Plant phosphorus acquisition and use strategies in the Amazon Forest with relevance to ecosystem models

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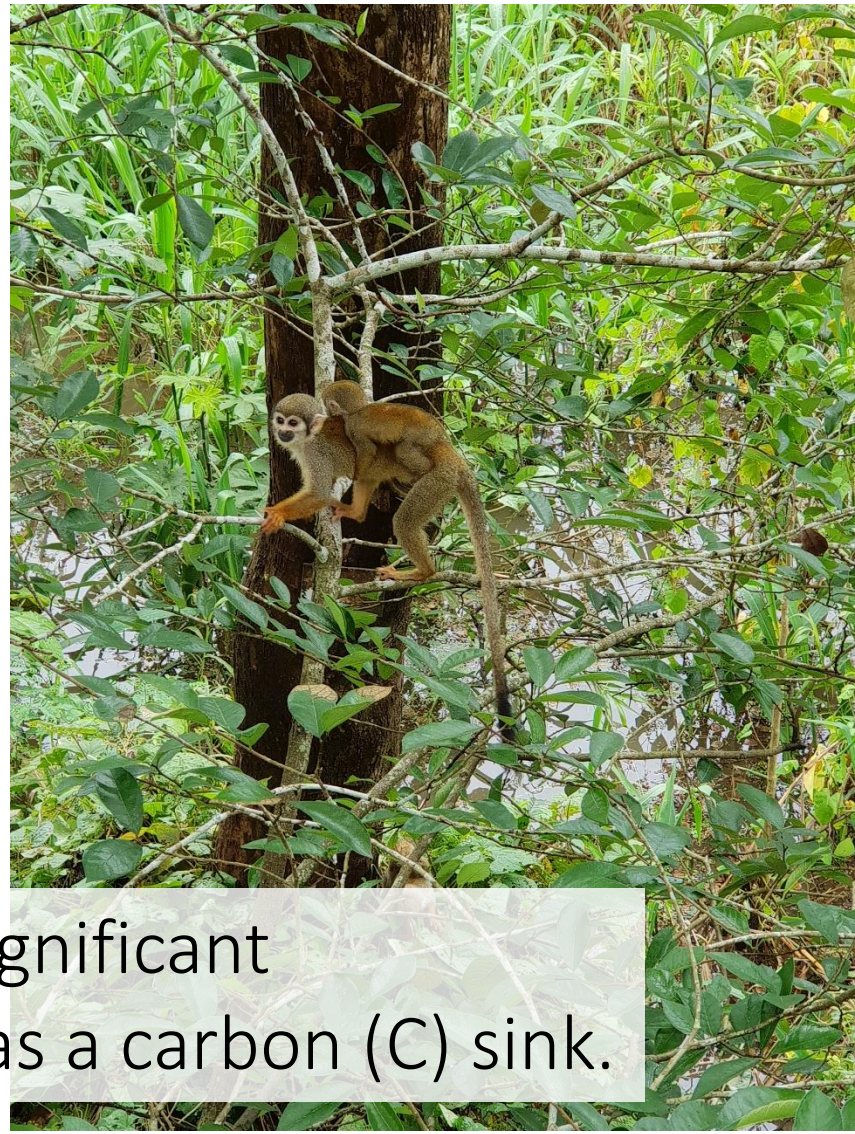
The Amazon rainforest



The Amazon rainforest provides significant global climate regulation services by acting as a carbon (C) sink.

How will the Amazon C sink respond to climatic and atmospheric changes?

Analysis shows a long term decreasing trend of C accumulation (Brienen et al., 2015).

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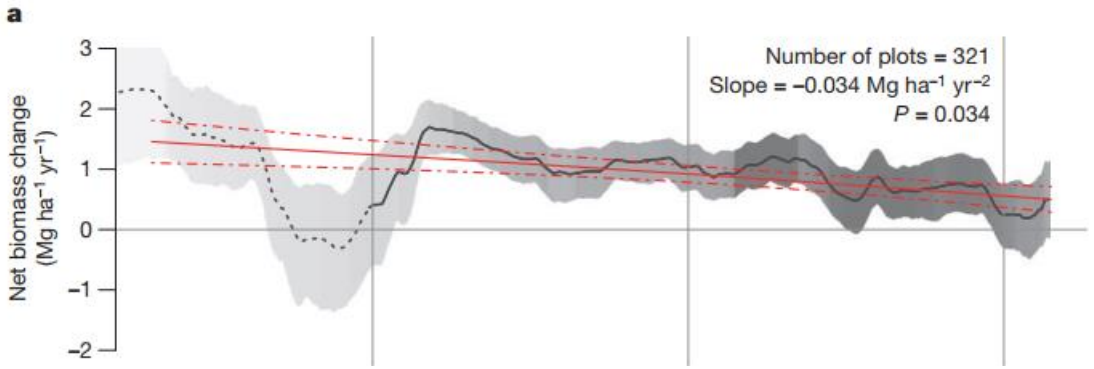
Long-term decline of the Amazon carbon sink



Vegetation model projections of the Amazon biomass C vary significantly

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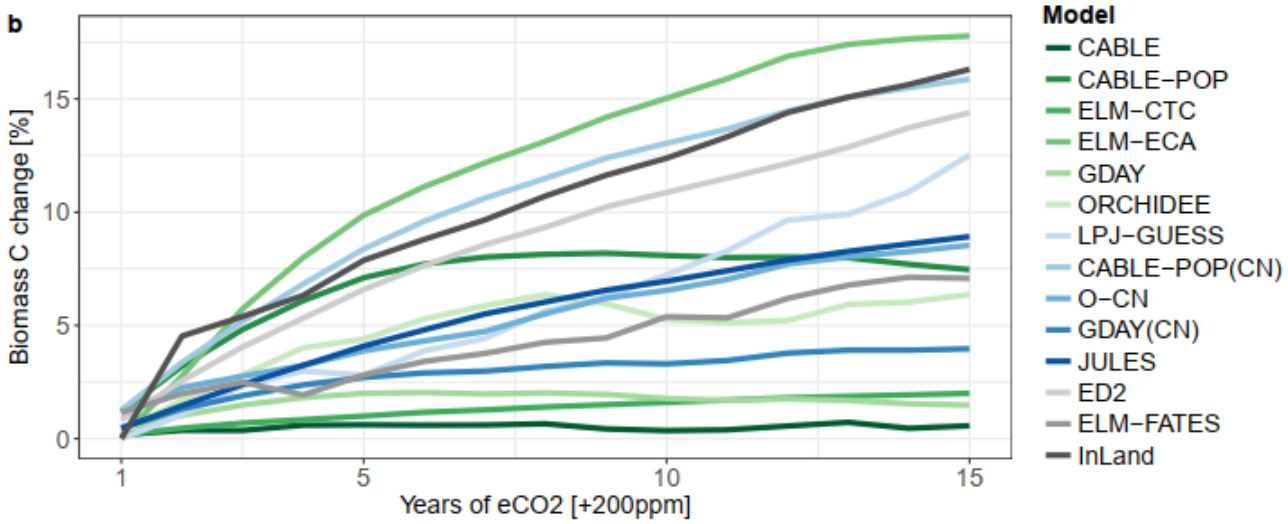
Amazon forest response to CO_2 fertilization dependent on plant phosphorus acquisition

Fleischer et al., 2019



Biomass C response to elevated CO_2:
5 to 140 g C m^{-2} $year^{-1}$

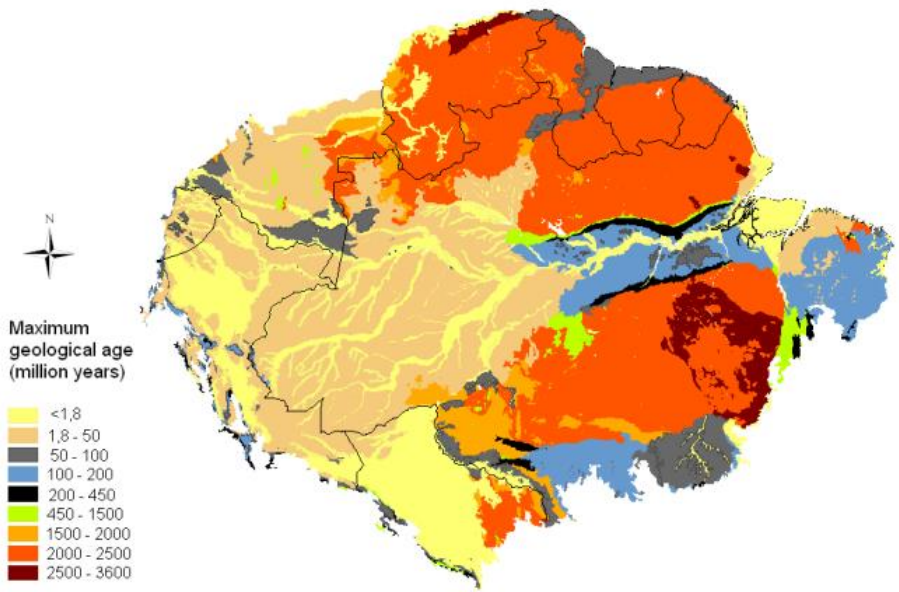
Variation is attributed to "the **contrasting plant phosphorus (P) use and acquisition strategies** considered among the models" (Fleischer et al., 2019).

See also Fleischer et al. in this session.

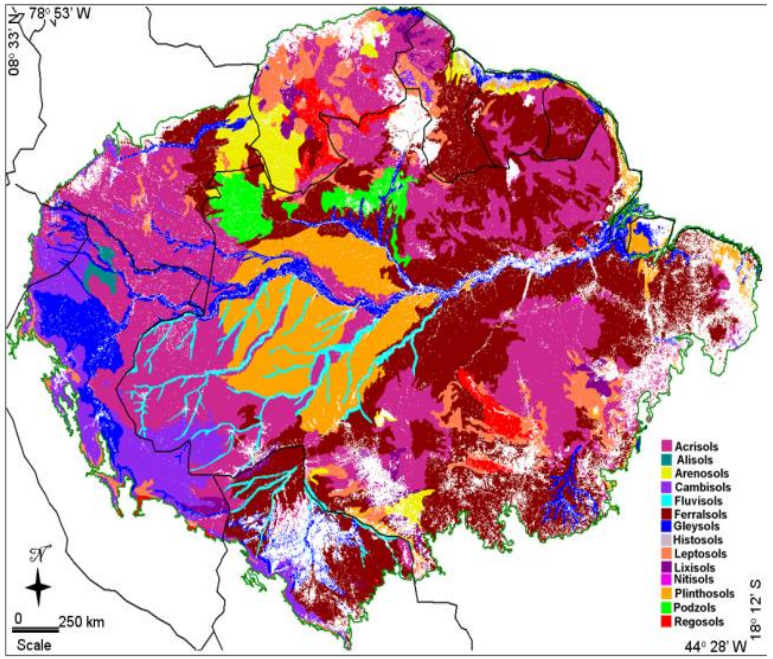
The Amazon rainforest phosphorus gradient

- Soils in the Amazon rainforest are very diverse and vary in age.
- The oldest and more weathered soils can have P_{total} concentrations as low as 25 mg/kg

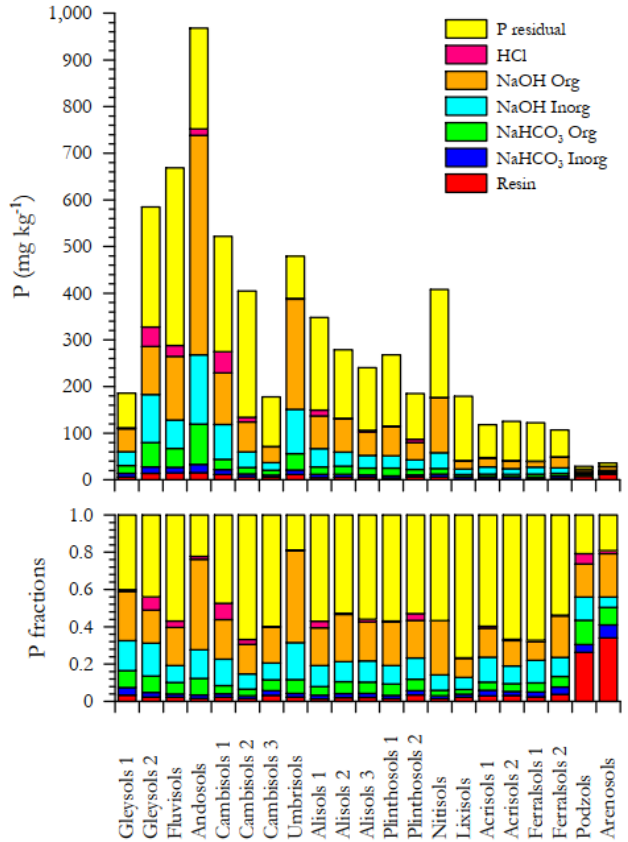
Amazon basin maximum Geological age[1]



Amazon basin soil diversity[1]



P variation in Amazonian soils[2]

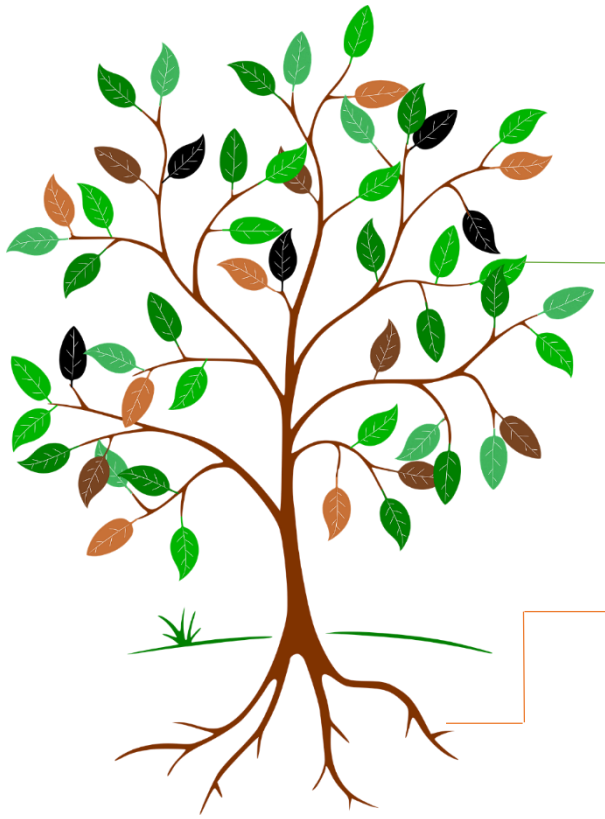


[1]Quesada et al., 2011 Soils of Amazonia with particular reference to the RAINFOR sites.

[2]Quesada et al., 2010 Variations in chemical and physical properties of Amazon forest soils in relation to their genesis.

Plants invest in the employment of different strategies to conserve and acquire phosphorus

Here, we are interested in the following:



- Foliar P resorption
- Root P foraging
- Phosphatase exudation
- Arbuscular mycorrhizal symbiosis
- Organic acids exudation

Foliar P resorption

The re-absorption and recycling of P from senescing foliar tissues before they are dropped.

Root P foraging

Group of fine-root morphological traits that facilitate spatial soil exploration for P.

Arbuscular mycorrhizal Symbiosis

Arbuscular mycorrhizae act as an extension of roots, exploring large volumes of soil in search of P.

Phosphatase exudation

Extracellular phosphatases are enzymes secreted by roots which perform the mineralization of organic P forms.

Organic acids exudation

Roots secrete low molecular weight organic acids that act by mobilizing P from Al, Fe, and clay complexes.

Research

Bringing experimental/observational research and vegetation modeling research together.

1. How are P use and acquisition strategies represented in vegetation models?
2. How are plant P use and acquisition strategies in the Amazon rainforest affected by soil fertility? – Plasticity.
3. What is the potential for plant P use and acquisition strategies upregulation with increased P demand?
4. What are the plant energetic costs involved in the employment of the strategies?
5. What are the most pressing measurements needed to improve our ecological understanding and vegetation models?

Addressed with a literature review

Few preliminary results - Ongoing work.
Two **hypotheses** are proposed here for a discussion!

- All P use and acquisition strategies covered in this review, are employed through most of the P gradient in the Amazon rainforest. However, C investment in mining strategies such as phosphatase and organic acid exudation grow with declining P, as mining strategies grow in importance in soils with high proportion of organic P and adsorbed P.
- While all P use and acquisition strategies are very plastic, not all can be upregulated under elevated CO_2 and higher P demands in areas of the Amazon rainforest with very old and weathered soils, independent of C costs. Strategies like fine root P foraging and leaf P resorption will have little to no room for upregulation. While fine root productivity will be constrained by P and other nutrients, leaf P resorption is already highly proficient.

If you are interested in the topic and our research questions, feel free to get in touch and start a conversation.

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