Does biodiversity control ecosystem functioning & associated ecosystem services of tropical forests?

SCIENTIFIC REPORTS

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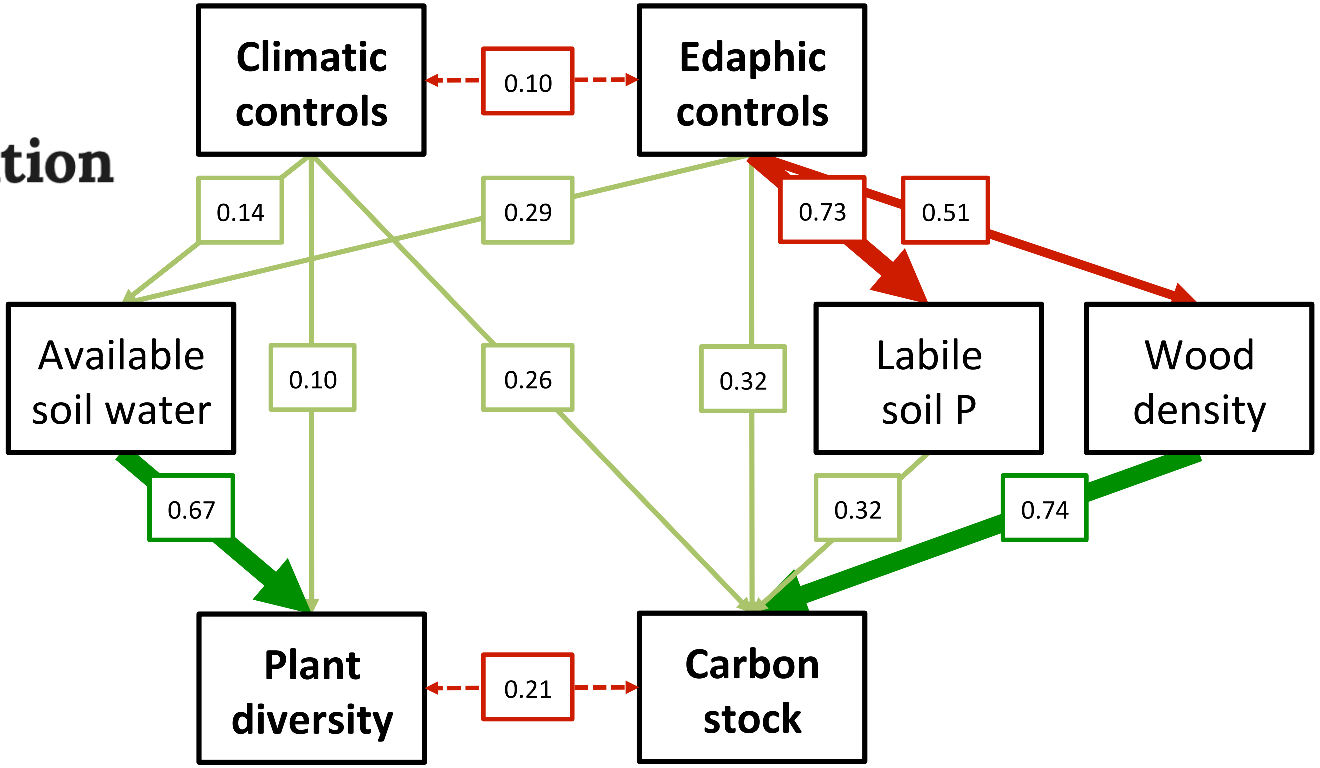
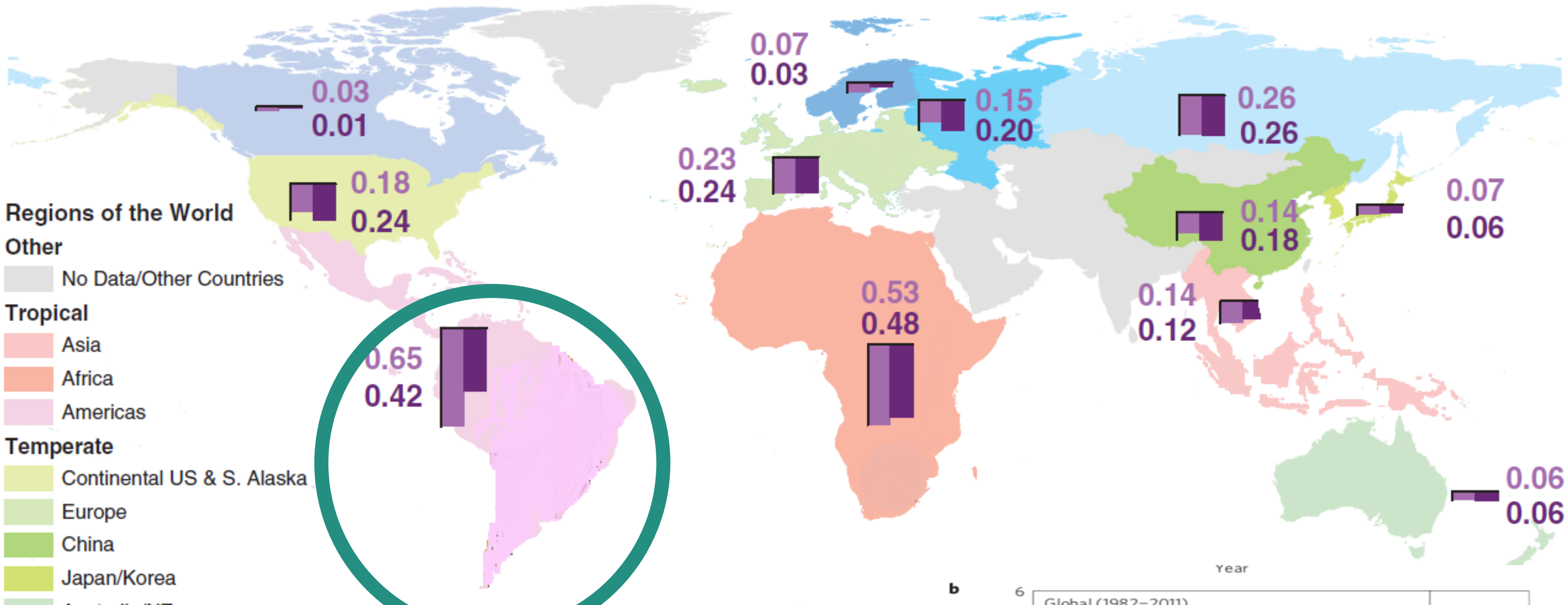
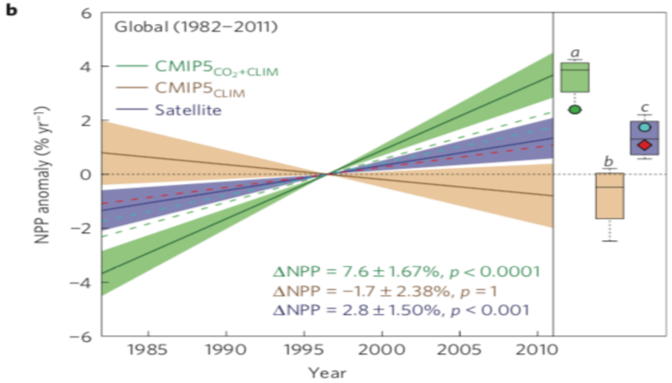
Climatic and edaphic controls over tropical forest diversity and vegetation carbon storage



58th Meeting of the *Association for Tropical Biology and Conservation (ATBC)* 11 July 2022

Tropical forests provide crucial ecosystem services





Tropical forests contribute greatly to global terrestrial C sink strength and provide multiple ecosystem services:

- 50% of global carbon cycle
- 30% of global water cycle
- 25% of fossil fuel emissions
- 20% of oxygen production

Tropical forest species diversity:

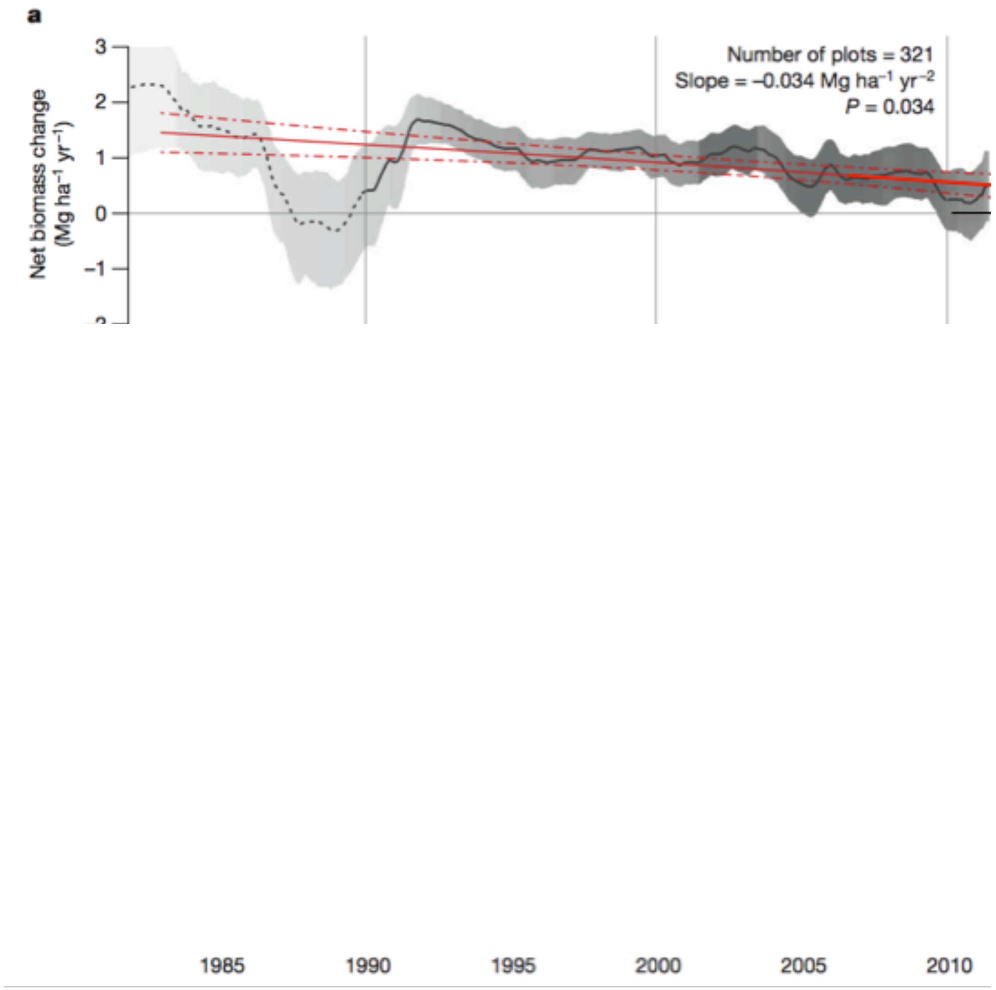
- 390 billion trees
- 16,000 tree sp.
- Biomass accumulates C worldwide but decreasing sink strength (1990-2007)
- ~0.4-0.6 / 2.3 Pg C yr^{-1} (~25%)

Discrepancy between estimates:

- **Field research**
- **Remote sensing**
- **Model simulations**

Pan et al. 2011 Science; Le Quéré et al. 2018 ESSD

Reduction of C sink strength (ground observation)



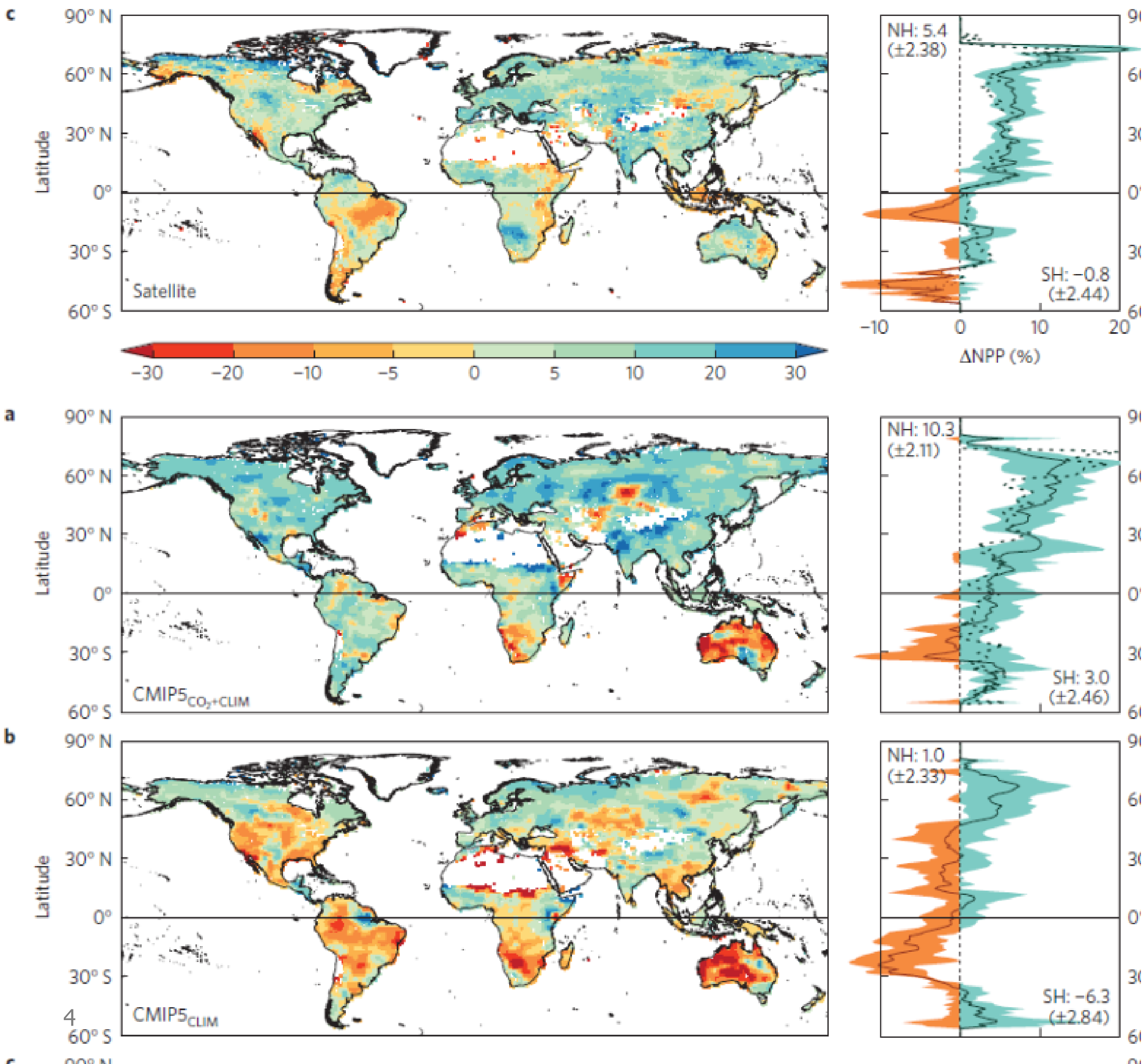
Observation based NPP estimate:

- Net biomass change **decreasing**

→ **tree mortality rates** and **turnover time** should be accounted for when projecting C sink strength

Brienen et al., (2015) Nature doi:10.1038/nature14283; Brienen et al., (2019) Nature Comm doi:10.1038/s41467-020-17966-z

Increase of C sink strength (remote sensing)

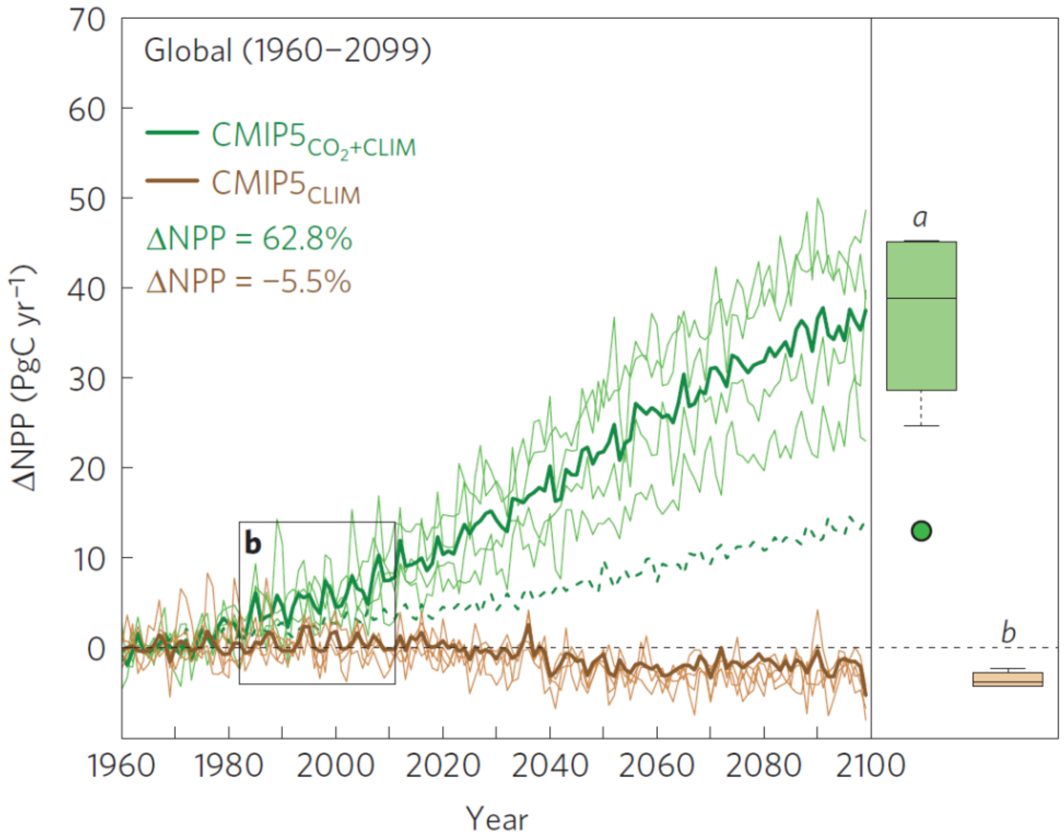


<u>Satellite-based NPP estimate:</u>

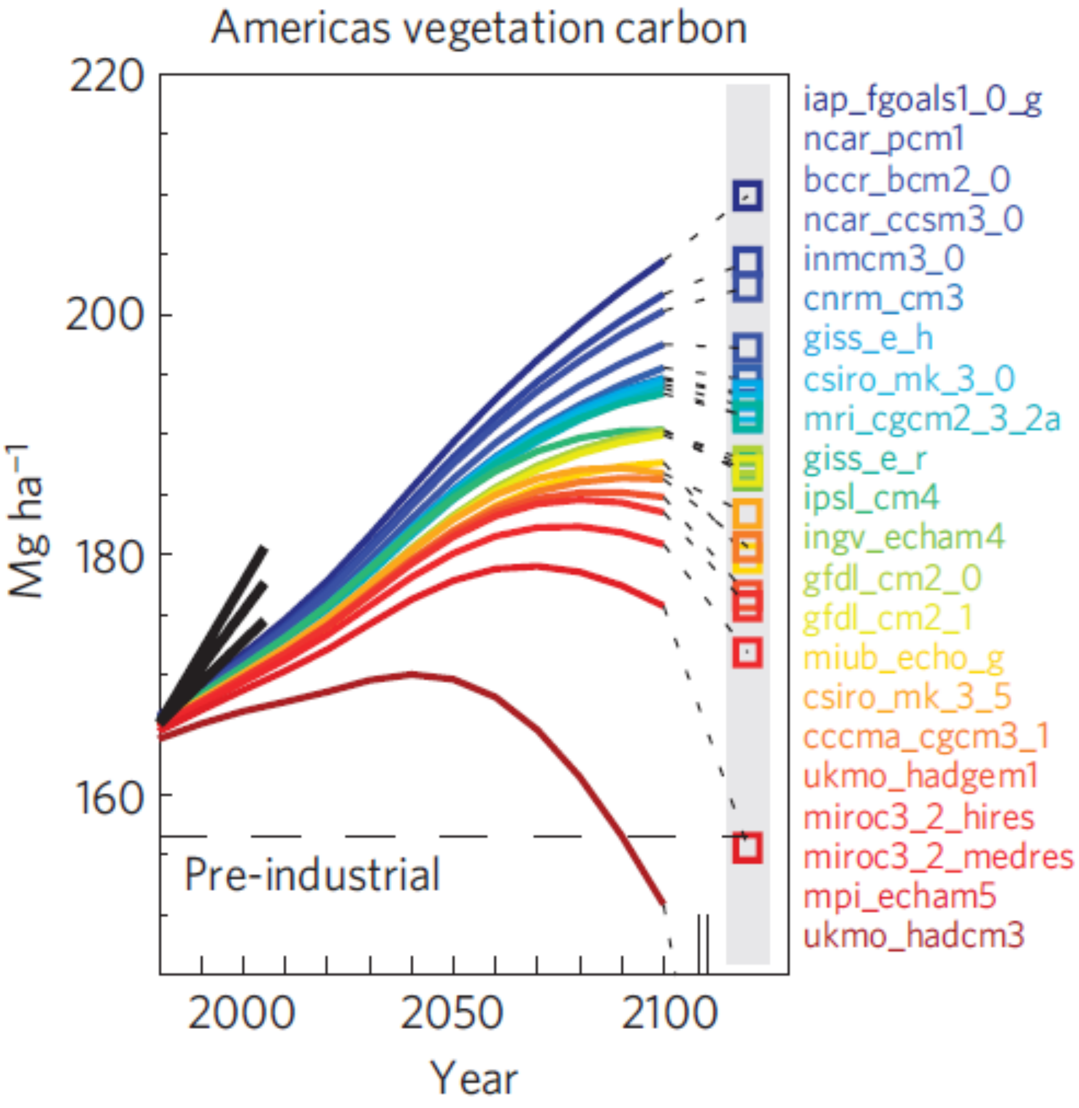
- Satellite observation **+ 3%**
- CMIP5 (CO2 + clim.) **+ 8%**
- CMIP5 (climate only) **- 2%**

Smith et al. (2016) Nature Geoscience

CO2 fertilization effect (model projection)



- Earth System Models predict increase in NPP (+ **63%**)
- Excluding CO_2 fertilization effect suggests reduction (- **6%**)
- **Large uncertainties in model representation of vegetation response to projected climate change!**



Huntingford 2013 Nature Geoscience; Smith et al. 2016 Nature Geoscience

Spatial scales and edaphic controls of geomorphology

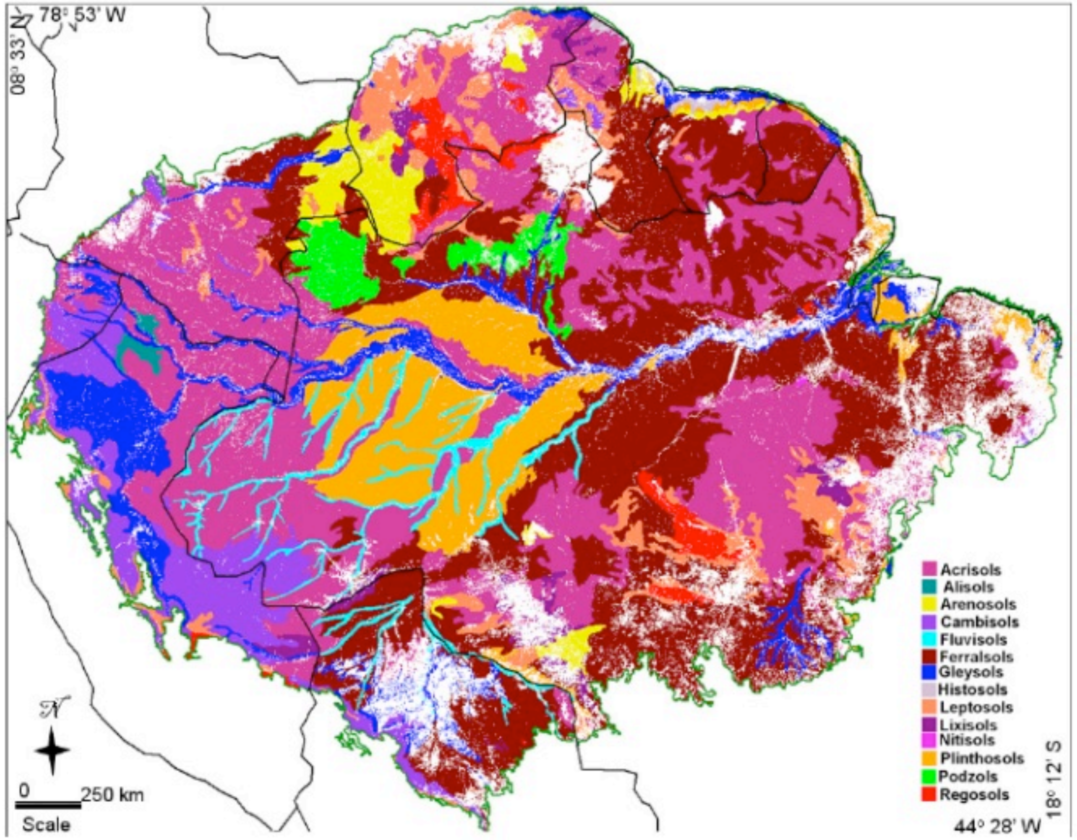


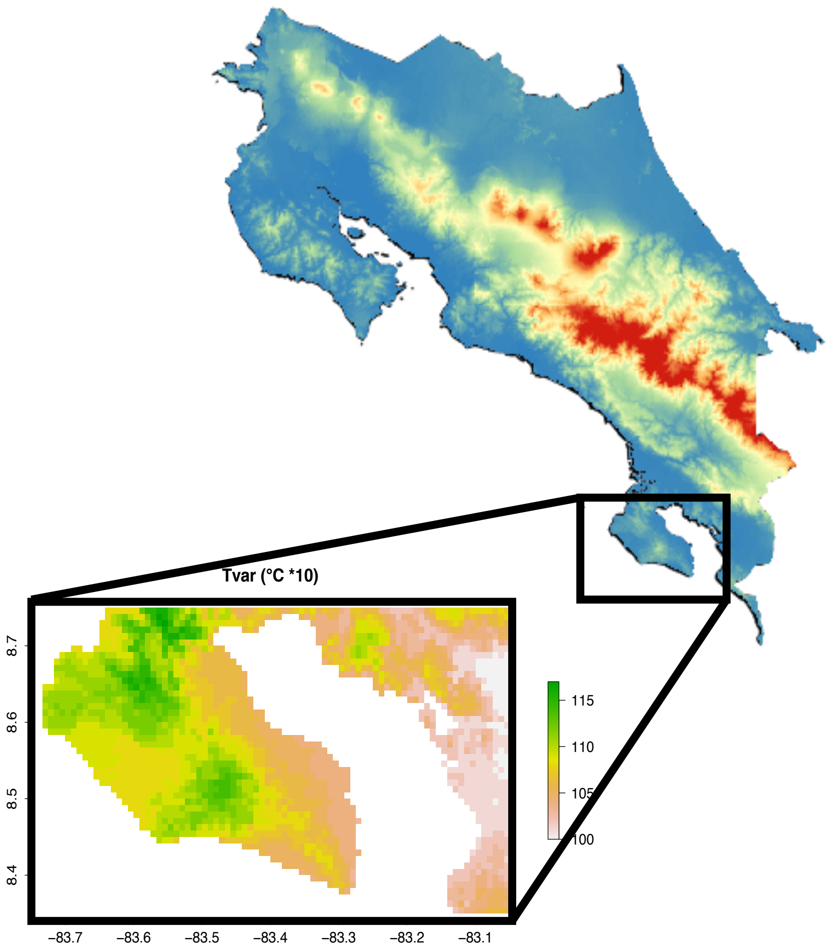
Fig. 4. Basin wide distributions of soils under forest vegetation. Map based on the SOTERLAC–ISRIC soil database (version 2.0, 1:5 million scale) and the vegetation database of Saatchi et al. (2008) for South America.

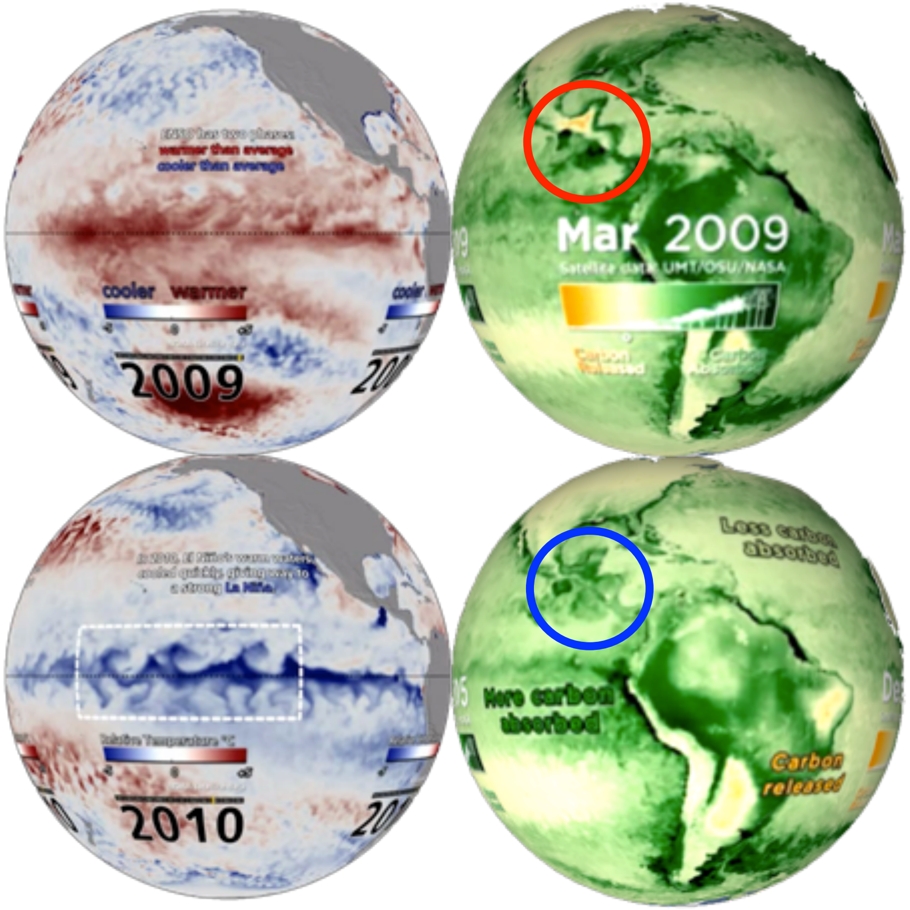
Edaphic controls of geomorphology:

- Soil texture and chemistry affect aboveground C storage via the productivity & turnover of plant species across the Amazon basin[1]
- Differences in nutrient (P) availability across most of Amazon rainforest[1]
- Nutrient availability constrains on C sink strength uncertain but certain to be significant[2]
- Phosphorus availability enhances forest growth but the response to P fertilization is not consistent)[3]
- Some species respond to fertilization others don't (functional strategy?!)

1Quesada et al. 2010, 2012; 2Wieder et al. 2015, Yang et al. 2016; 3Wright et al. 2018, 2019

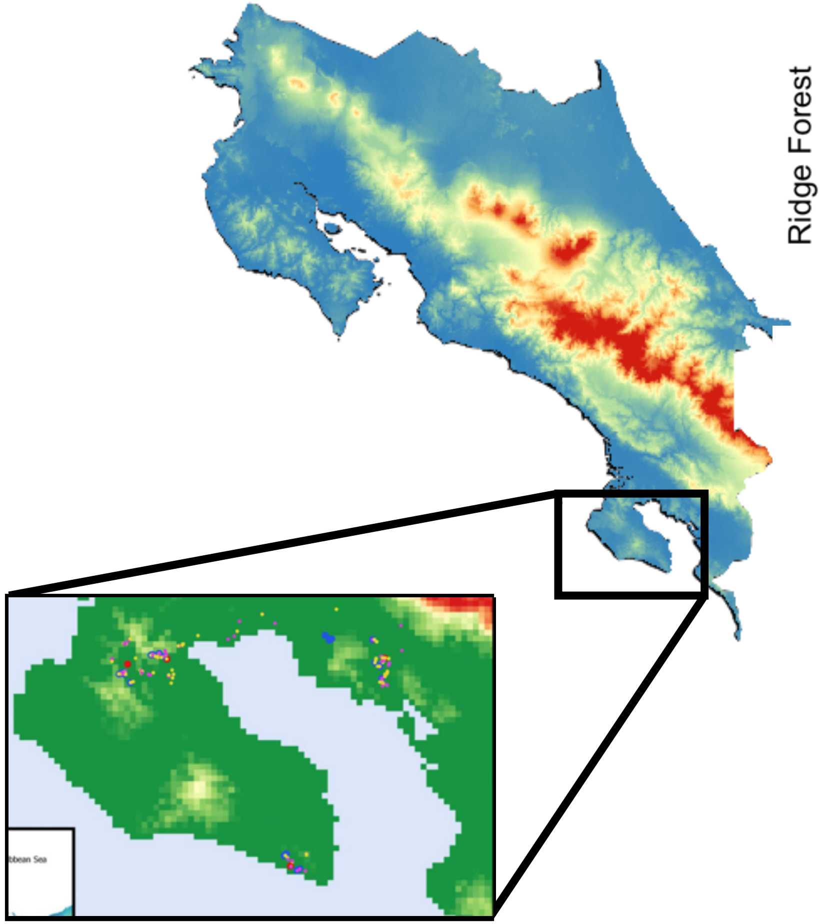
Spatial and temporal response to climate extremes





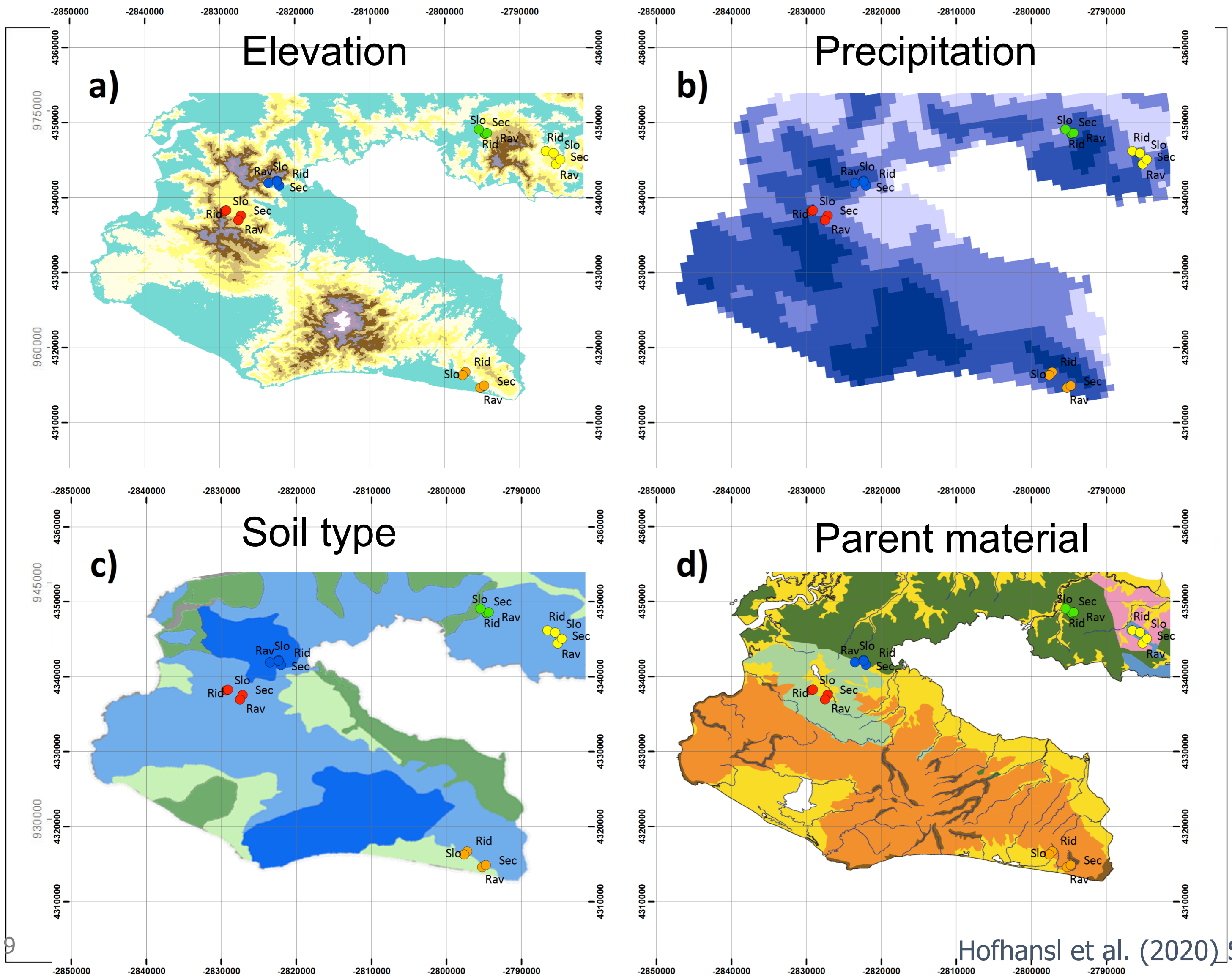
Hofhansl et al. (2014) Global Biogeochemical Cycles, 28 (12), 1437–1454. doi:10.1002/ 2014GB004934

Spatial variability in topography (and microclimate)



Hofhansl et al. (2020) Sci Rep 10, 5066. https://doi.org/10.1038/s41598-020-61868-5

Local heterogeneity in topography and edaphic properties



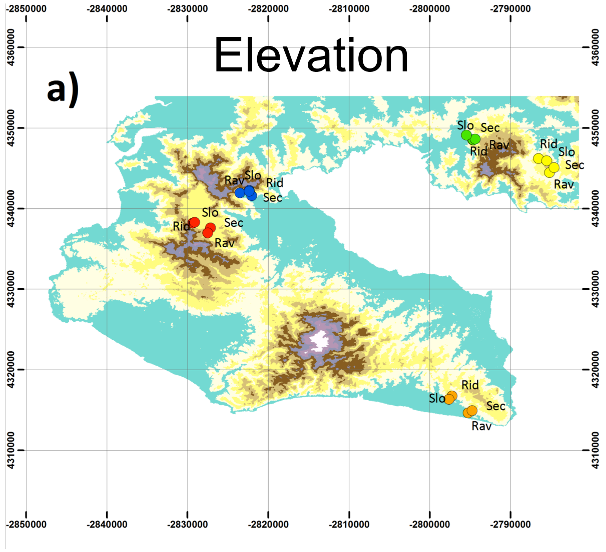
Local forest inventory plot network:

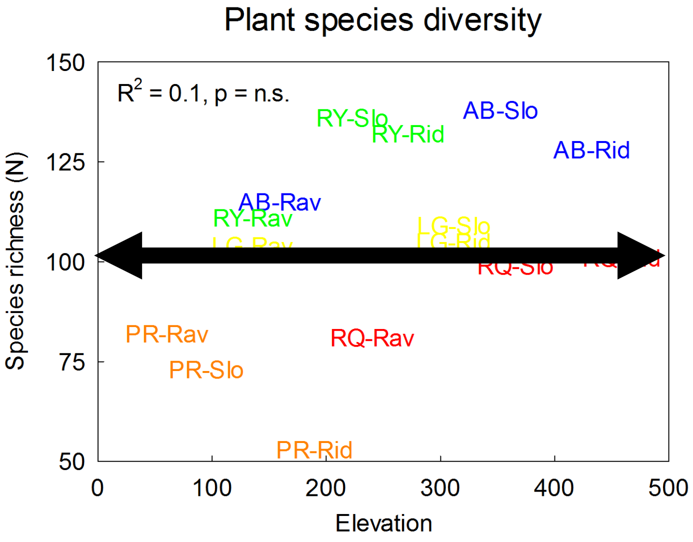
- Monitoring 7,752 individuals and 447 species of tropical trees, palms, lianas
- local-scale resource availability gradients affect the composition of plant species due to differences in their life-history strategy
- vegetation C stocks differ with the locally dominant plant functional group

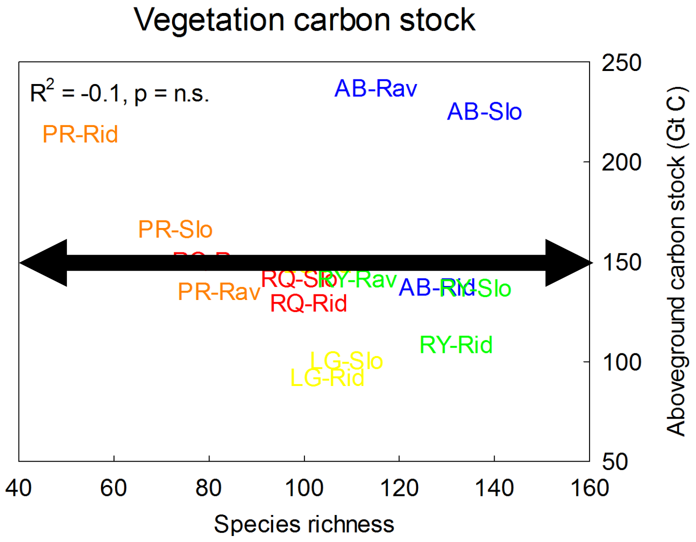
→ increase our understanding of the mechanistic factors determining tropical ecosystem functioning

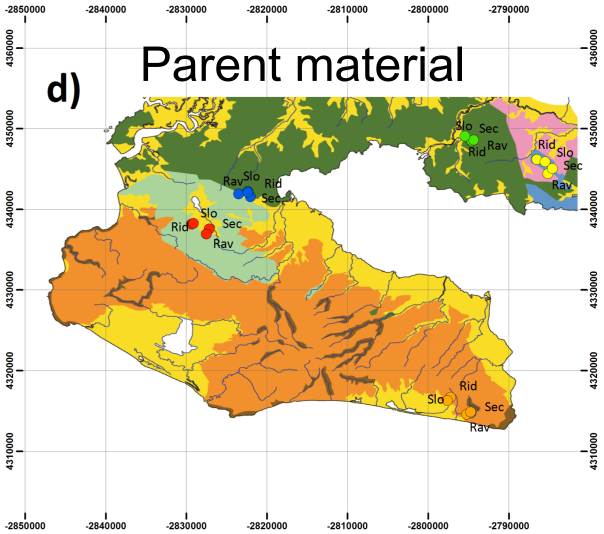
Hofhansl et al. (2020) Sci Rep 10, 5066. https://doi.org/10.1038/s41598-020-61868-5

Biodiversity and C stock differ across the landscape









Species richness (N)

Hofhansl et al. (2020) Sci Rep 10, 5066 (2020). https://doi.org/10.1038/s41598-020-61868-5

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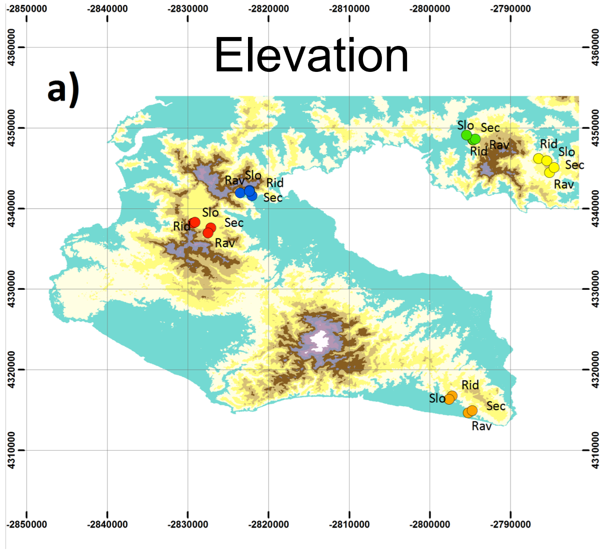

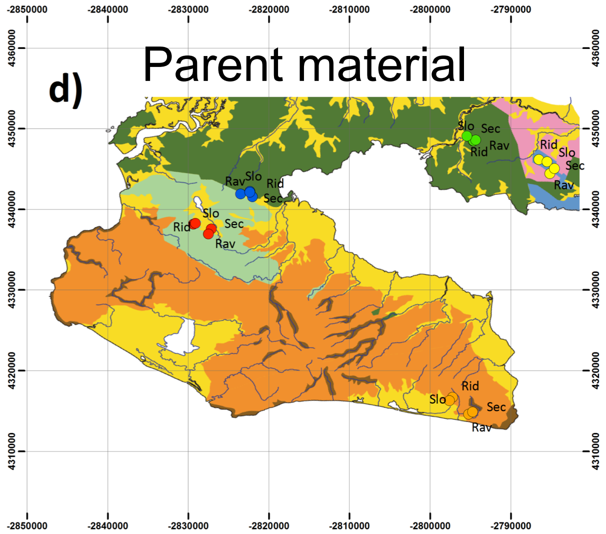

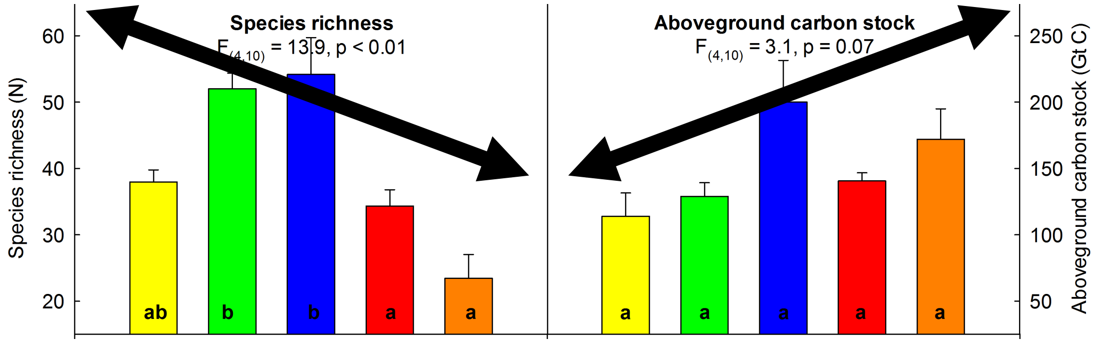

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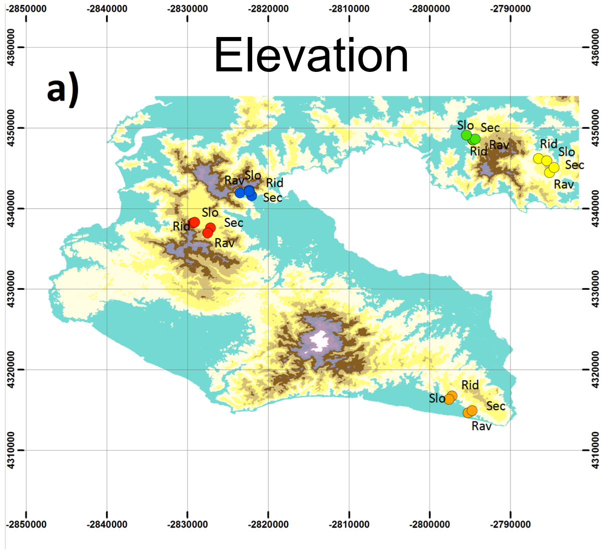
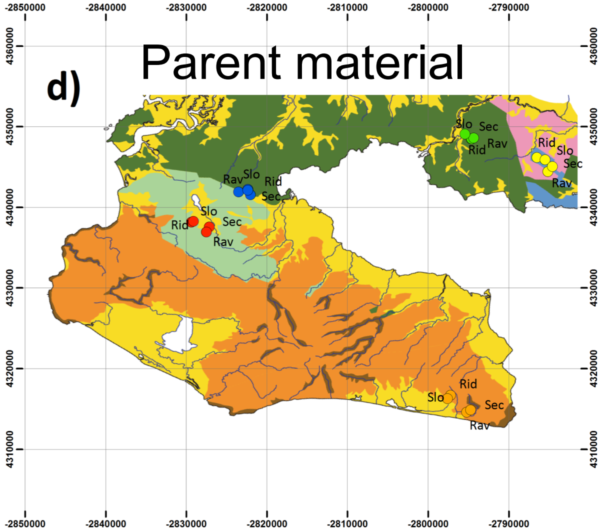
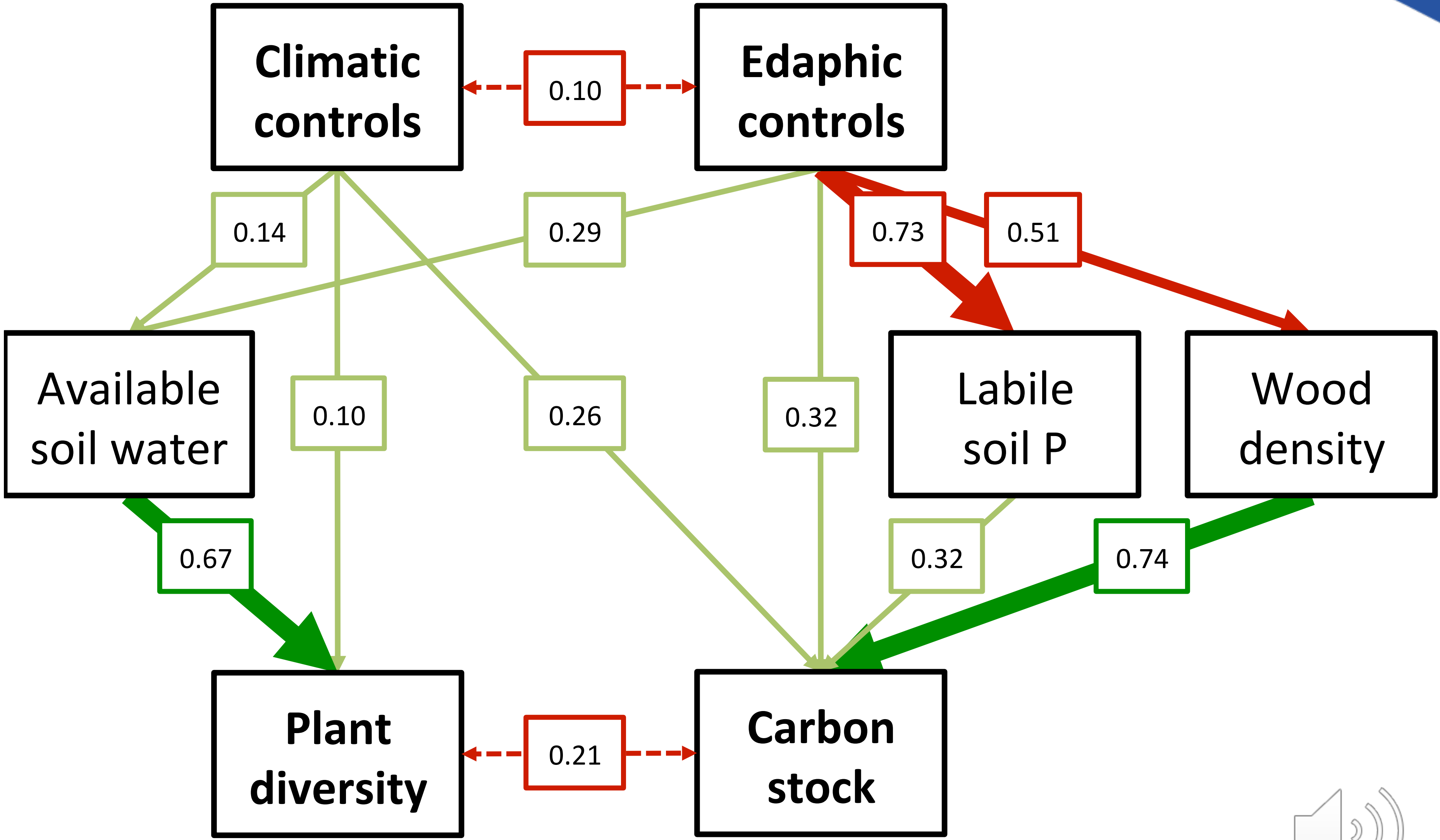
Multiple factors drive plant functional diversity







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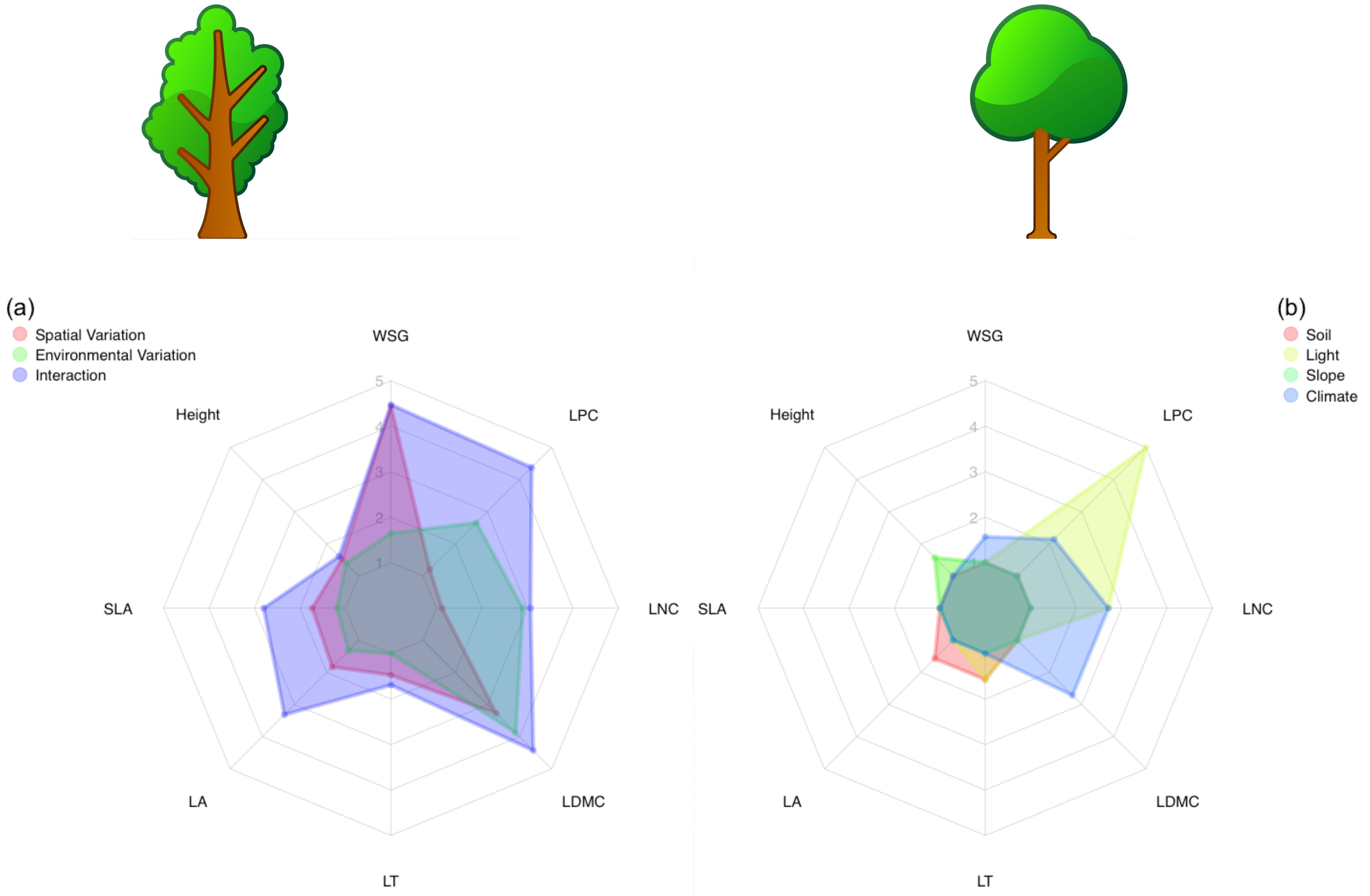
Abiotic and biotic drivers of plant functional traits



Tropical tree communities
& associated functional traits:

- **Spatial variation (distance)**
increases with geographic distance and local environmental heterogeneity

- **Environmental variation (climate)**
increases with topo-edaphic variation along gradients and sampling sites

- **Interactive effects (biotic)**
due to biotic interactions among spp., seed dispersal, and competition for limiting resources.

→ Species sorting along environmental gradient and resources (**light**/**water**/**nutrients**).

→ Affects the expression of plant functional traits in response to environmental cues.

Hofhansl et al. (2021) Ecology and Evolution doi: 10.1002/ece3.7256

For further questions please contact me via the QR code linked to my personal website: https://tropicalbio.me/

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