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

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

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Climatic controls

Edaphic controls

Available soil water

Labile soil P

Wood density

Plant diversity

Carbon stock

0.14

0.29

0.73

0.67

0.26

0.32

0.32

0.21

0.74

0.10

0.51
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)

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**

\[ \rightarrow \text{tree mortality rates and turnover time} \text{ should be accounted for when projecting C sink strength} \]
Increase of C sink strength (remote sensing)

Satellite-based NPP estimate:

- 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 CO₂ 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

**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?!)

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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

Spatial variability in topography (and microclimate)

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
Biodiversity and C stock differ across the landscape.
Biodiversity and C stock differ across the landscape

Multiple factors drive plant functional diversity

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.

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

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