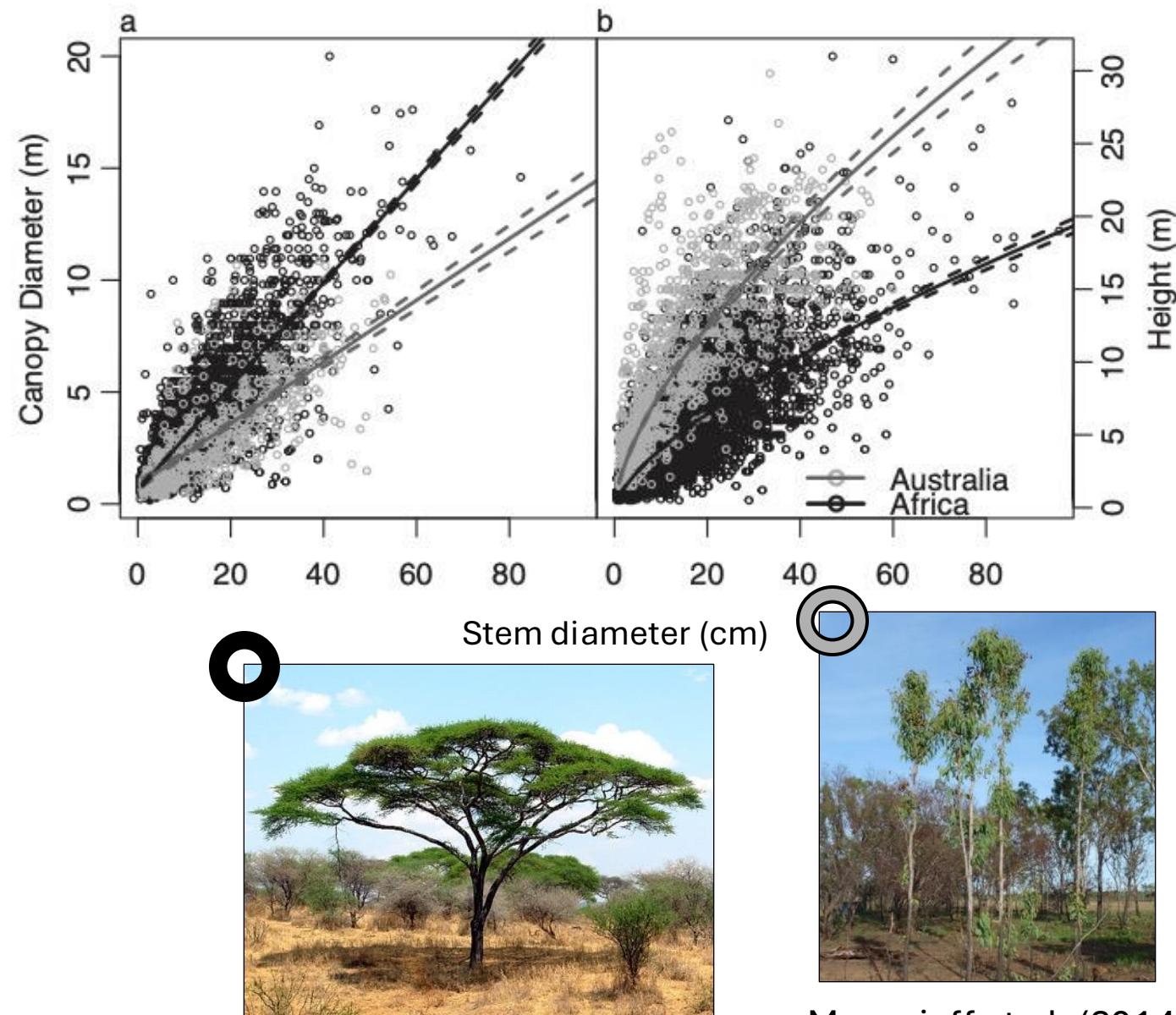


Biogeographic variation in tree architecture

E.g. wide crown miombo vs. tall and skinny eucalypt savanna
(Moncrieff et al. 2014).

How does variation in species composition and structure affect ecosystem function?

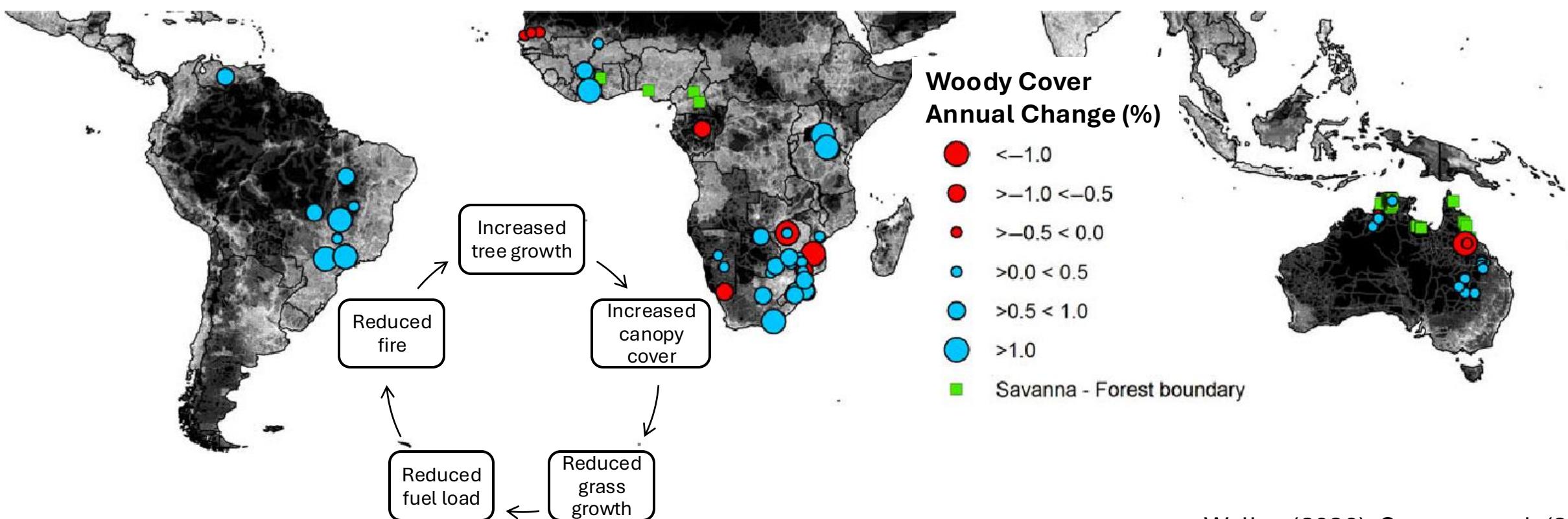
Which groups contribute most to biomass turnover / persistence?



Moncrieff et al. (2014)

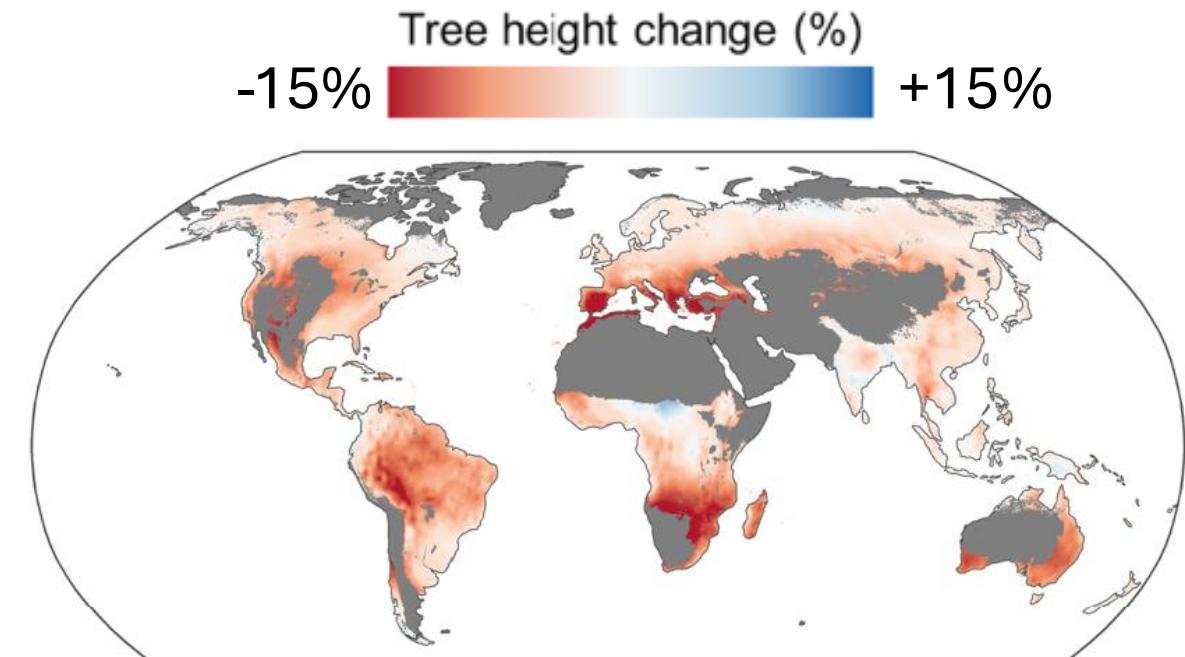
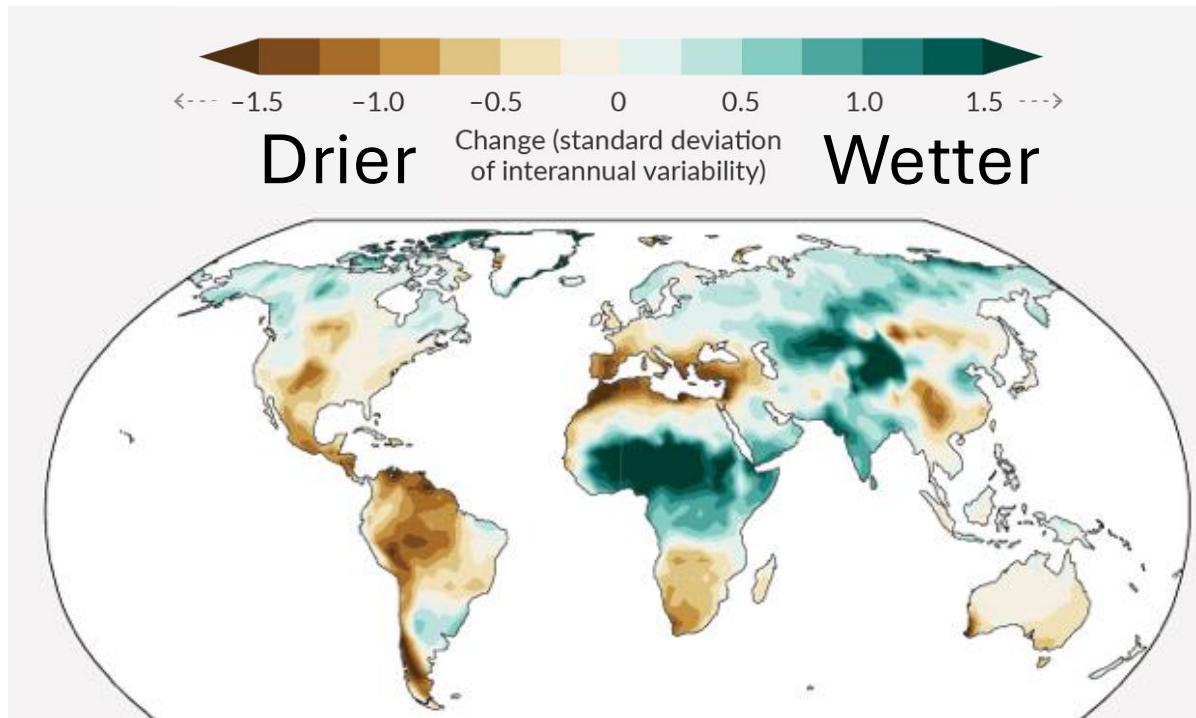
Drivers of change: increasing atmospheric CO₂

- Boost tree growth. Trees can benefit from higher CO₂ while grasses cannot.
- Continental variation in rates of encroachment – attributed to nitrogen fixers, able to colonise grassy patches.



Drivers of change: warming and drying

- Increased rainfall seasonality.
- Increased inter-annual variability in rainfall.
- Reduced woody productivity, increased mortality.
- Reduced maximum tree height



Drivers of change: altered fire regimes

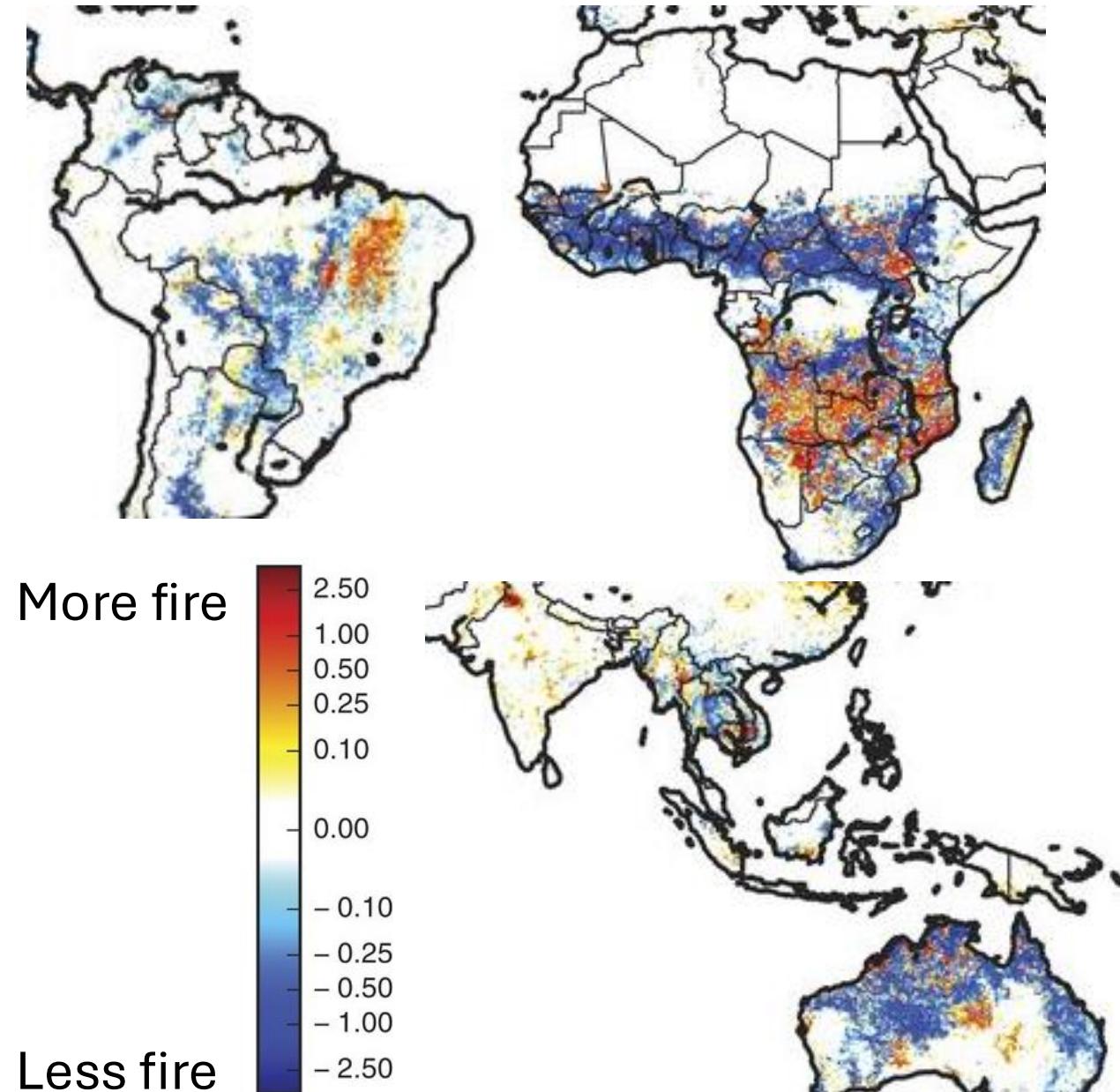
Andela et al. (2017)

Global burned area declined
~25% between 1998 and 2015
($\pm 8.8\%$).

Mostly due to changes in human
land use.

Strong contrasts among regions
within continents.

Fire affects demographic rates
and ecosystem structure.

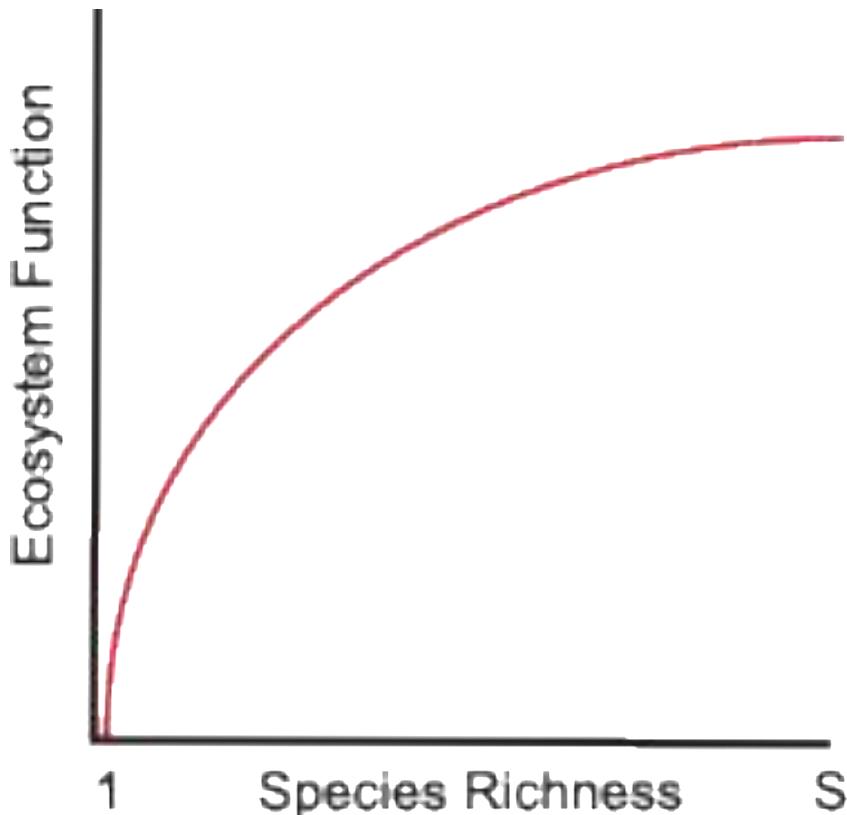


Biodiversity – biomass relationships in dry tropical woodlands

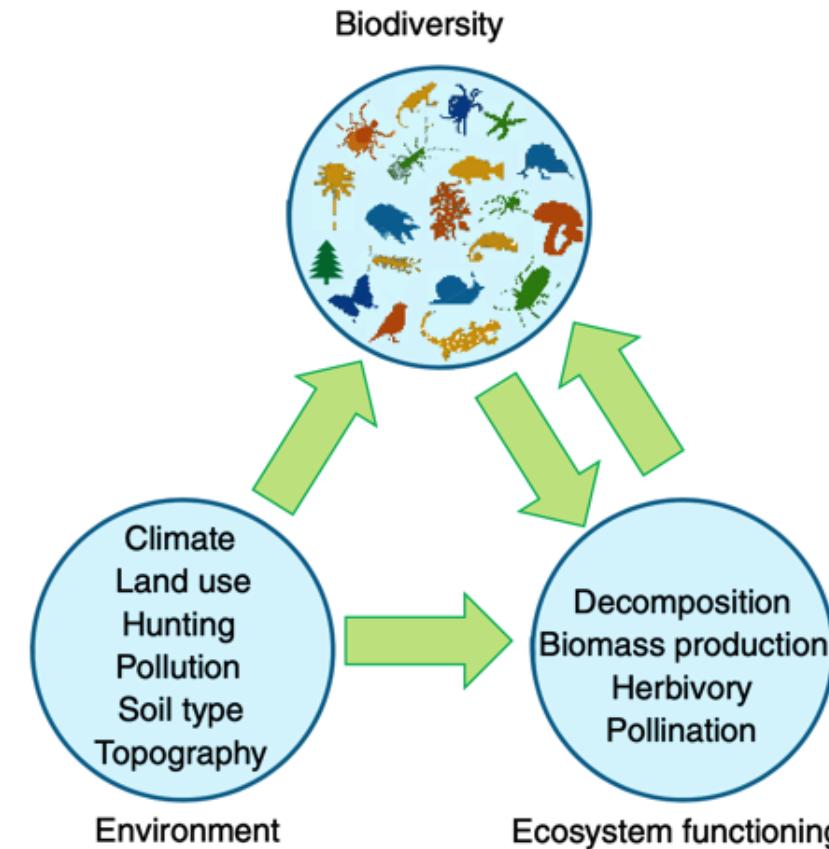


Determinants of woody biomass in African woodlands

Positive biodiversity-
ecosystem function
relationship



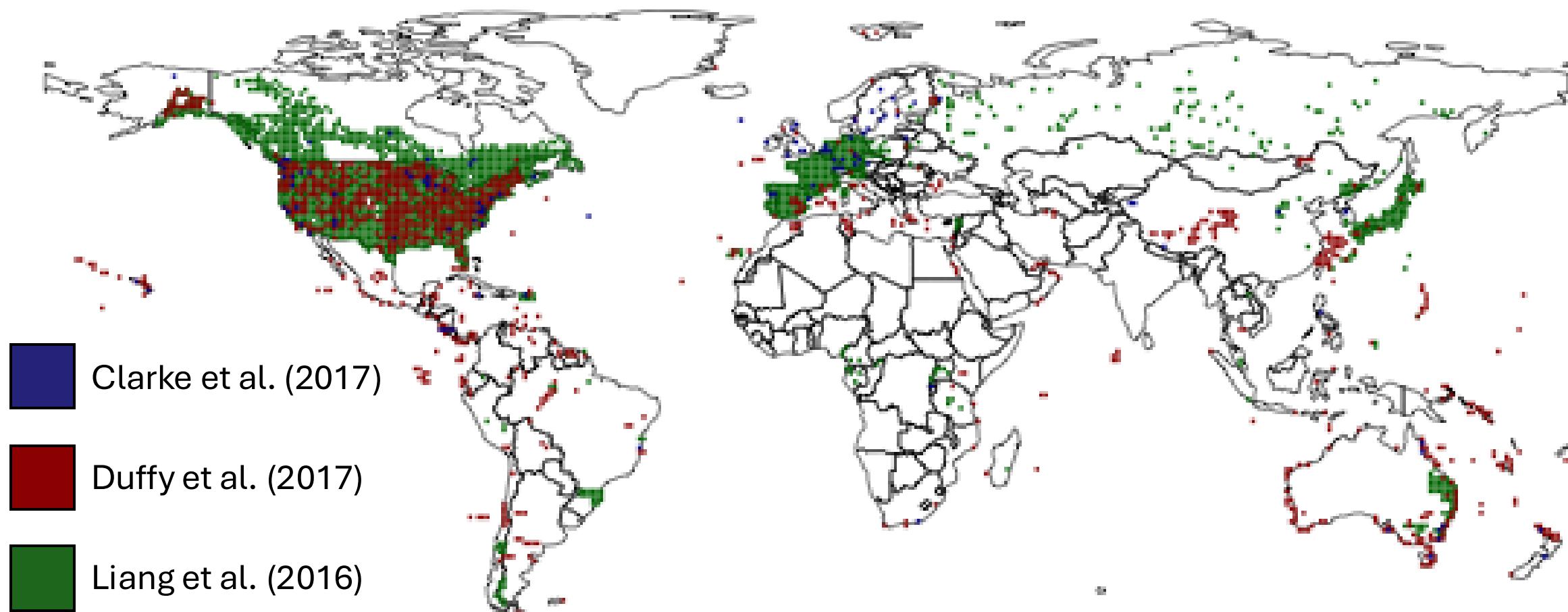
Complex interactions
between environment,
diversity and function



Determinants of woody biomass in African woodlands

Majority of previous BEF studies conducted in experimental mesocosms, or temperate systems.

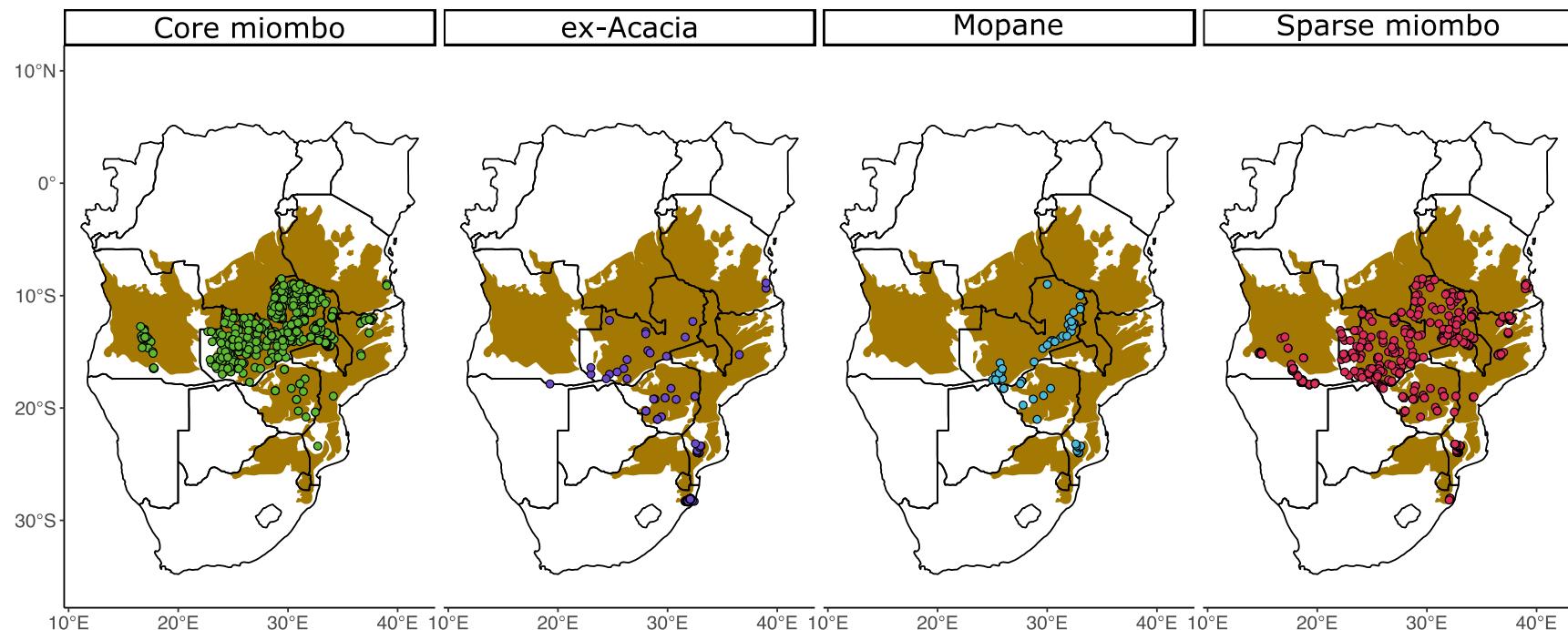
Chronic disturbance could reduce the importance of niche differentiation



Determinants of woody biomass in African woodlands

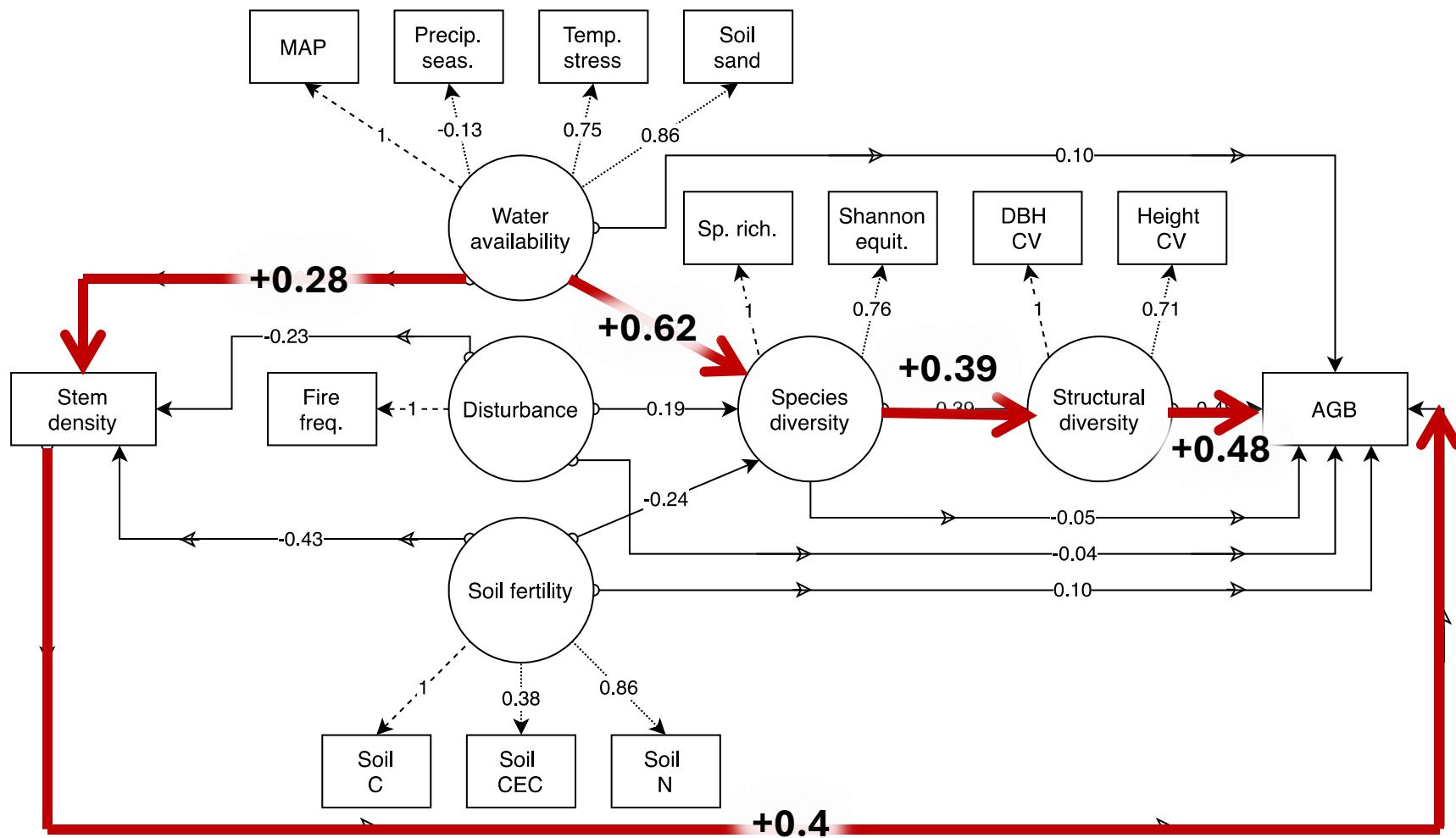
How do biodiversity
and environment
jointly affect woody
biomass in African
savannas?

SEOSAW



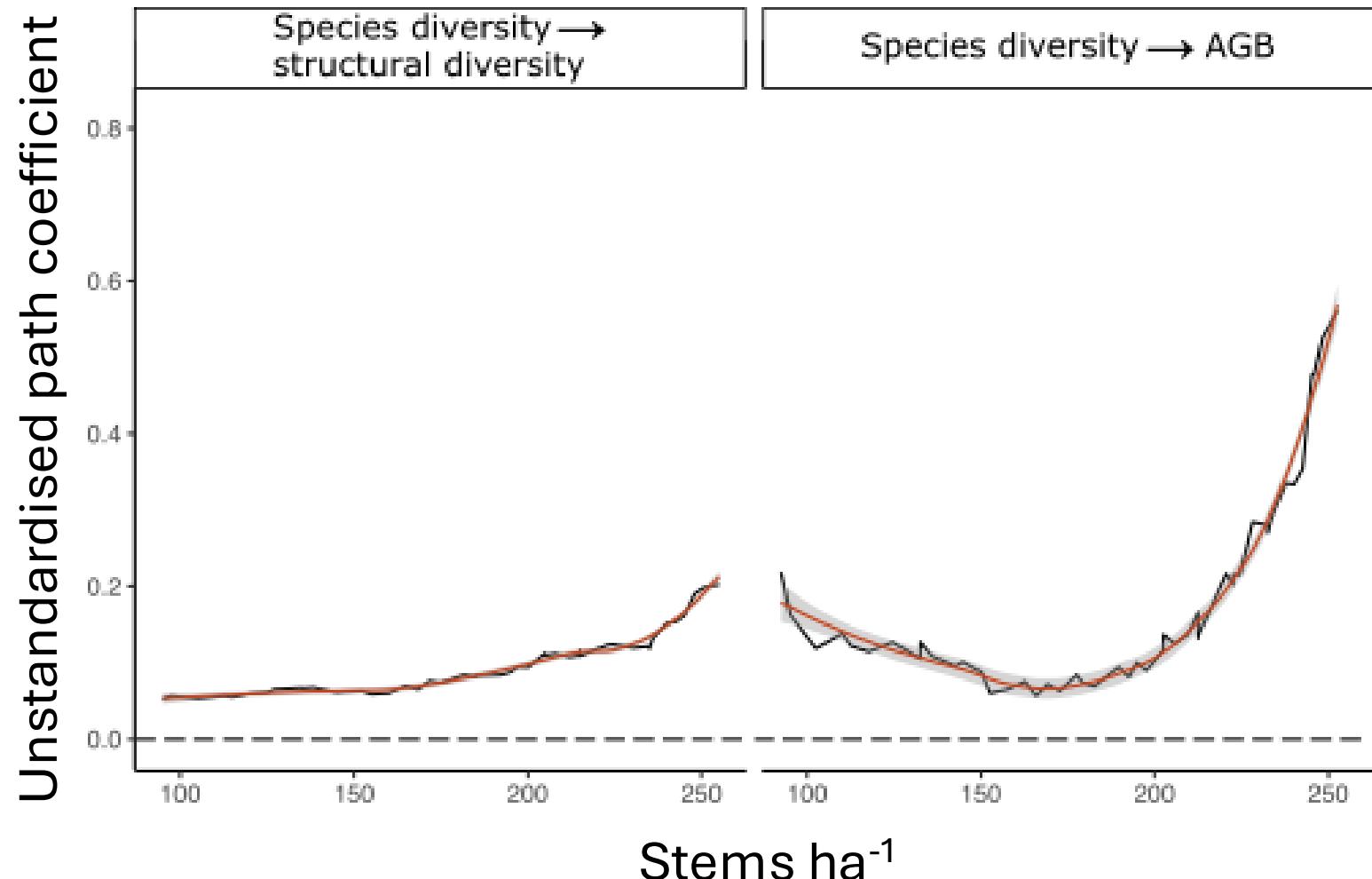
Determinants of woody biomass in African woodlands

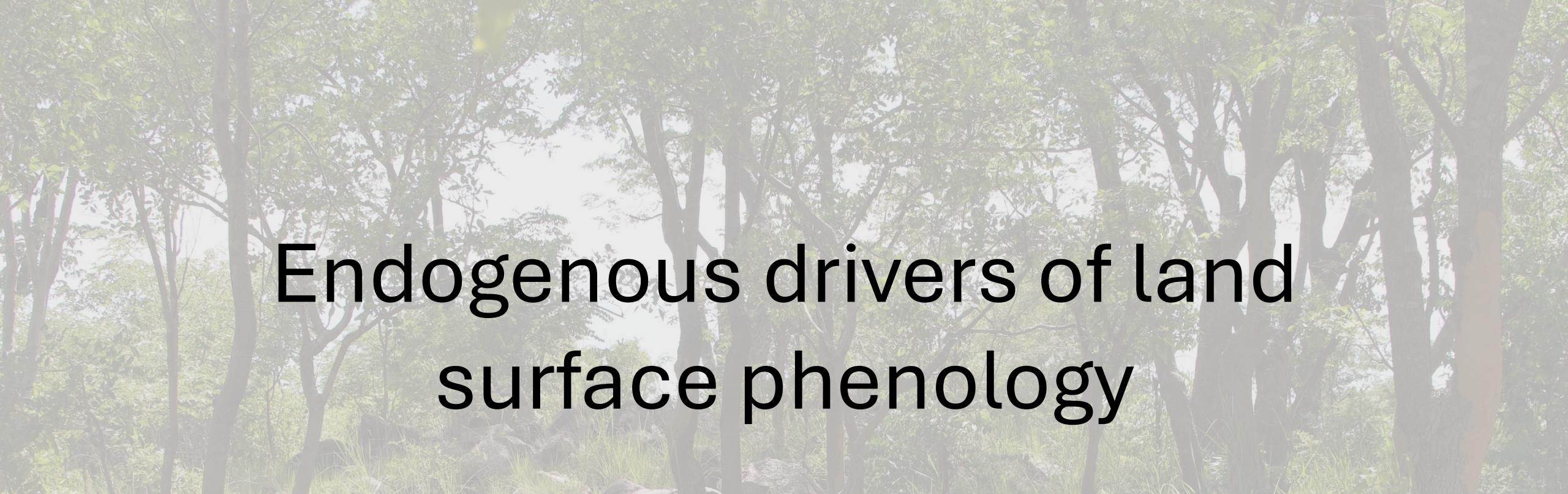
1. Water availability drives biomass via species diversity and stem density
2. Structural diversity as an axis of niche differentiation



Determinants of woody biomass in African woodlands

1. Water availability drives biomass via species diversity and stem density
2. Structural diversity as an axis of niche differentiation
3. Bootstrapping:
Stem density mediates species diversity – biomass relationship





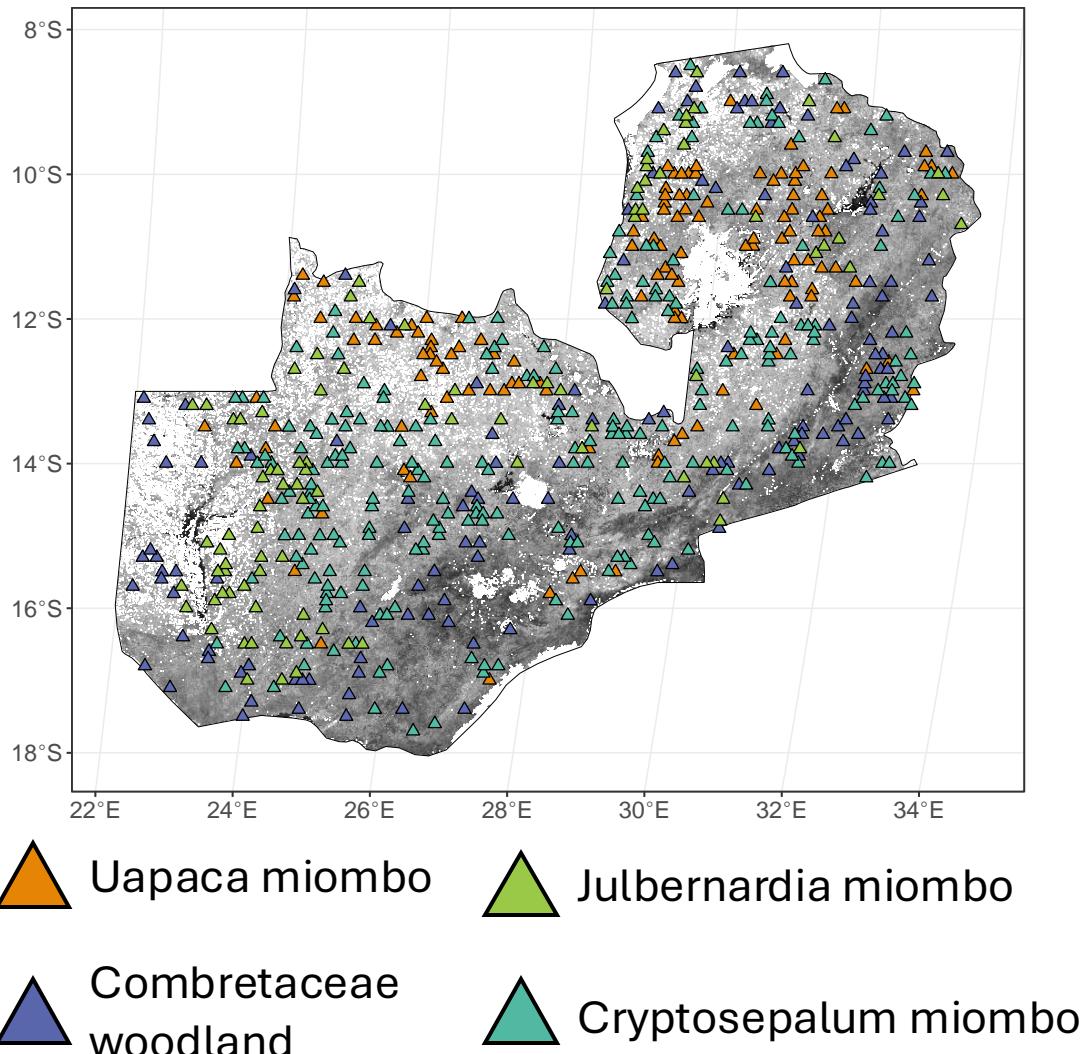
Endogenous drivers of land surface phenology



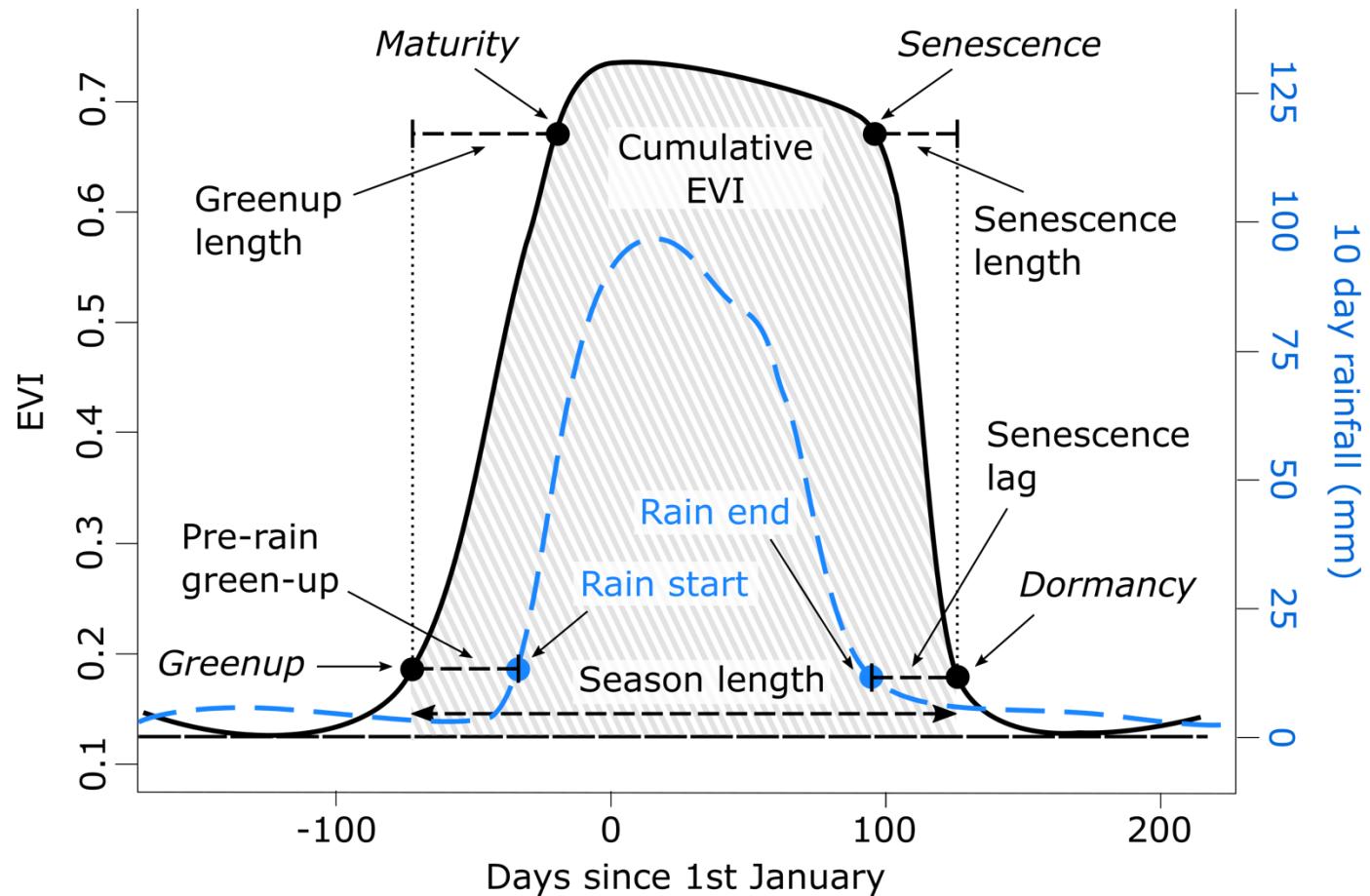
Linking land surface phenology and diversity



Zambian ILUAI –
National Forest Inventory



MODIS EVI – Enhanced Vegetation Index

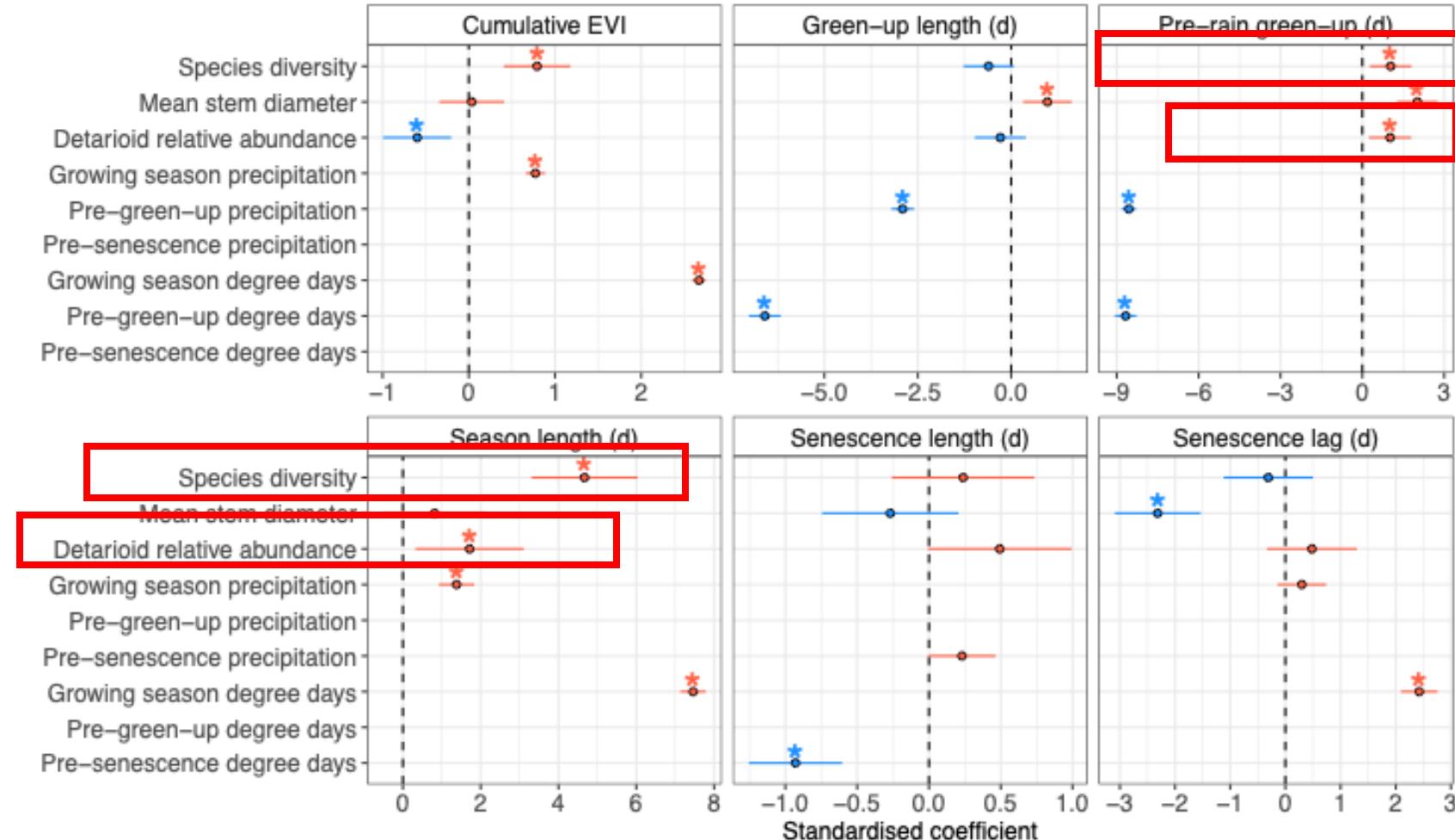


Linking land surface phenology and diversity



Species diversity and keystone species abundance associated with **longer growing season, earlier pre-rain green-up**.

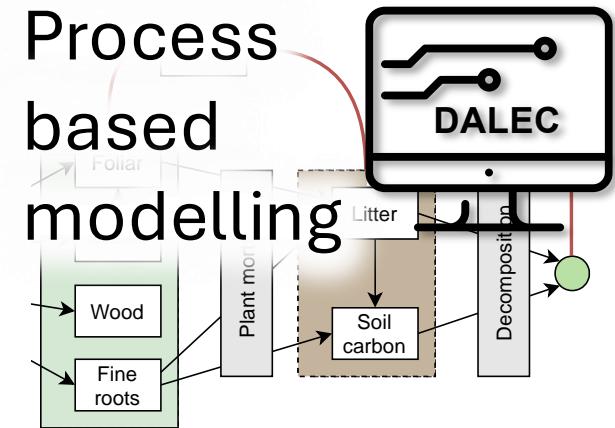
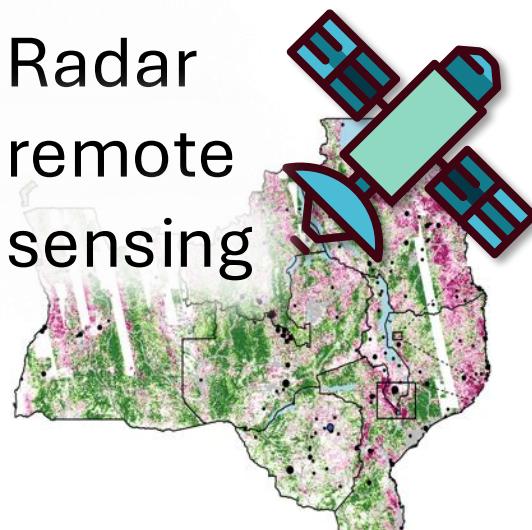
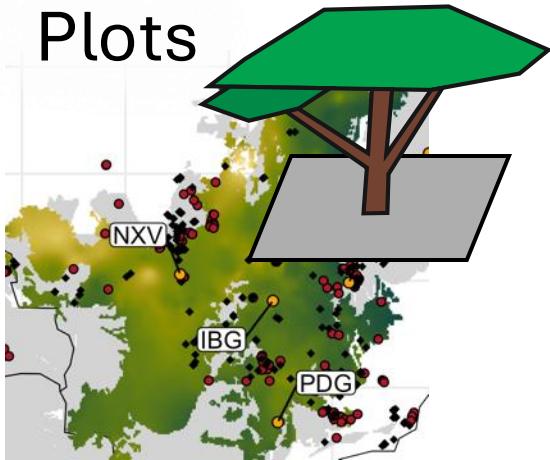
Developing maps of savanna functional composition based on land surface phenology.



A photograph of a tropical forest floor. In the foreground, a large, fallen tree trunk lies diagonally across the frame. The ground is covered with a mix of green leaf litter and dry brown debris. Several small, thin trees or saplings are scattered throughout the scene, some leaning at angles. The background is filled with the intricate network of branches and leaves from the surrounding trees, creating a dense, textured canopy.

Woody carbon dynamics in the dry tropics

The SECO project: Methodological approach



Plots provide:

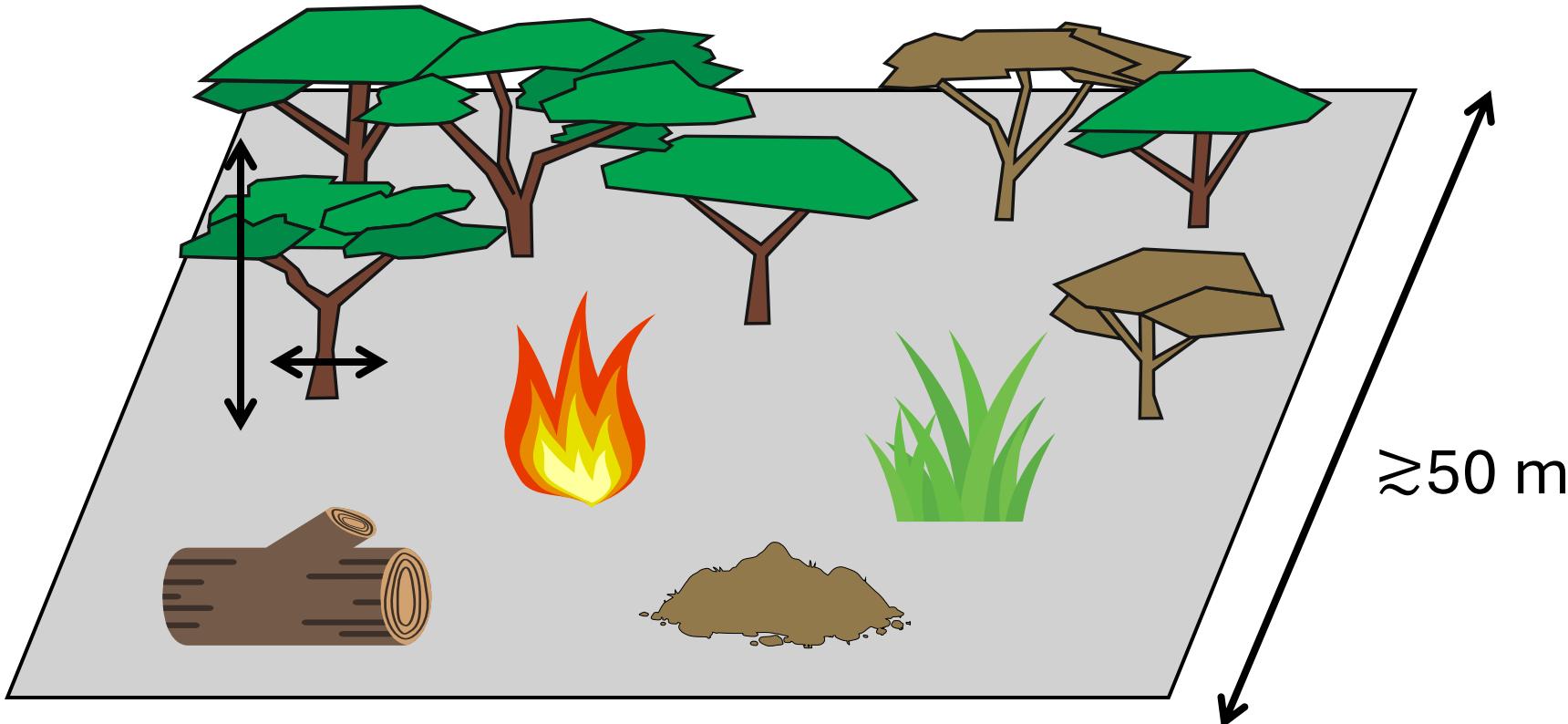
- Individual-level rates of growth and mortality
- Species composition and community structure
- Infrastructure to collect auxiliary data – plant traits, phenology, soil, woody debris, herbaceous biomass etc.
- Woody biomass stocks and canopy structure to calibrate remote sensing

What's in a plot?

SEOSAW

FORESTPLOTS.NET

tern
Ecosystem Research Infrastructure



- Tree species
- Stems within a tree
- Stem diameter
- Stem height
- Coarse woody debris

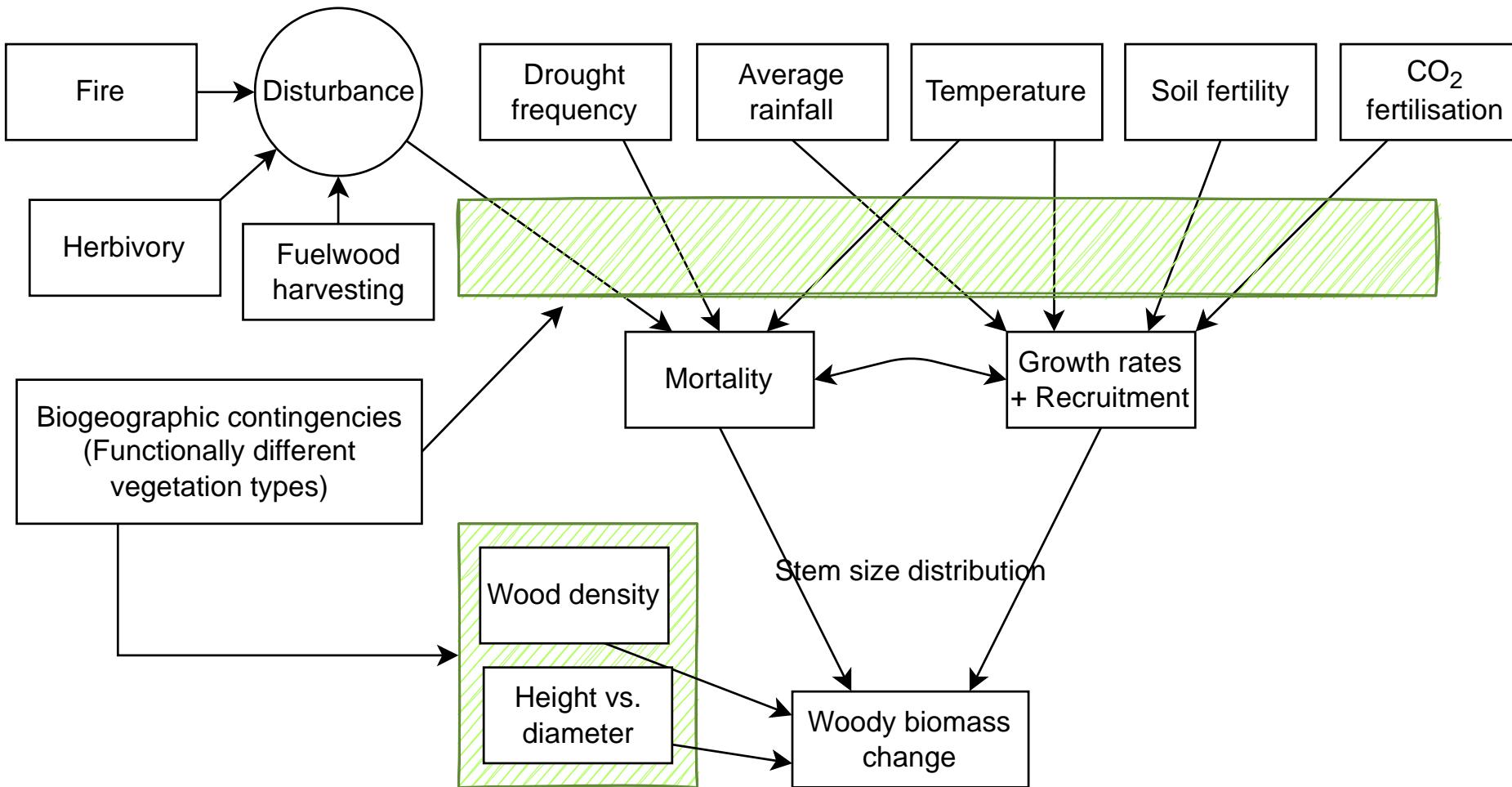
- Fire disturbance regime
- Soil carbon and nutrients
- Herb. biomass and comp.
- Tree mortality
- Leaf phenology



Tags on all woody
stems $>5 \text{ cm}$ diameter

Dry tropical woody carbon dynamics

Broad aim: Resolve uncertainties in the carbon cycle of the dry tropics.



Funded by:



Collaboration with:



UNIVERSITY OF LEEDS



FORESTPLOTS.NET

SEOSAW

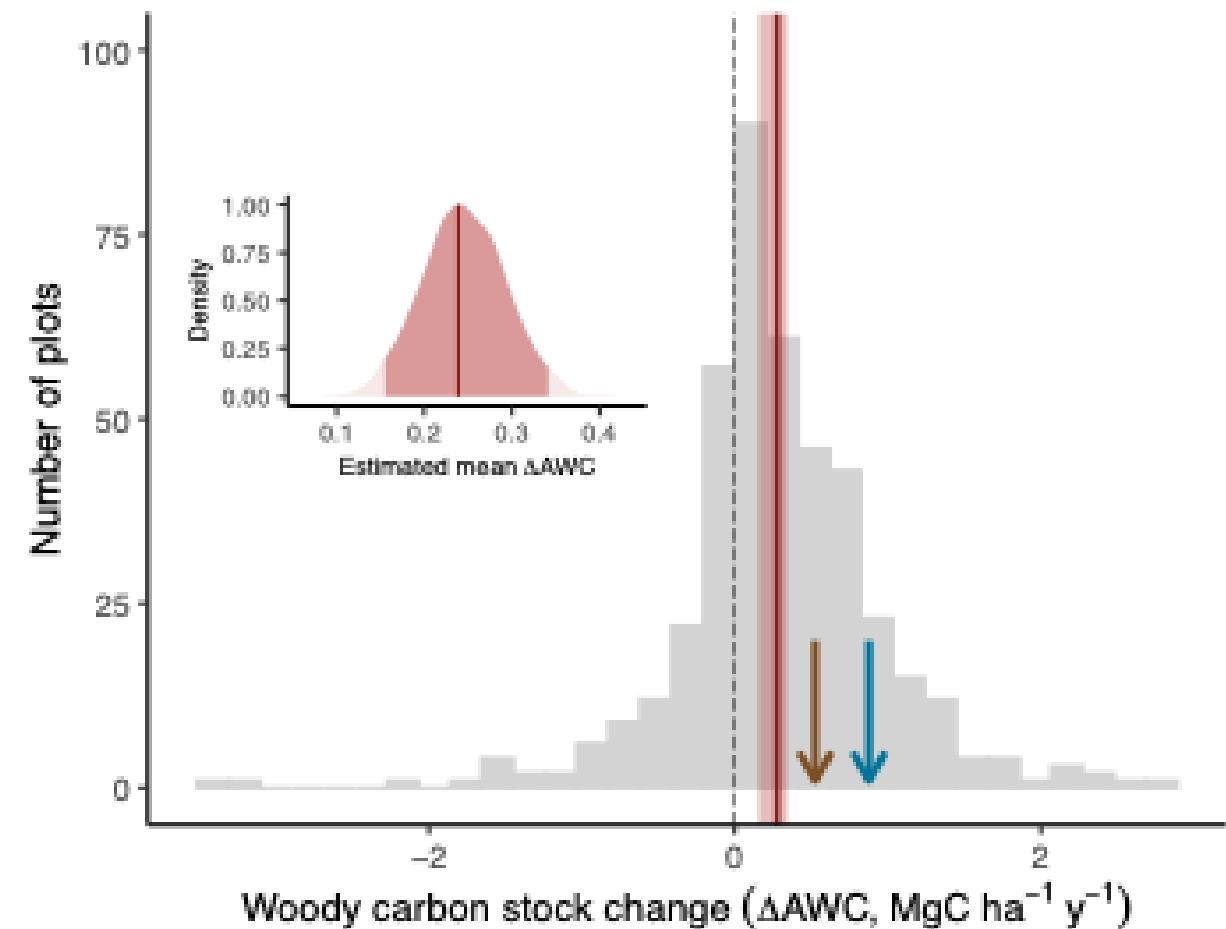
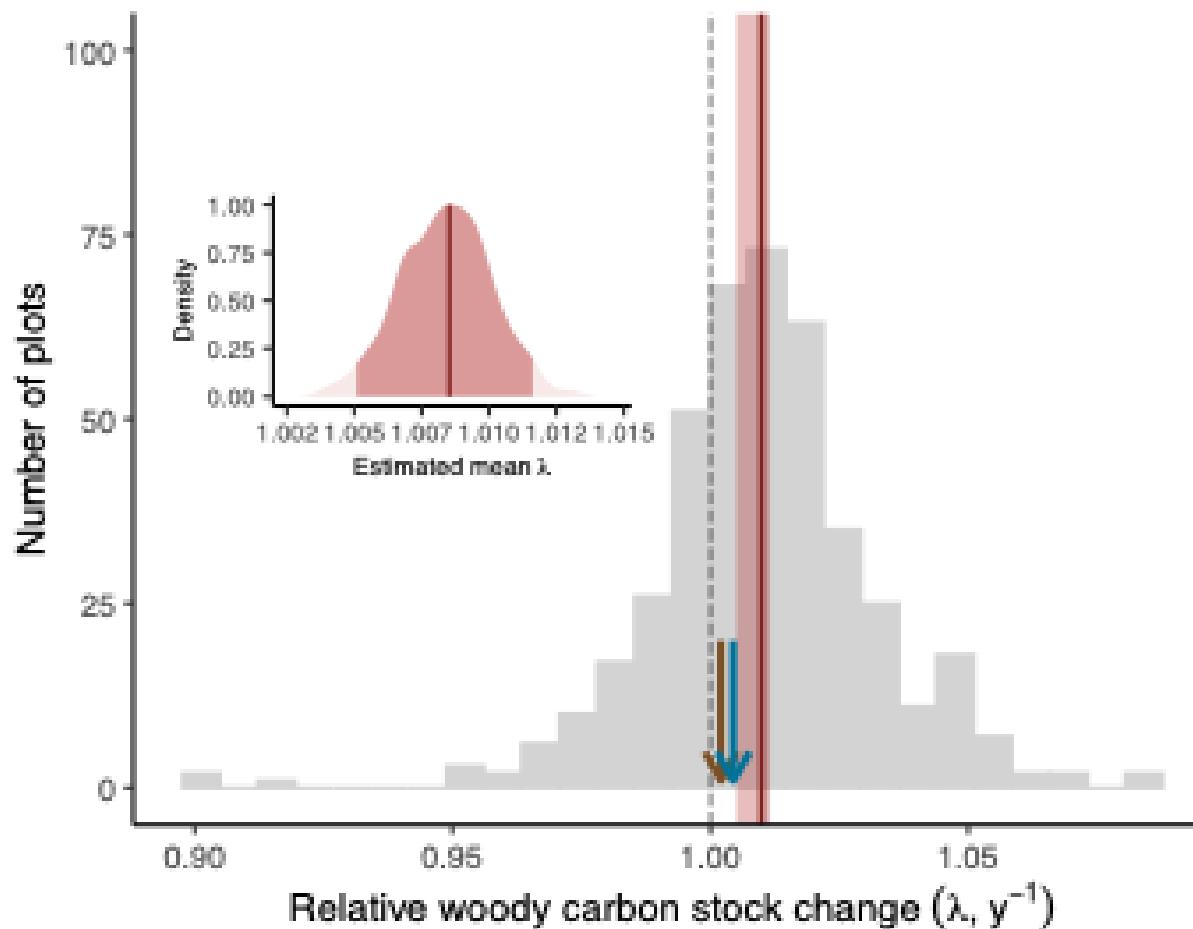
+22 international
partners

Drivers of biomass change in the dry tropics

424 plots

> 0.1 ha plot area

2000-2023 time period



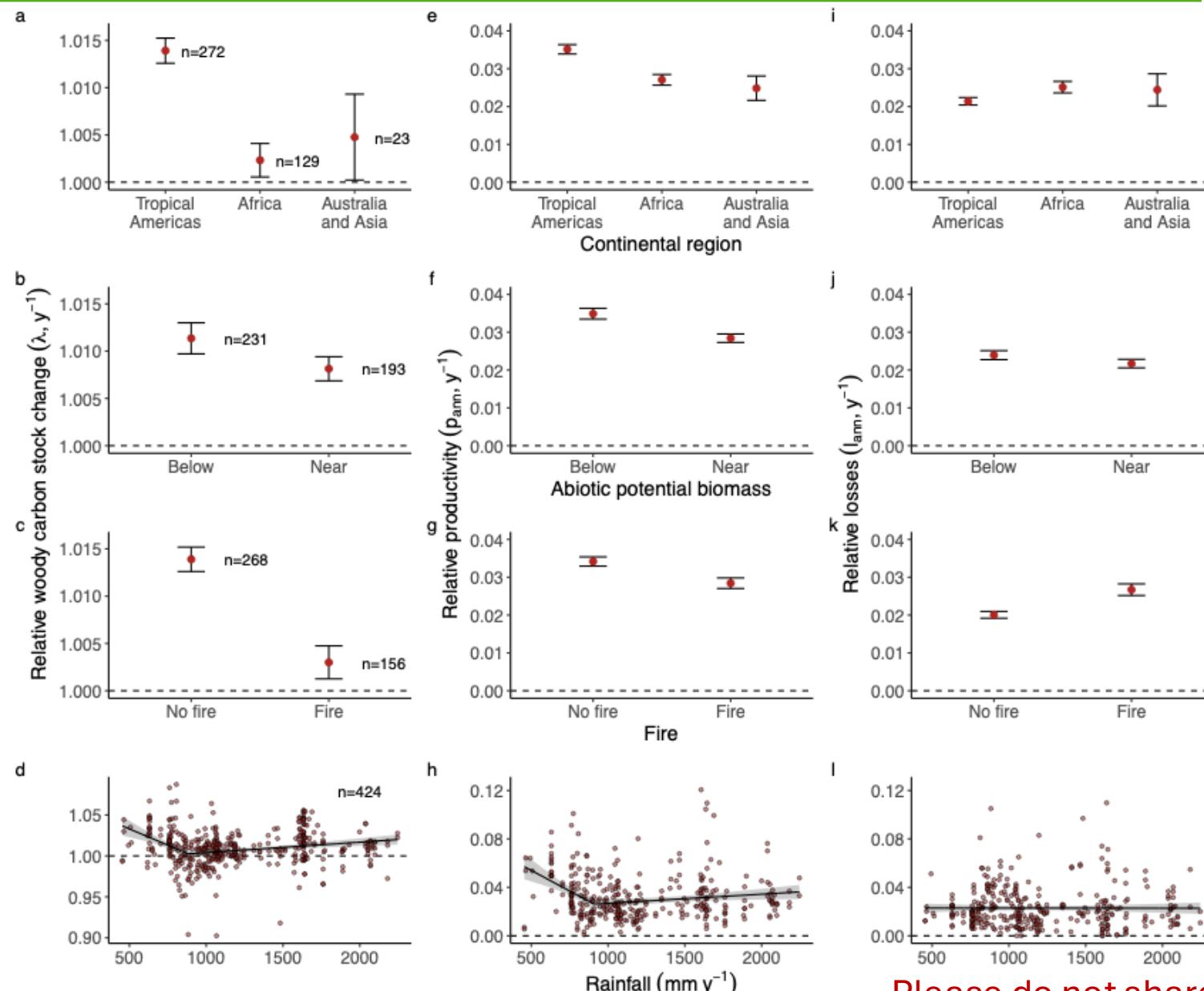
Drivers of biomass change in the dry tropics

Woody carbon increasing across all continents.

Fire limits the carbon sink, increasing mortality and decreasing losses.

Greater increases at low rainfall (<880 mm).

Signal of biomass recovery, or competition effects at high biomass

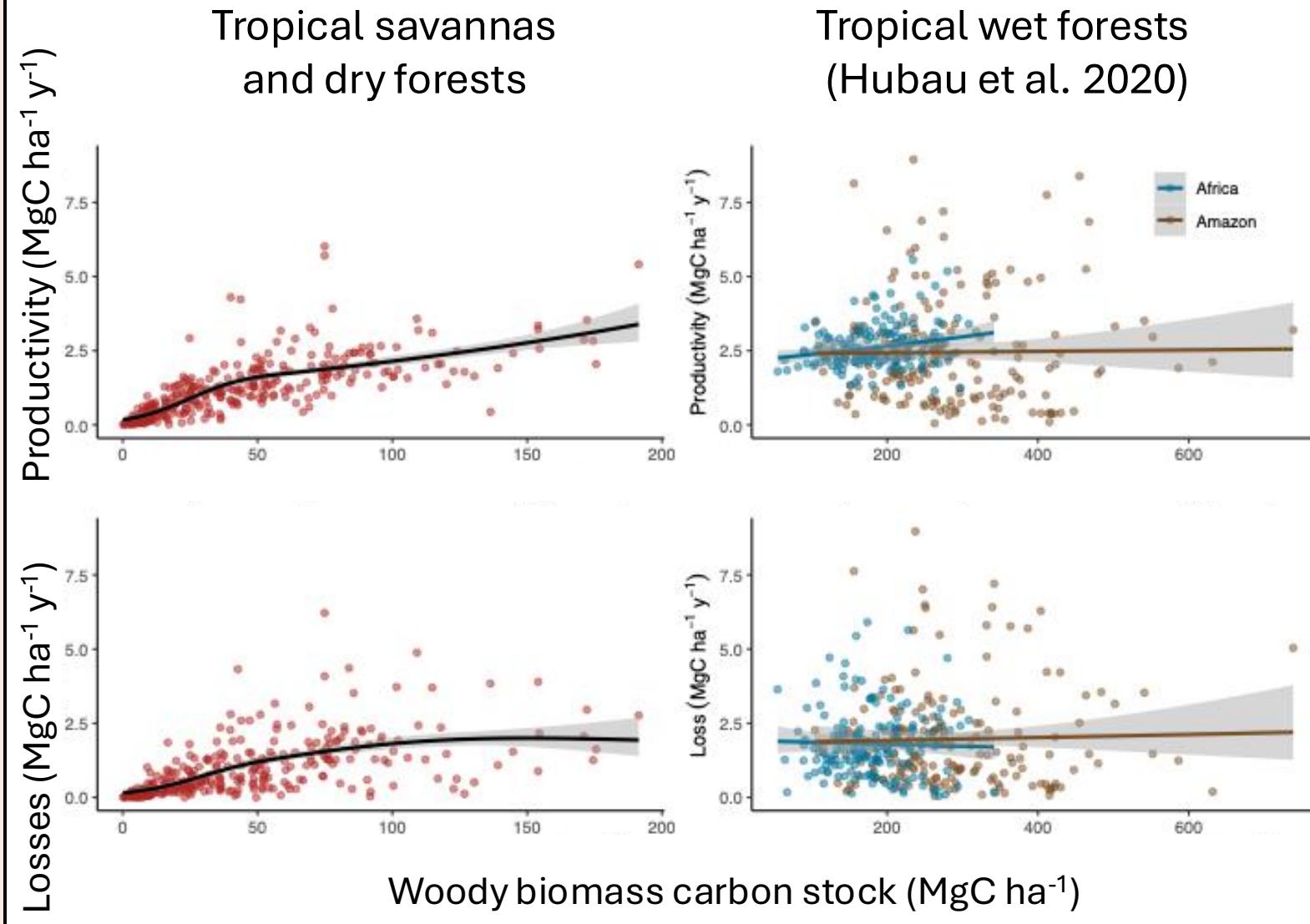


Drivers of biomass change in the dry tropics

Positive association of productivity and losses with biomass stocks, unlike wet forests.

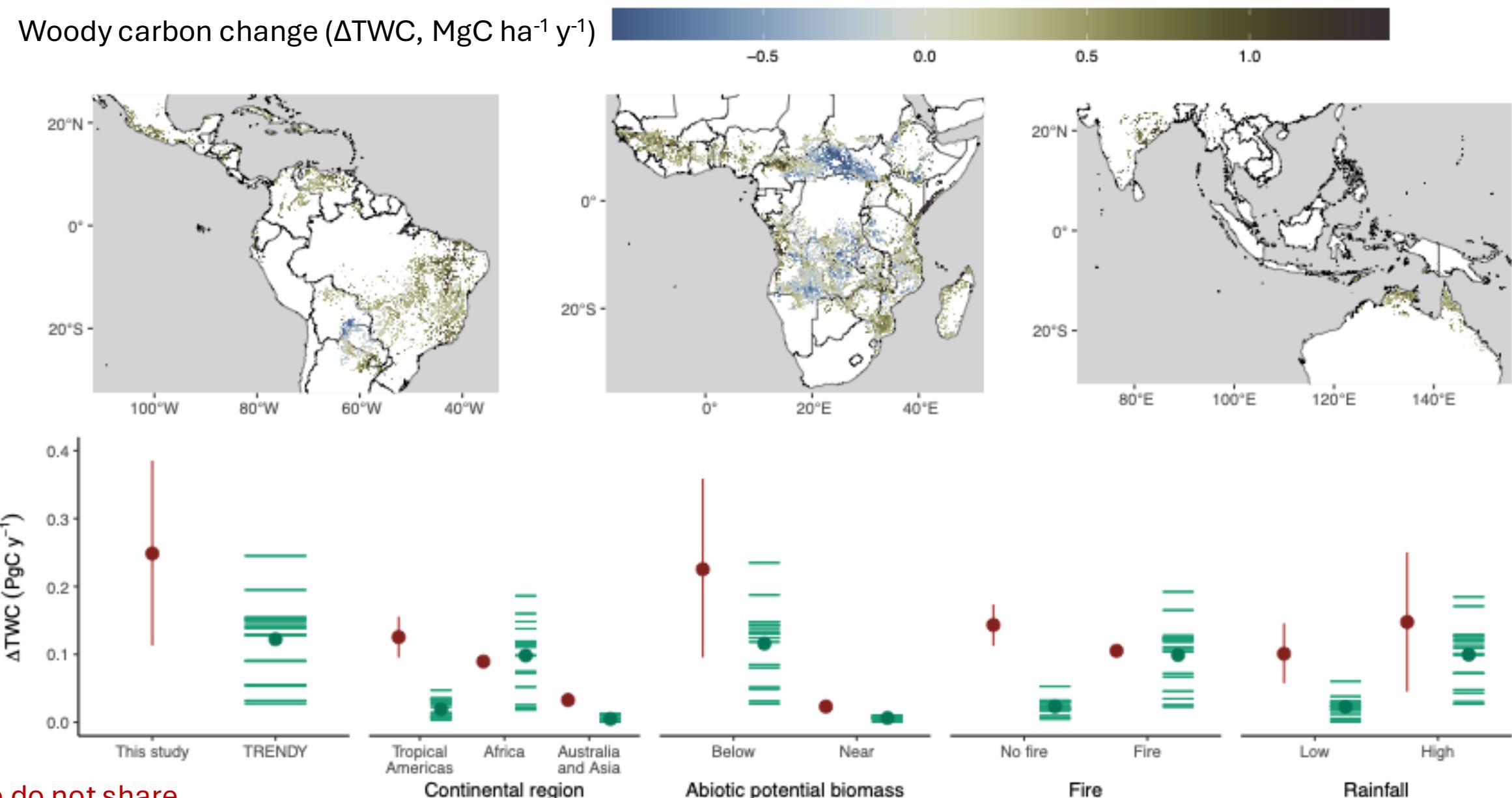
Chronic disturbance keeps biomass below abiotic potential.

Constant regrowth means that biomass scales with productivity.



Drivers of biomass change in the dry tropics

Woody carbon change (ΔTWC , $\text{MgC ha}^{-1} \text{y}^{-1}$)

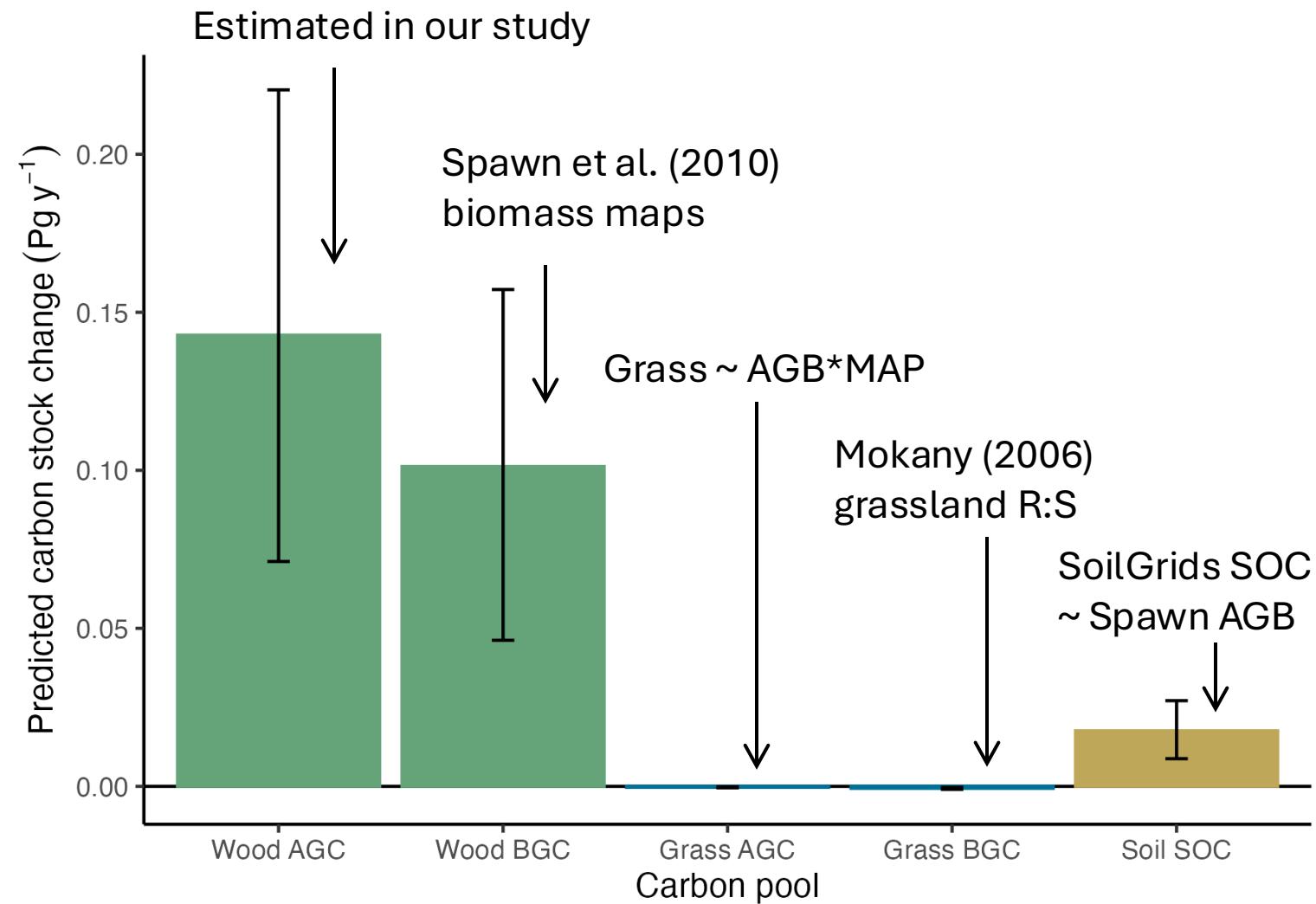


Drivers of biomass change in the dry tropics

A large total ecosystem carbon sink in tropical savannas and dry forest.

Soil carbon increase despite lower grass biomass.

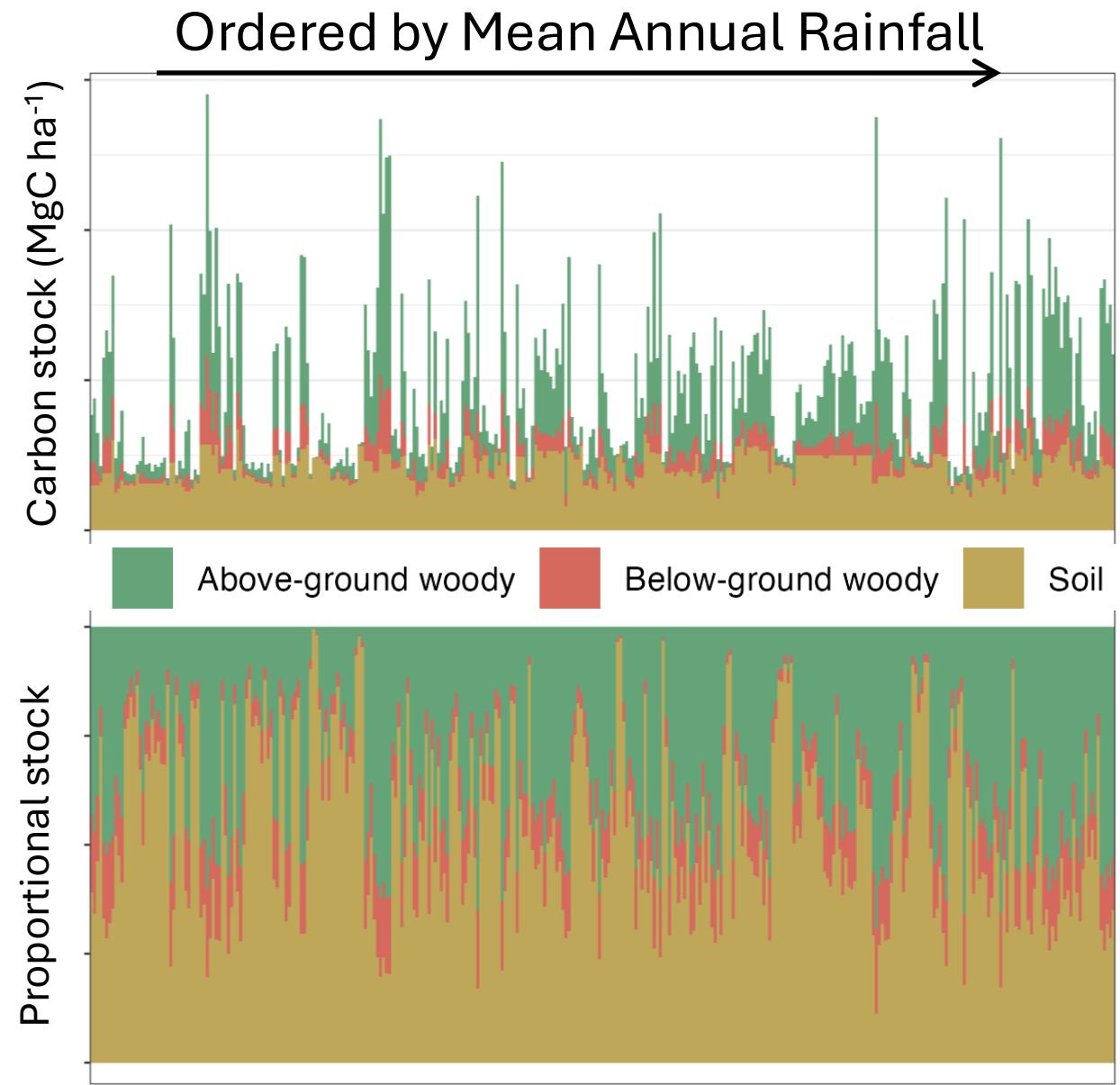
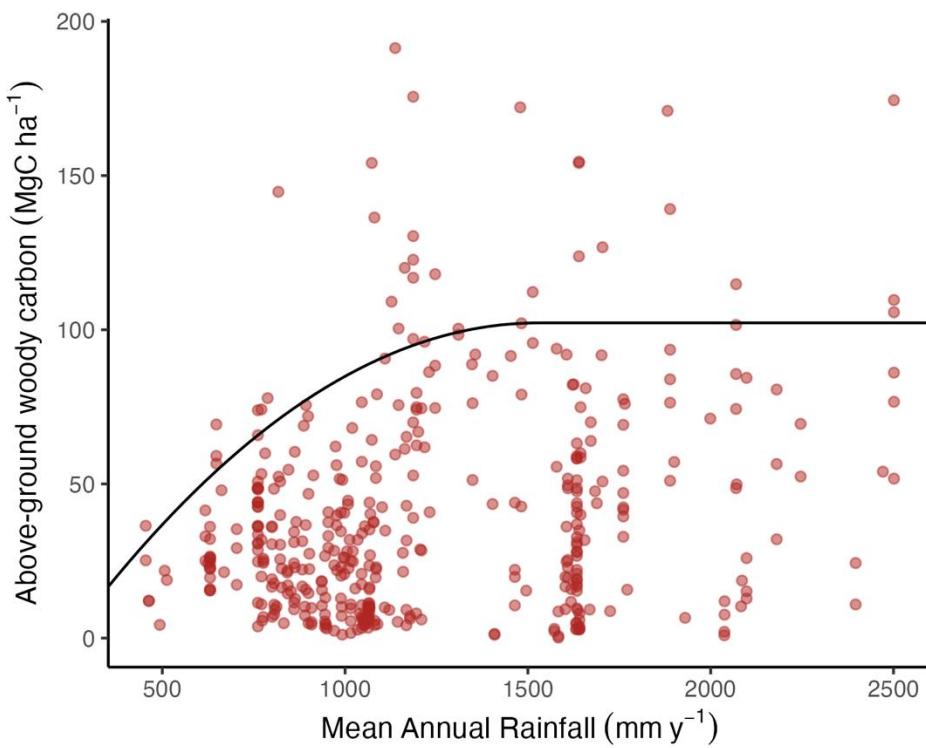
Still much uncertainty in our estimate of the carbon sink, but at least we quantified it!

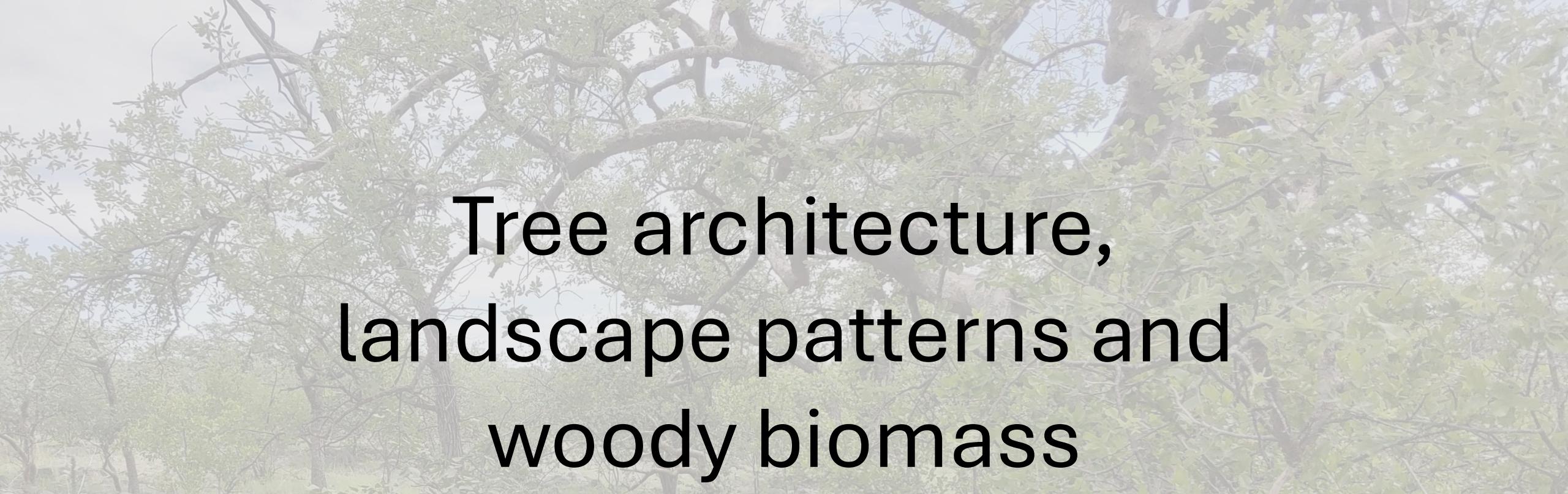


Drivers of biomass change in the dry tropics

No association of water availability and carbon stocks in plots.

Water availability sets upper limit of woody biomass.





Tree architecture, landscape patterns and woody biomass

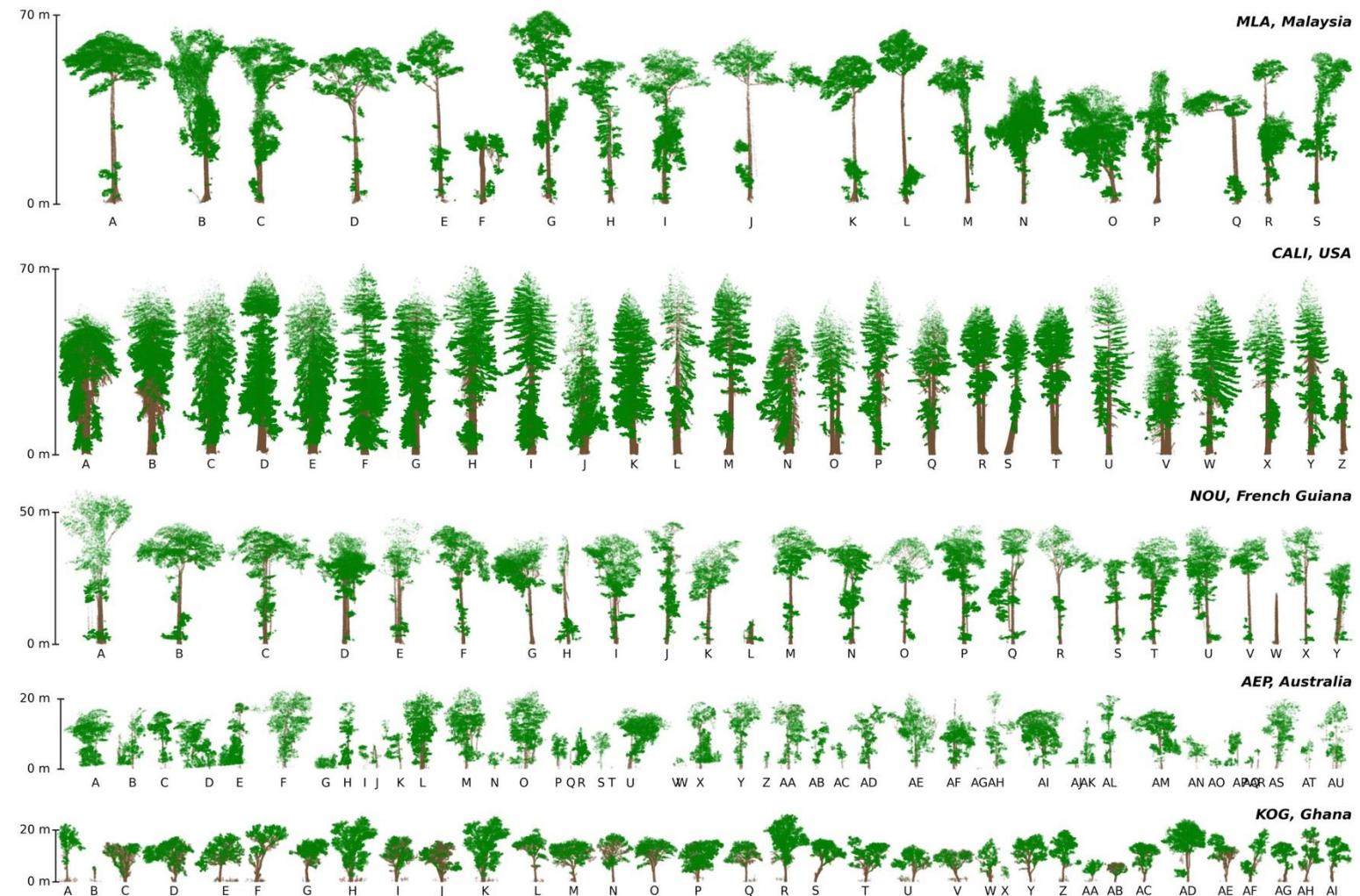


Tree architecture and woody biomass stocks

Tree architecture varies among biomes. Reflects life history strategy, ontogeny, growth history.

Are biomass allometries representative of global forests?

How does tree architecture bound potential woody biomass stocks?



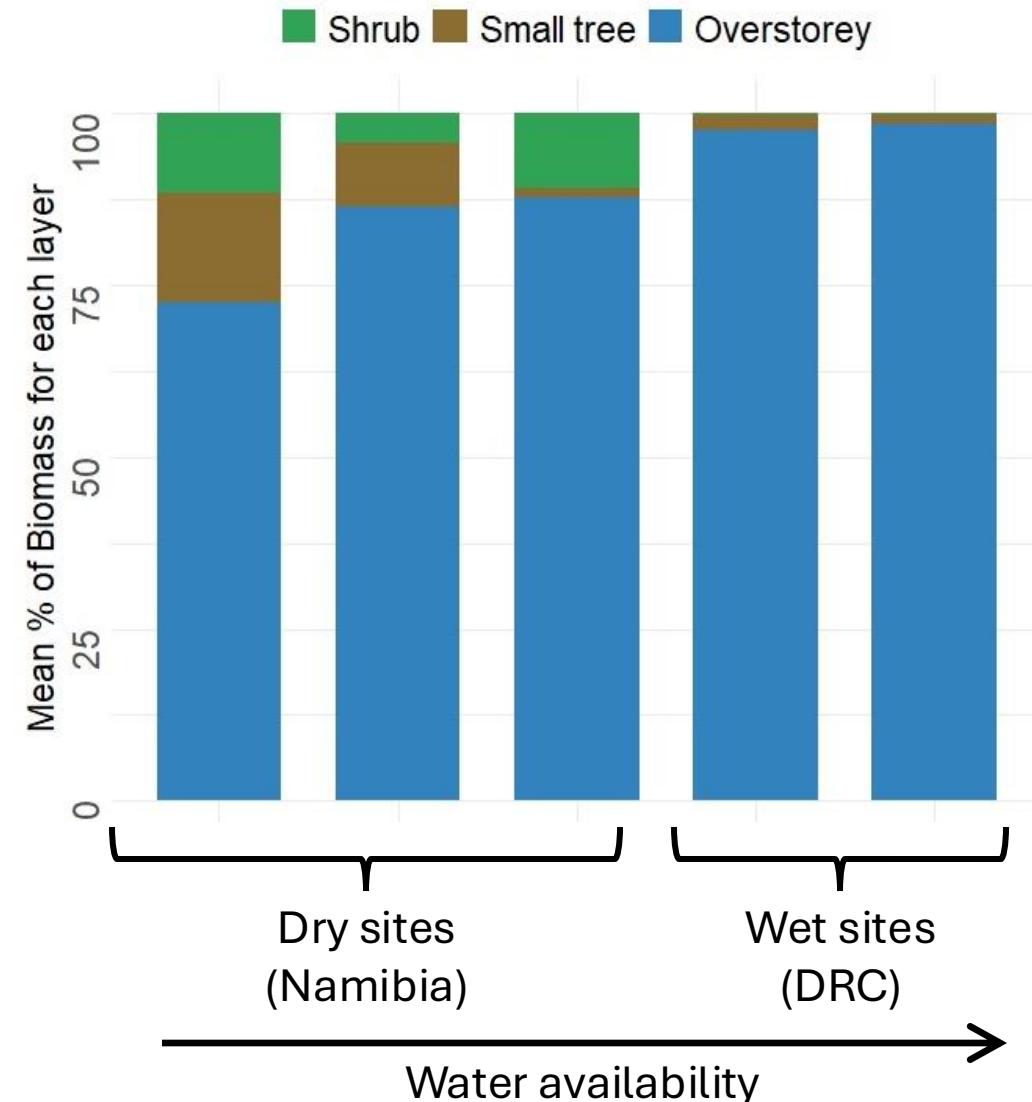
Biomass in other carbon pools

Small stems (<5 cm diameter), lianas, roots, soil carbon, etc, rarely surveyed.

Current methods of estimating biomass in non-tree vegetation are under-developed.

Can we build better allometries for small trees, shrubs, lianas, grass?

How do other carbon pools covary with tree community structure?



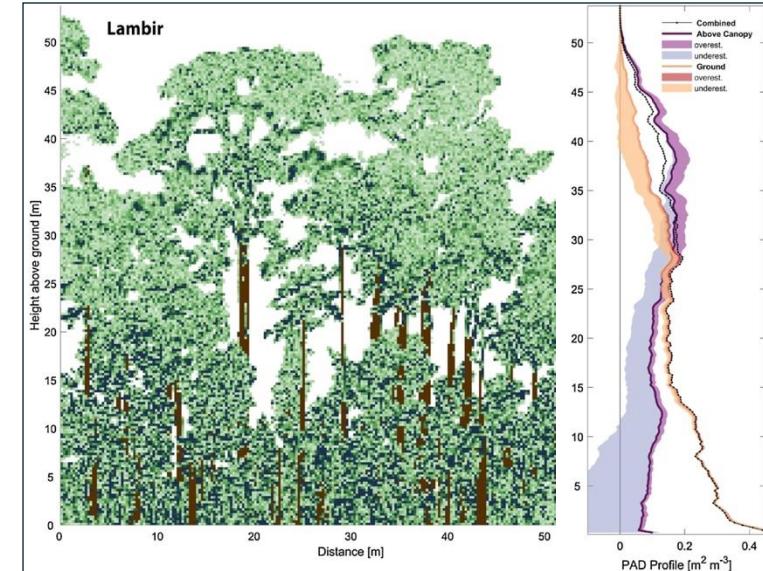
Landscape patterns: biomass, structure, diversity

Are there general rules governing the spatial distribution of biomass within a landscape?

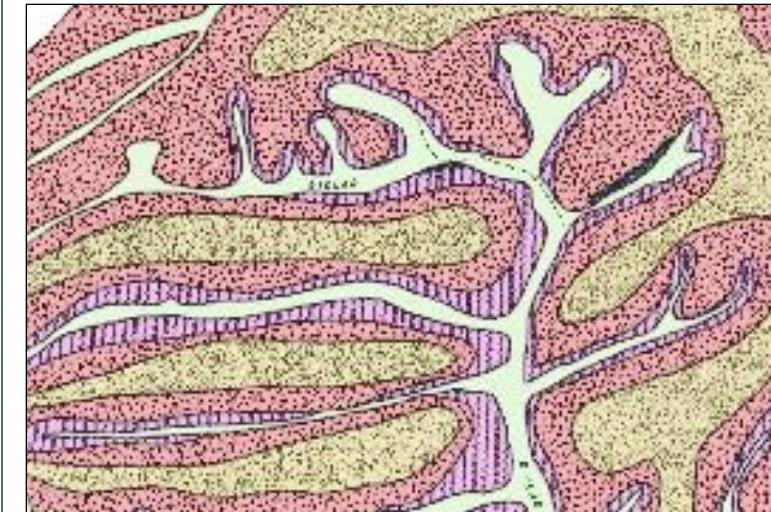
Are there multiple ways to achieve abiotic potential biomass through different ecosystem structure?

Within a landscape, how do biomass, structure and diversity covary?

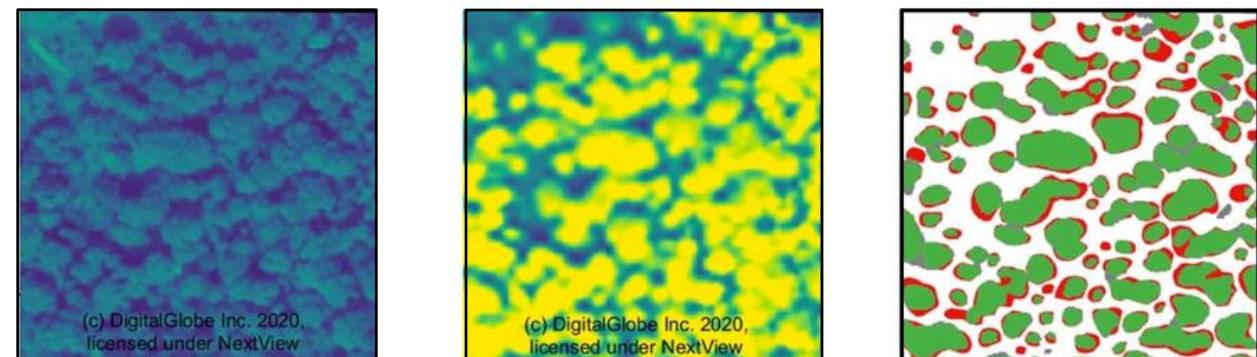
ALS-/TLS-derived canopy profiles



Predictable patterns of stand structure at landscape scales



ALS / WorldView maps of tree size



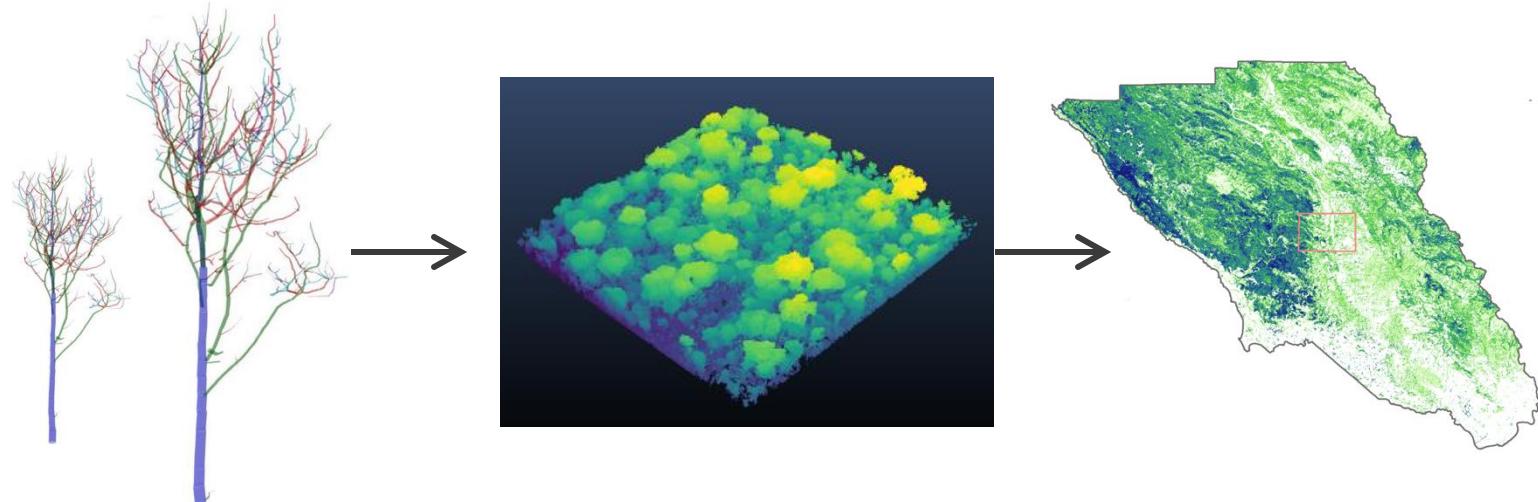
If we have dynamics data ...

Which forests will be the future carbon sink hotspots?

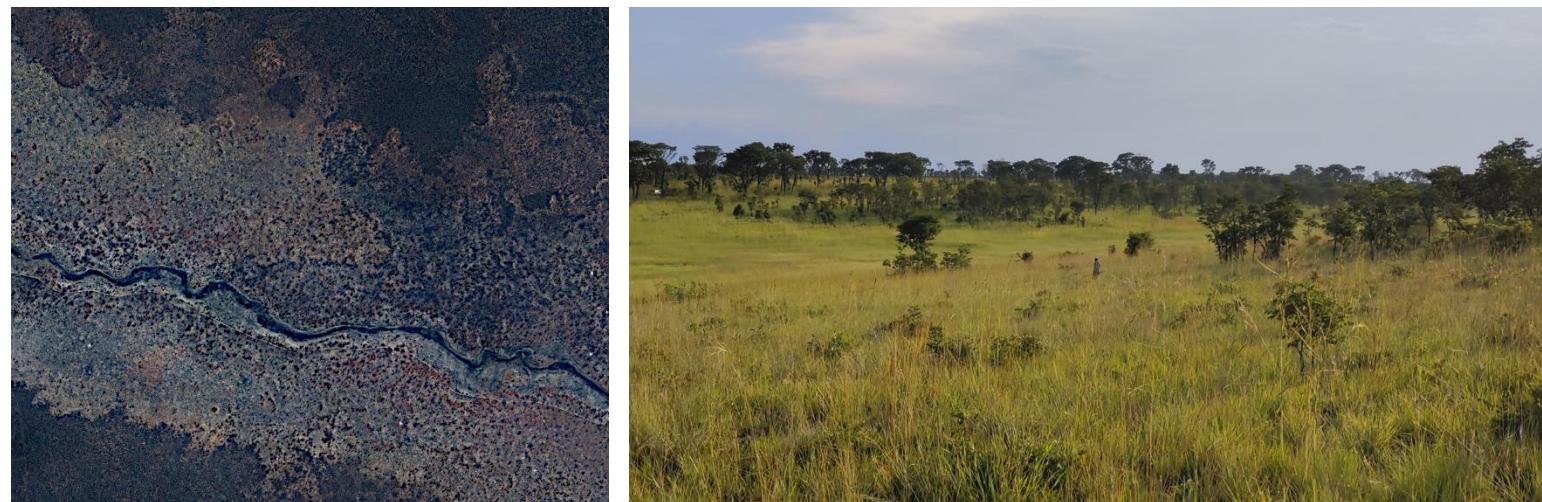
Landscape-level biomass dynamics overcome stochasticity from plots.

How will environmental change affect spatial patterns of vegetation mosaics?

Scaling dynamics from individuals to plots to landscapes



Retreating forest edge in Bicuar National Park, Angola



Summary

- Broad interests in the role of tree biodiversity and ecosystem function.
- Experience managing multi-network collaborations, using large plot datasets to refine understanding of terrestrial vegetation carbon cycle.
- Commitment to building capacity for research in the global south.
- Use unique data from GEO-TREES to explore tree architecture, ecosystem structure, and its role in shaping forest biomass stocks.



EXTRA SLIDES

A wide-angle photograph of a tropical landscape. In the foreground, there's a field of tall, dry grass and several small, leafy trees. A large, dense green tree stands prominently on the right side. The middle ground shows a lush green hillside covered in various trees and bushes. In the background, there are more hills and mountains, all partially obscured by a thick layer of fog or mist, creating a sense of depth and atmosphere.

Suitability of commonly used biomass allometries



celebrating 20 years

Global Change Biology (2014), doi: 10.1111/gcb.12629

Improved allometric models to estimate the aboveground biomass of tropical trees

JÉRÔME CHAVE¹, MAXIME RÉJOU-MÉCHAIN¹, ALBERTO BÚRQUEZ², EMMANUEL CHIDUMAYO³, MATTHEW S. COLGAN⁴, WELINGTON B.C. DELITTI⁵, ALVARO DUQUE⁶,

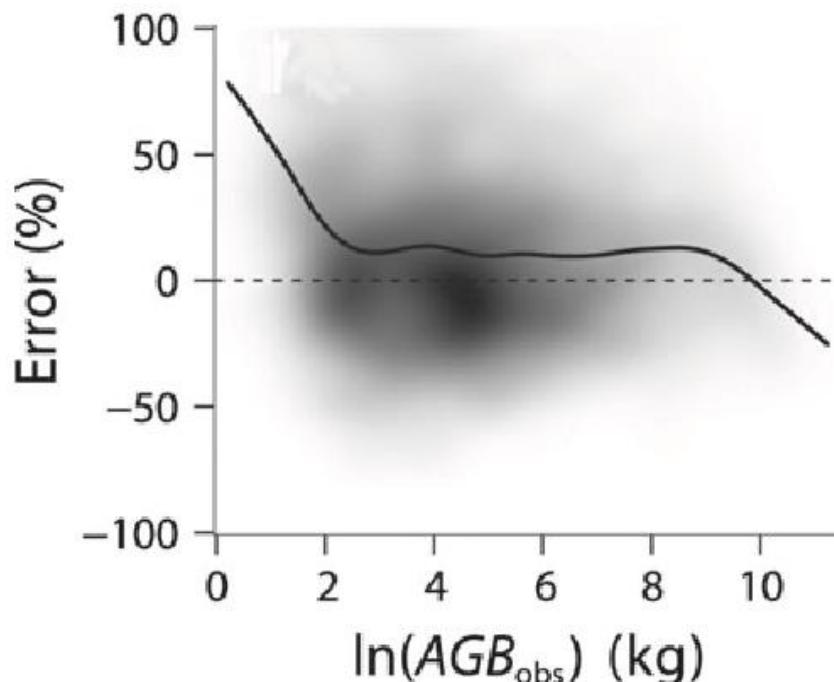
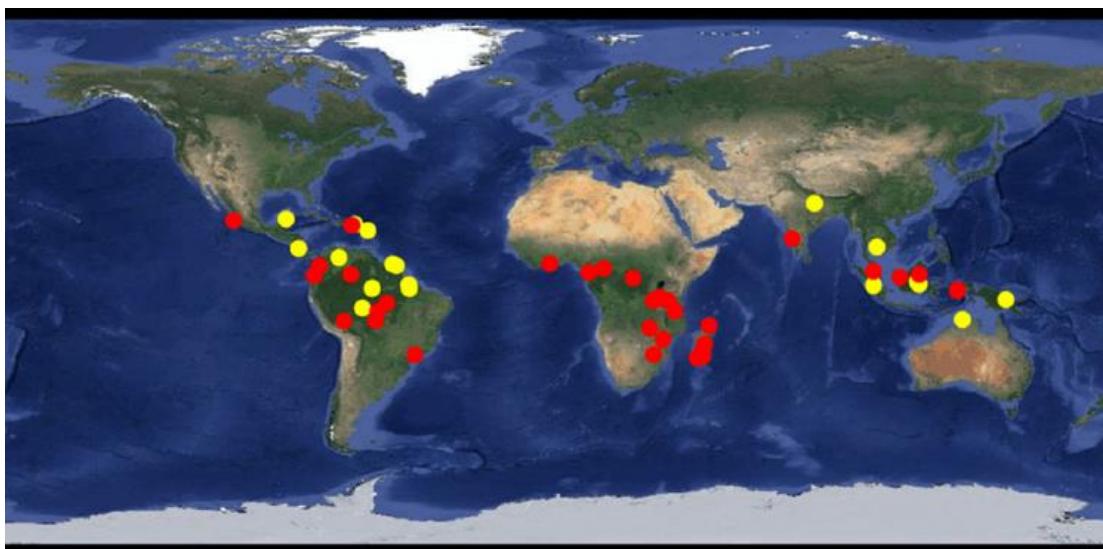
D = Stem diameter

ρ = Wood density

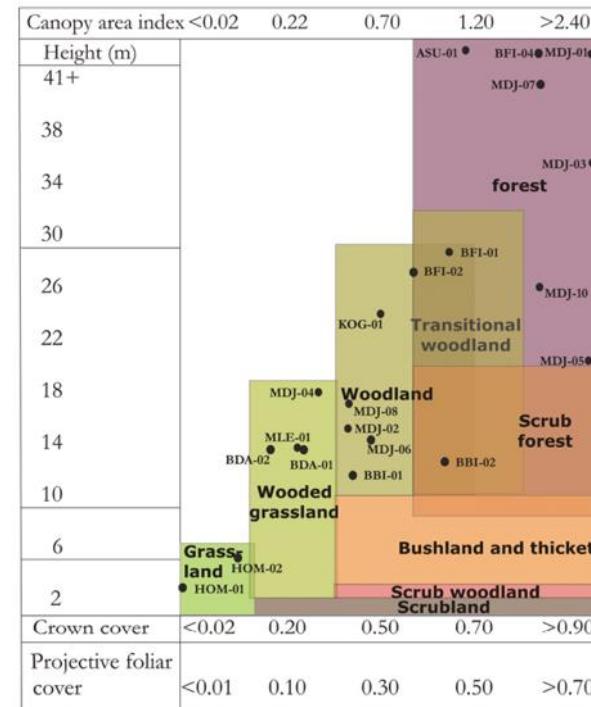
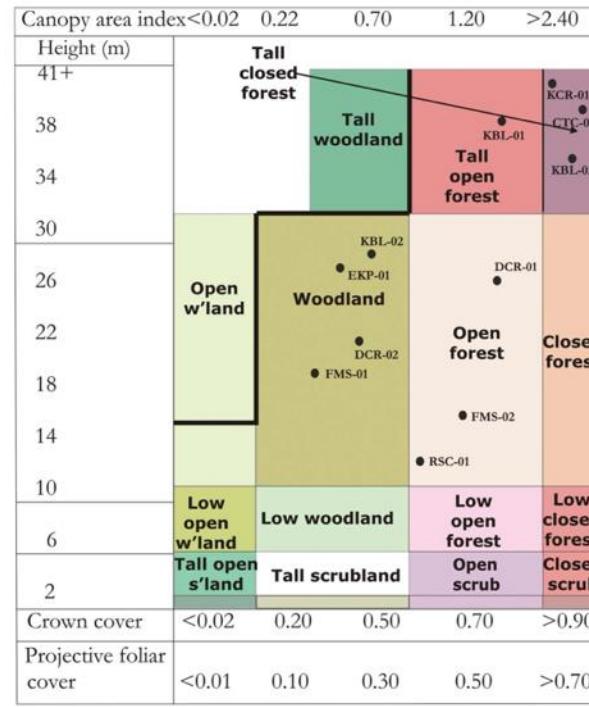
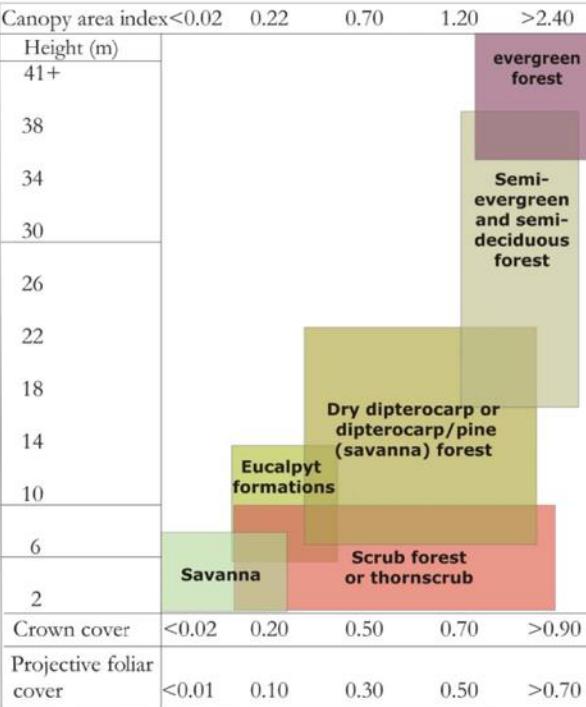
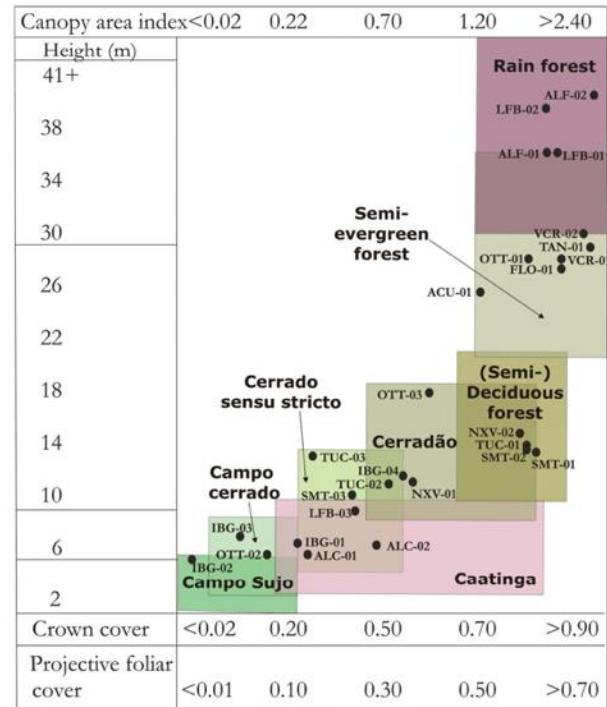
E = Water availability

OR

H = Stem height



Ecosystem structure in the dry tropics is highly variable



South America

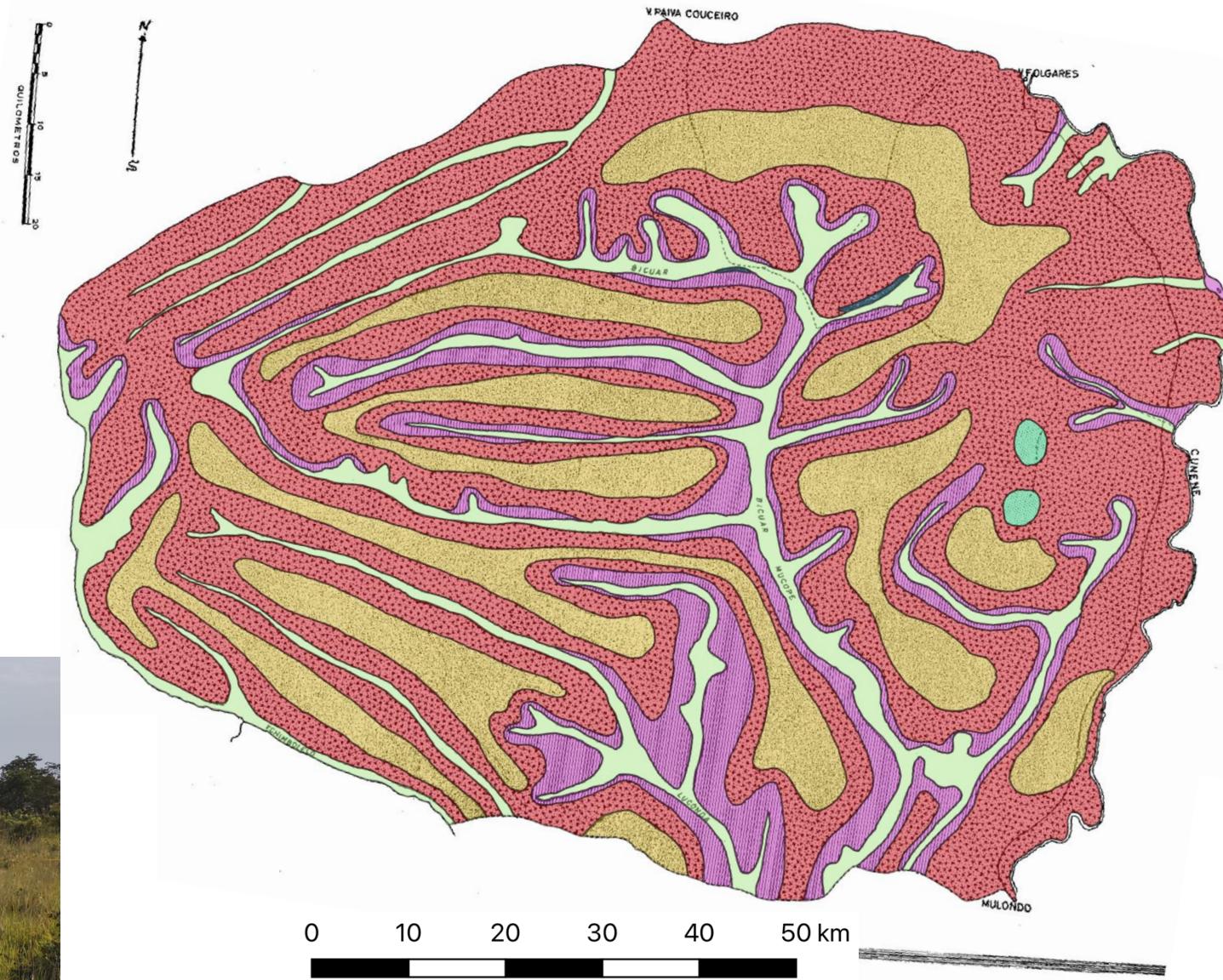
South-East Asia

Africa

Australia

Landscape patterns in vegetation structure

Bicuar National Park,
Angola.



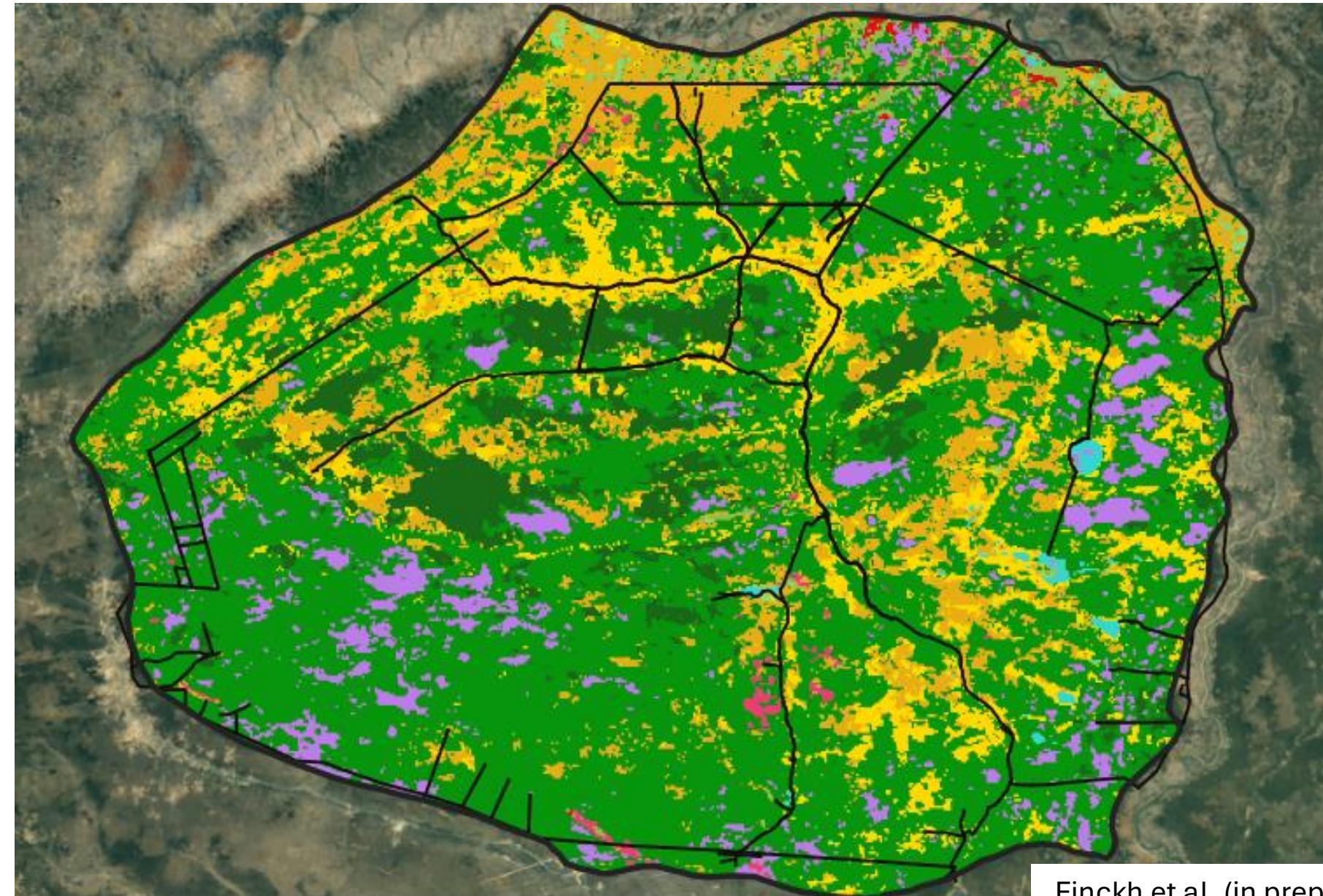
Catenal sequence. Vegetation
boundaries drift over time.



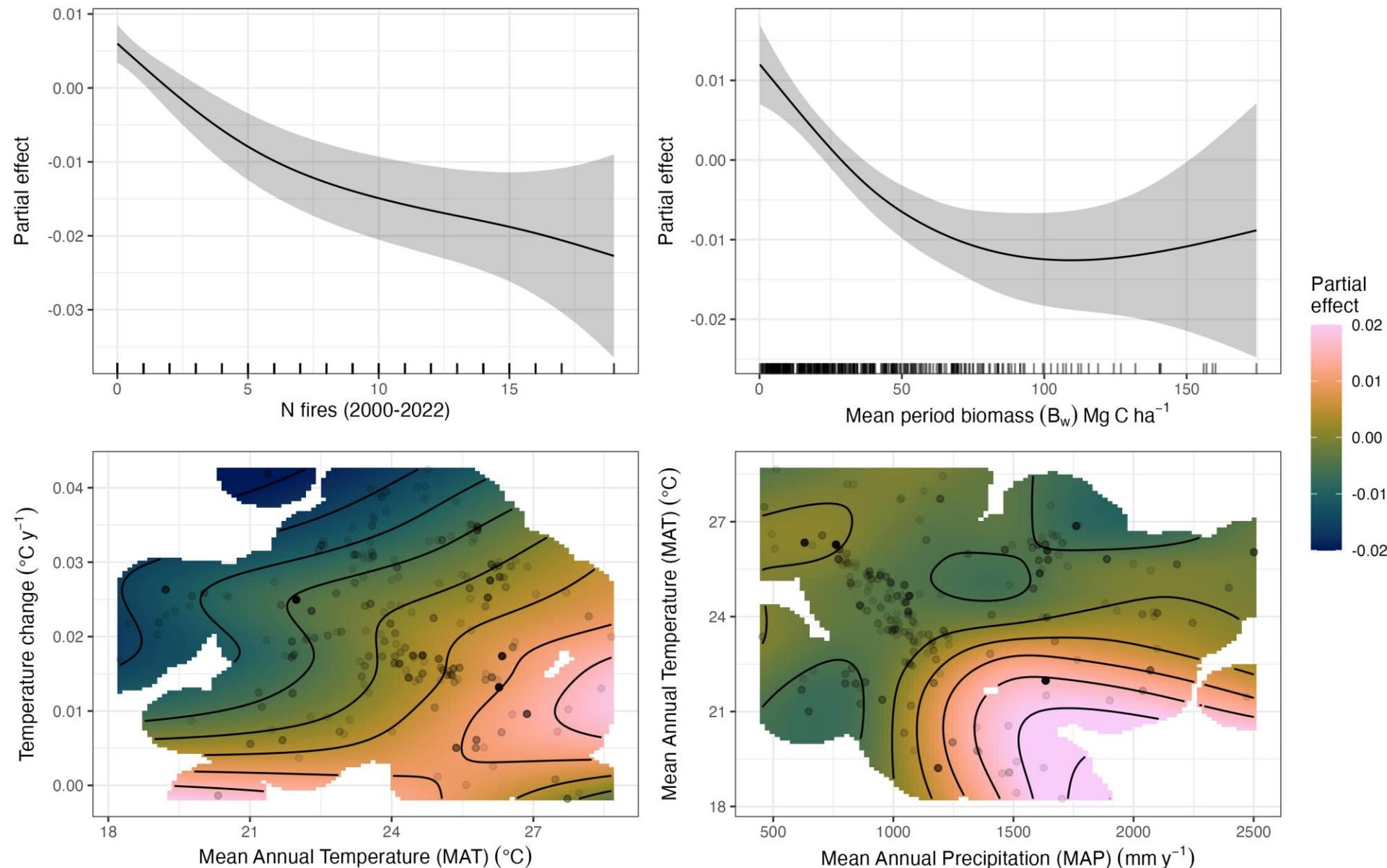
Landscape patterns in vegetation structure

Bicuar National Park,
Angola

- High
- Medium
- Low
- Baikiaea forest (biomass)
- Burkea woodland
- Geoxyle grassland
- Wild pasture



Partial effects in ΔAGB upscaling model



My role at the GEO-TREES sites

Impossible to visit all sites!

Sites will require different levels of capacitation.

Site development needs to be sustainable. Seek buy-in from local stakeholders, research institutions.

Visiting some sites necessary to understand how to harmonise protocols.

Training in tree measurement



Guidance in field campaign management



Previously established two sites in southern Africa



Strategies for collaboration

Grow communication among site teams.

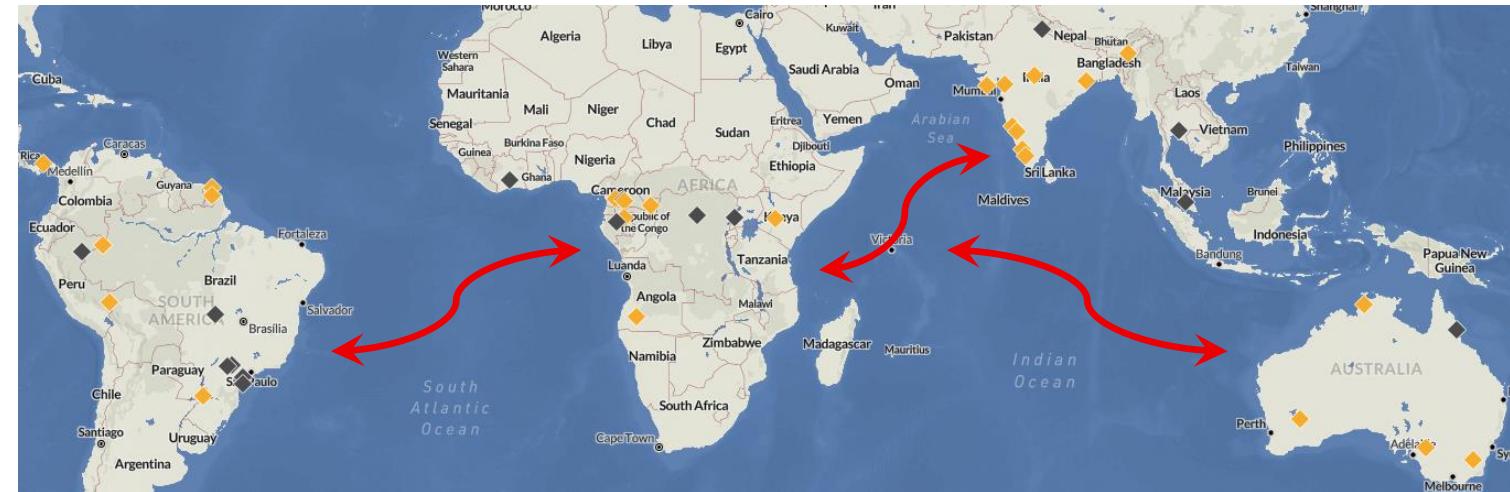
Research theme groups:

- Develop research goals
- Deliver training

Stratify time investment by:

- Biome?
- Continent?
- Linguistic group?

Facilitate cross-continental communication



Online and in-person workshops



Week-long science meetings



Goals for the first year

Capacity building:

1. Hold online meetings with site teams to gauge capacity and engagement.
2. Develop working groups for site teams based on research themes. Organise in-person meeting for site teams to discuss research goals.
3. Identify gaps in site coverage within network. Consult widely on strategy to fill gaps.

Research:

1. Develop outlines of papers, share widely. Build research plan with diverse voices.

Data management:

1. Build data harmonisation pipeline, to integrate field data from diverse protocols.
2. Develop tools for field data management and basic analysis.