Nutrient availability increases leaf nitrogen at the expense of whole plant growth in a closed canopy temperate forest

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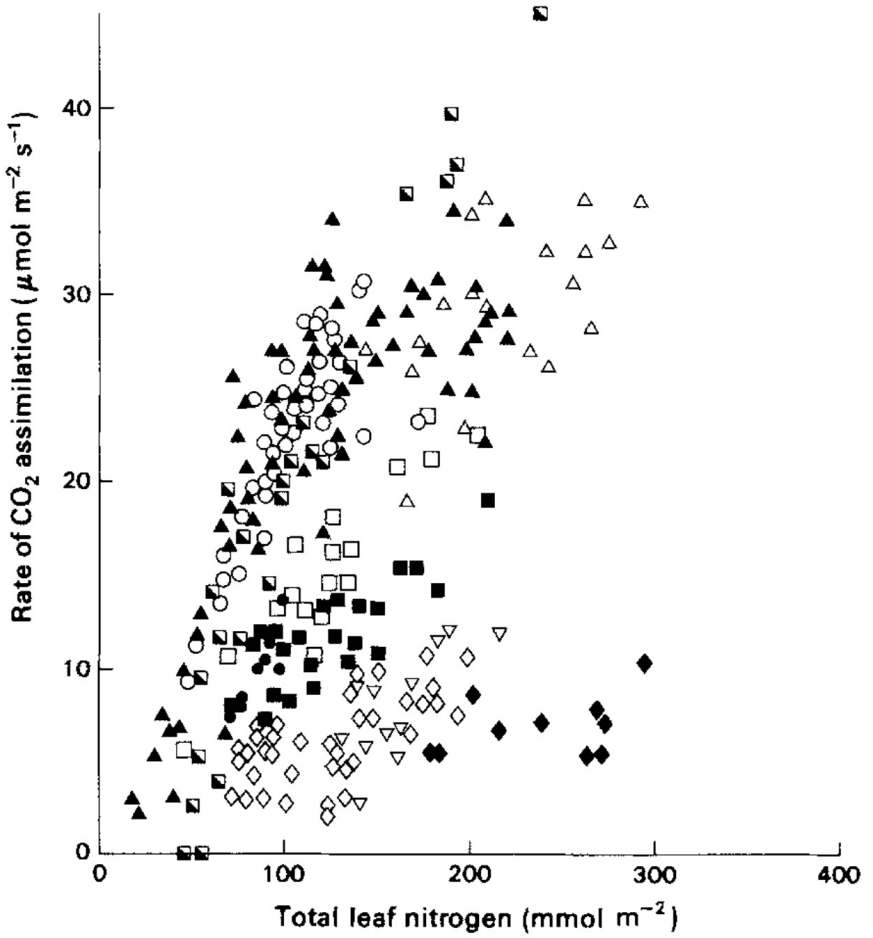
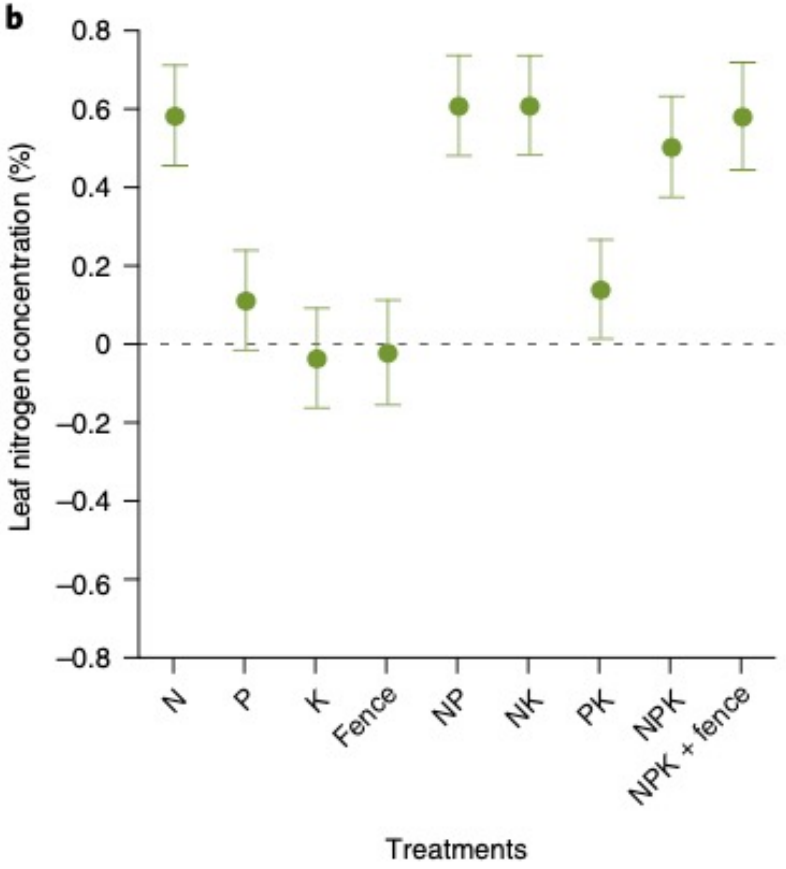
Leaf nitrogen is a common surrogate for estimating leaf-level photosynthetic capacity



Evans (1989) *Oecologia*

Soil nitrogen has been shown to positively influence leaf nitrogen



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Firn et al. (2019) *Nature*

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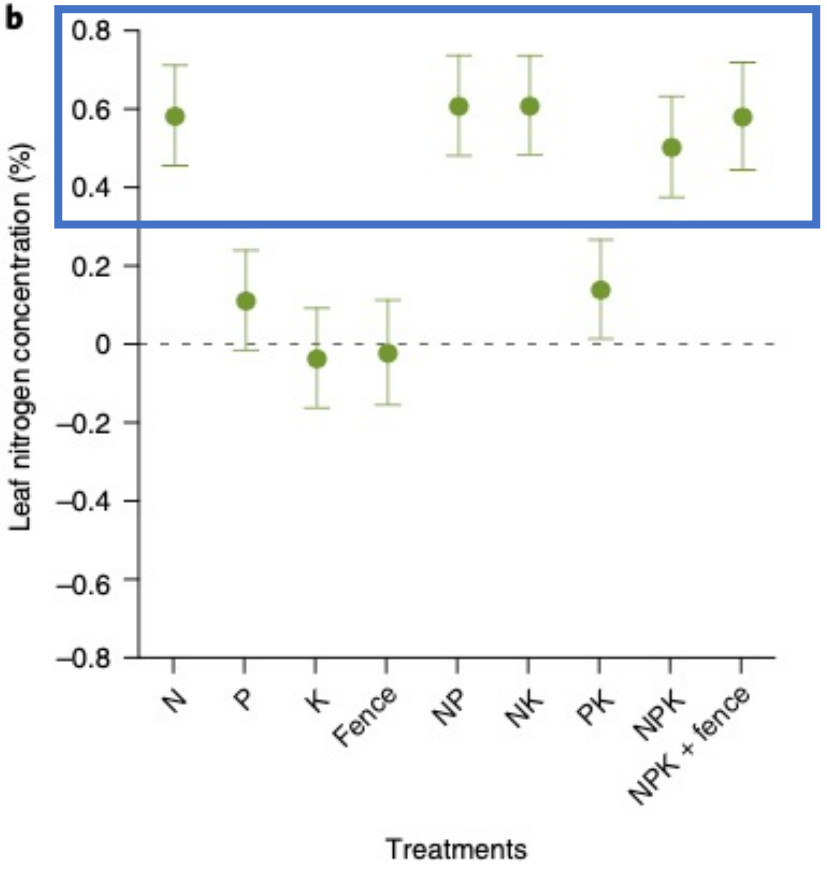
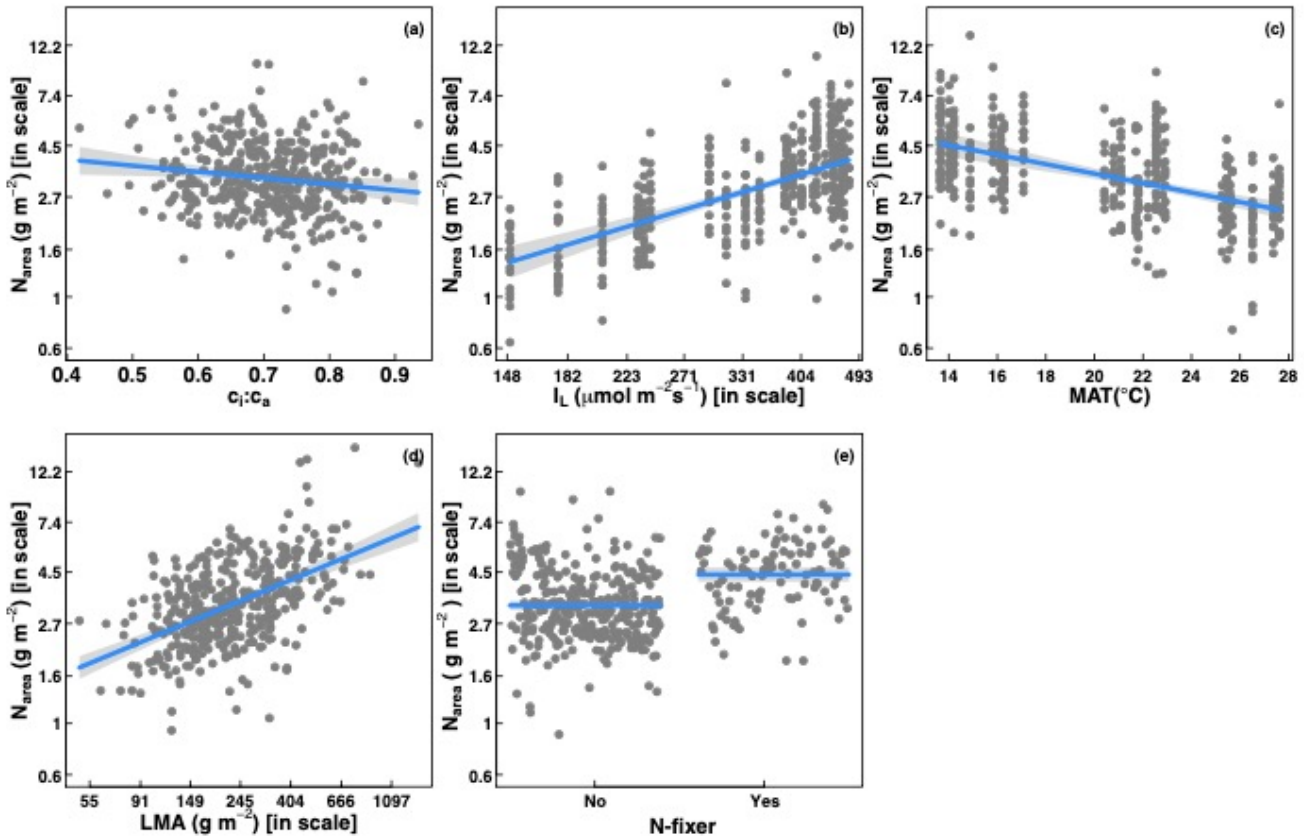


Plots that received nitrogen had higher leaf nitrogen content

Firn et al. (2019) *Nature*

However, leaf nitrogen can also be predicted independent of soil nitrogen



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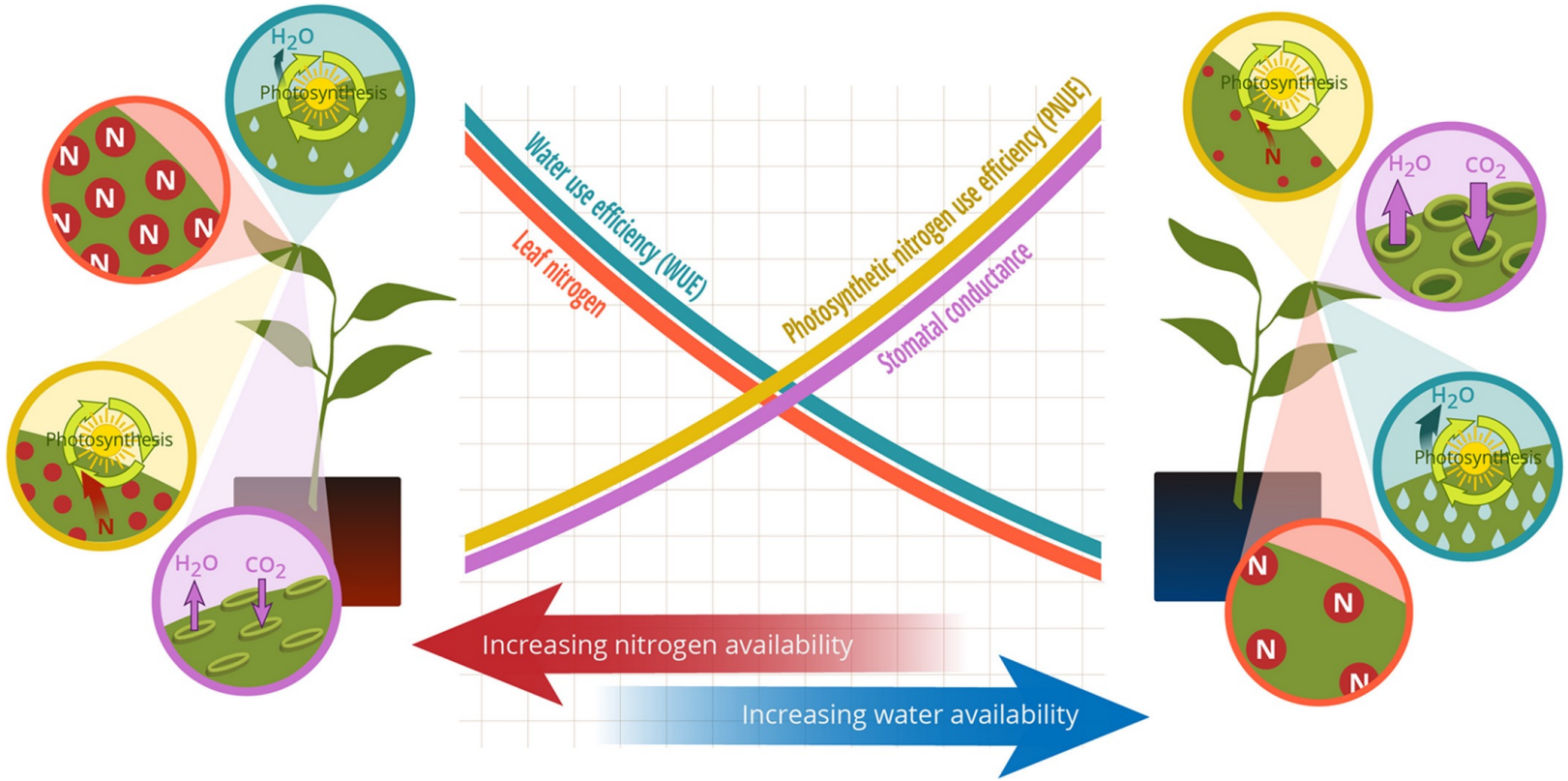
Dong et al. (2017) *Biogeosciences*

Leaf nitrogen is likely a product of plant allocation responses to soil nitrogen and climate

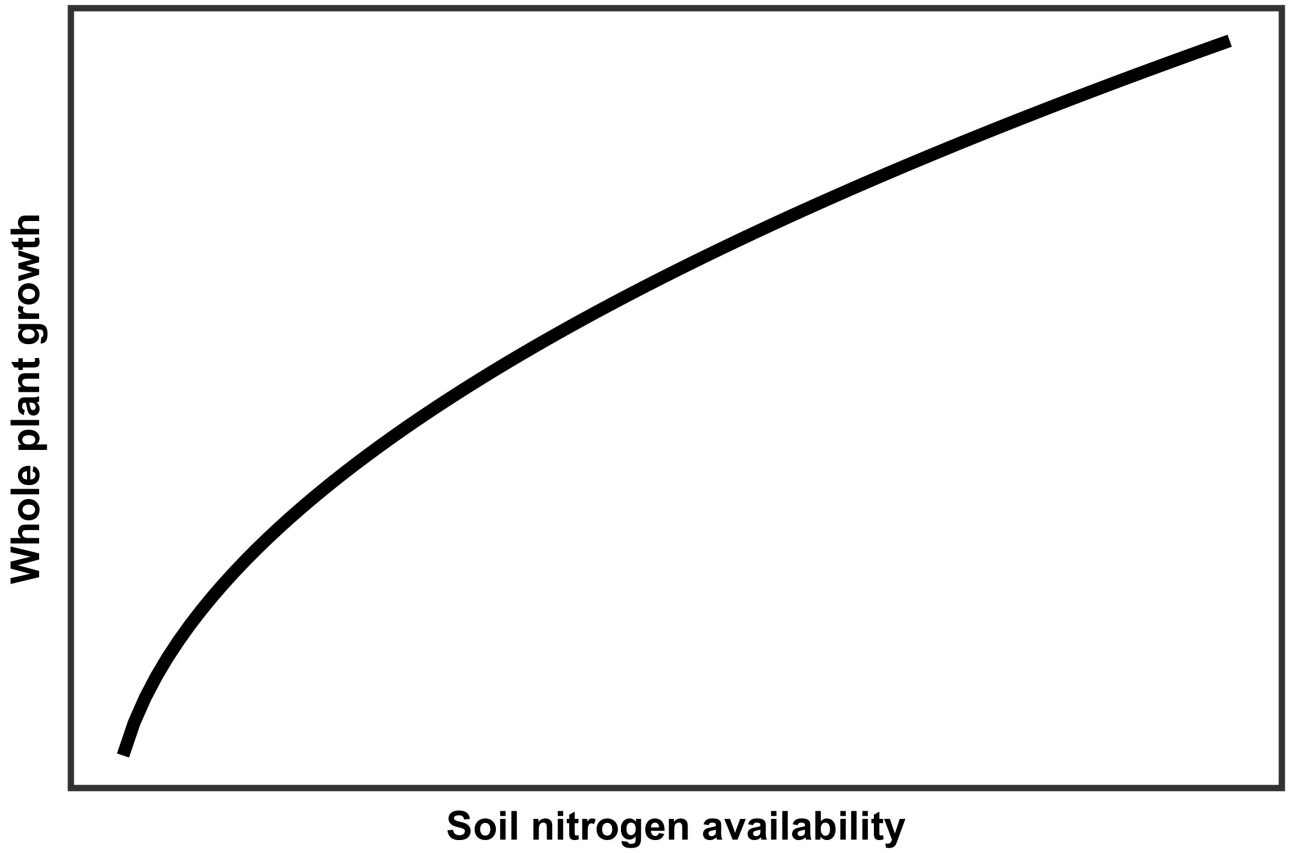
Yet, we do not fully understand when and where soil nitrogen impacts nitrogen allocation to leaf tissue vs. other tissues

Option #1: Maintain photosynthesis with greater water-use efficiency at expense of photosynthetic nitrogen-use efficiency



Bialic-Murphy *et al*. (2021) *Ecol. Letters*

Option #2: Invest extra nitrogen toward whole plant growth at expense of leaf nitrogen



Study Question

How do leaf and whole plant processes respond to soil nutrient availability in a closed canopy system?

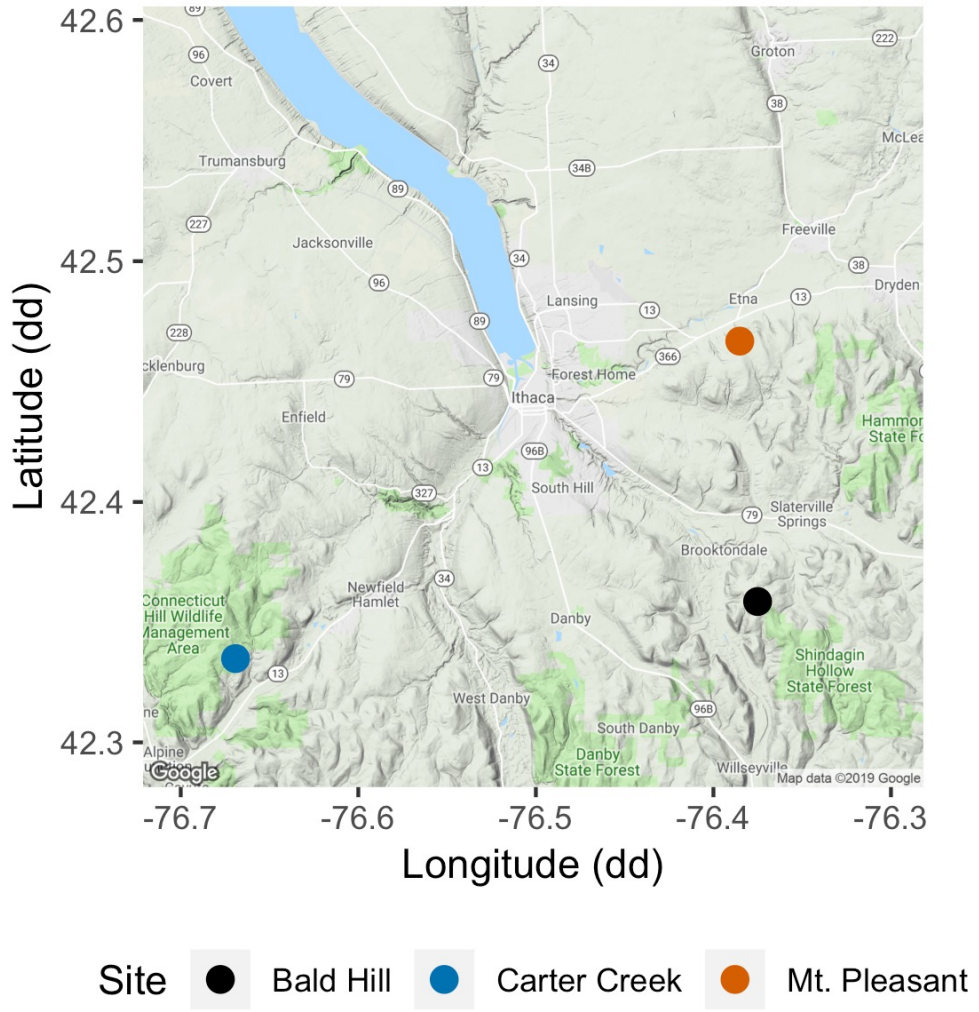
Study system

Soil fertilization treatments

- 0 kg ha^{-1} yr^{-1} N; 0 kg ha^{-1} yr^{-1} S
- 0 kg ha^{-1} yr^{-1} N; 57 kg ha^{-1} yr^{-1} S
- 50 kg ha^{-1} yr^{-1} N; 0 kg ha^{-1} yr^{-1} S
- 50 kg ha^{-1} yr^{-1} N; 57 kg ha^{-1} yr^{-1} S

Sites

- Bald Hill
- Mount Pleasant
- Carter Creek



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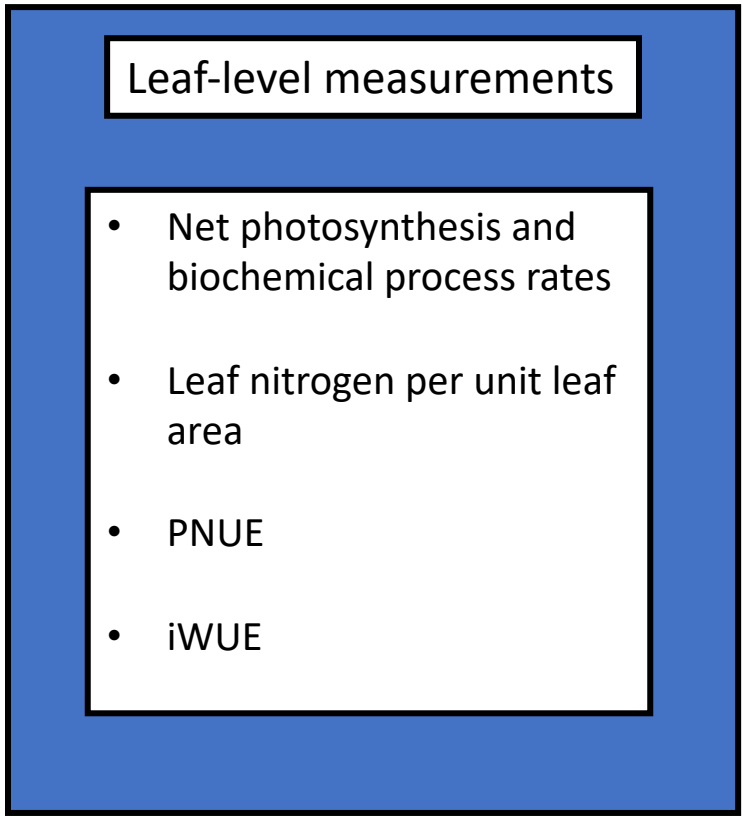
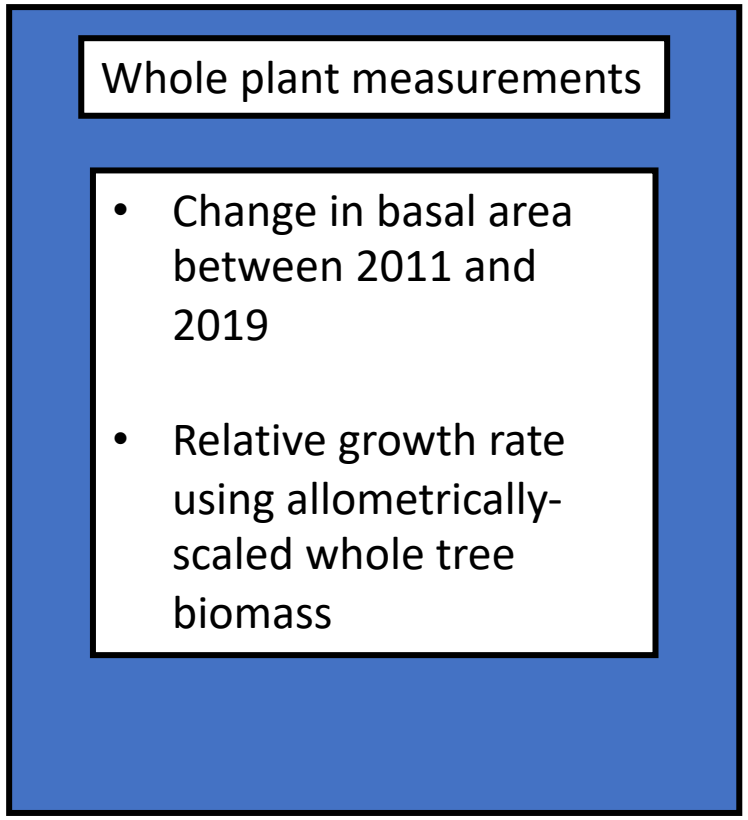
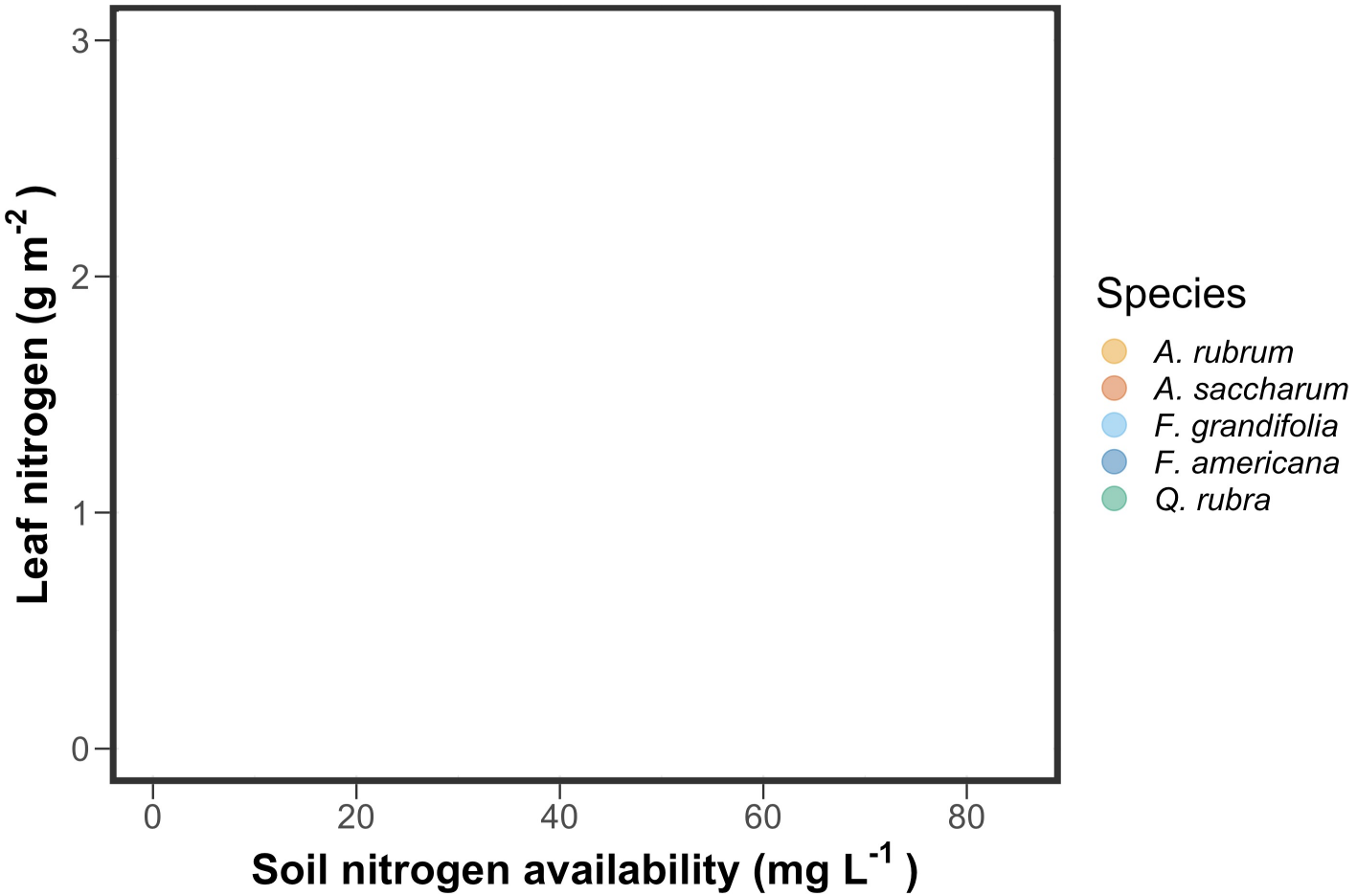
Leaf sampling

- Fully sunlit canopy leaves brought down with arborist's slingshot
- Branches recut underwater
- CO_2 response curve using LI-COR 6800

Plant measurements







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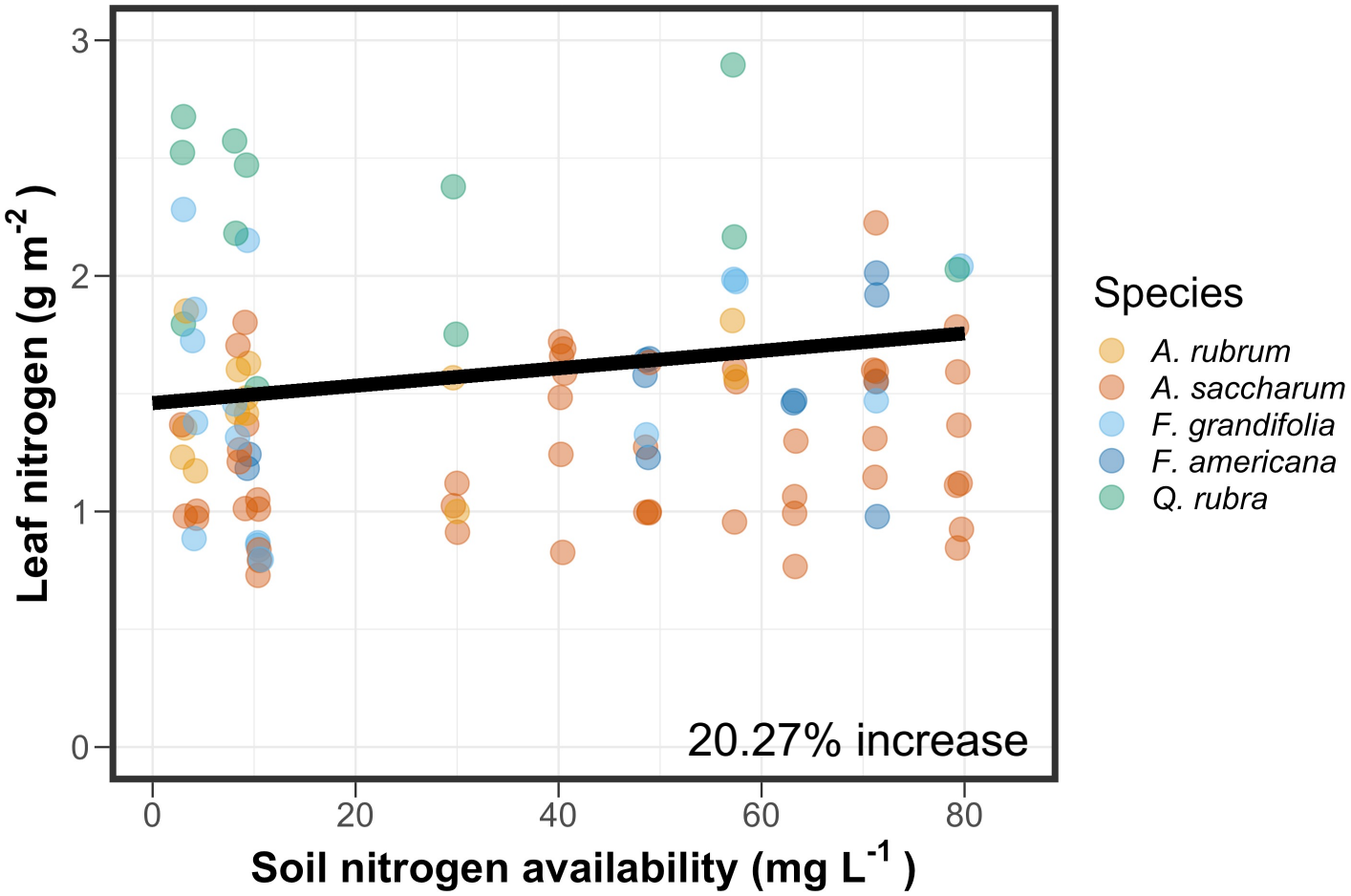
Soil nitrogen availability increases leaf nitrogen



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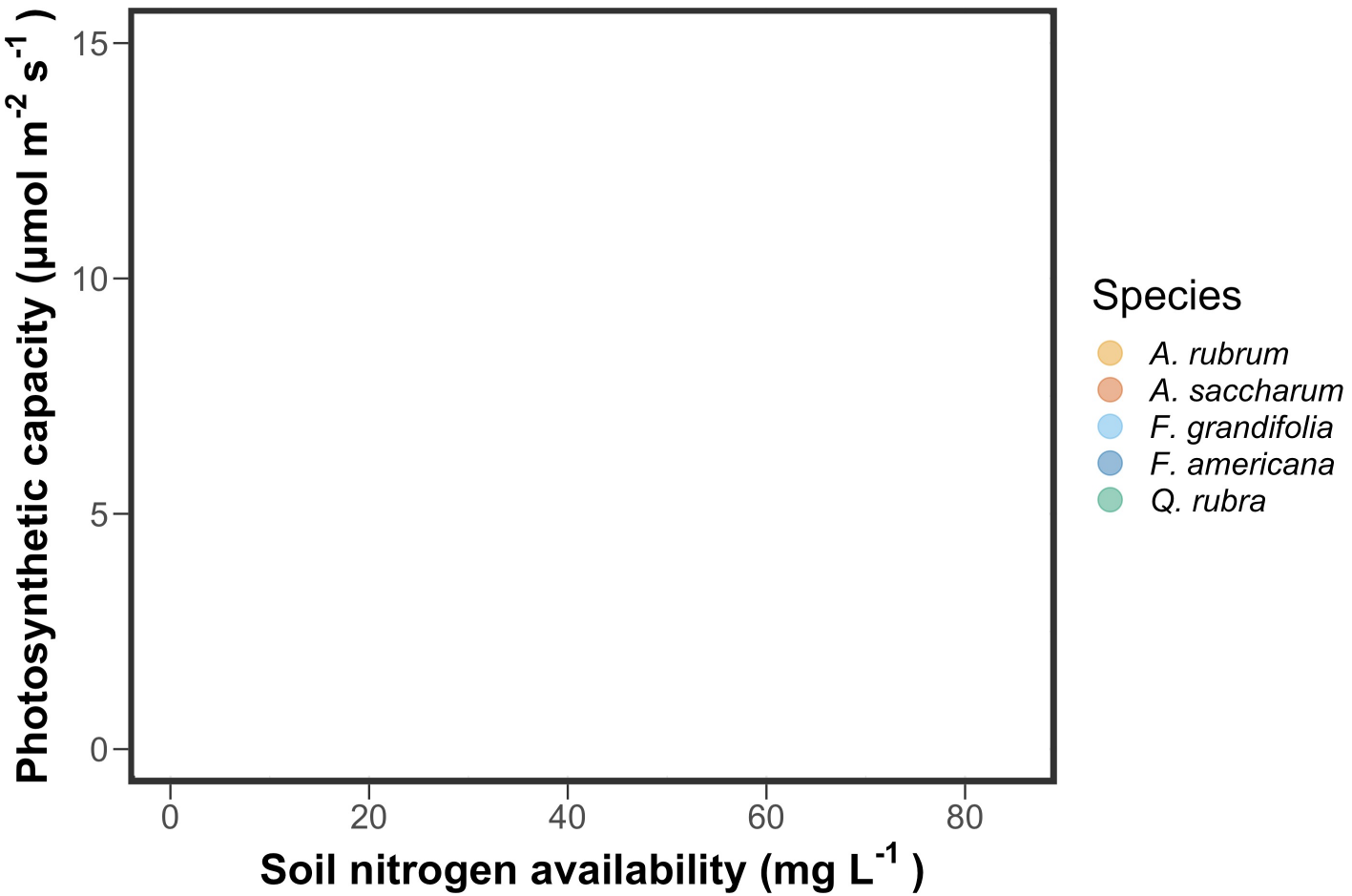
Soil nitrogen availability increases photosynthetic capacity



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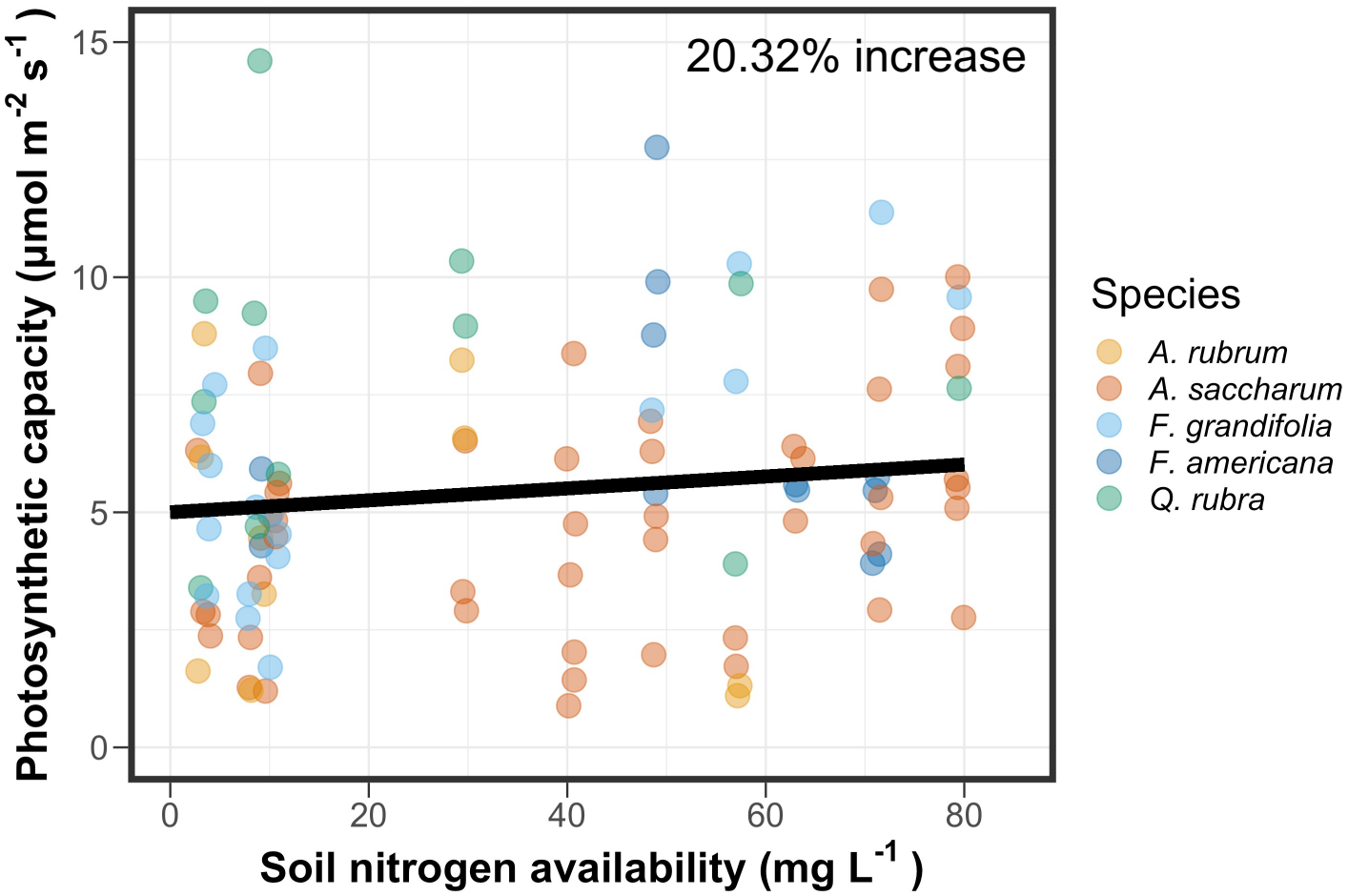

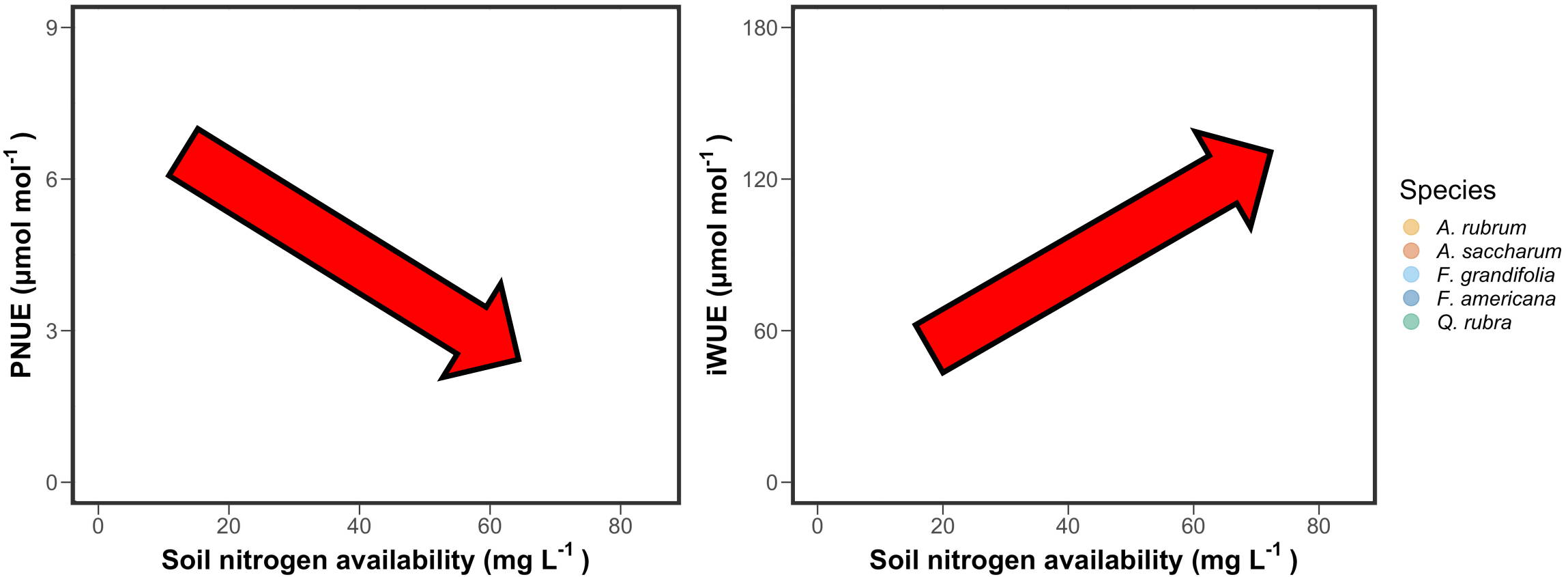

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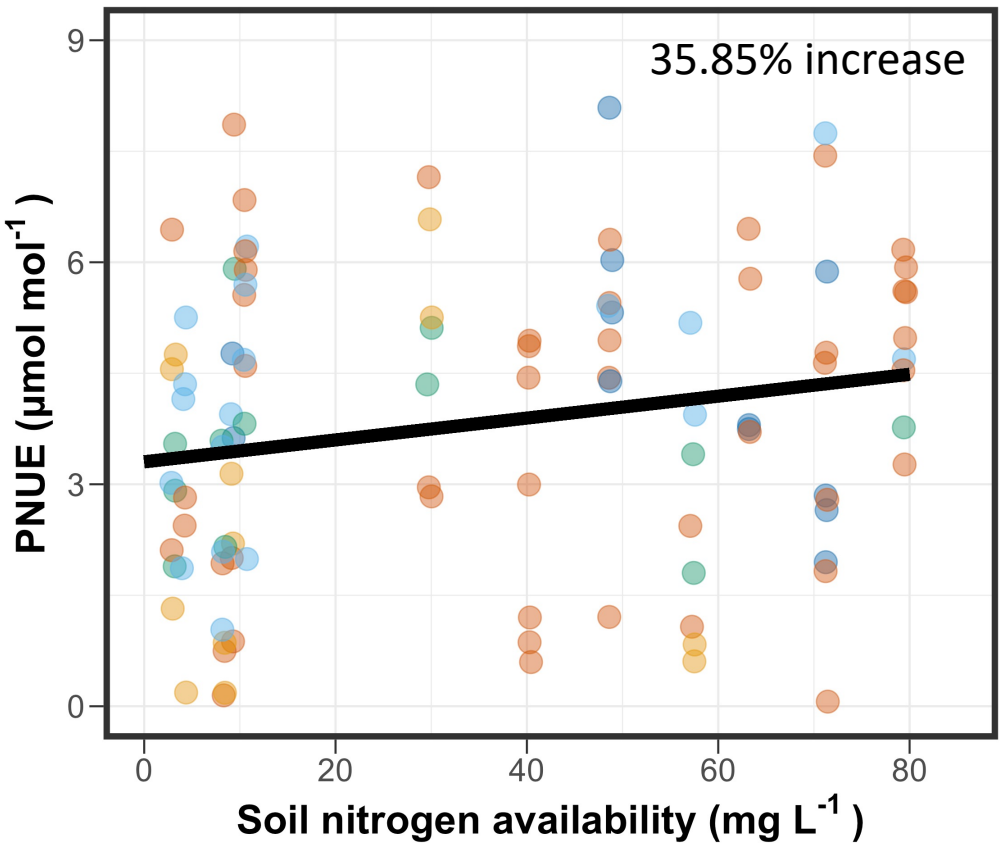
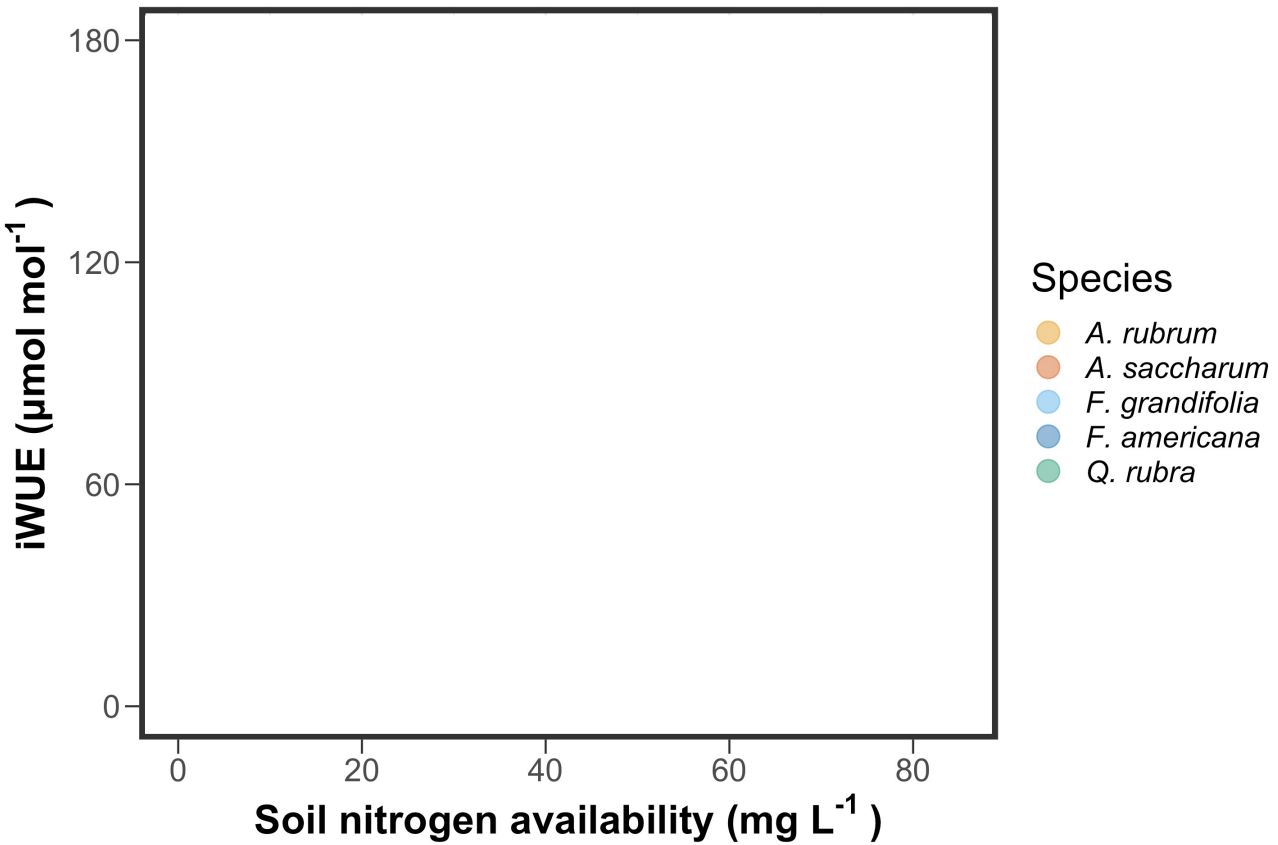
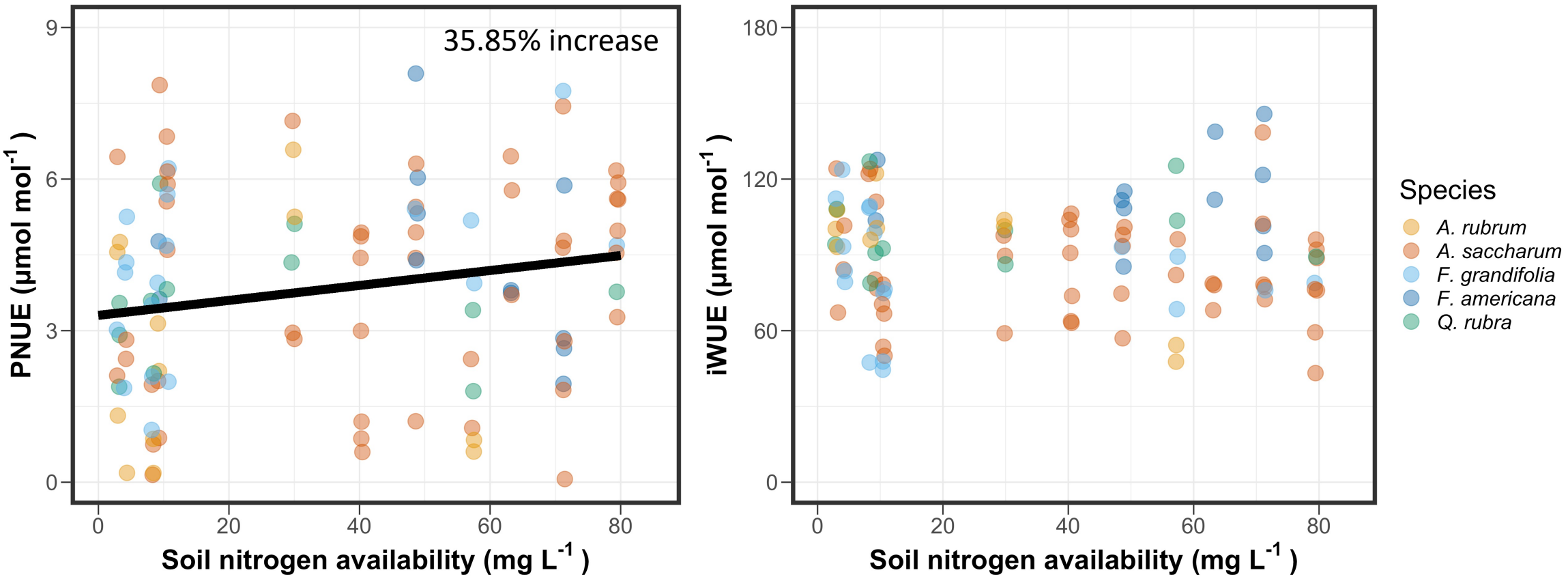
Soil nitrogen availability increases photosynthetic nitrogen-use efficiency…





… but not water-use efficiency



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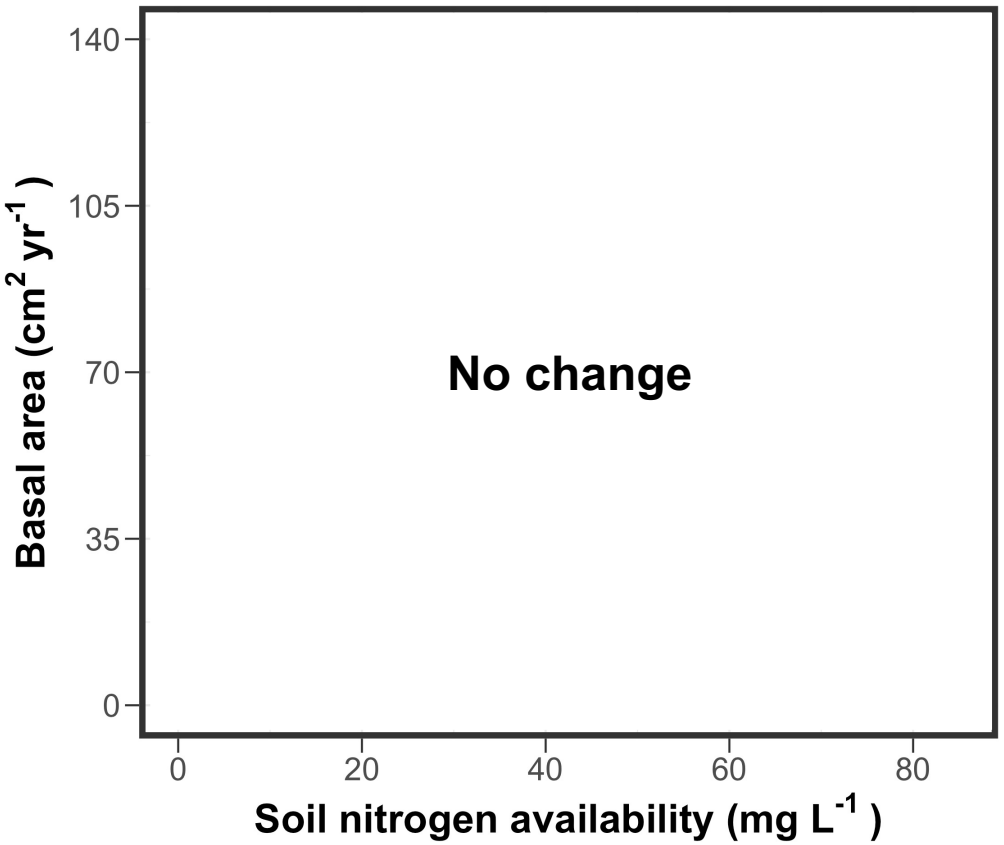
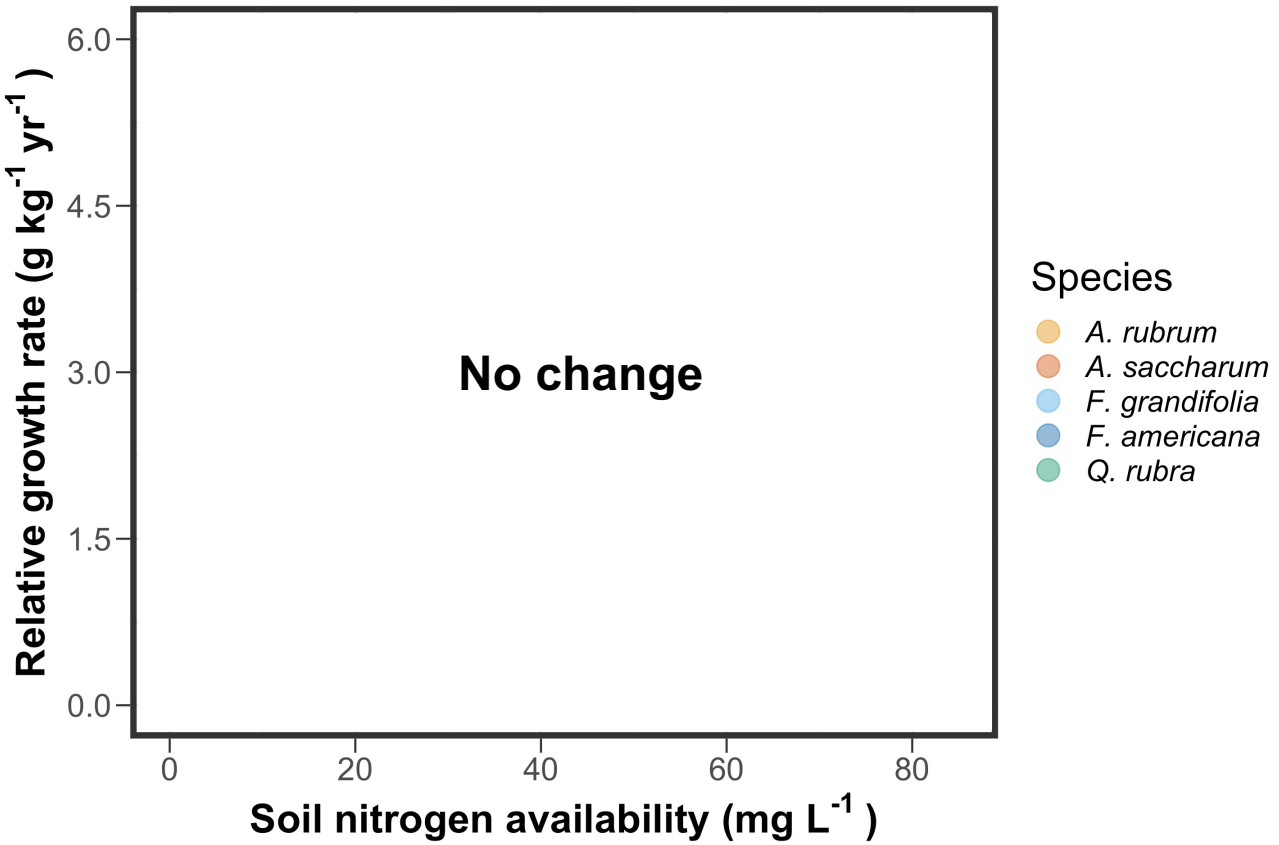
If leaf nitrogen increases with increasing soil nitrogen availability, then:





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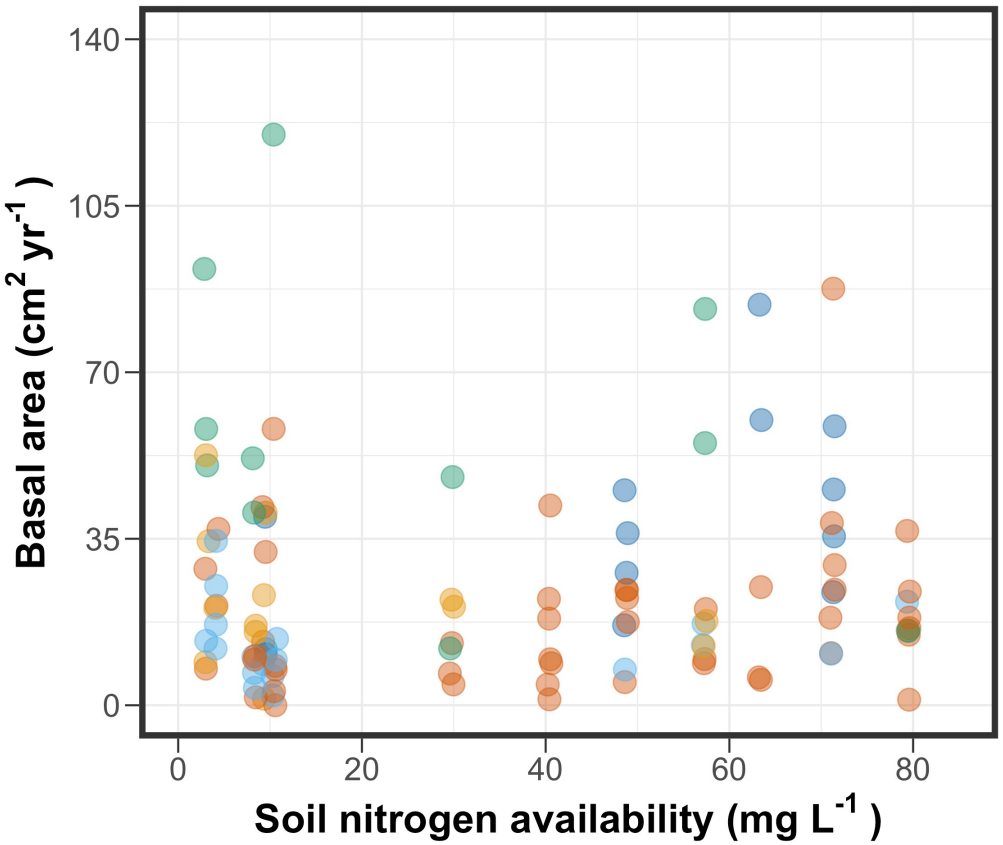
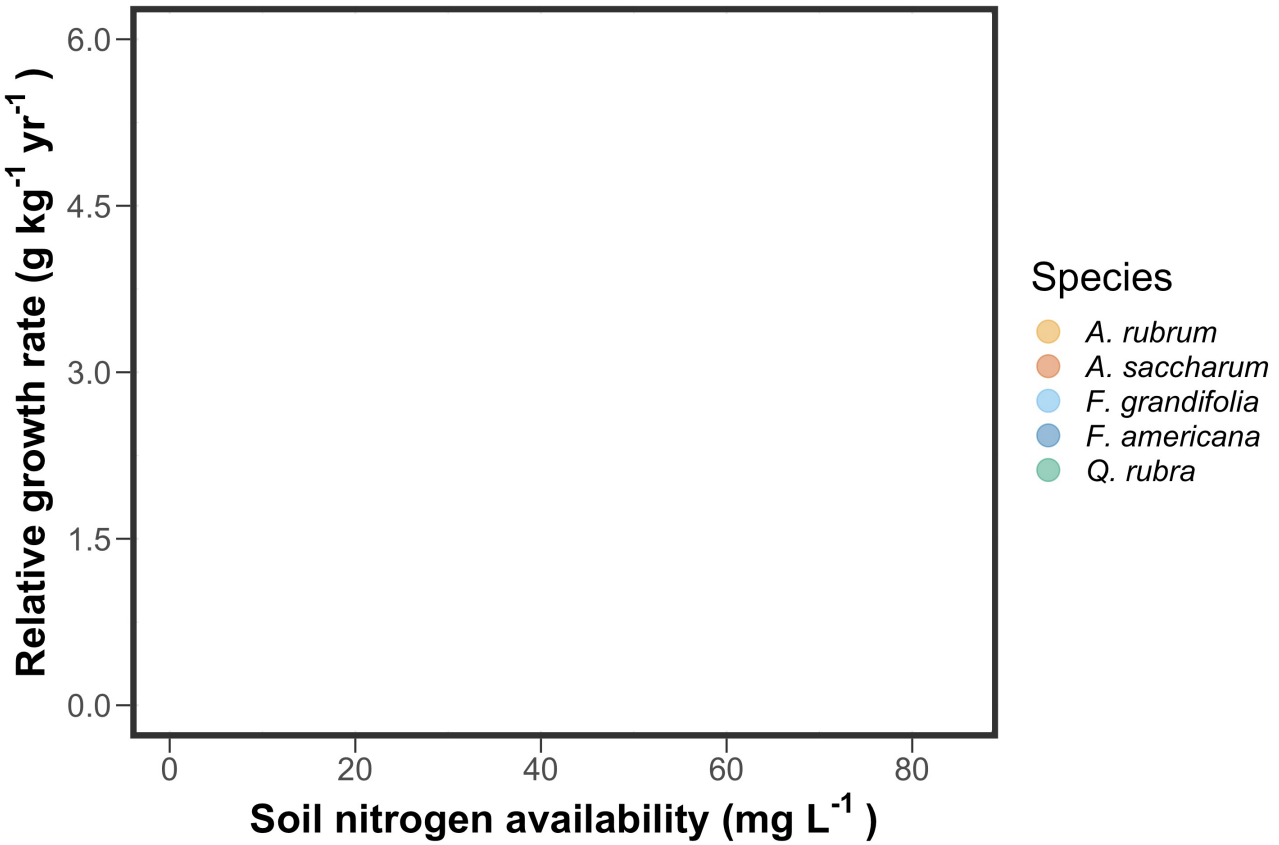
Soil nitrogen availability does not influence woody tissue production…





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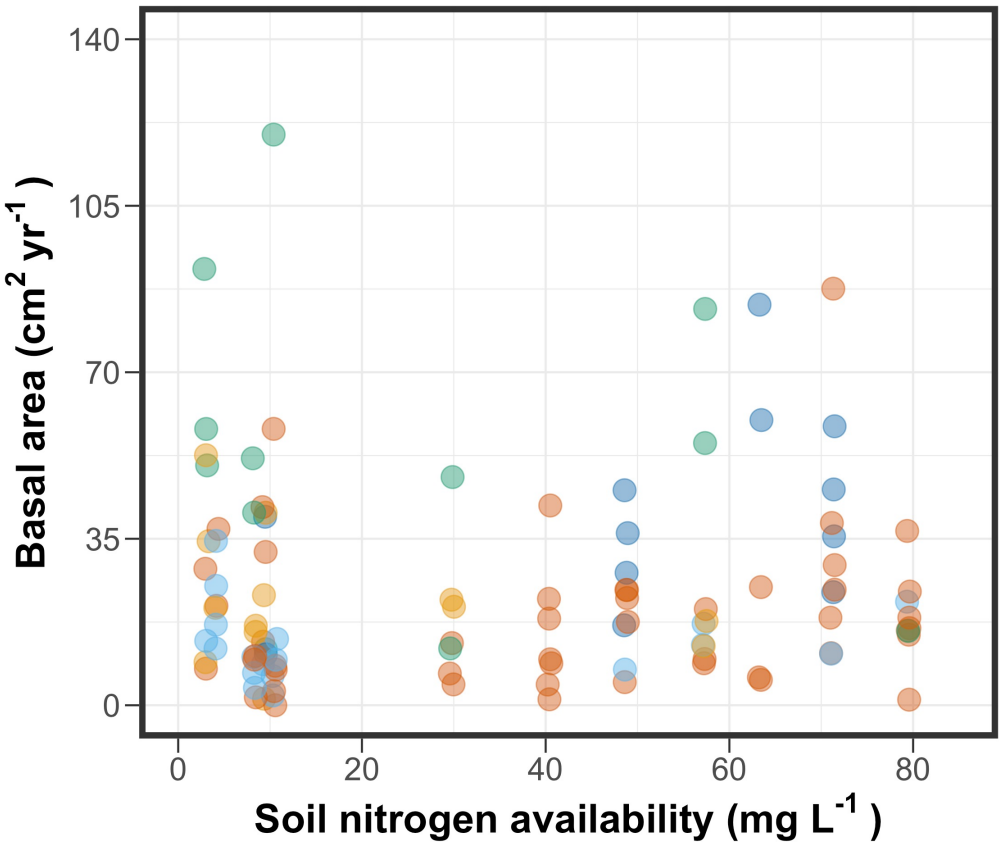
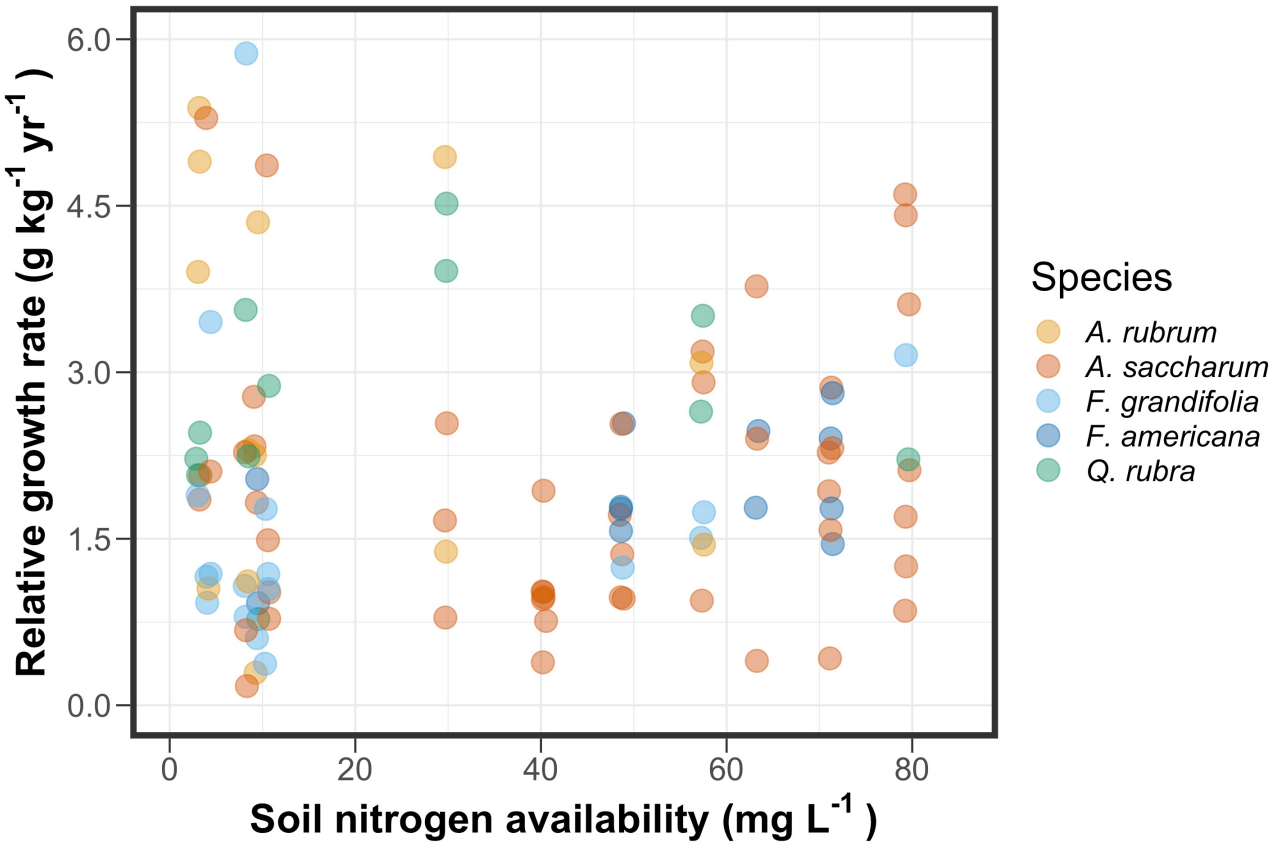
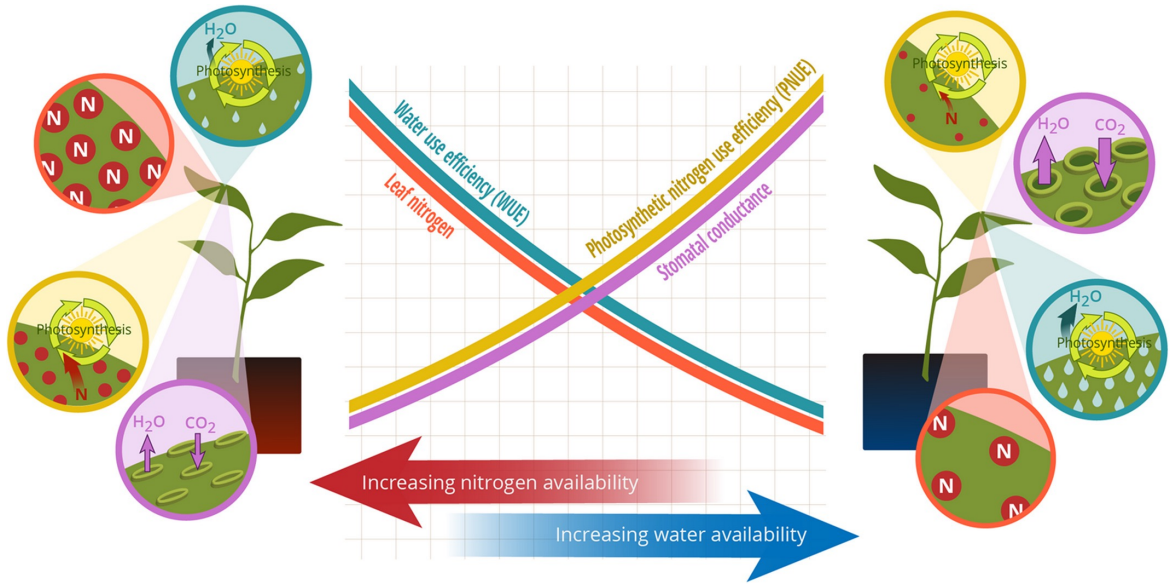
… or relative growth rate





Revisiting Option 1

Did soil N allow photosynthesis rates to be achieved with higher water use efficiency at the expense of nitrogen-use efficiency?

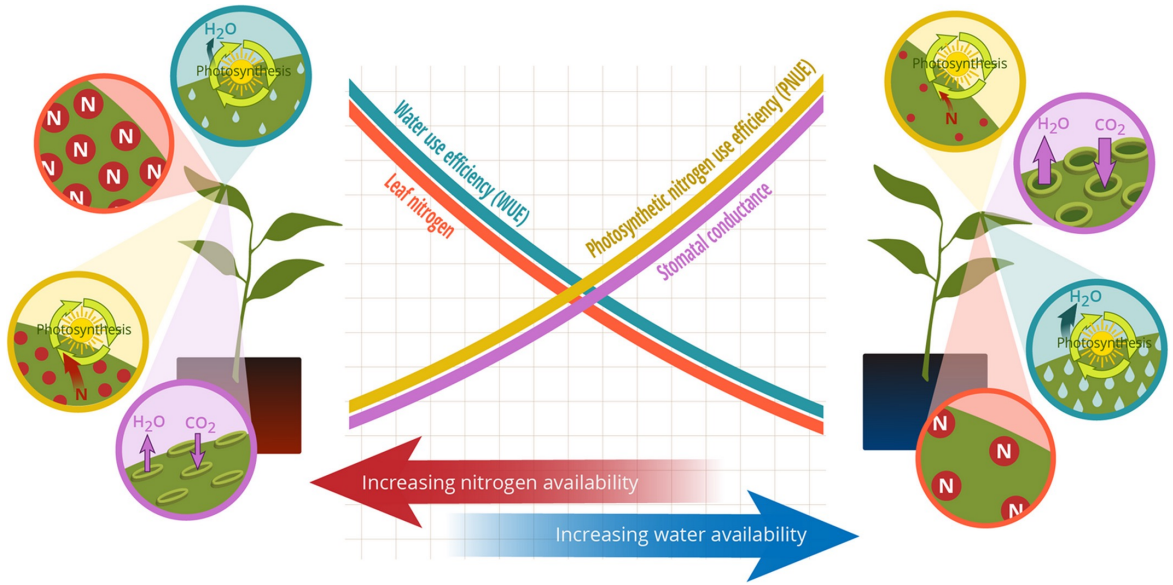


Bialic-Murphy *et al*. (2021) *Ecol. Letters*

Revisiting Option 1

Did soil N allow photosynthesis rates to be achieved with higher water use efficiency at the expense of nitrogen-use efficiency?

No, increased soil N increased nitrogen-use efficiency and did not influence water-use efficiency



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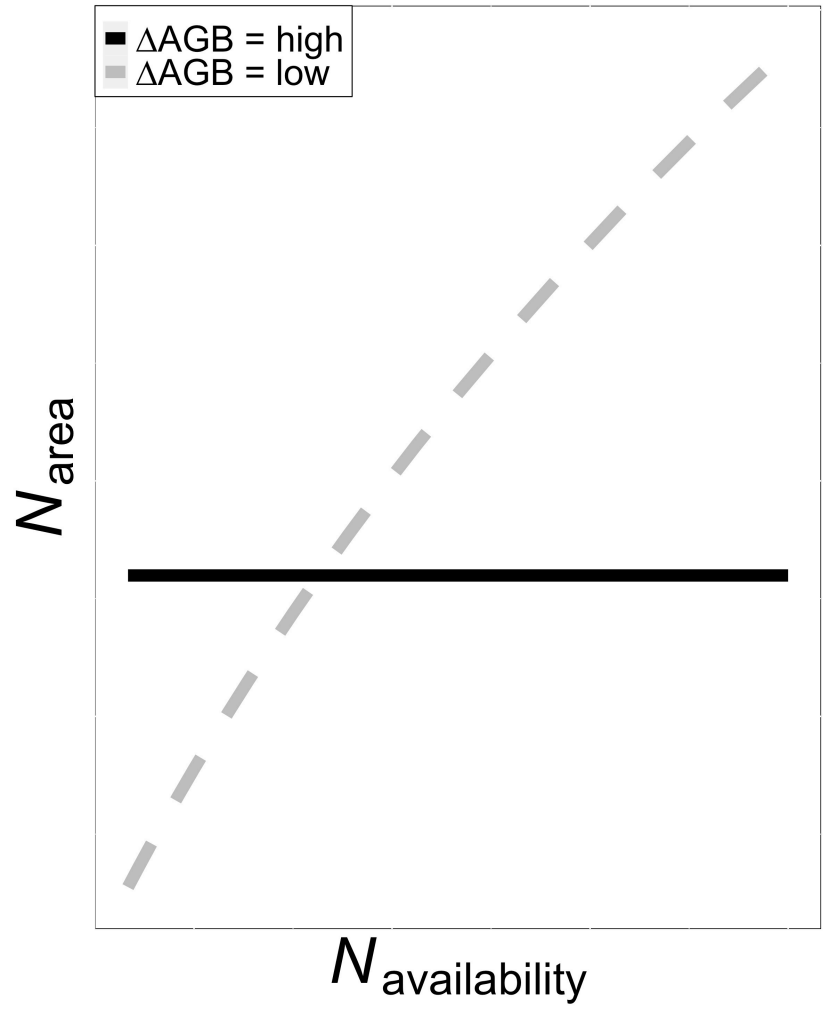
Revisiting Option 2

Did soil N invoke tradeoffs between biomass production and N_{area}?

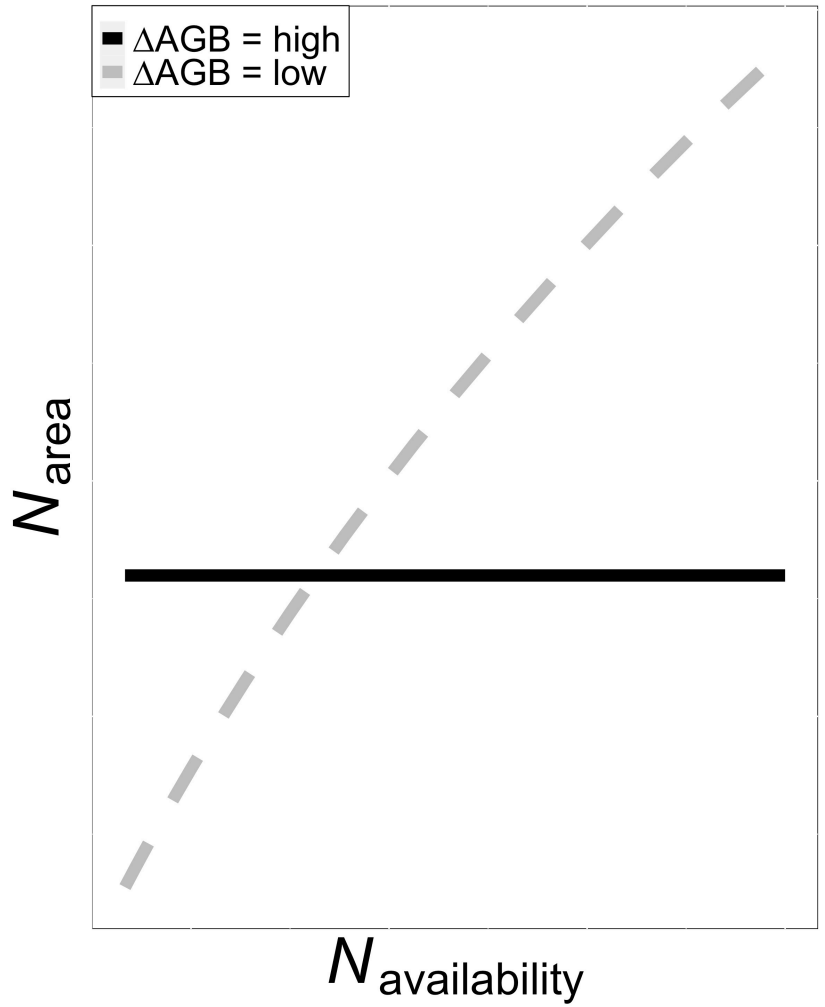


Smith *et al*. (in prep)

Revisiting Option 2

Did soil N invoke tradeoffs between biomass production and N_{area}?

Yes! Soil N did not influence whole plant growth, but increased N_{area}.



Smith *et al*. (in prep)

Final thoughts

- Trees invested more nitrogen toward leaf tissue at expense of whole plant growth
    - Overinvest in leaf nitrogen to be more productive during high sunlight hours
    - System is experiencing high rates of tree mortality – freeing of canopy space?

Future and Ongoing Work

- What is the role of light availability in driving demand to allocate nitrogen toward photosynthetic leaf tissue vs. whole plant growth?
- Are these patterns observed in other ecosystem and/or different canopy architecture types?
- How do these results compare to those simulated by Earth system models?

Acknowledgements

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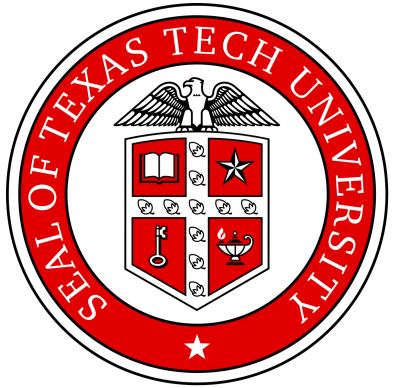
- Dr. Lizz Waring (TTU)



Thank you!

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