Research interests,
Previous work,
Ideas for GEO-TREES

John L. Godlee

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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

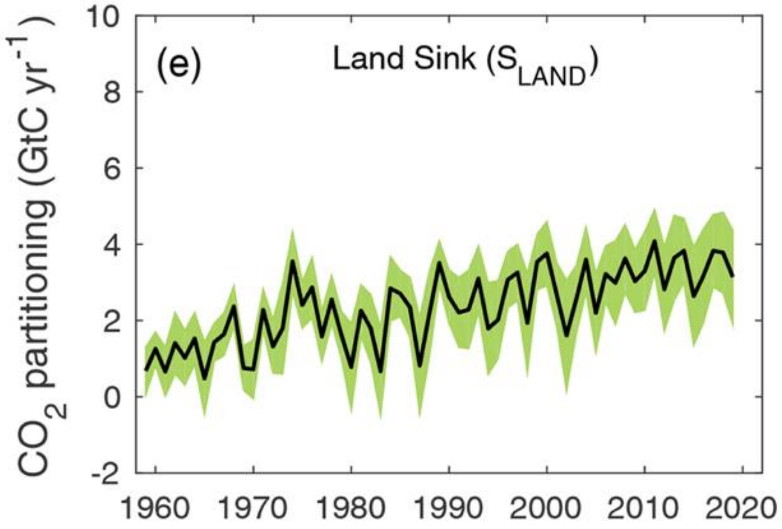
Oak woodland, northern England

Motivations and approach

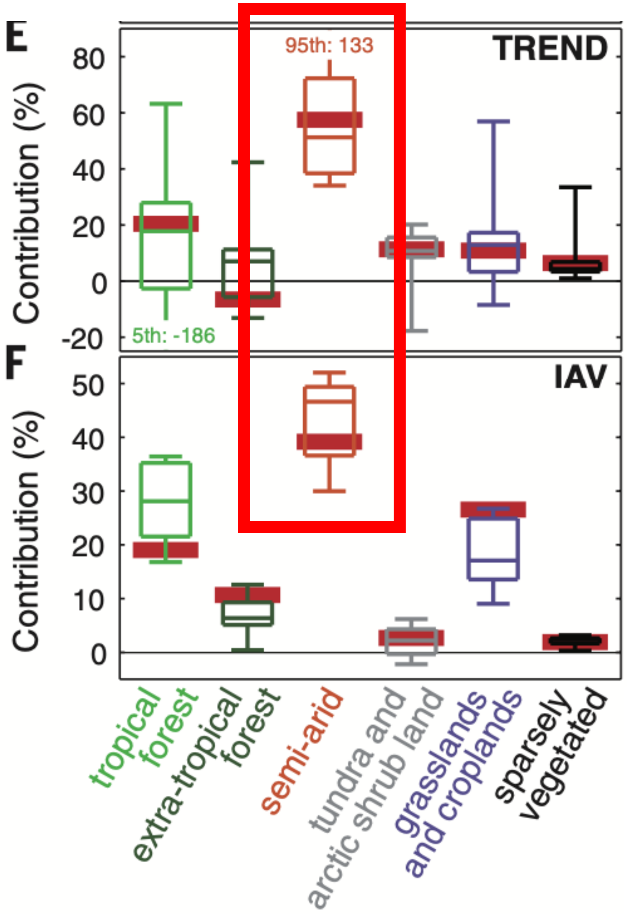
Grand challenges:

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

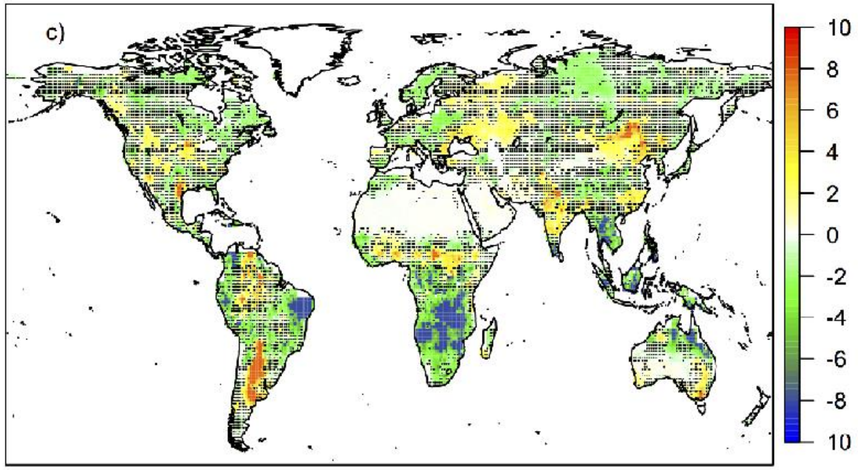
Models: increasing terrestrial carbon sink



Uncertainty in trend and inter-annual variability of carbon sink



Spatial variability in carbon flux trend



Ahlstrom et al. (2015), Sitch et al. (2015), La Quere et al. (2020)

Motivations and approach

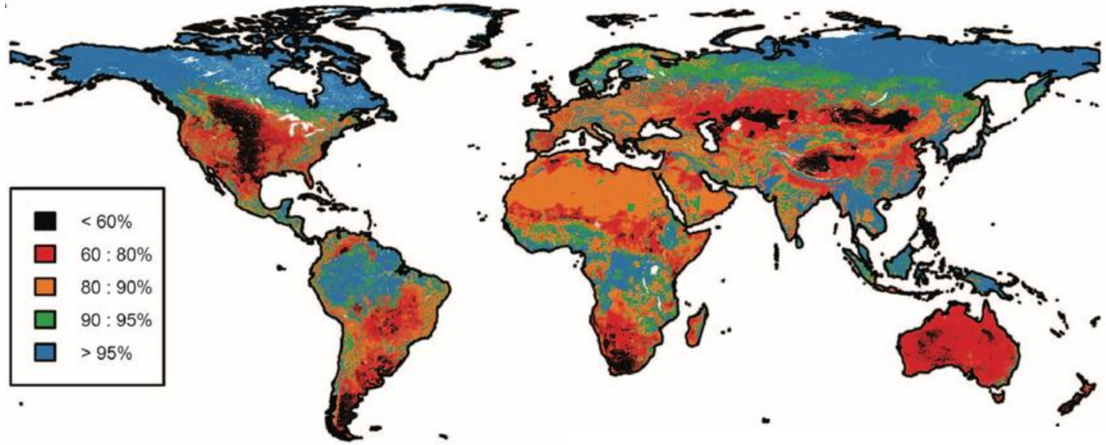
Grand challenges:

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

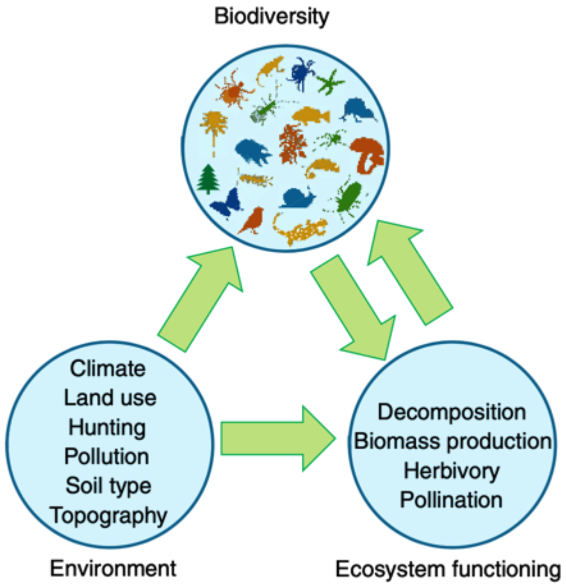
2. How do biodiversity and environment jointly affect ecosystem structure and function?

Ecosystem integrity is under threat

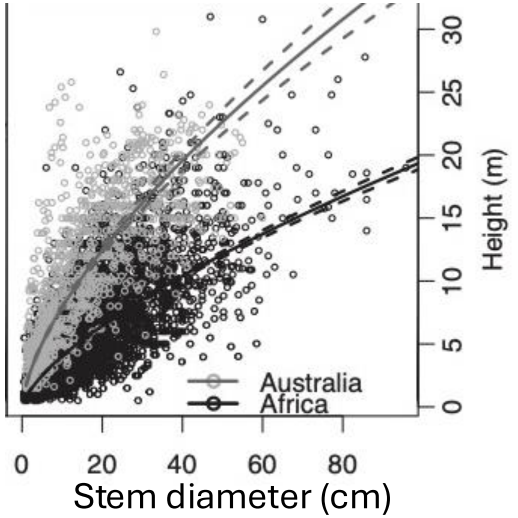
Ecosystem integrity (%)



Complex biodiversity-function feedbacks



Biogeographic mediation of structure and function



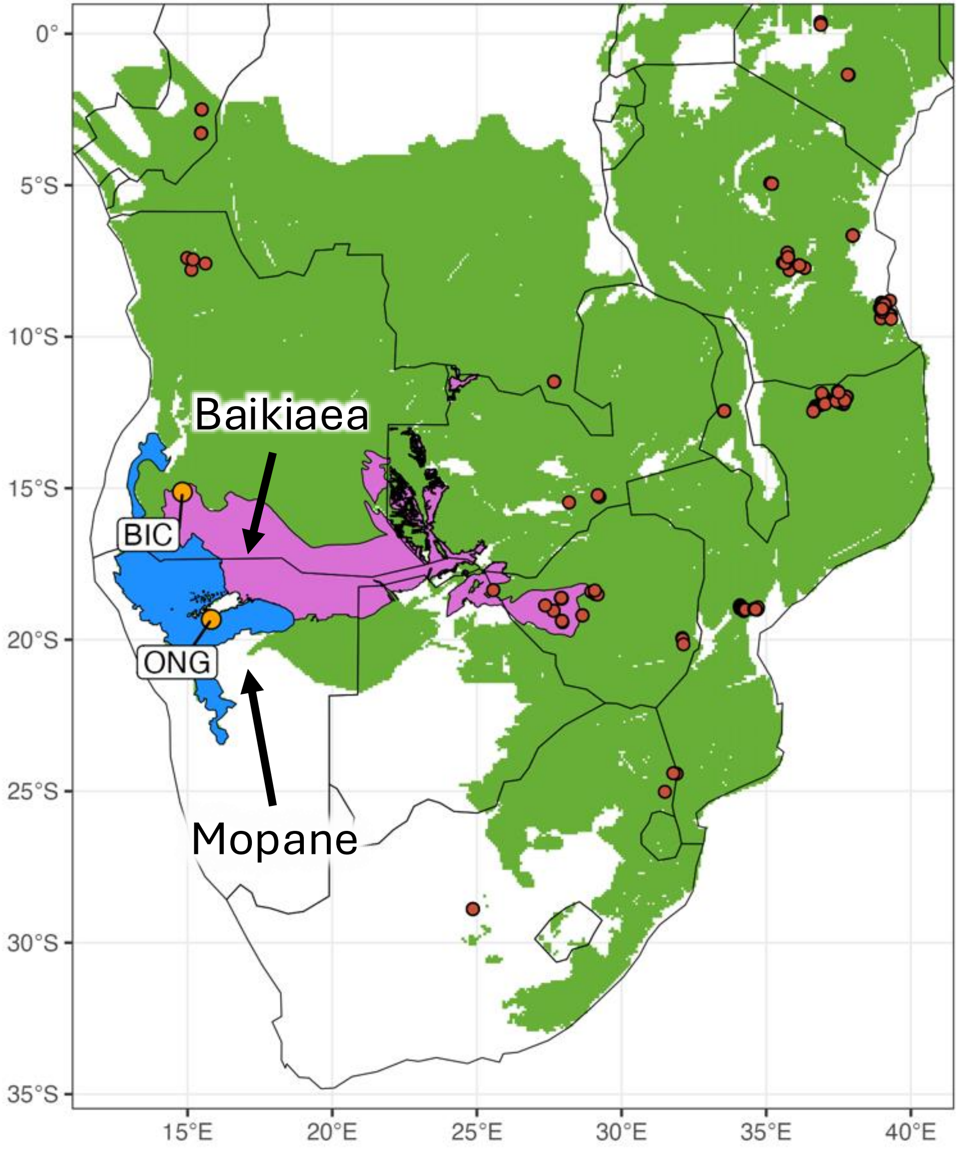
Newbold et al. (2016), van der Plas (2019), Moncreiff et al. (2014)

Developing vegetation monitoring infrastructure

Building capacity for research in the global south.

Ensuring sustainable site provision.

Miombo ecoregion



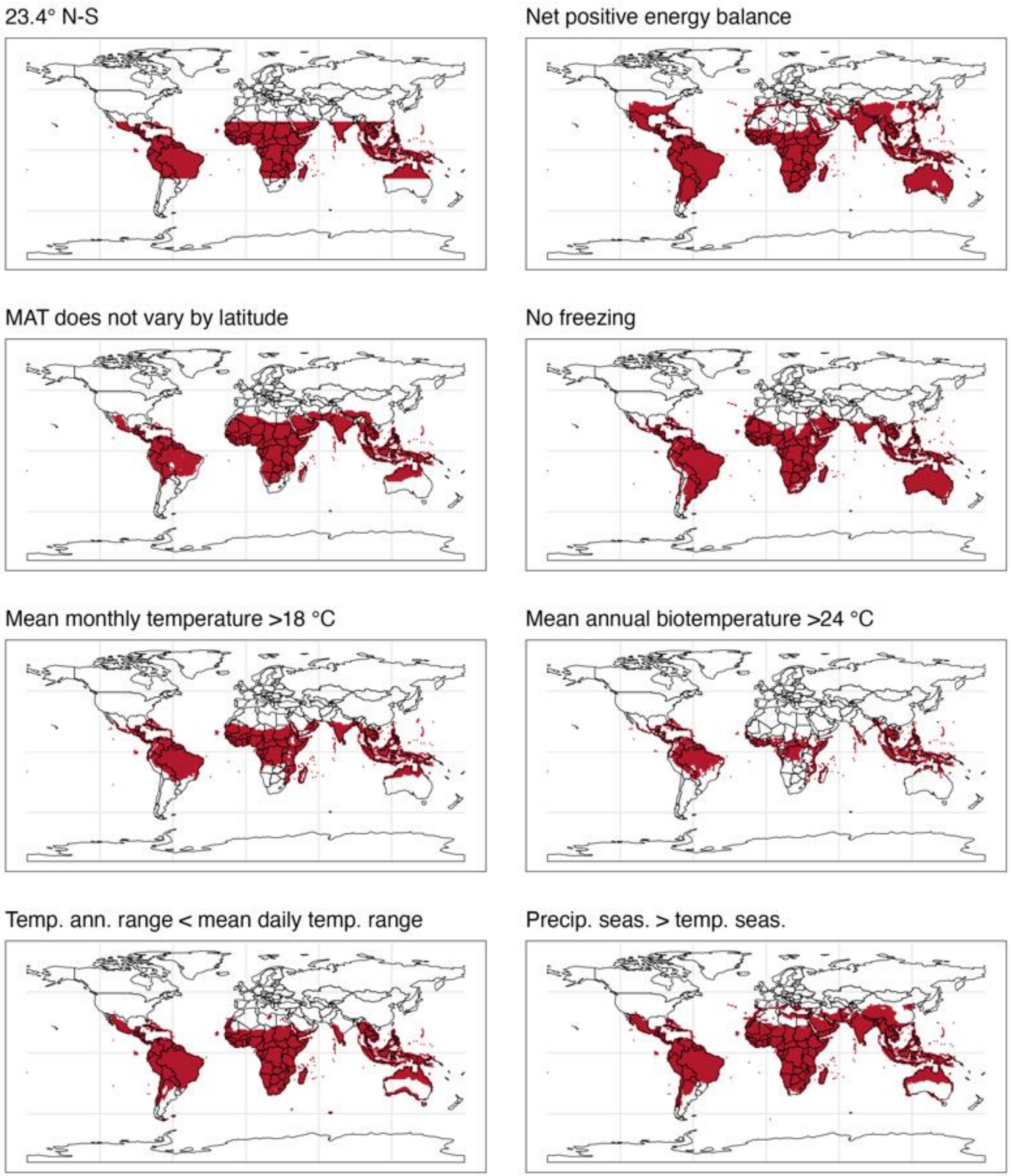
SEOSAW

Miombo savanna,
Bicuar National Park (BIC)

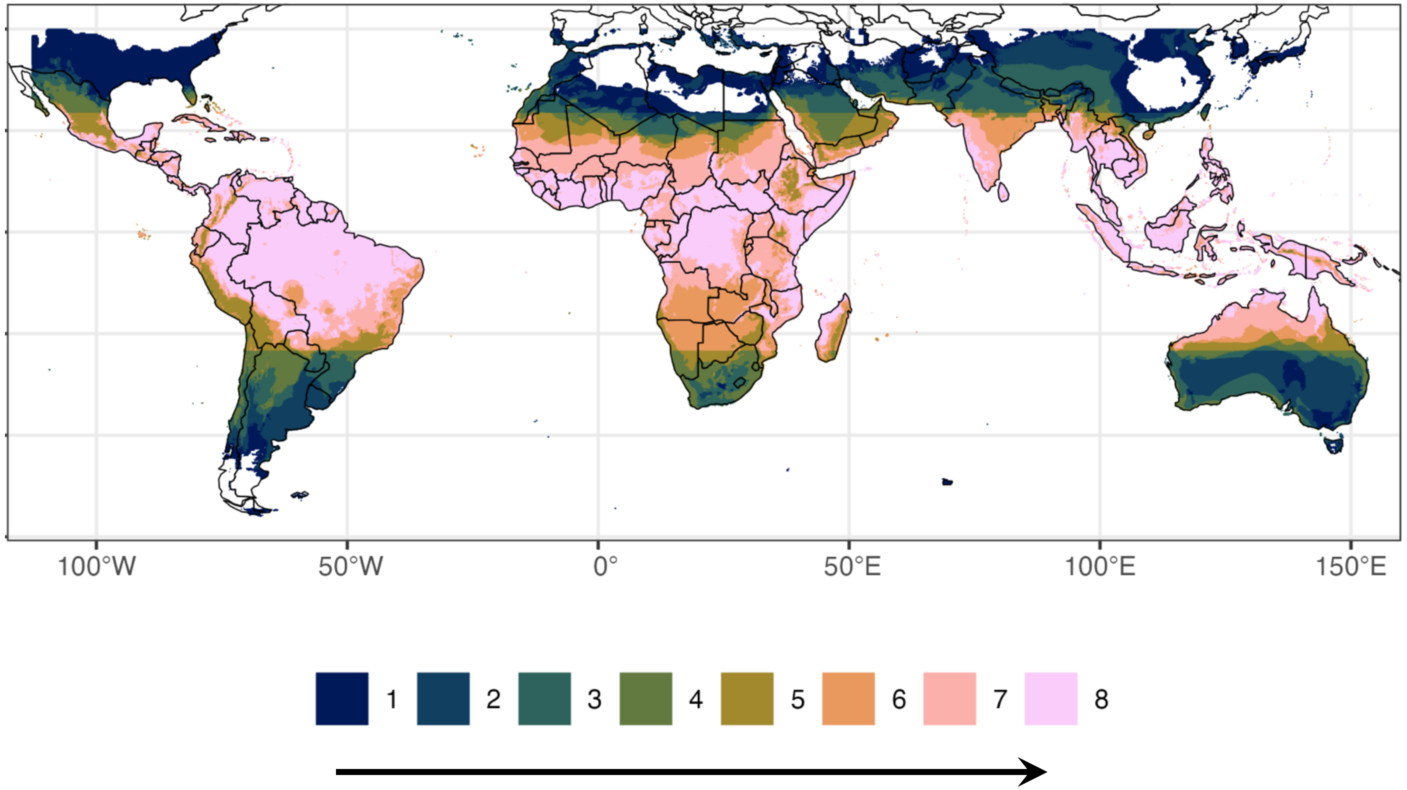
Succulent dry forest,
Ongava Reserve (ONG)

The dry tropics:
Tropical savannas and dry forests

Where are the tropics?



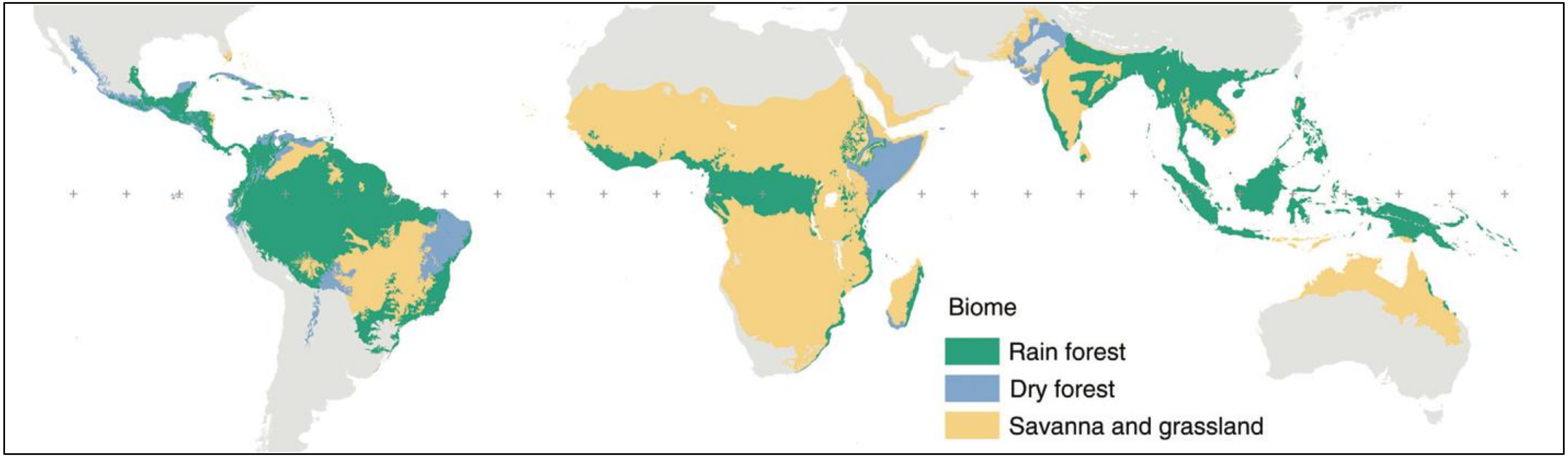
Definition is important: determines how our work will be interpreted.



Increased "tropicality"

Feeley and Stroud (2018)

Half of the global tropics are "dry"

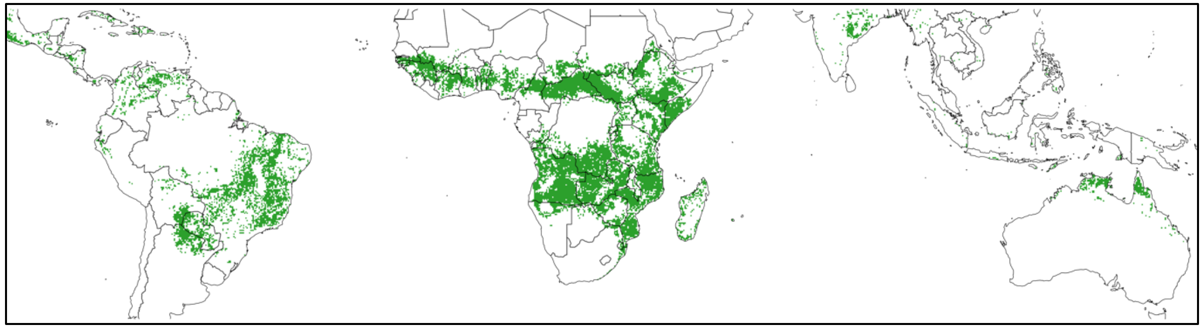


Pennington et al. (2018), after Olson et al. (2001)

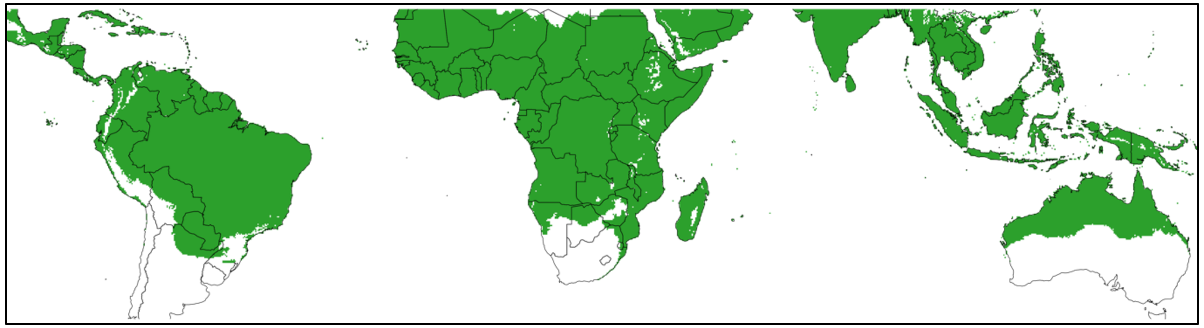
Where are the (seasonally dry) tropics?

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

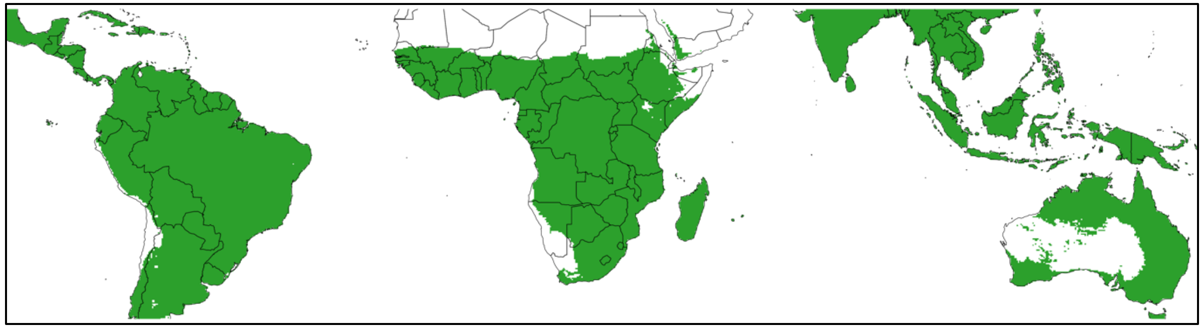
Not human-transformed landscape



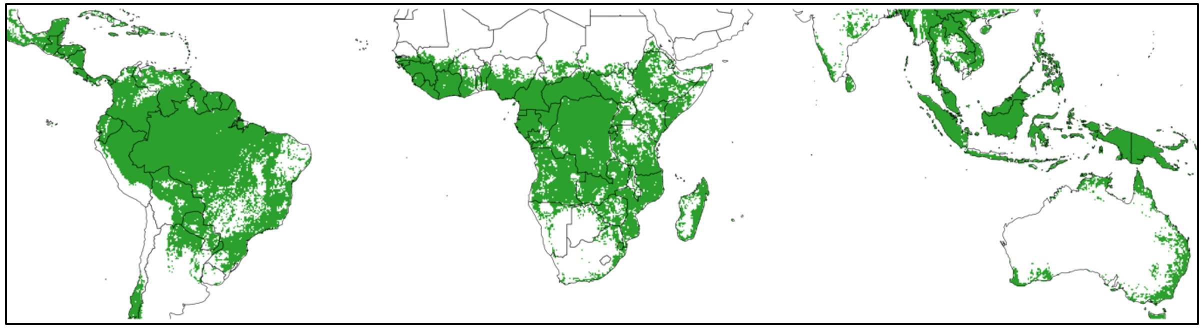
Temperature of coldest quarter > 15°C



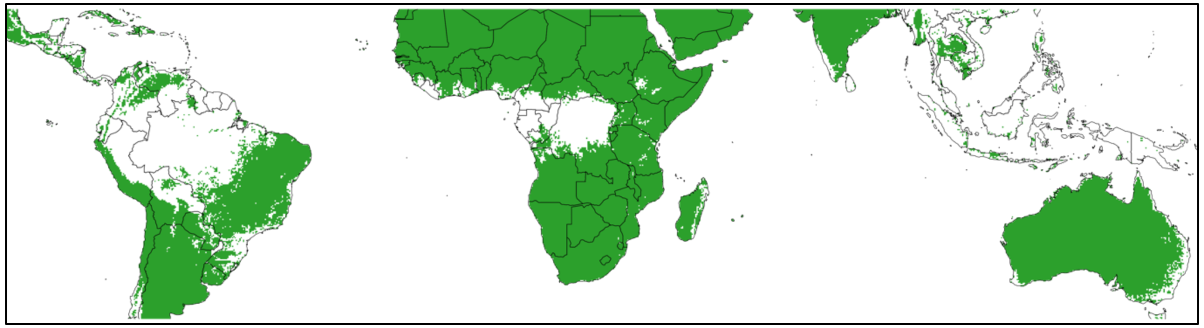
>3 wet months (>30 mm rainfall)



Woody biomass >5 MgC ha^{-1}



Not tropical wet forest (Terrestrial Ecoregions)

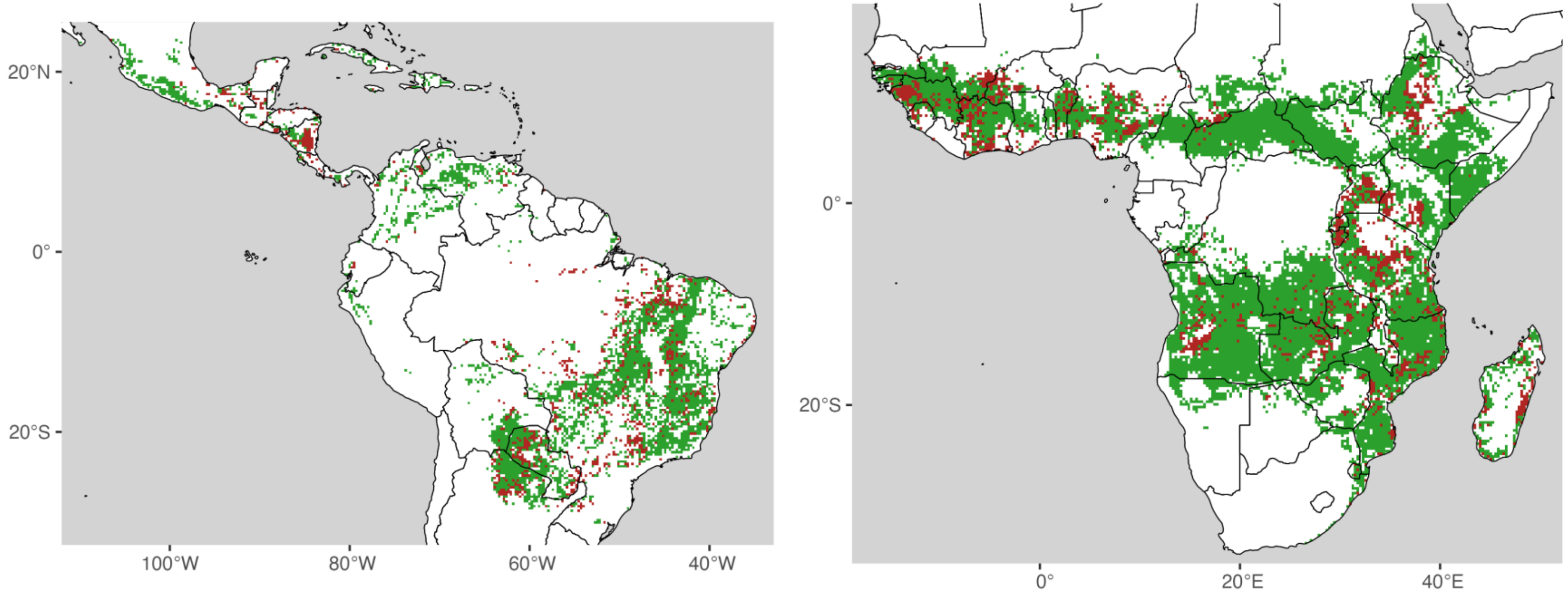


Ack: Sam Harrison, Godlee et al. (in prep, 2025), Dinerstein et al. (2017)

Tropical savannas and dry forests are patchy

Human-transformed landscapes

Remaining woody vegetation



Ack: Sam Harrison, Godlee et al. (in prep, 2025)

The dry tropics are functionally diverse

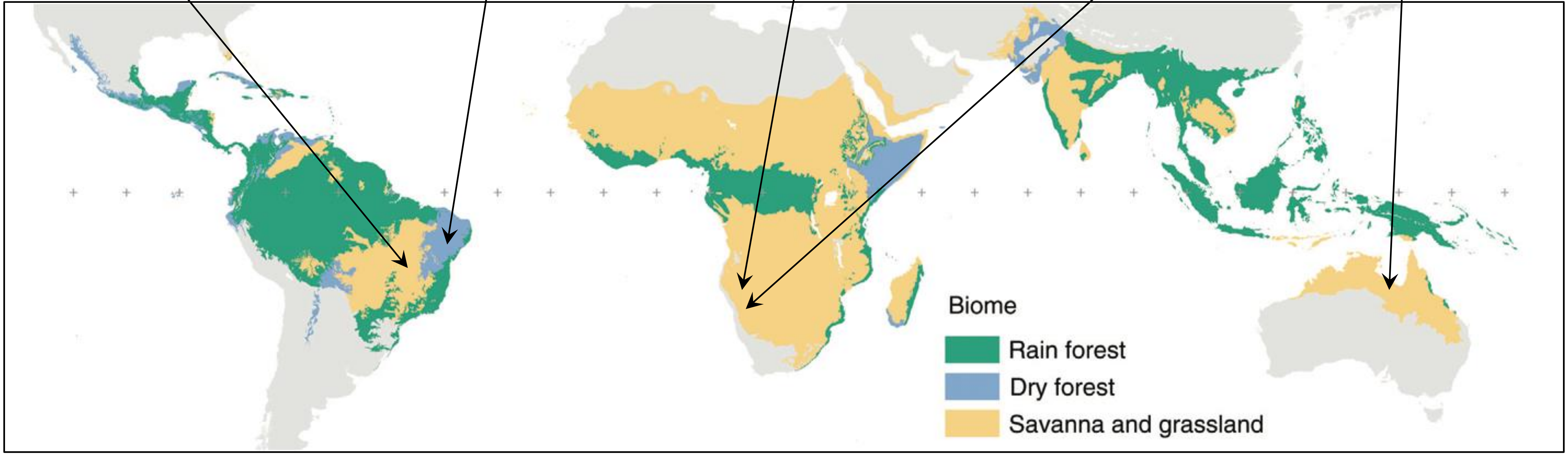
Cerrado,
Brazil

Caatinga,
Brazil

Miombo,
Angola

Mopane dry forest,
Namibia

Eucalypt savanna,
Australia



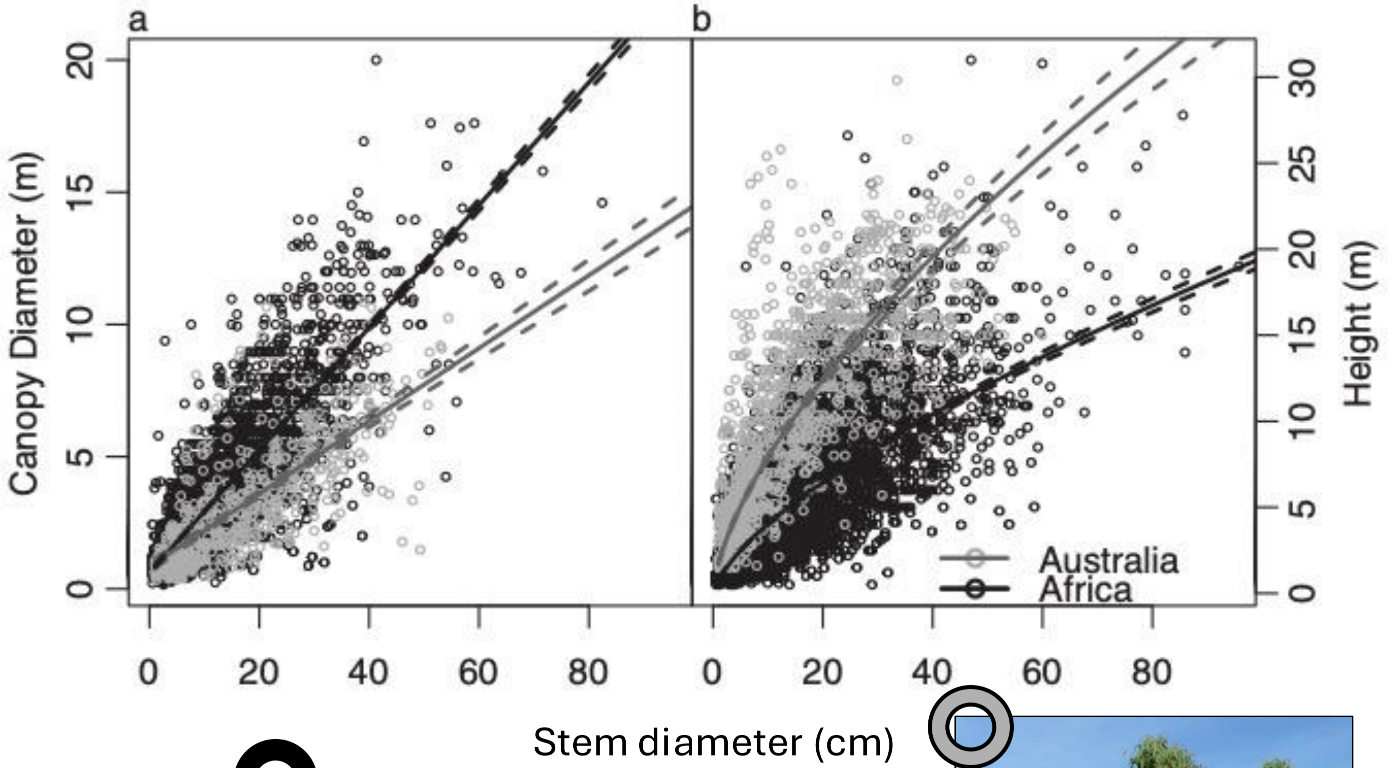
Pennington et al. (2018), after Olson et al. (2001)

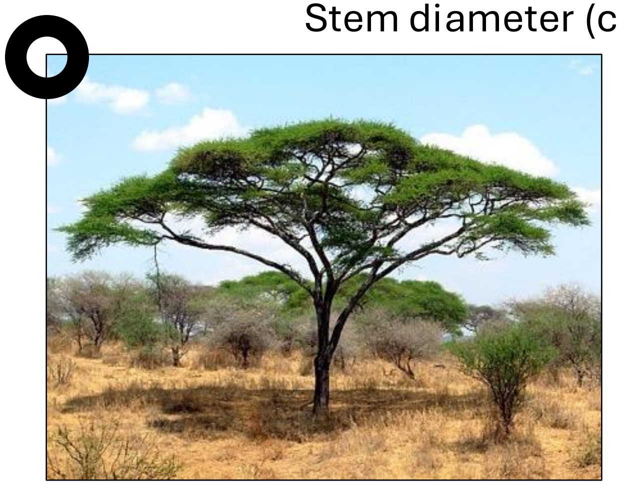
Biogeographic variation in tree architecture

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?

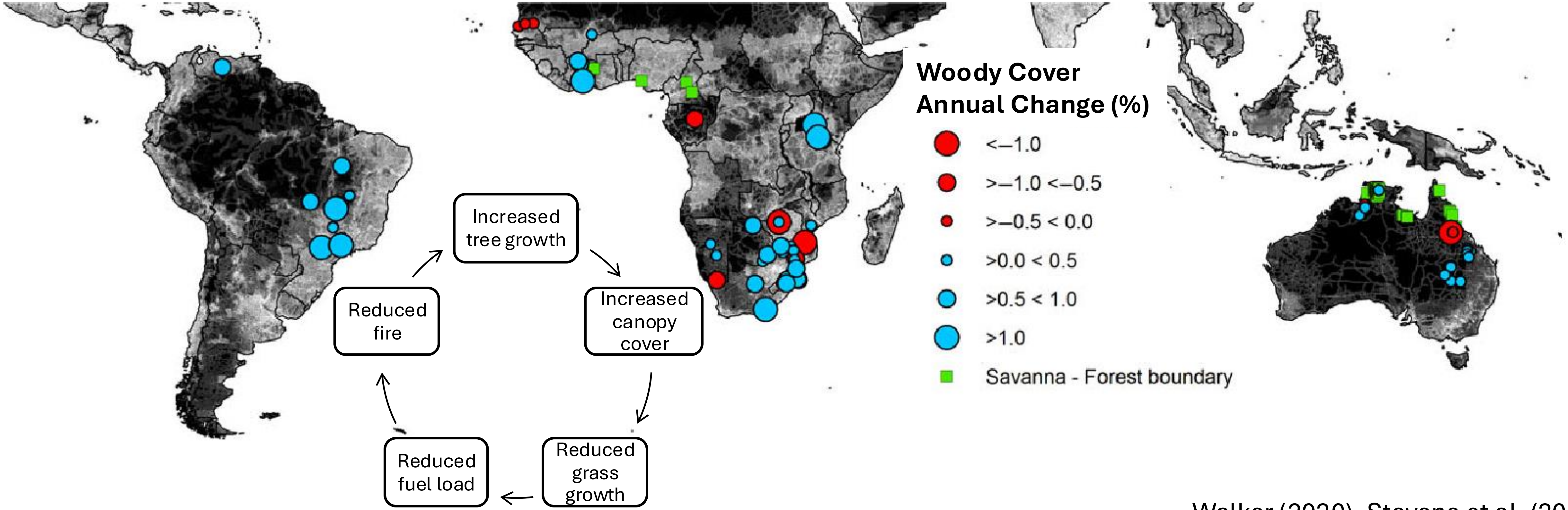




Moncrieff et al. (2014)

Drivers of change: increasing atmospheric CO_2

- Boost tree growth. Trees can benefit from higher CO_2 while grasses cannot.
- Continental variation in rates of encroachment – attributed to nitrogen fixers, able to colonise grassy patches.

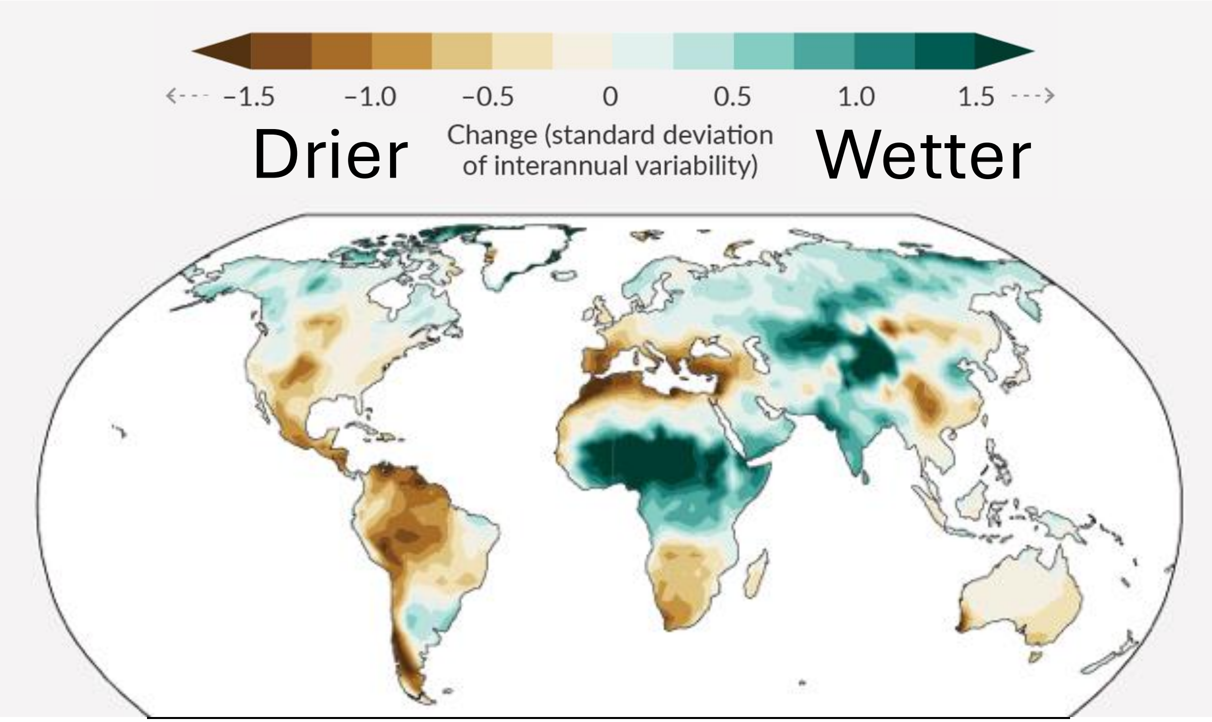


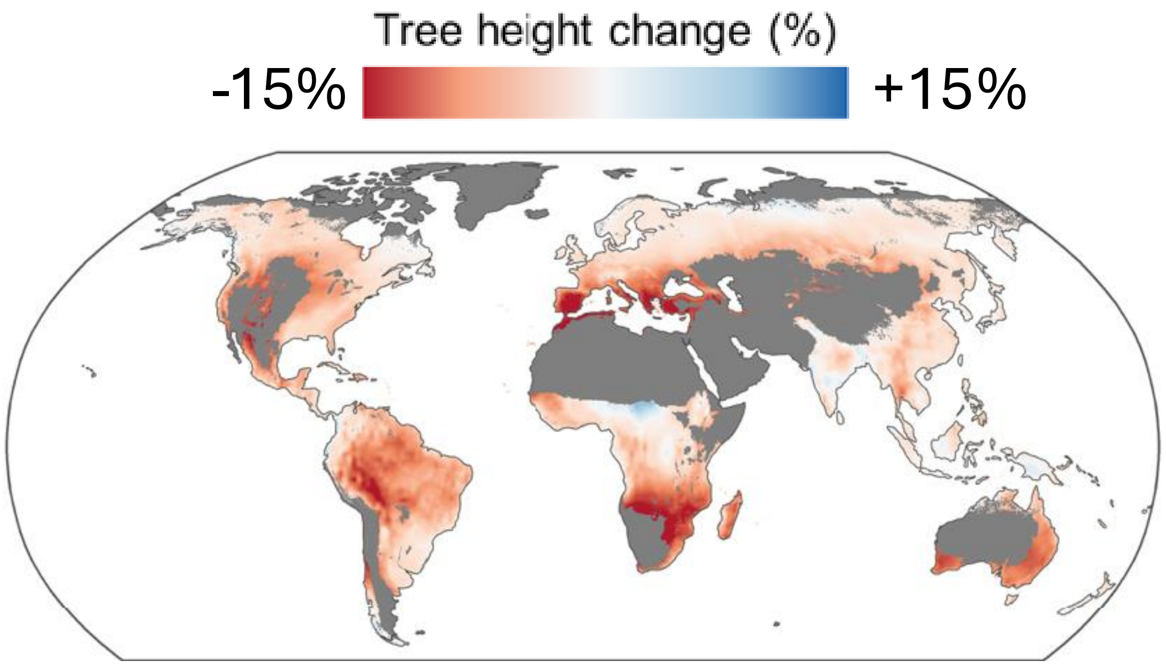
Walker (2020), Stevens et al. (2016)

Drivers of change: warming and drying

- Increased rainfall seasonality.
- Increased inter-annual variability in rainfall.

- Reduced woody productivity, increased mortality.
- Reduced maximum tree height





IPCC Chap. 3 (2021), Jucker et al. (2022)

Drivers of change: altered fire regimes

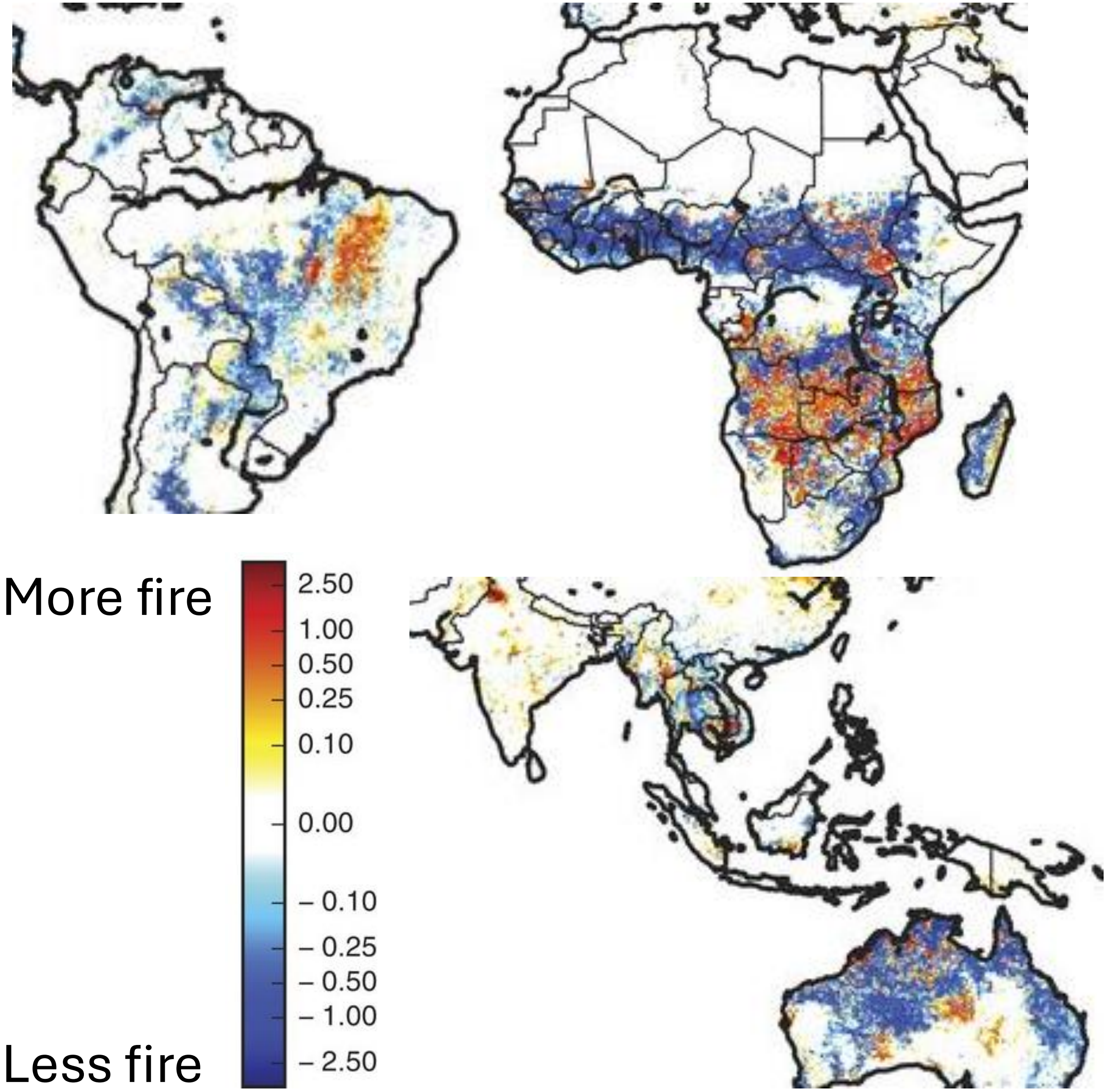
Andela et al. (2017)

Global burned area declined ~25% between 1998 and 2015 (±8.8%).

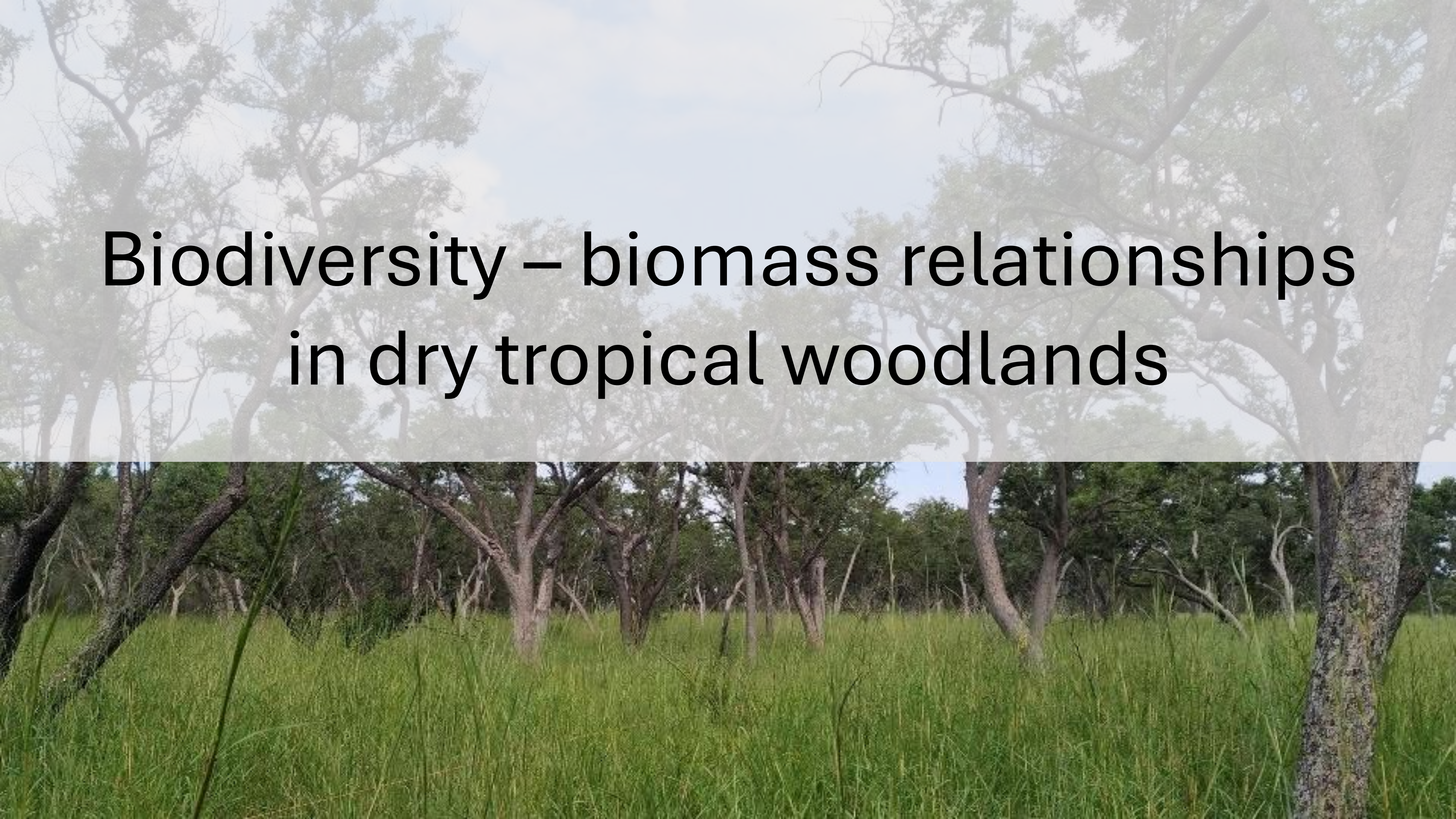
Mostly due to changes in human land use.

Strong contrasts among regions within continents.

Fire affects demographic rates and ecosystem structure.

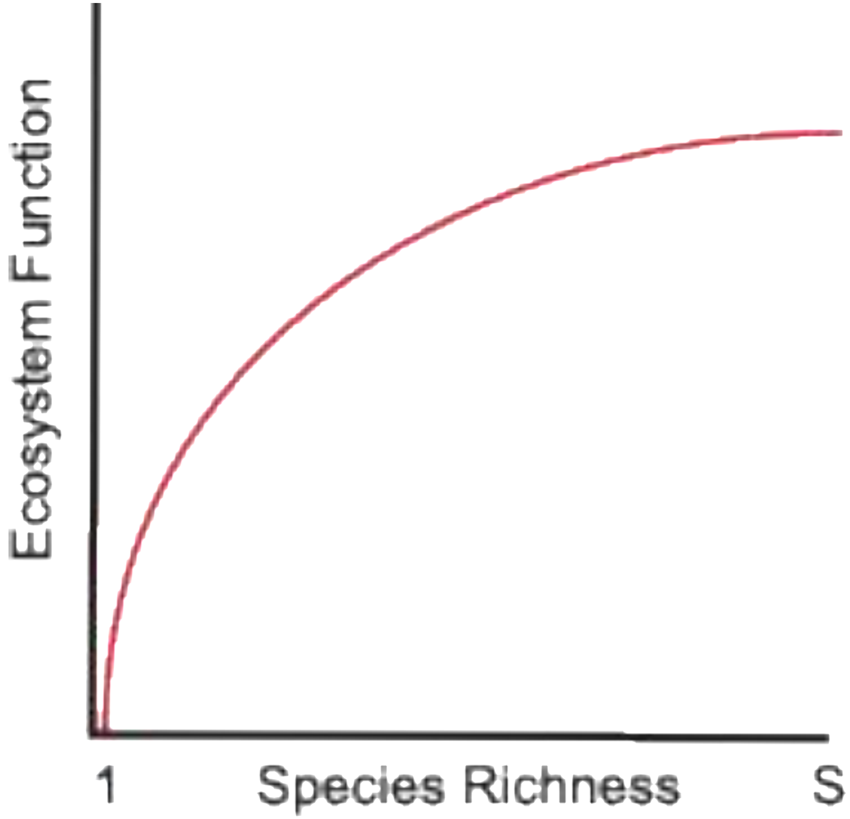


Biodiversity – biomass relationships in dry tropical woodlands

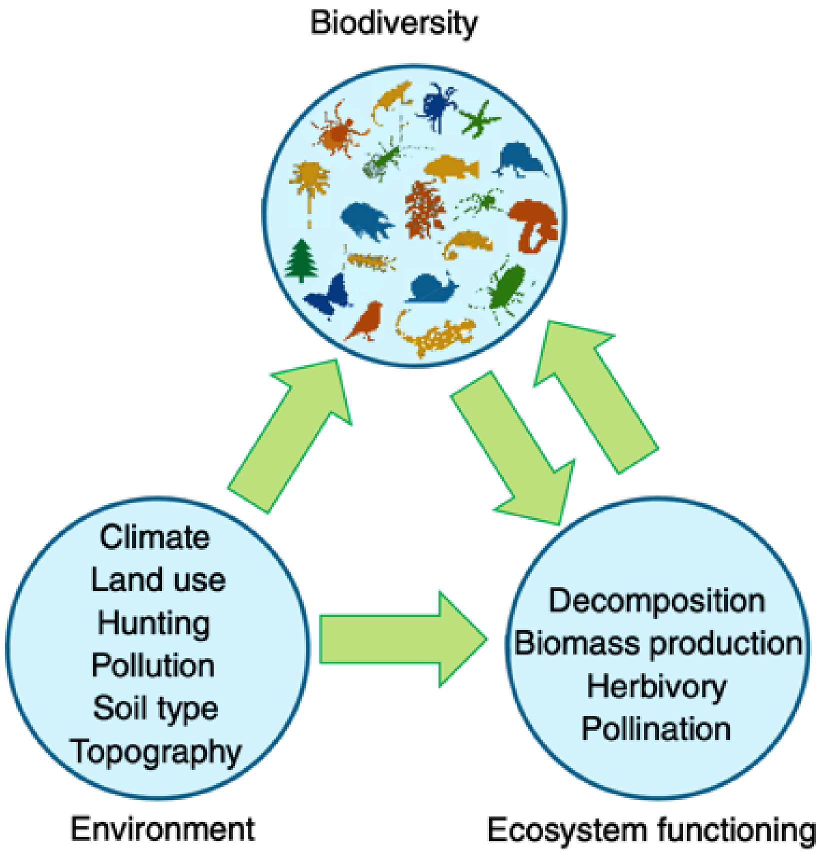


Determinants of woody biomass in African woodlands

Positive biodiversity-ecosystem function relationship



Complex interactions between environment, diversity and function

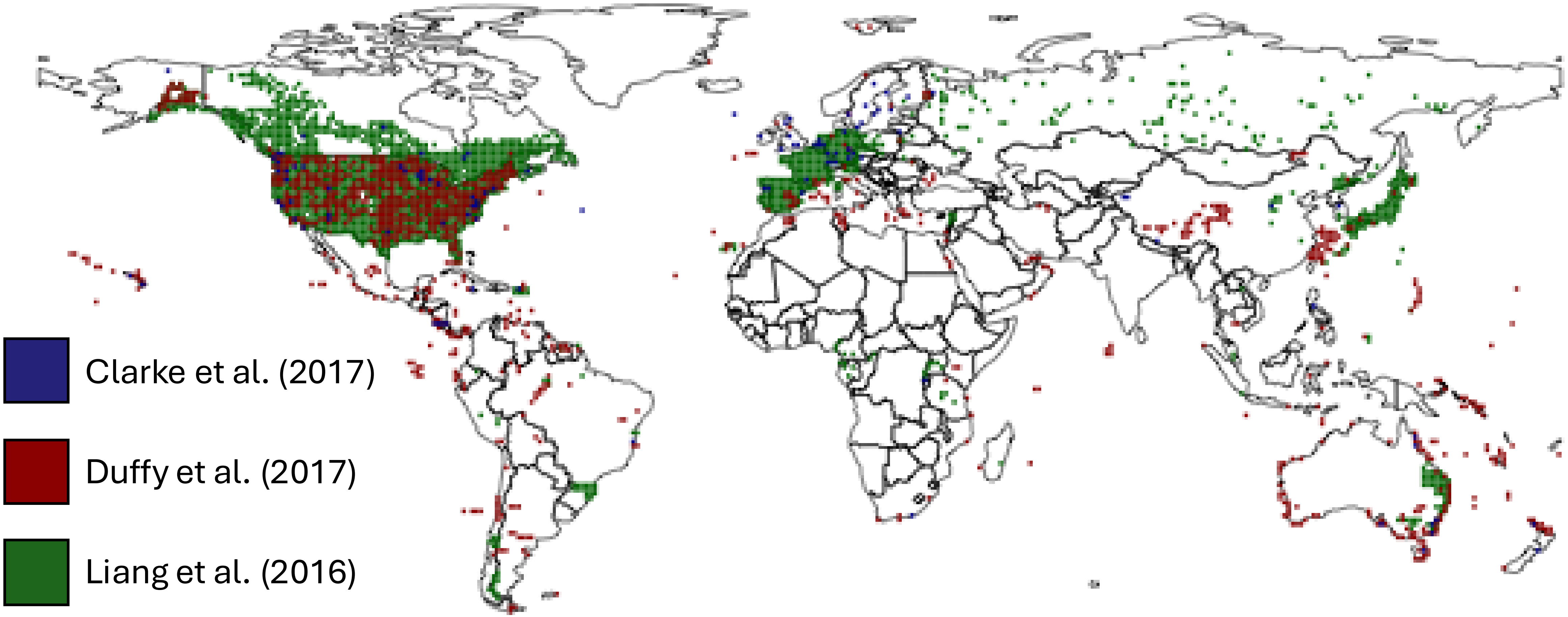


Tilman et al. (2014), van der Plas (2019)

Determinants of woody biomass in African woodlands

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

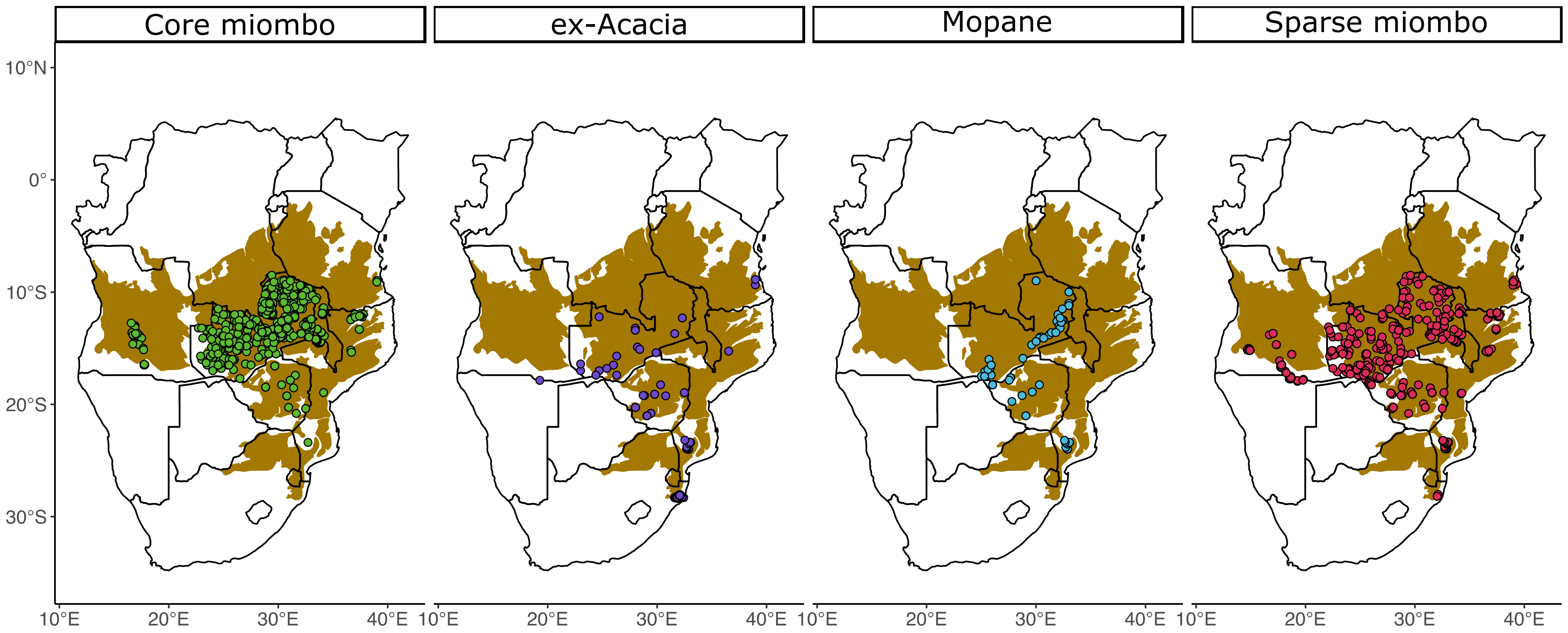
Chronic disturbance could reduce the importance of niche differentiation



Determinants of woody biomass in African woodlands

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

SEOSAW

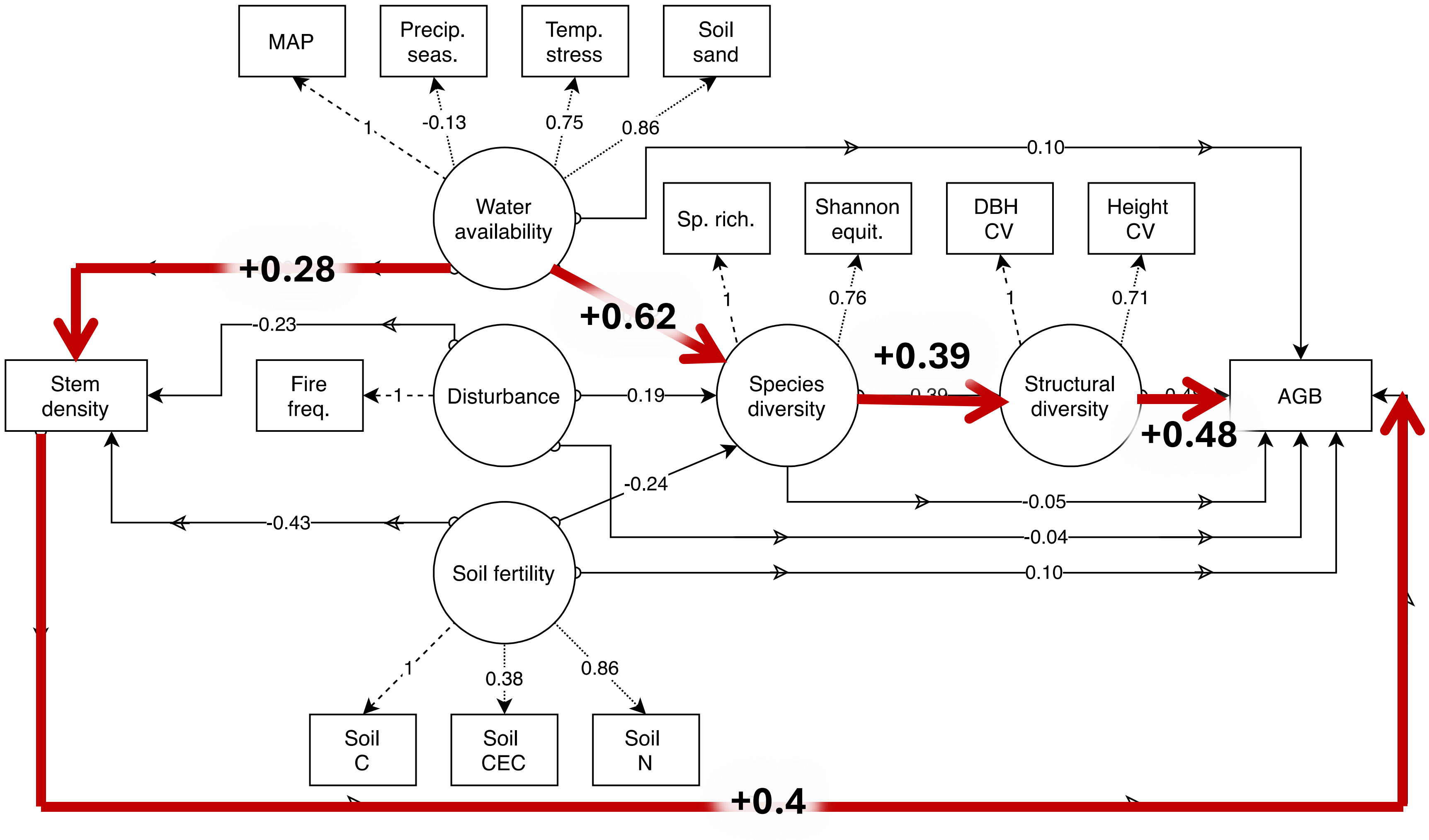


Godlee et al. (2021) *New Phytologist*

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



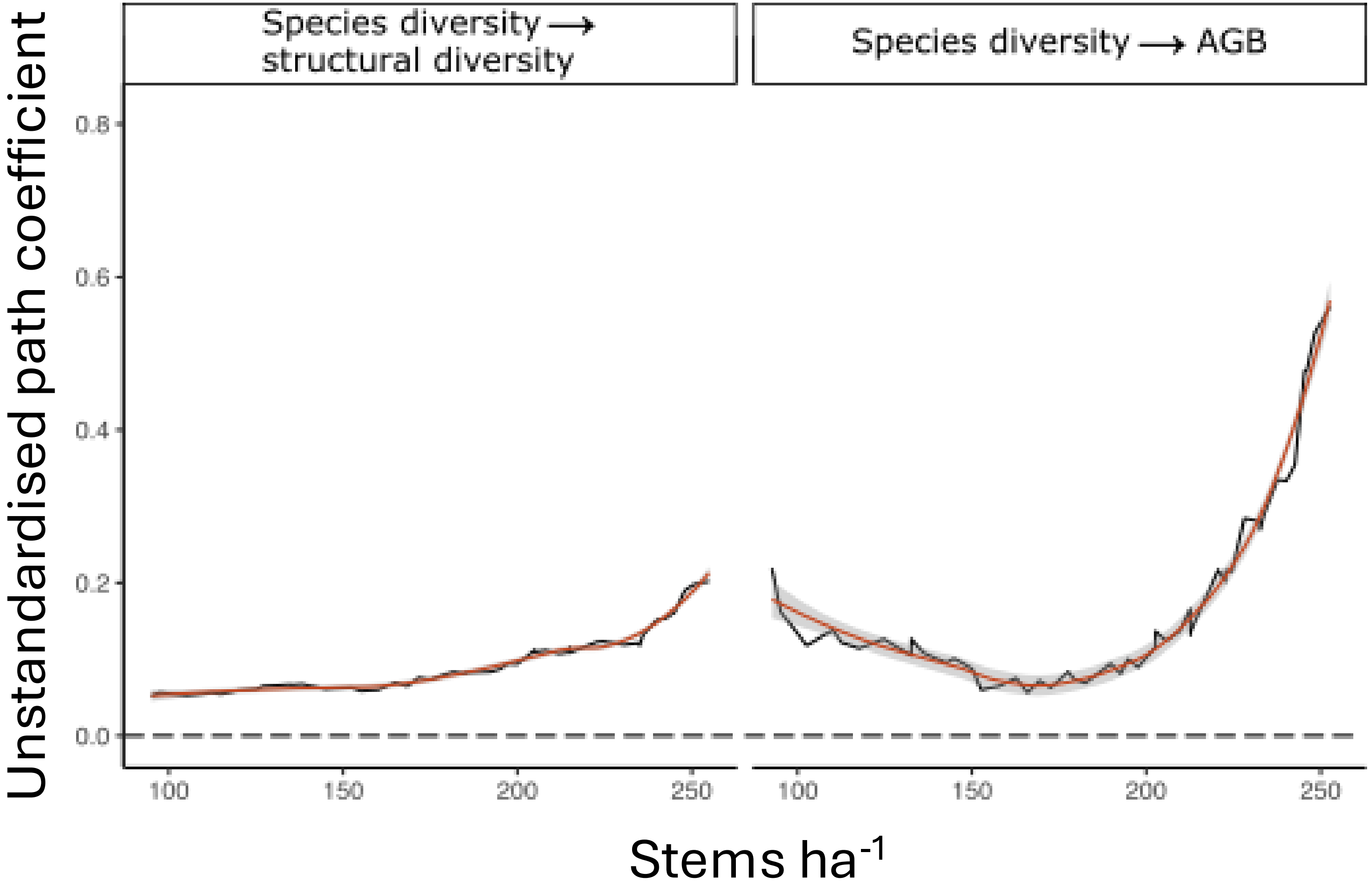
Godlee et al. (2021) *New Phytologist*

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

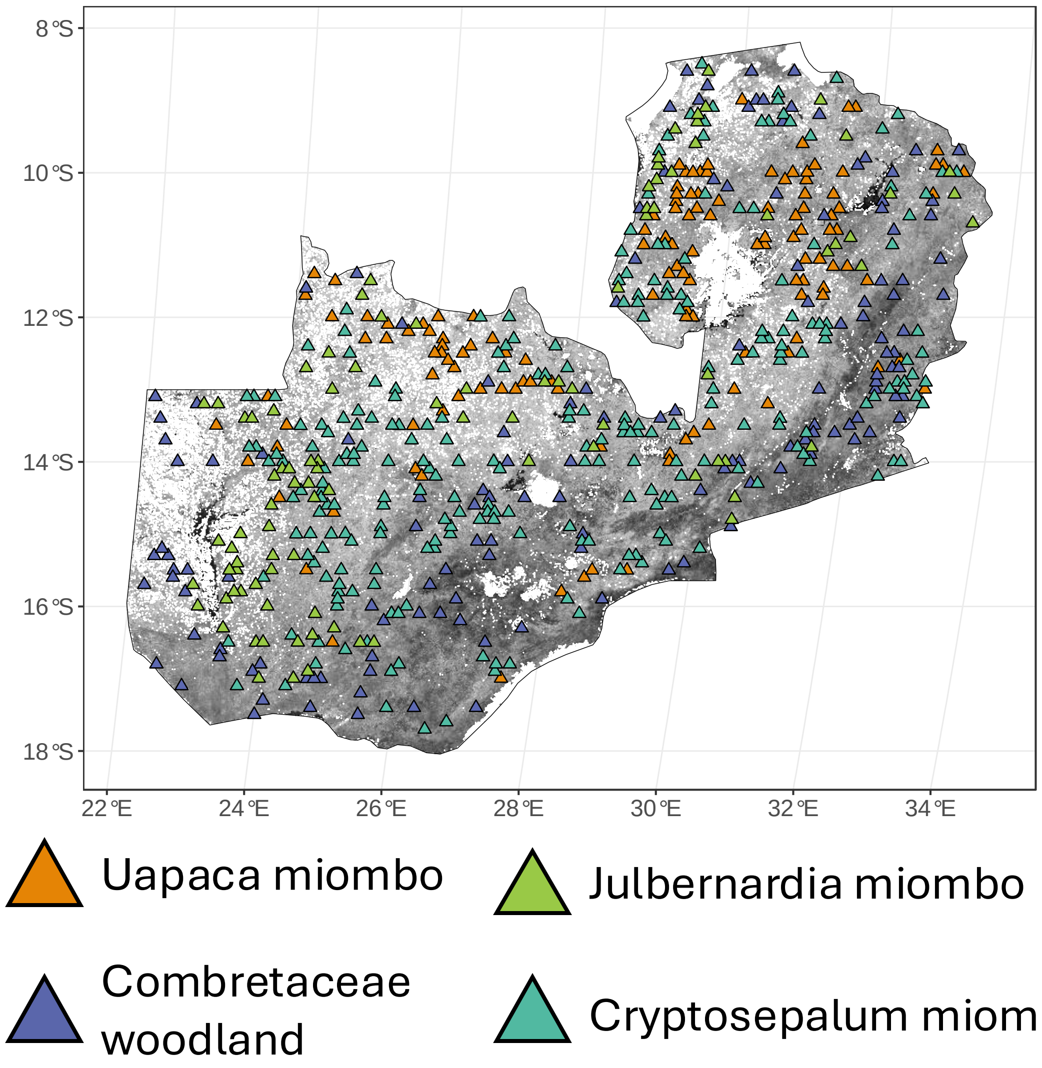


Godlee et al. (2021) *New Phytologist*

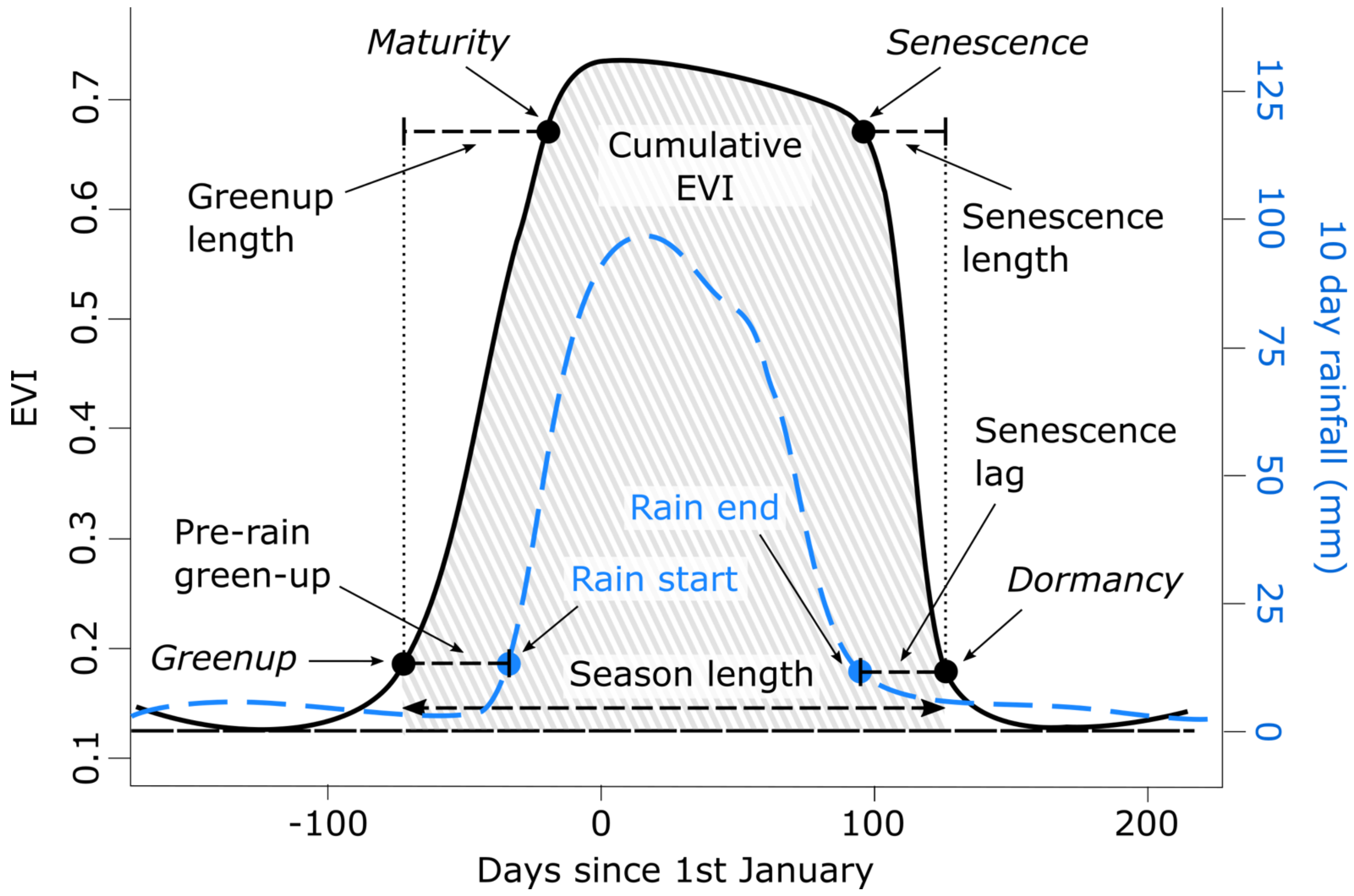
Endogenous drivers of land surface phenology

Linking land surface phenology and diversity

Zambian ILUAii –
National Forest Inventory



MODIS EVI – Enhanced Vegetation Index

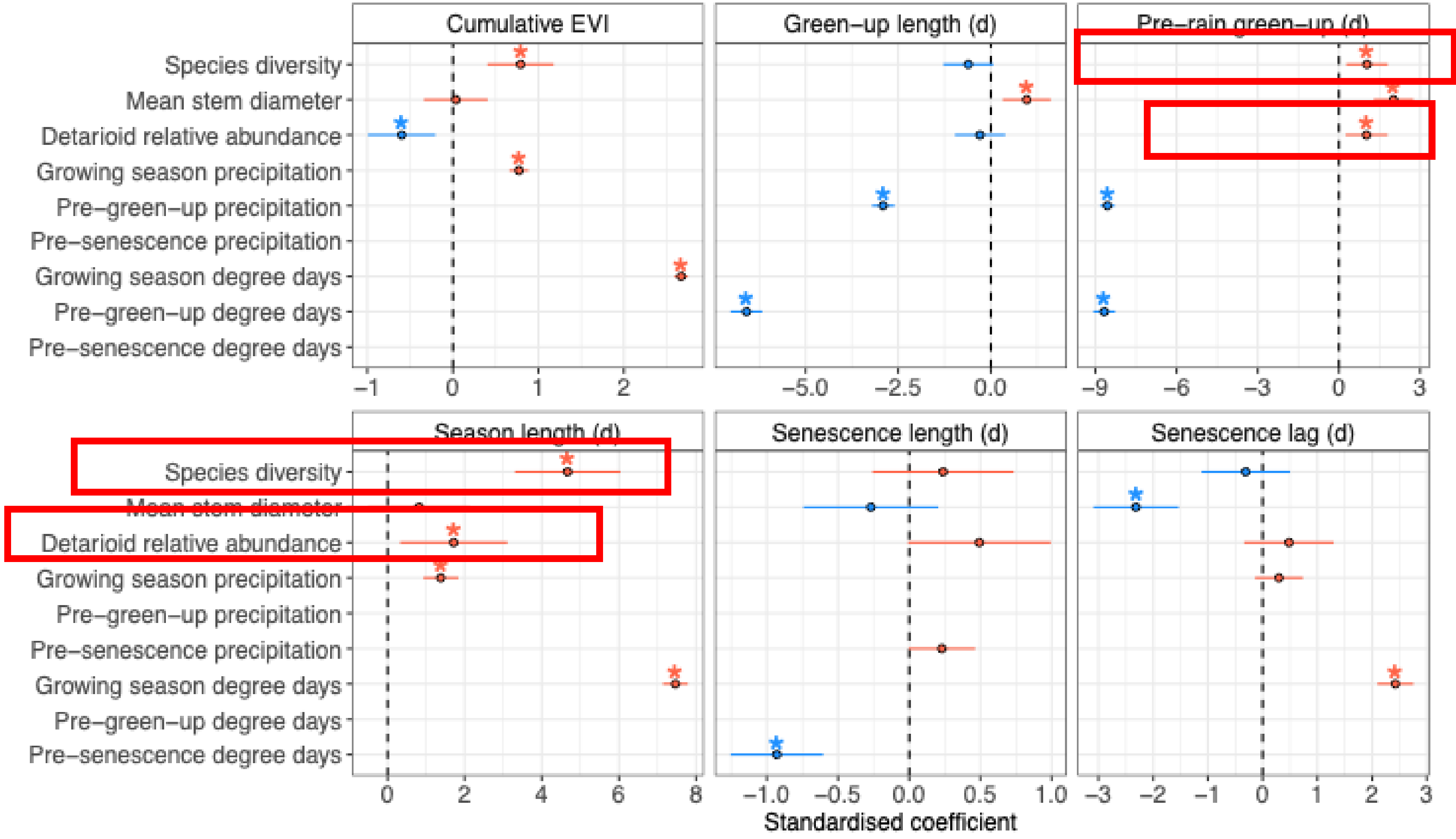


Godlee, Ryan, Siampale & Dexter (2024) – *Journal of Ecology*

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.

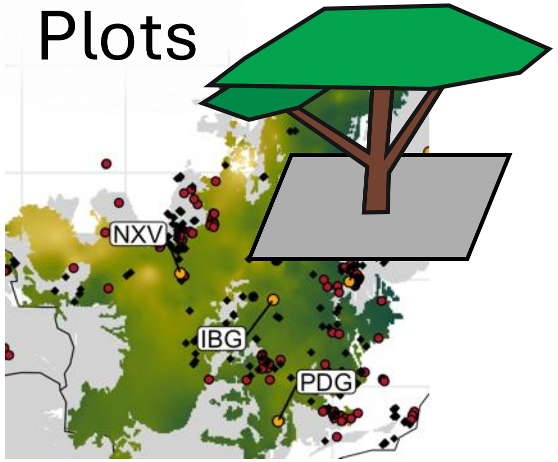


Godlee, Ryan, Siampale & Dexter (2024) – *Journal of Ecology*

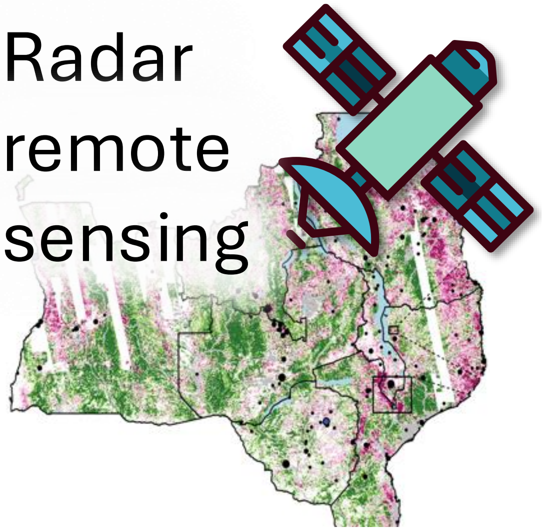
Woody carbon dynamics in the dry tropics

The SECO project: Methodological approach

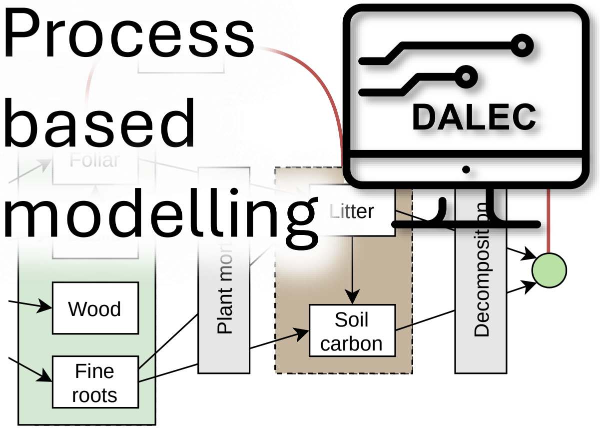
Plots



Radar remote sensing



Process based modelling



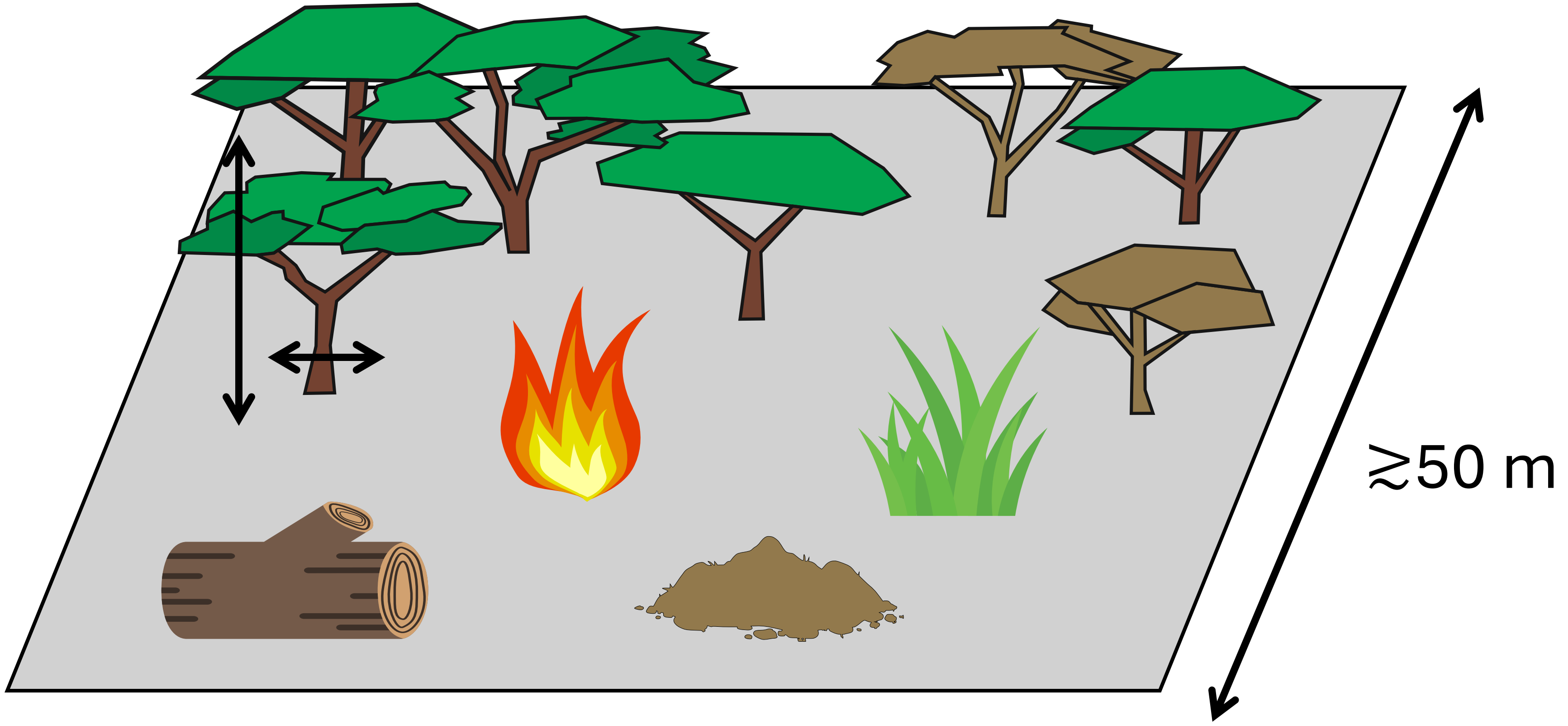
Plots provide:

- 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

PI: Dr. Casey Ryan (University of Edinburgh)

What's in a plot?

SEOSAW FORESTPLOTS.NET tern Ecosystem Research Infrastructure



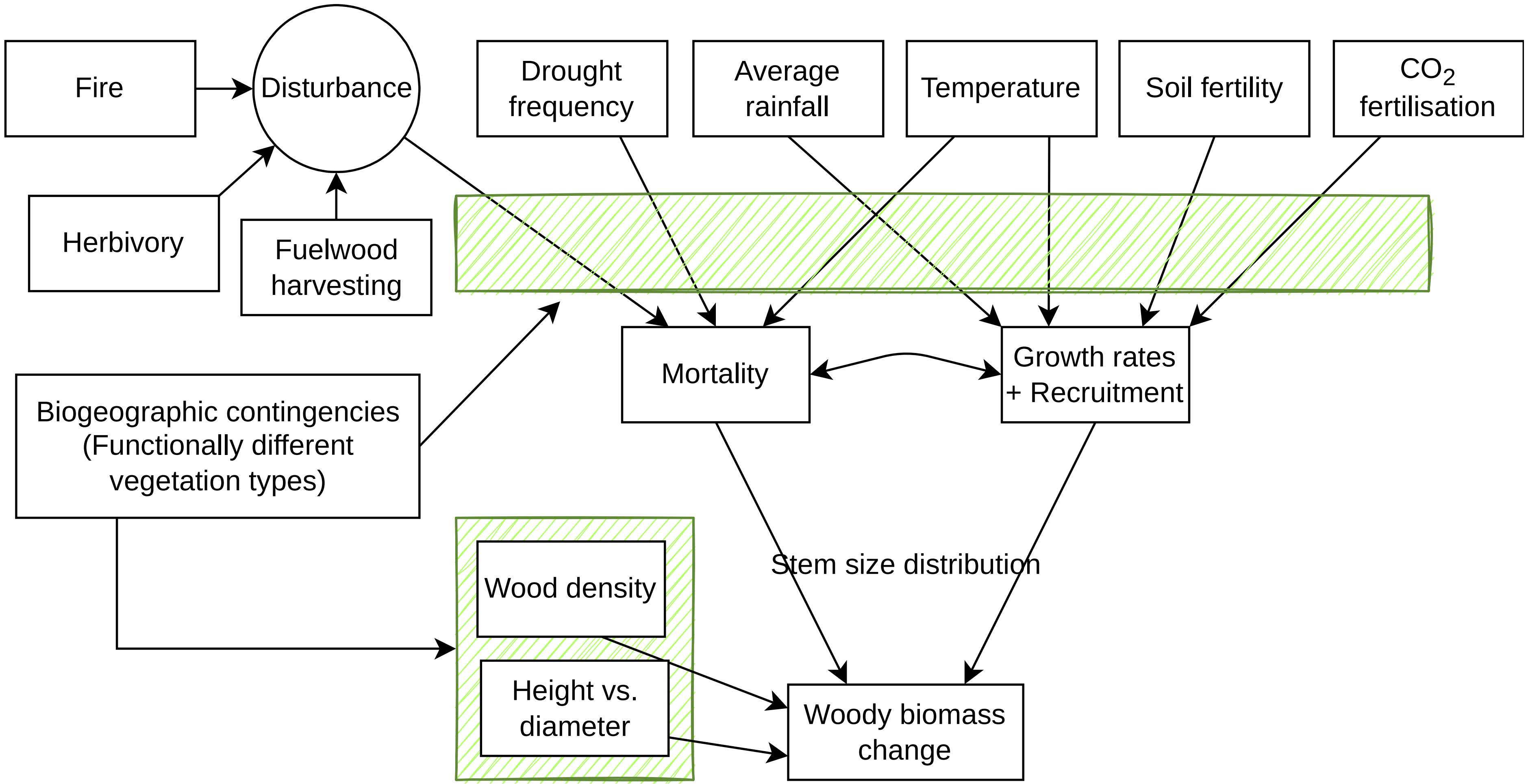
- Tree species
- Stems within a tree
- Stem diameter
- Stem height
- Coarse woody debris
- Fire disturbance regime
- Soil carbon and nutrients
- Herb. biomass and comp.
- Tree mortality
- Leaf phenology

Tags on all woody stems >5 cm diameter

SEOSAW (2020), ForestPlots.net (2021), Hutley et al. (2011)

Dry tropical woody carbon dynamics

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



Funded by:

NERC SCIENCE OF THE ENVIRONMENT

Collaboration with:

UNIVERSITY OF LEEDS

UNIVERSITY OF EXETER

FORESTPLOTS.NET

SEOSAW

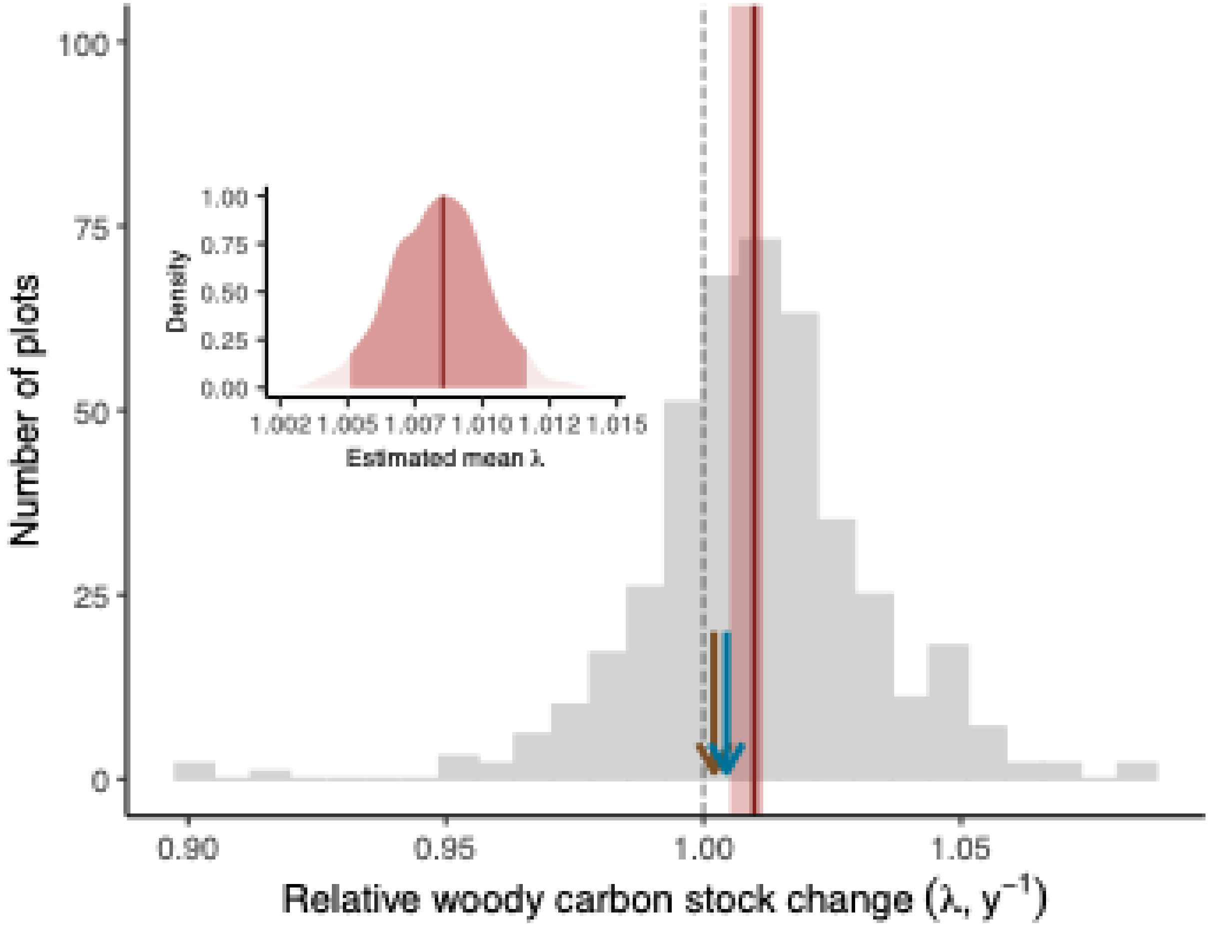
+22 international partners

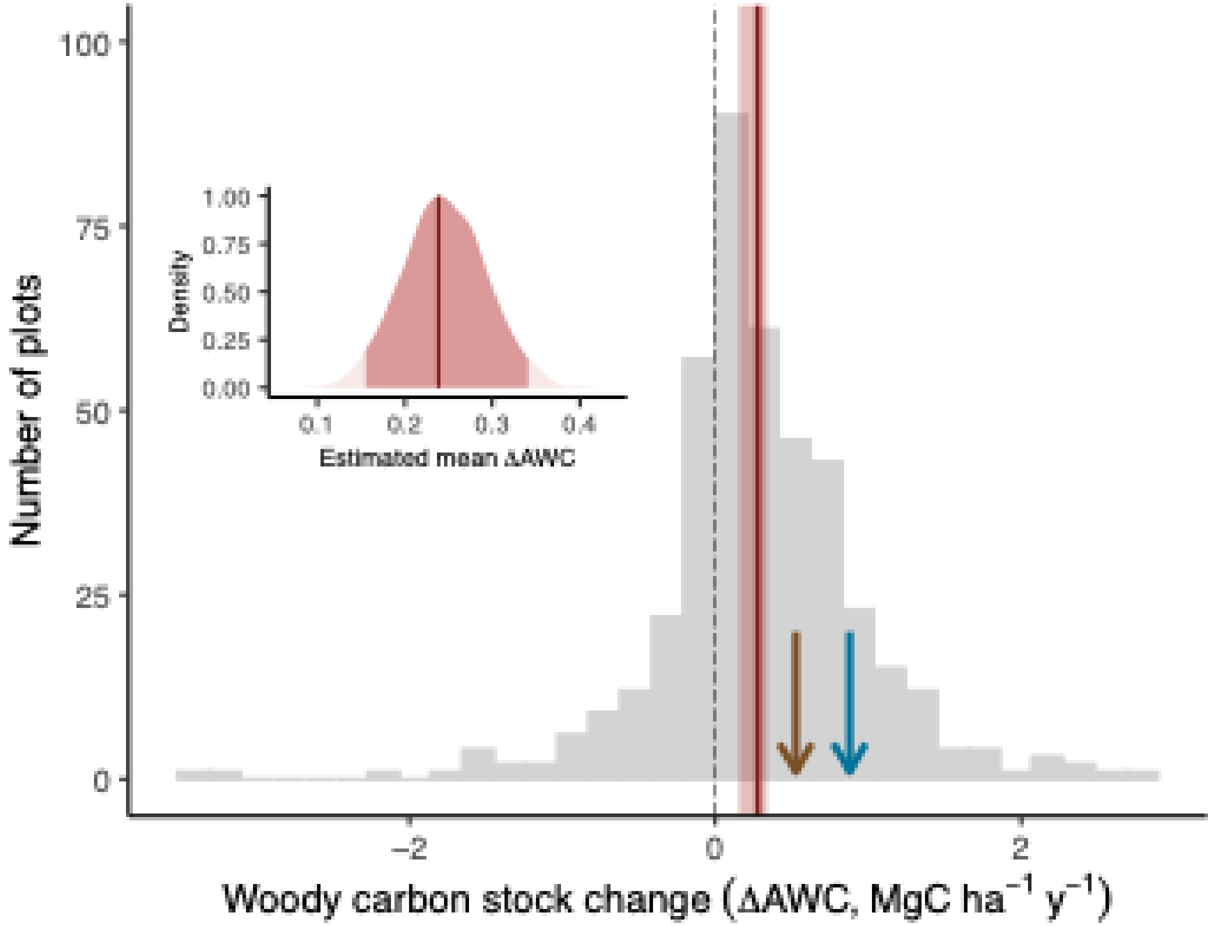
Drivers of biomass change in the dry tropics

424 plots

> 0.1 ha plot area

2000-2023 time period





Please do not share

Godlee et al. (in review)

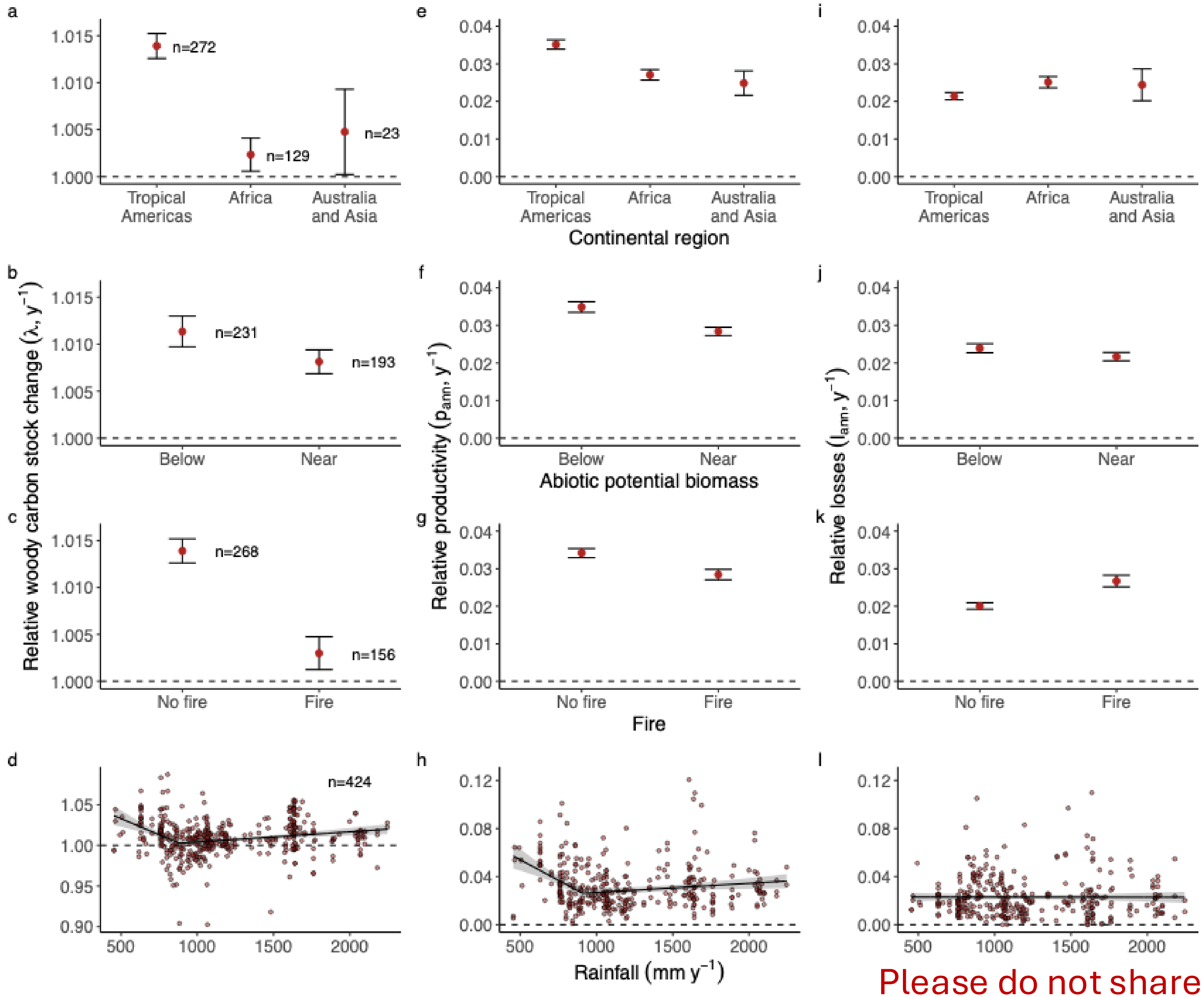
Drivers of biomass change in the dry tropics

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



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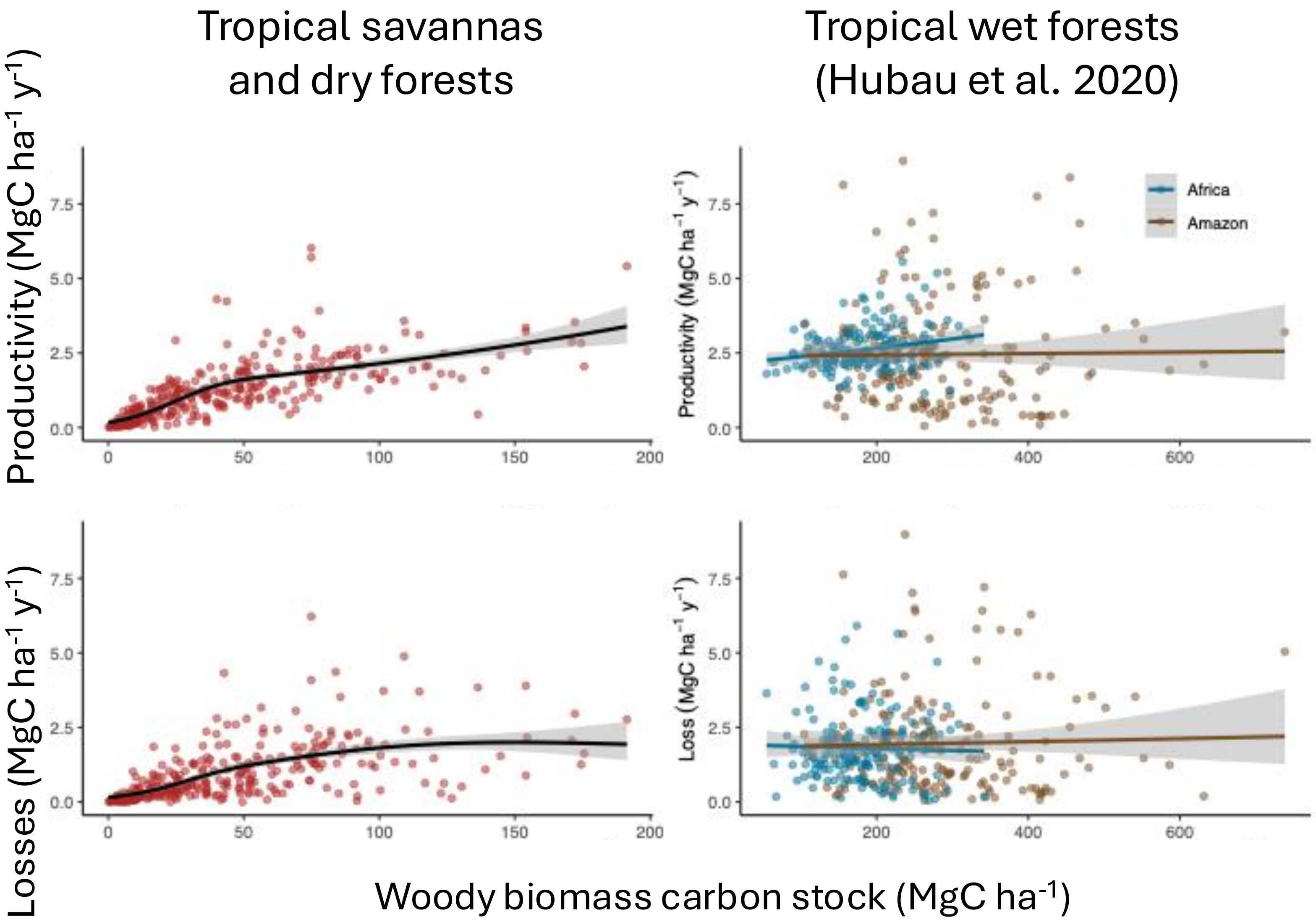
Drivers of biomass change in the dry tropics

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.



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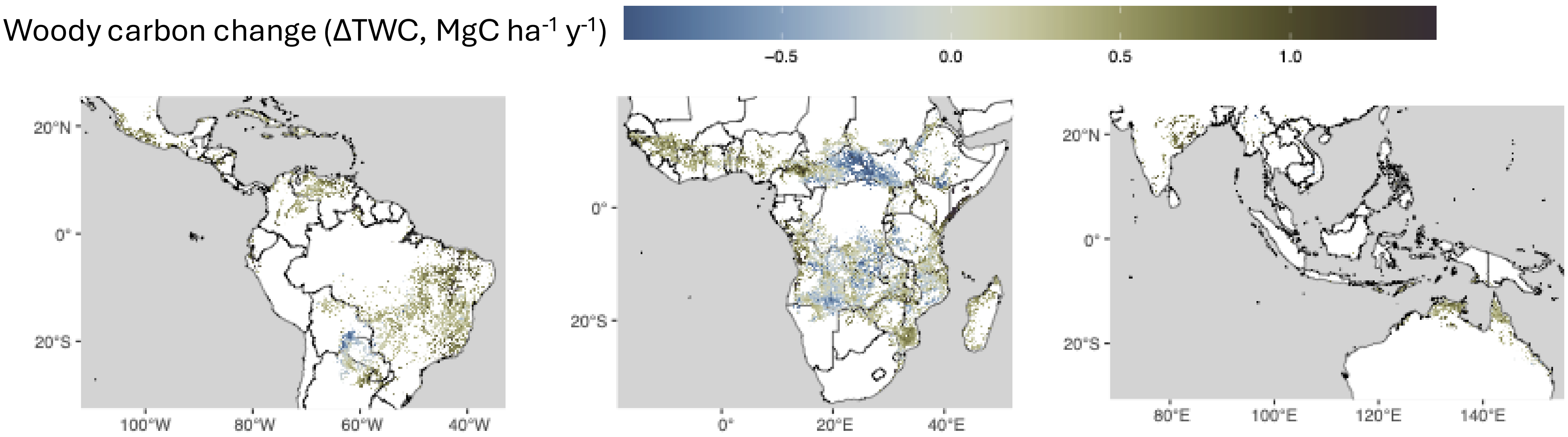
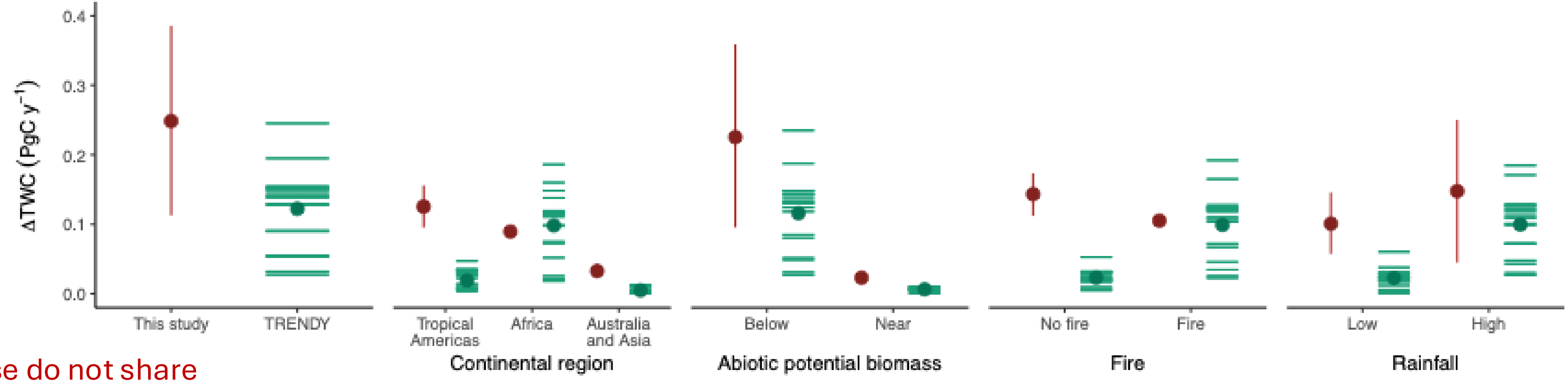
Drivers of biomass change in the dry tropics





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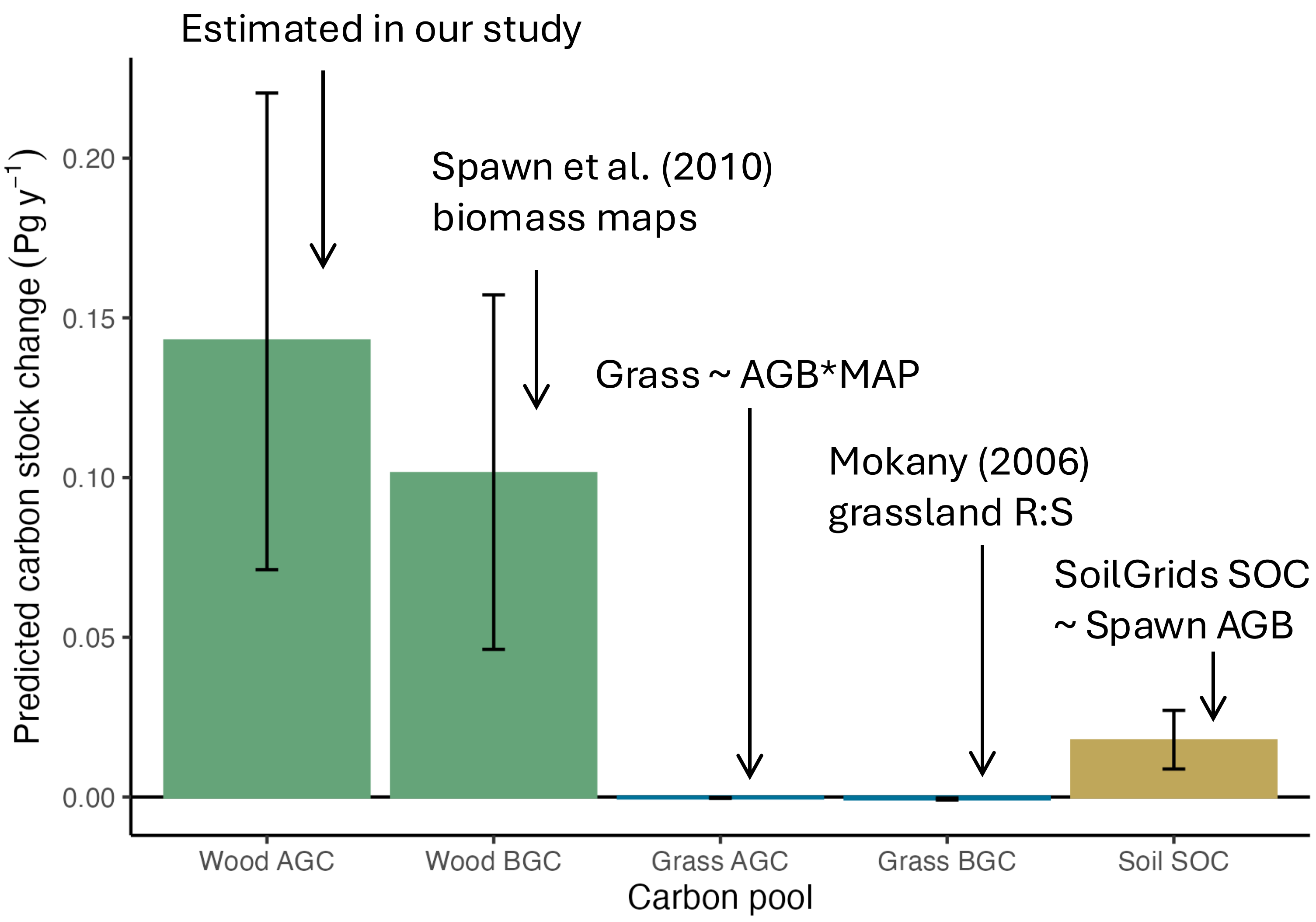
Drivers of biomass change in the dry tropics

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!

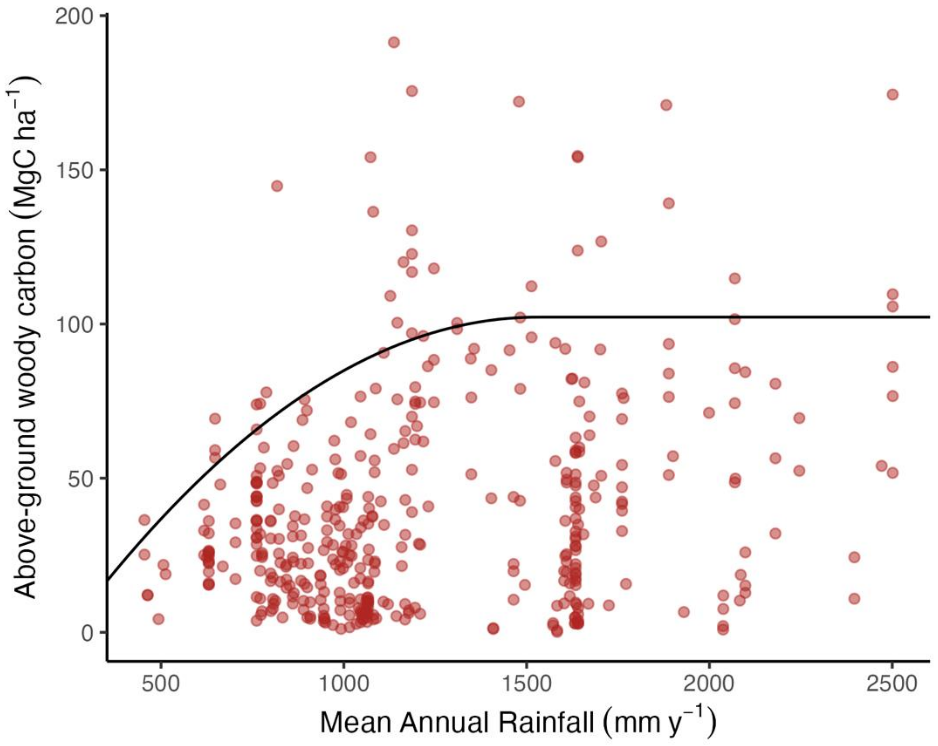


Please do not share

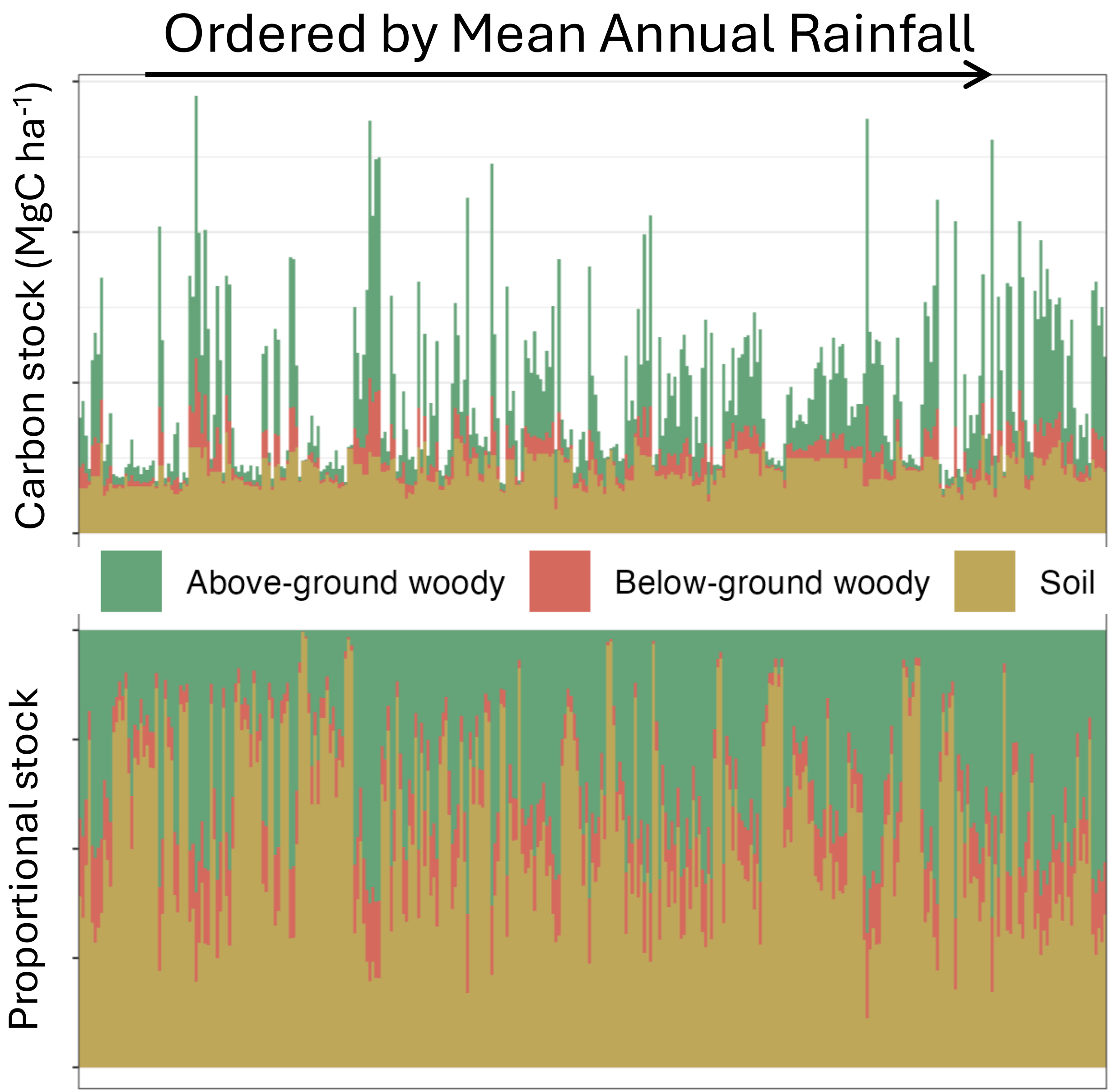
Drivers of biomass change in the dry tropics

No association of water availability and carbon stocks in plots.

Water availability sets upper limit of woody biomass.



After Sankaran et al. (2005)



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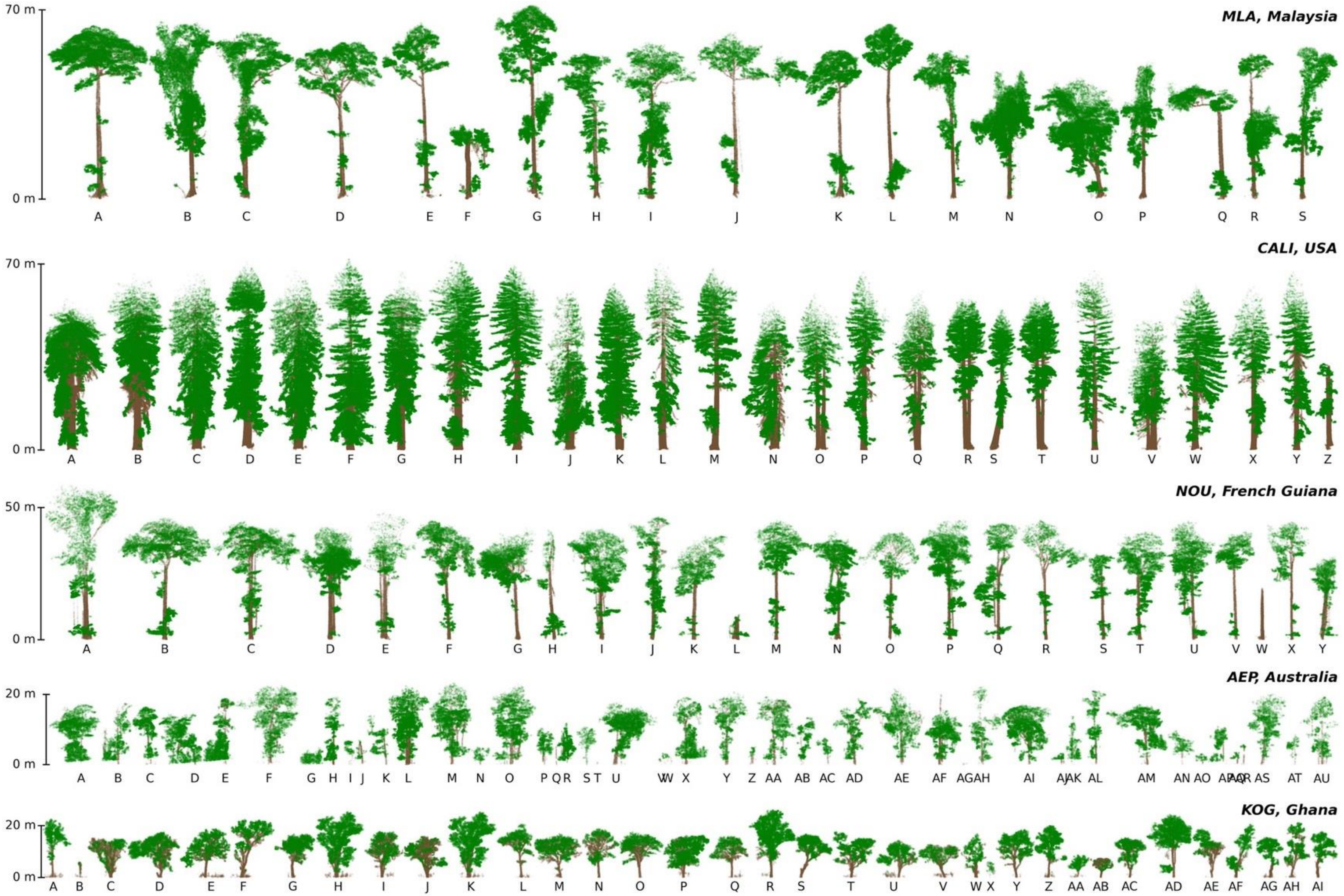
Tree architecture, landscape patterns and woody biomass

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?



Chave et al. (2014), Wilkes et al. (2023)

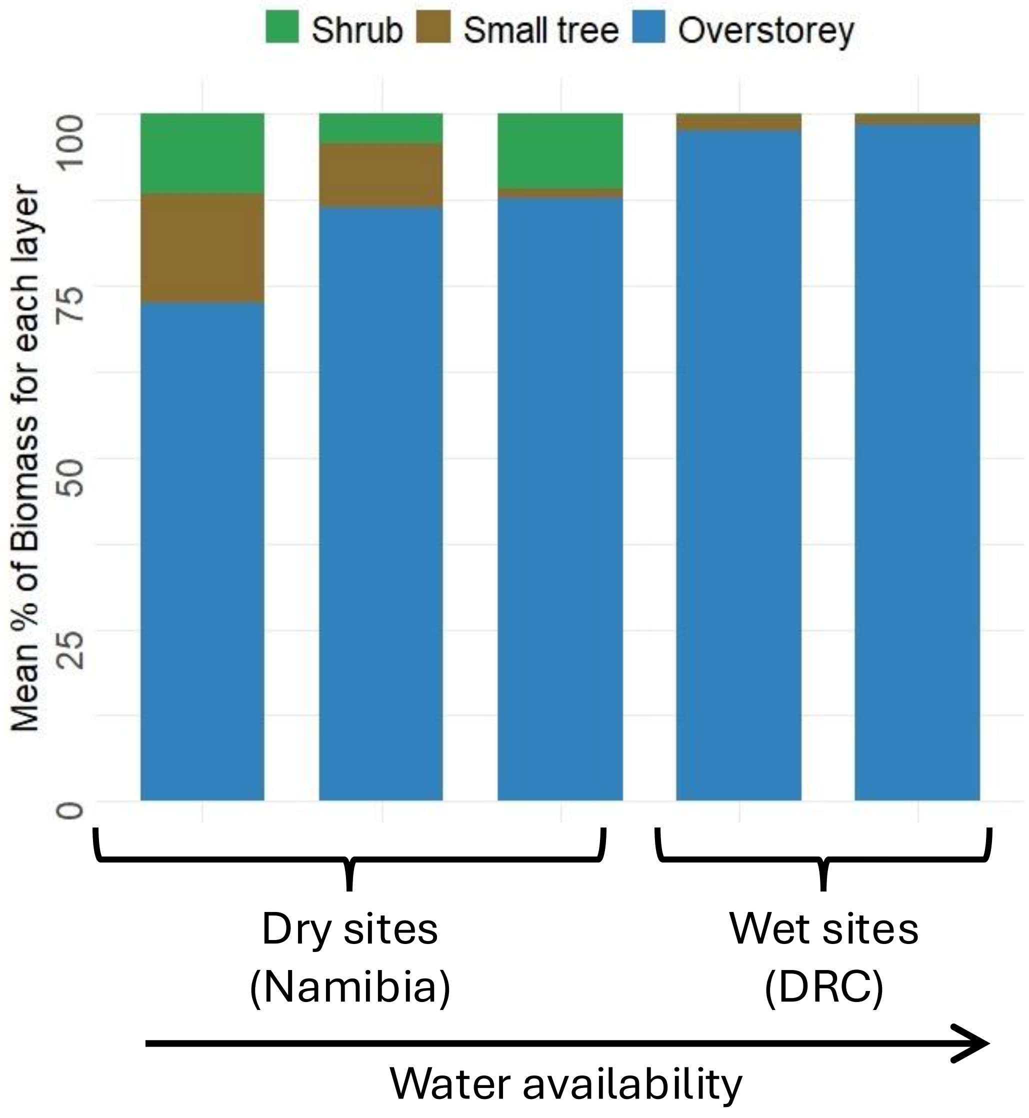
Biomass in other carbon pools

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?



Diesse, Godlee, et al. (in review) – Forest Ecosystems

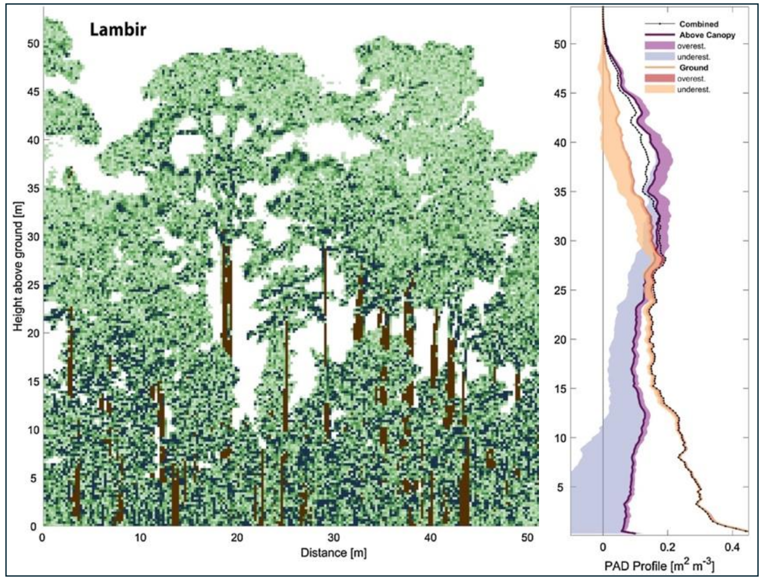
Landscape patterns: biomass, structure, diversity

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

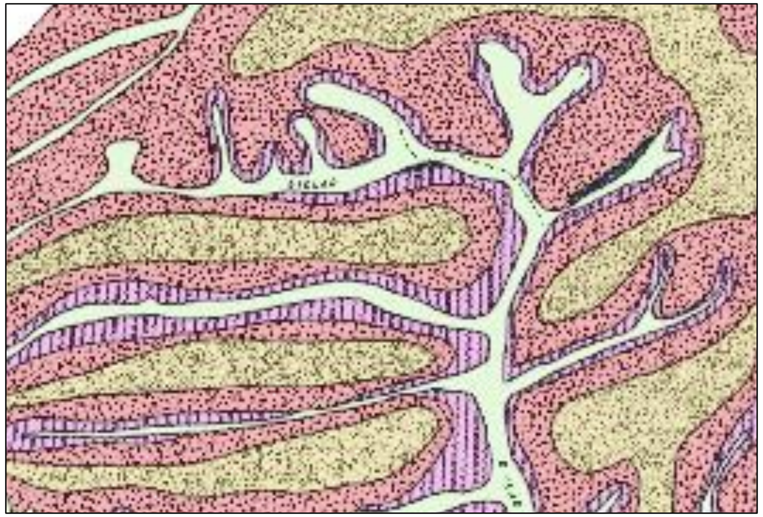
Are there multiple ways to achieve abiotic potential biomass through different ecosystem structure?

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

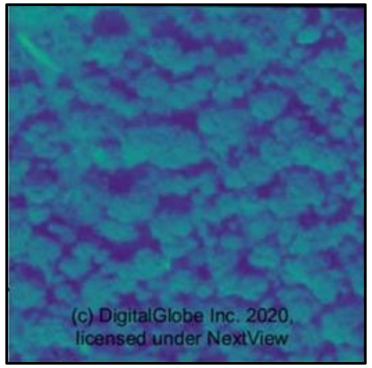
ALS-/TLS-derived canopy profiles

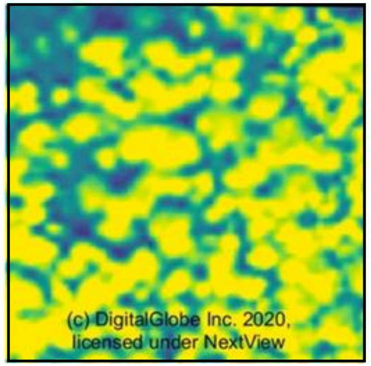


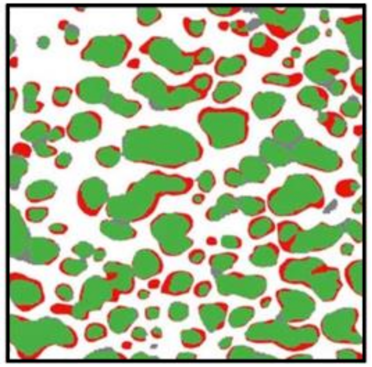
Predictable patterns of stand structure at landscape scales



ALS / WorldView maps of tree size







Schneider et al. (2019), Brandt et al. (2020)

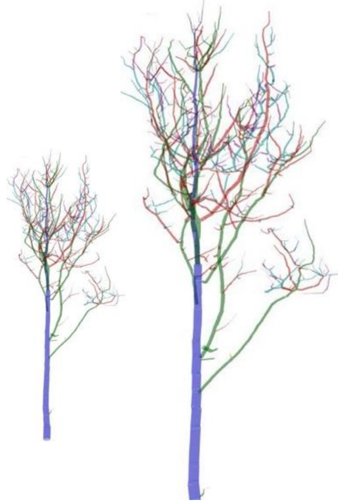
If we have dynamics data …

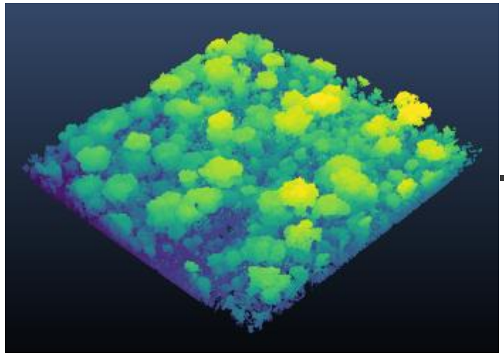
Which forests will be the future carbon sink hotspots?

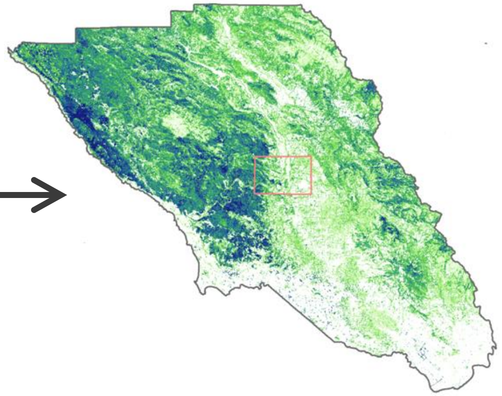
Landscape-level biomass dynamics overcome stochasticity from plots.

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

Suitability of commonly used biomass allometries


Global Change Biology

celebrating 20 years

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

Improved allometric models to estimate the aboveground biomass of tropical trees

JÉRÔME CHAVE[1], MAXIME RÉJOU-MÉCHAIN[1], ALBERTO BÚRQUEZ[2], EMMANUEL CHIDUMAYO[3], MATTHEW S. COLGAN[4], WELINGTON B.C. DELITTI[5], ALVARO DUQUE[6],

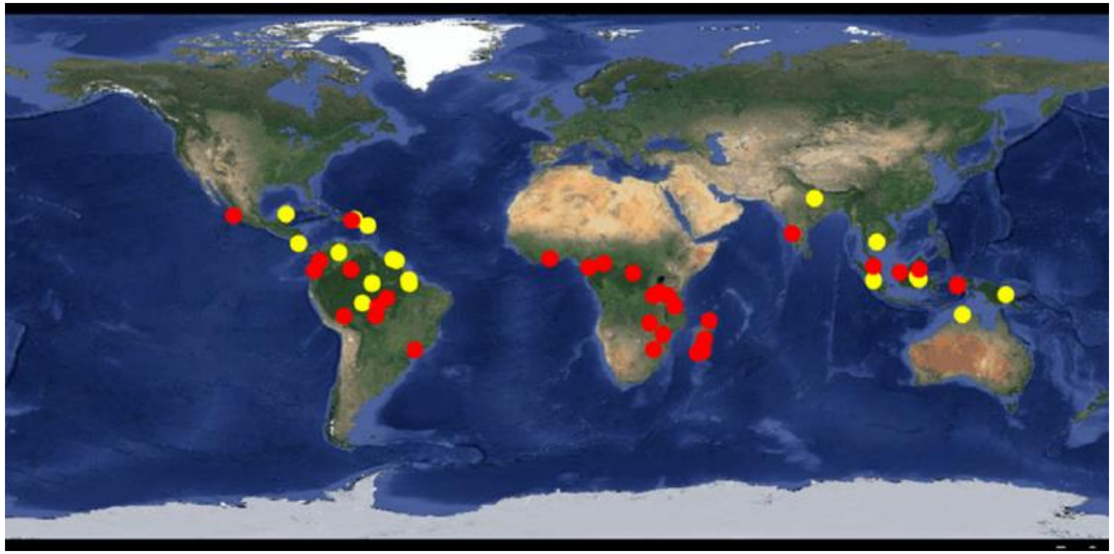
D = Stem diameter

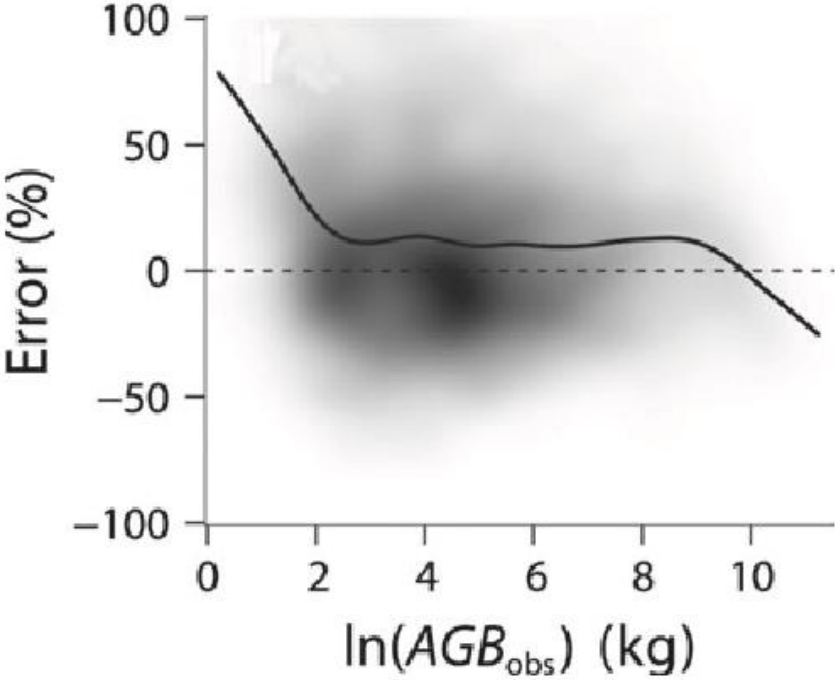
ρ = Wood density

E = Water availability

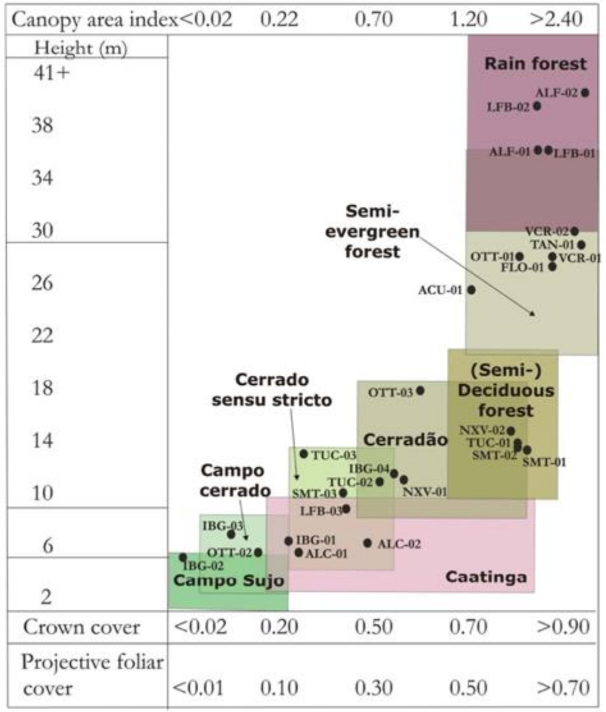
OR

H = Stem height

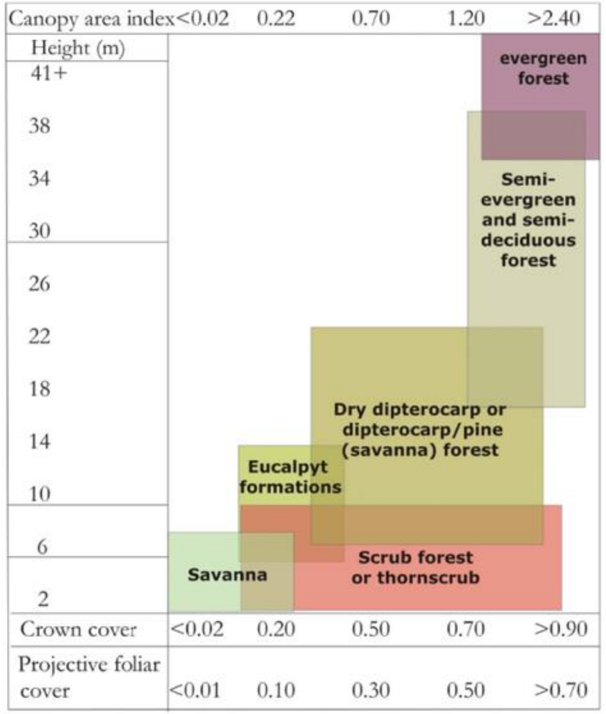




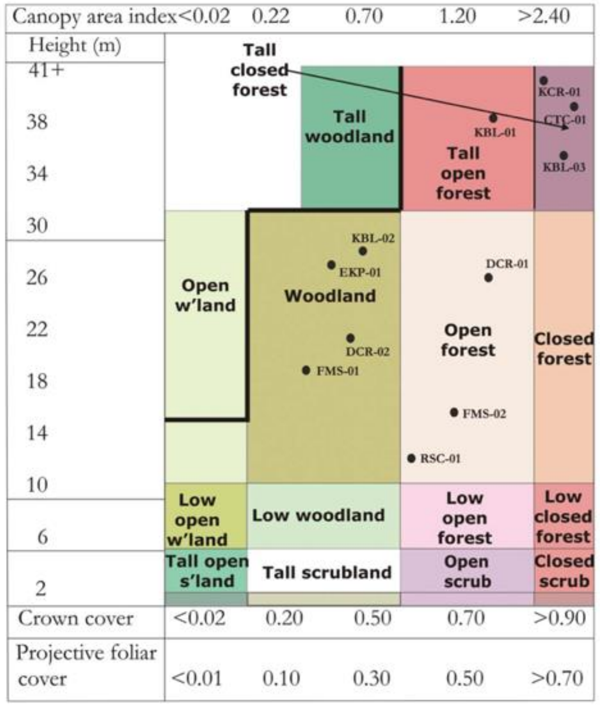
Ecosystem structure in the dry tropics is highly variable



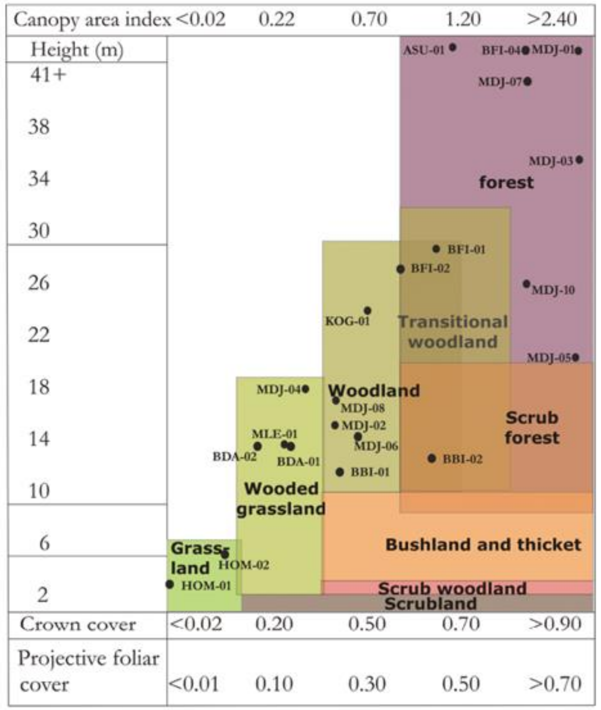
South America



South-East Asia



Africa



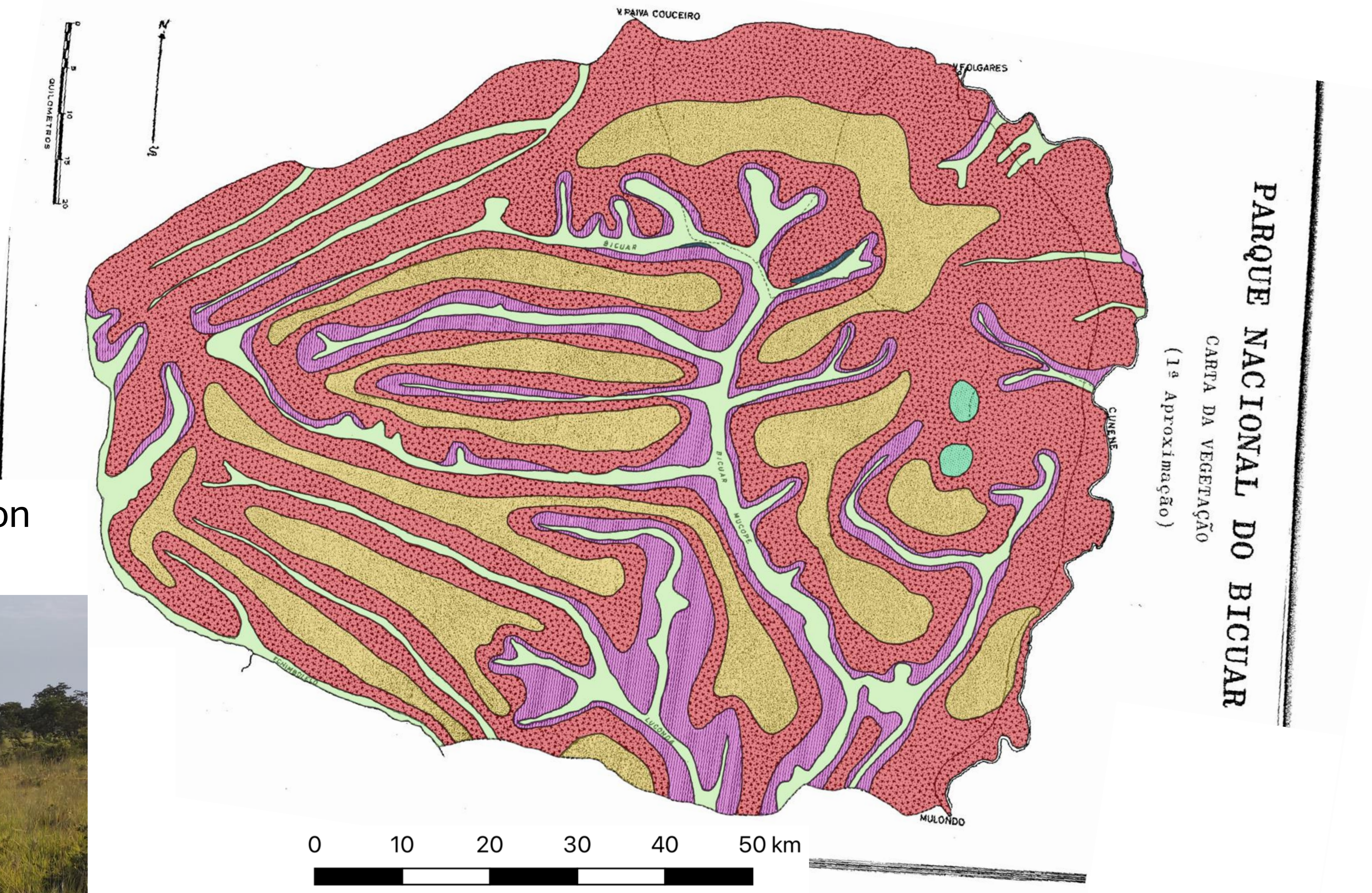
Australia

Torello-Raventos et al. (2013)

Landscape patterns in vegetation structure

Bicuar National Park, Angola.

Catenal sequence. Vegetation boundaries drift over time.



Teixeira (1968)

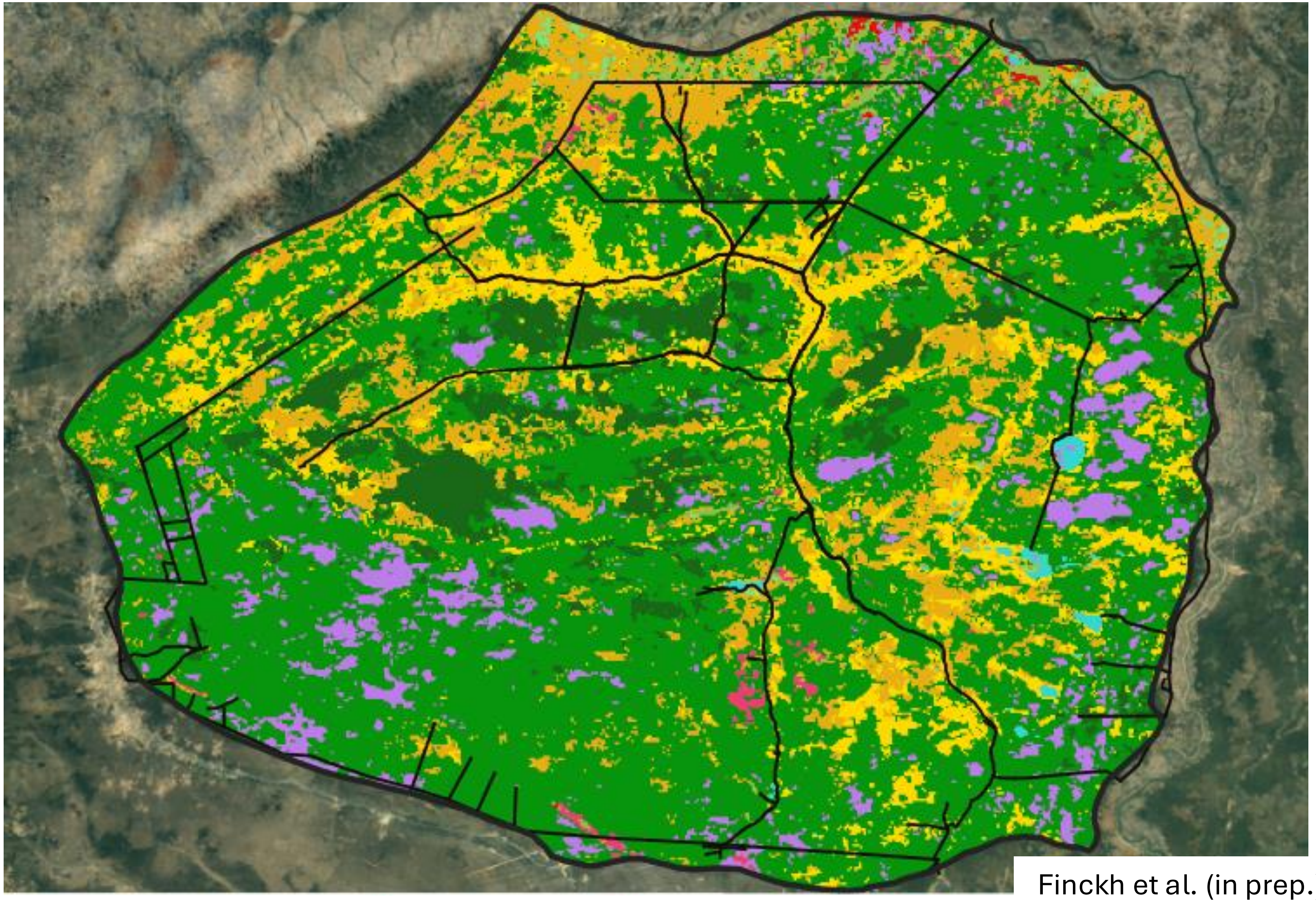
Landscape patterns in vegetation structure

Bicuar National Park, Angola

- High
- Medium
- Low

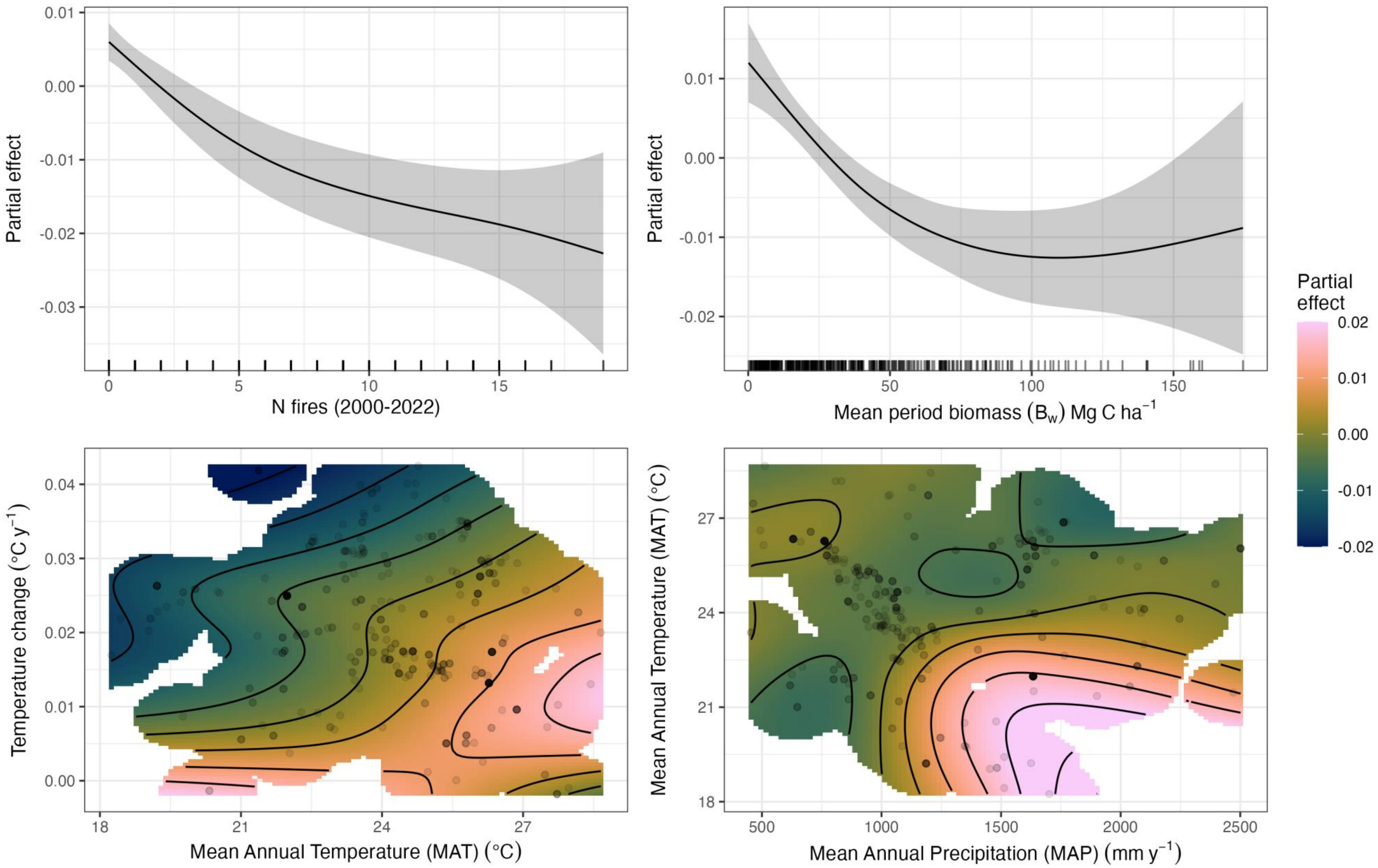
Baikiaea forest (biomass)

- Burkea woodland
- Geoxyle grassland
- Wild pasture



Finckh et al. (in prep.)

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.