

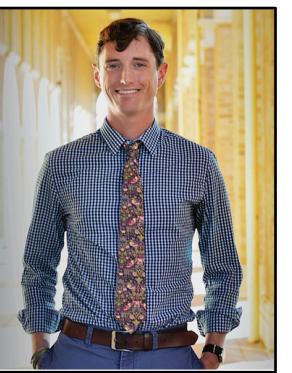
Nitrogen supply and demand control plant responses to elevated CO₂ at different scales



Evan
Perkowski



Ezinwanne
Ezekannagha



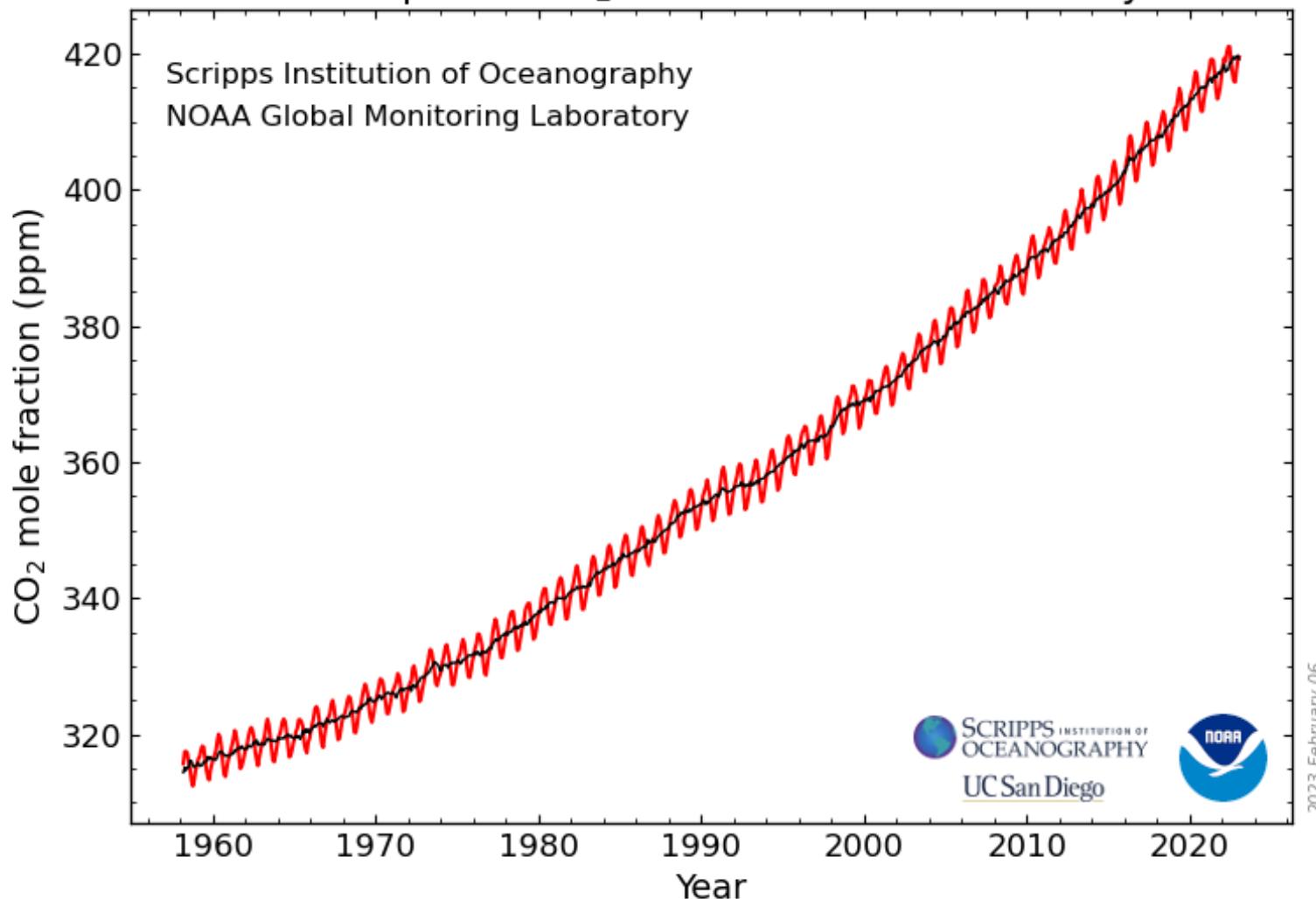
Nick
Smith

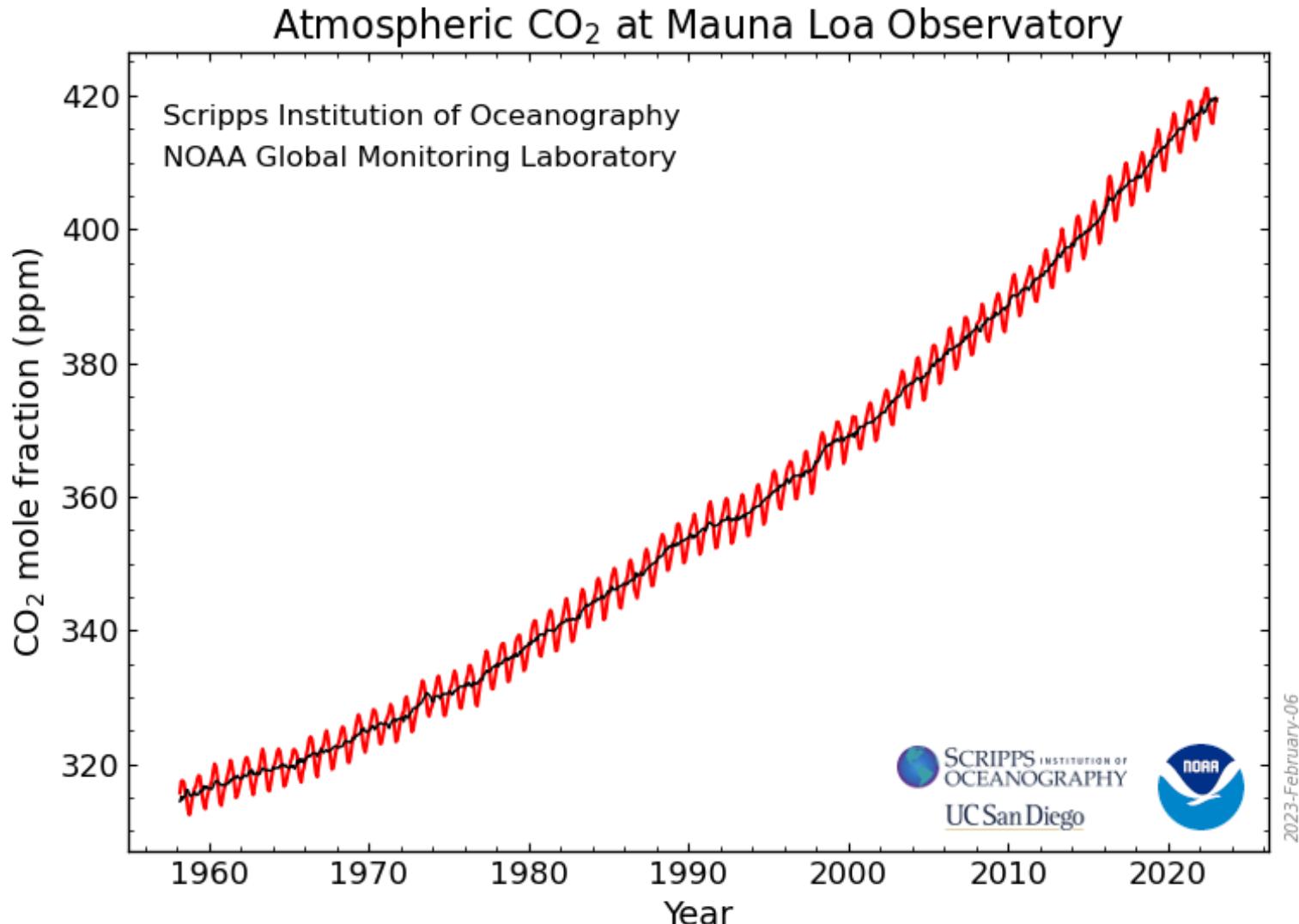


LEMONTREE
Land Ecosystem Models
based On New Theory,
obseRvations and
Experiments



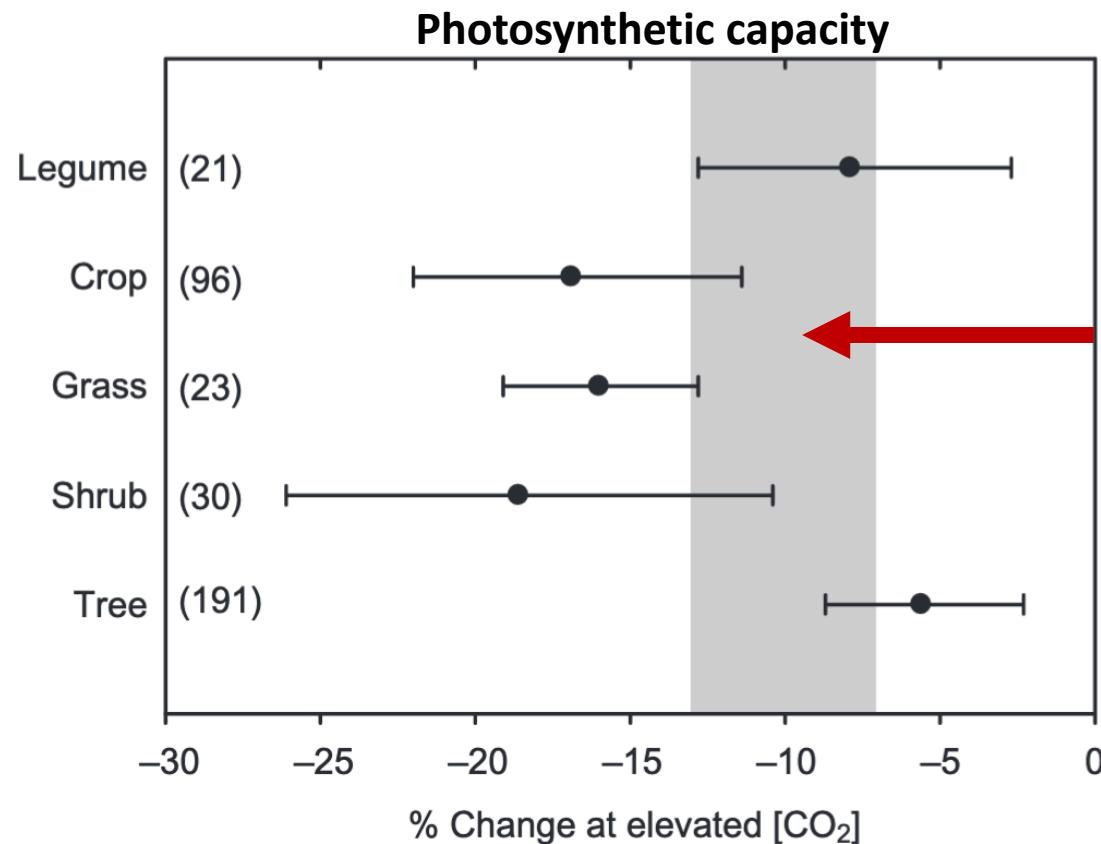
Atmospheric CO₂ at Mauna Loa Observatory



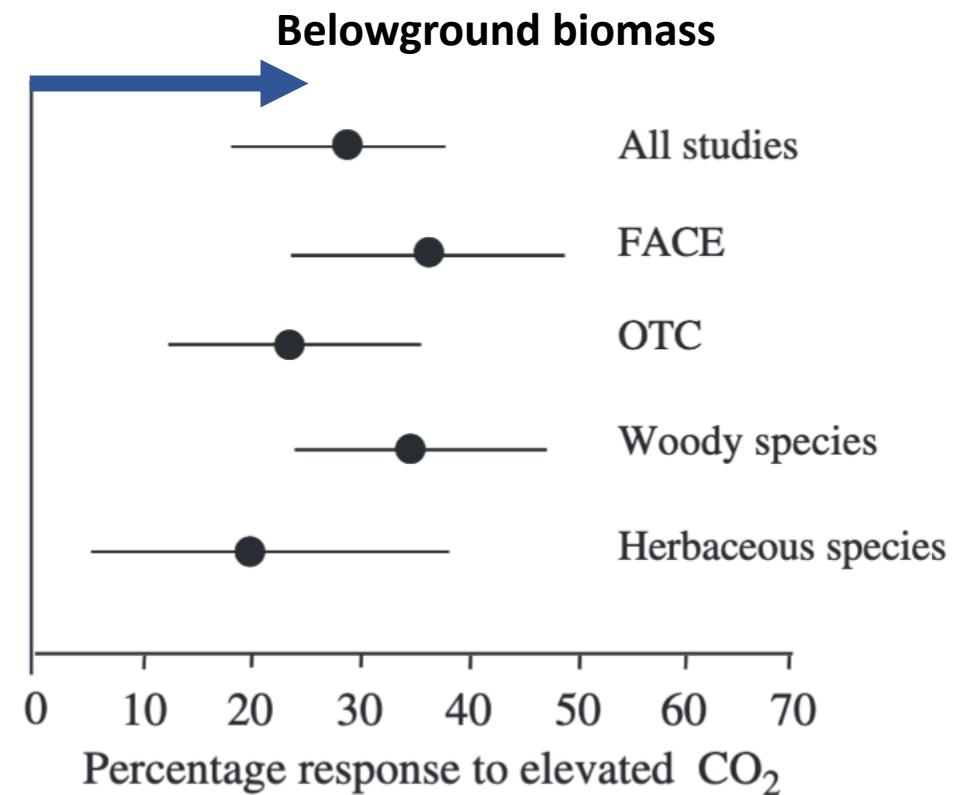
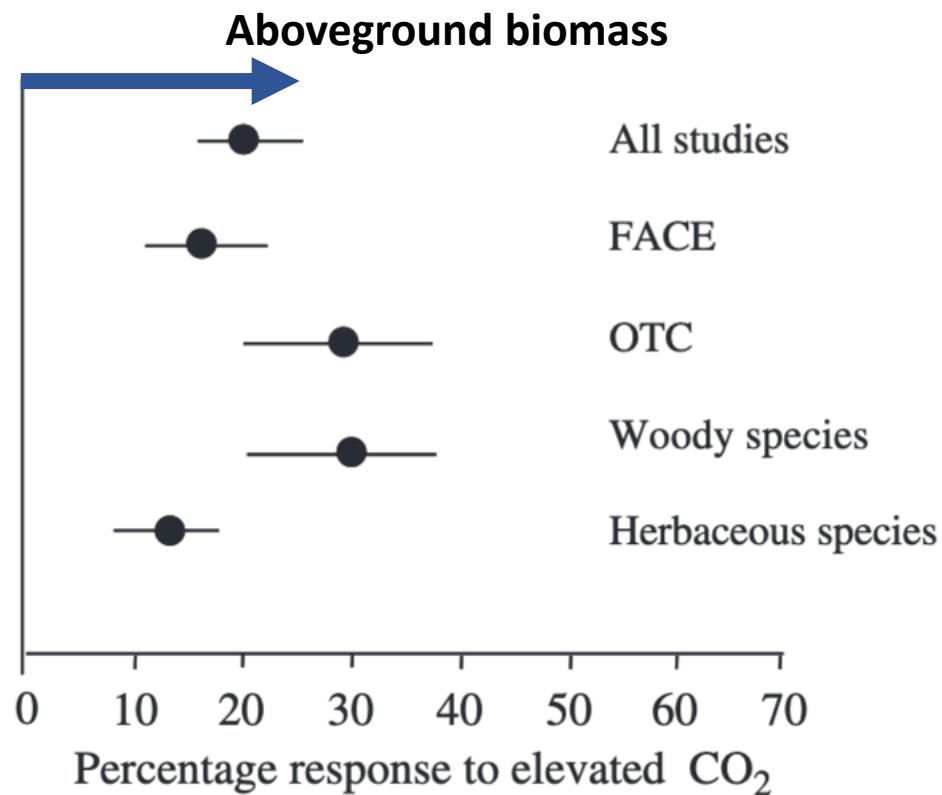


33% increase in CO₂ concentration since 1960
61% of this increase has occurred since 1990

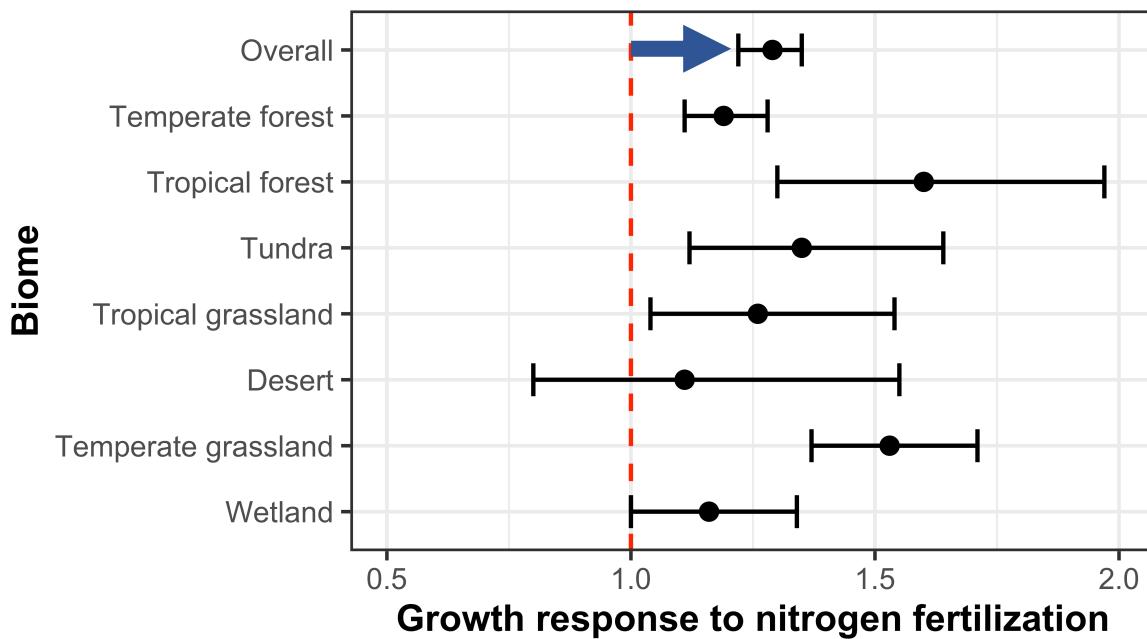
Plants grown under elevated CO₂ exhibit **reductions** in photosynthetic capacity



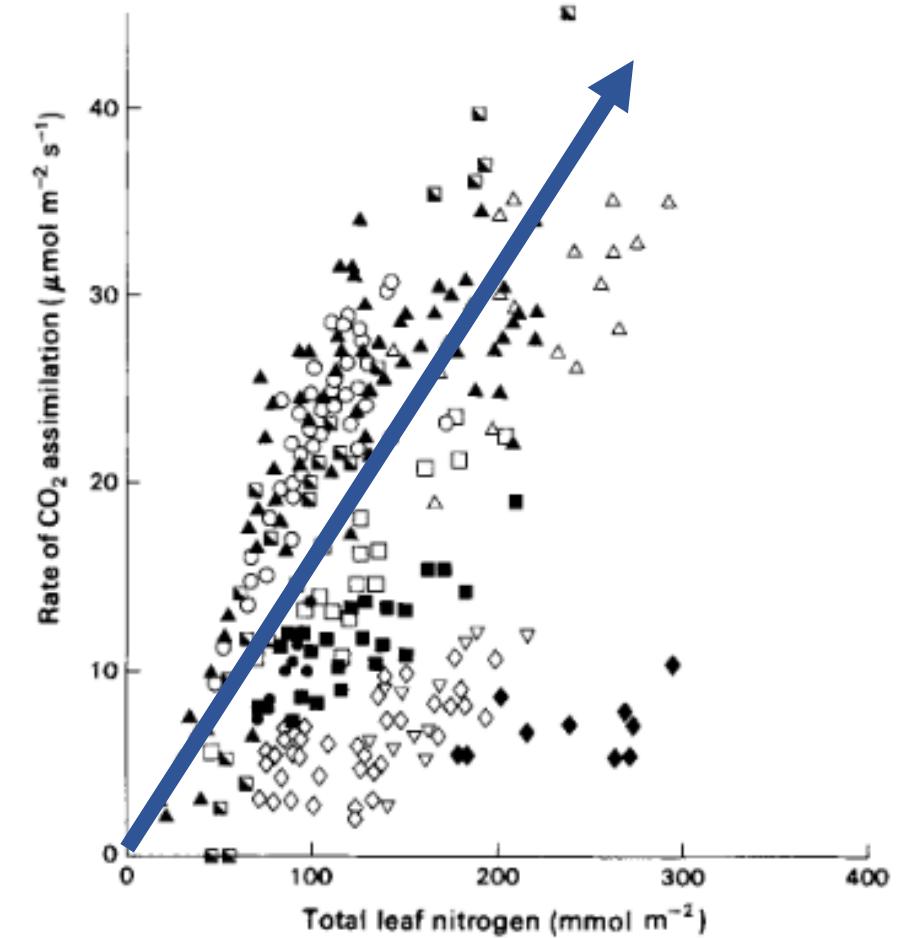
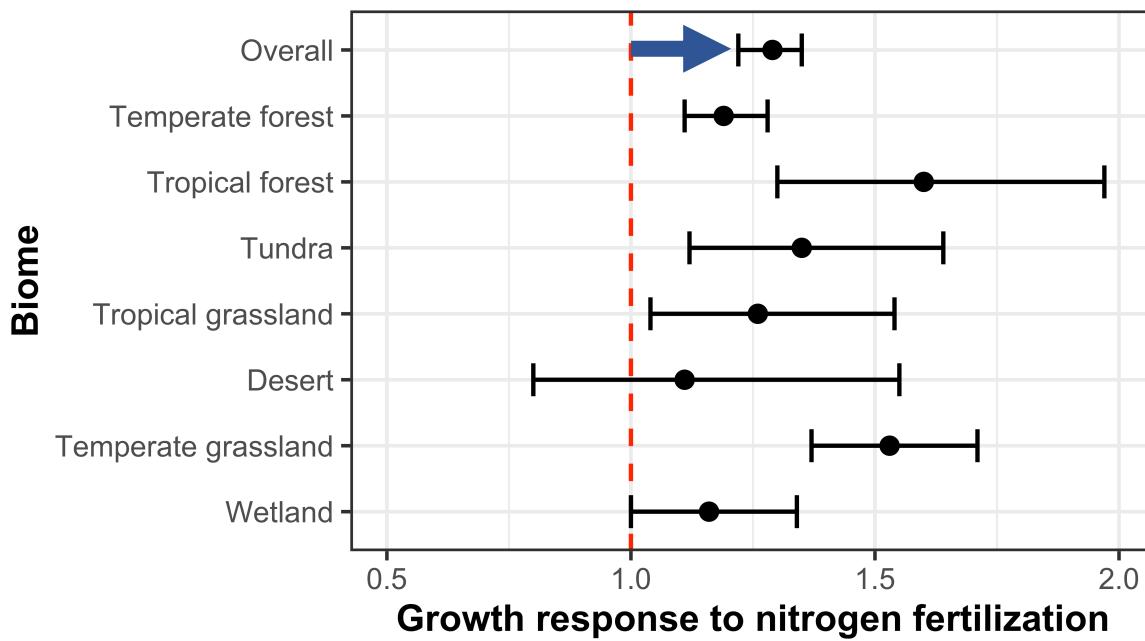
Reduced photosynthetic capacity under elevated CO₂ often corresponds with **increased** whole-plant growth



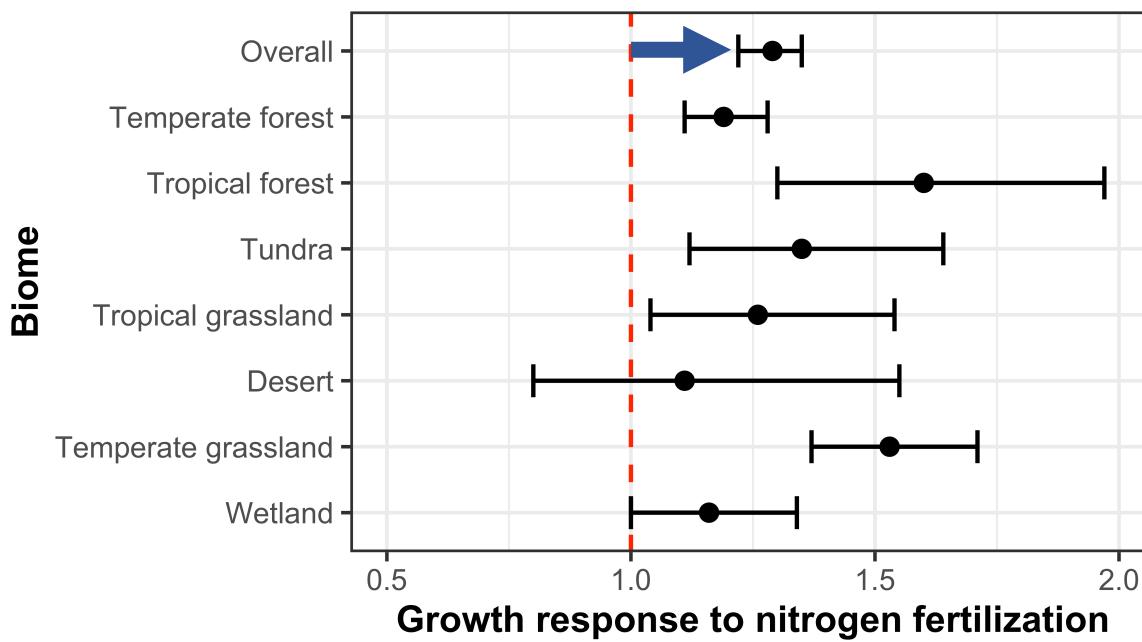
Some have hypothesized that nitrogen availability regulates plant responses to elevated CO₂



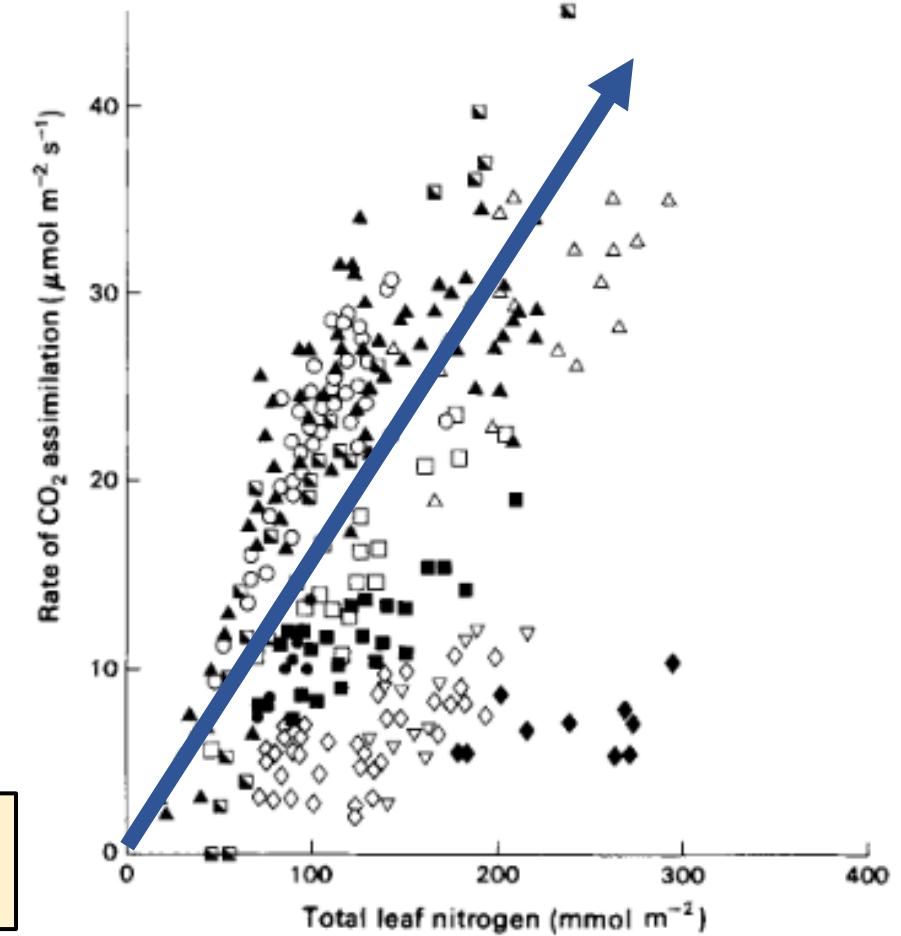
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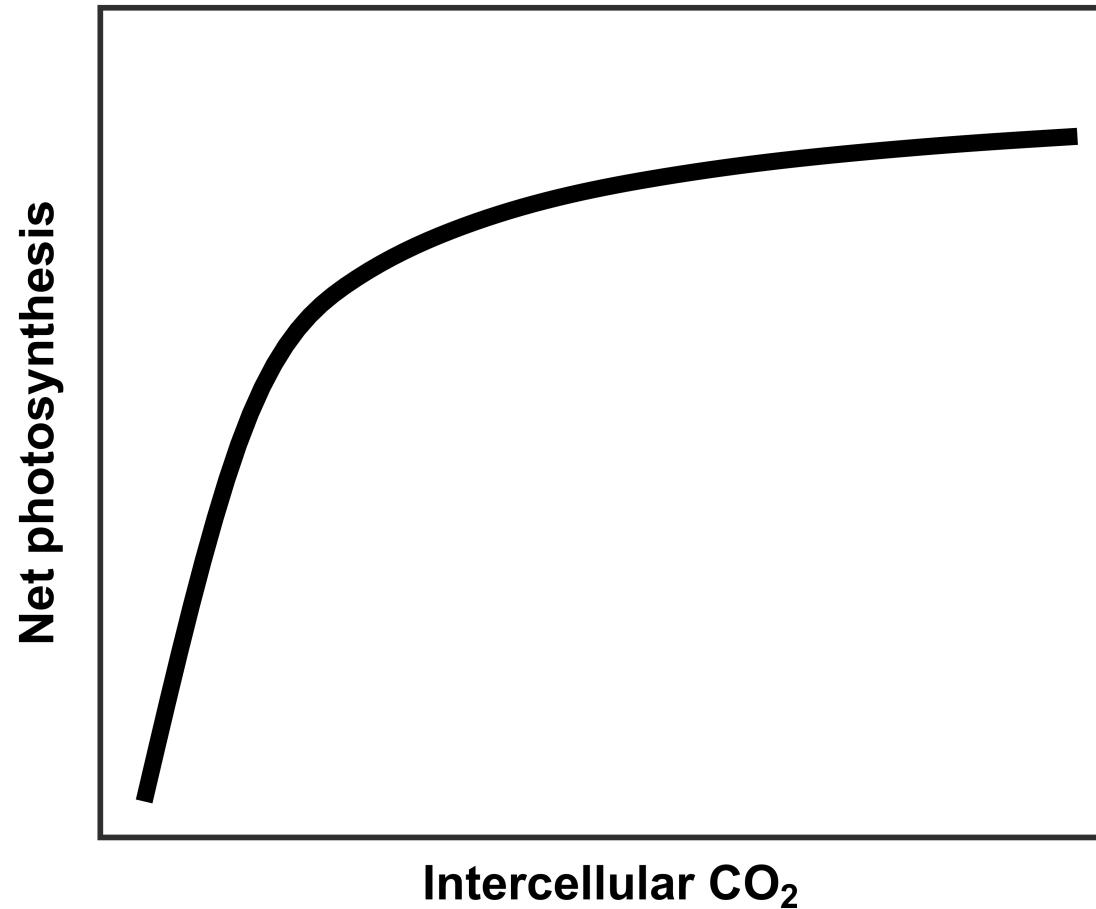
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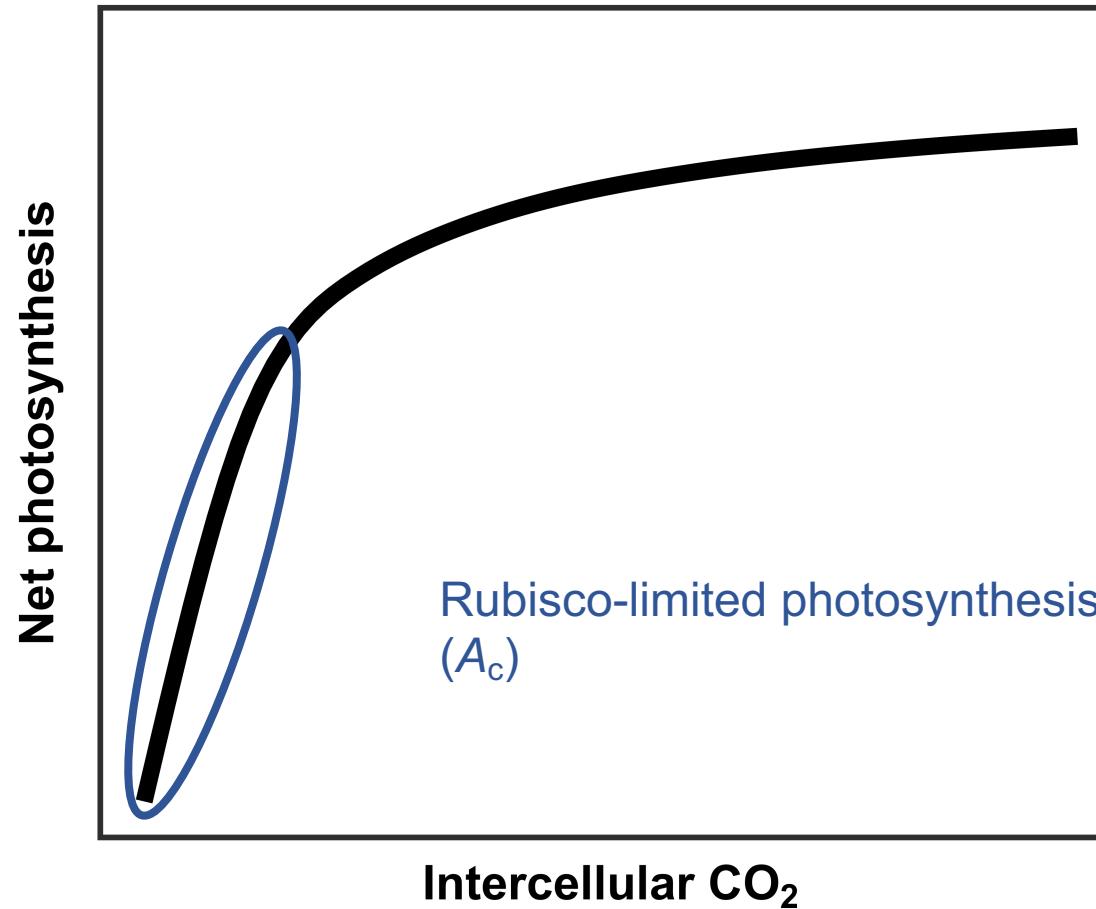
Increased demand to build and maintain photosynthetic enzymes might deplete plant-available soil N pools



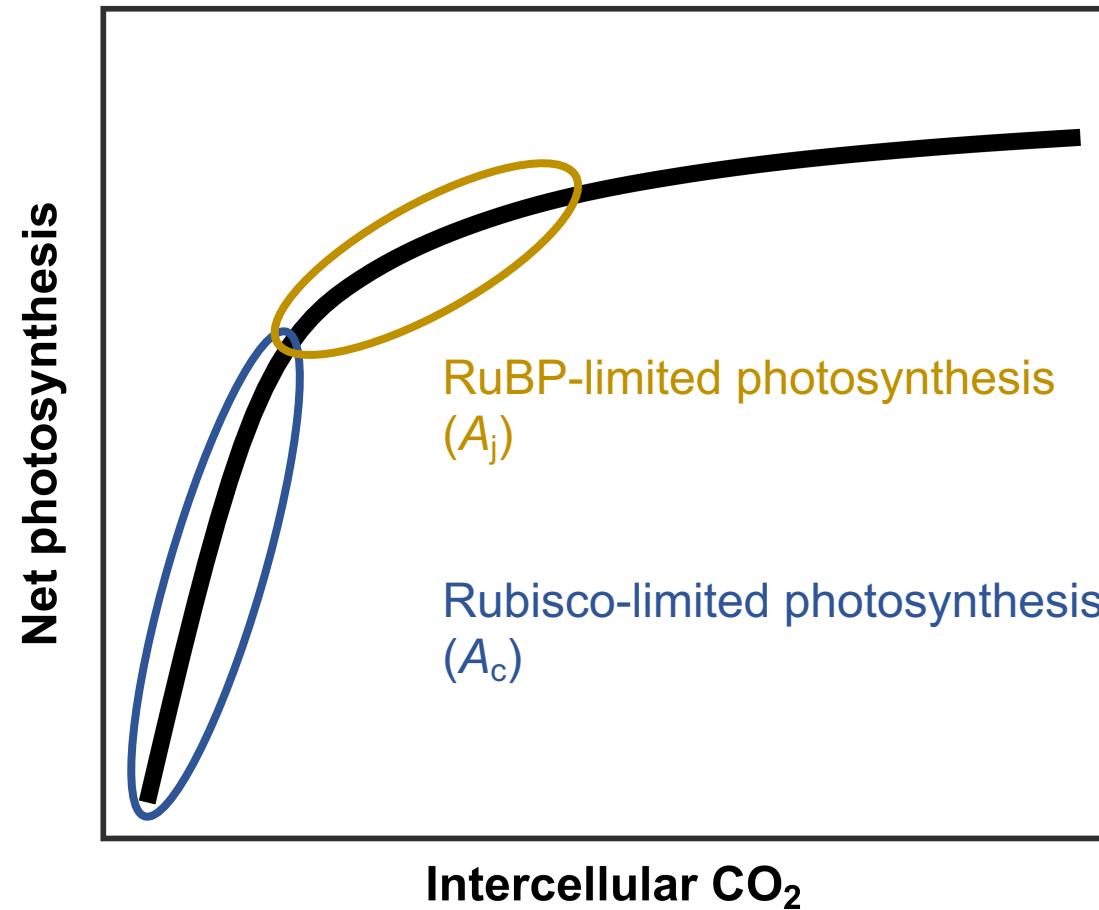
However, an alternative hypothesis suggests that plant demand to build and maintain photosynthetic enzymes drives the leaf response to CO_2



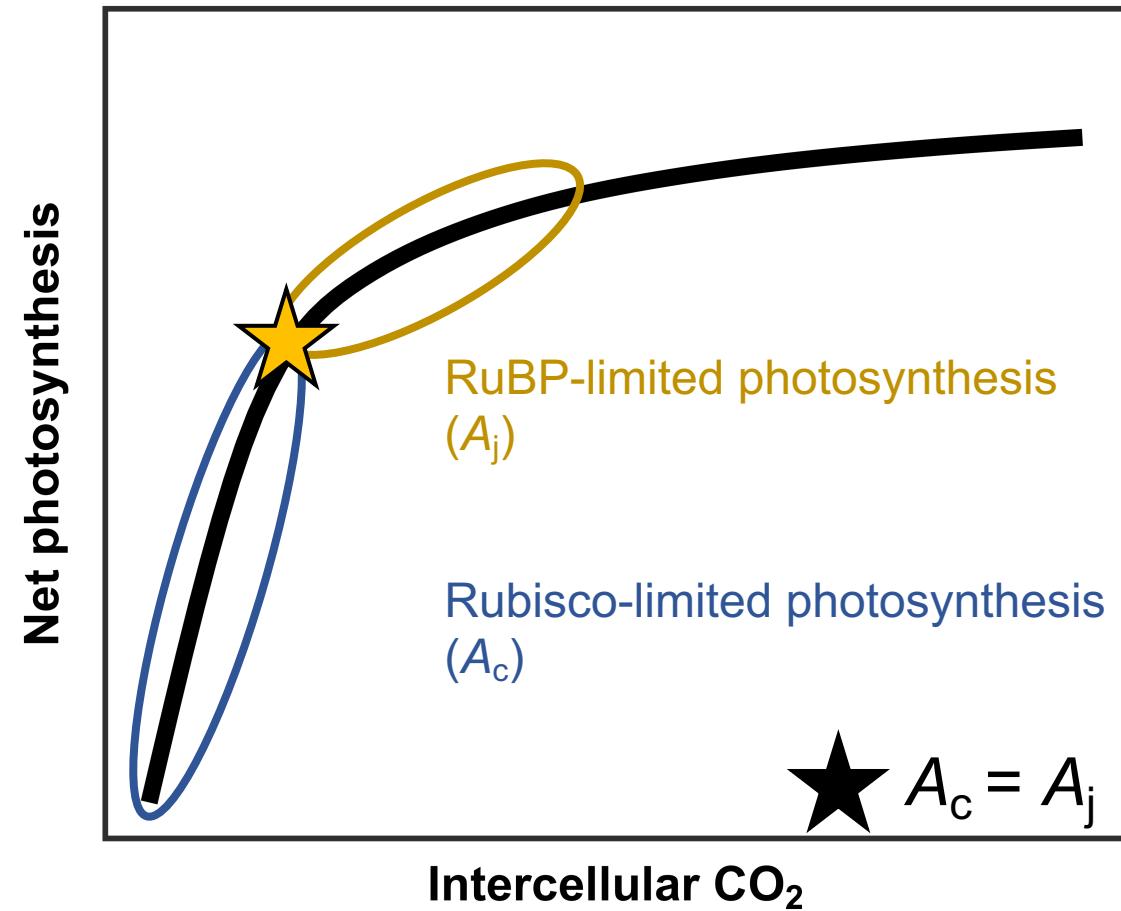
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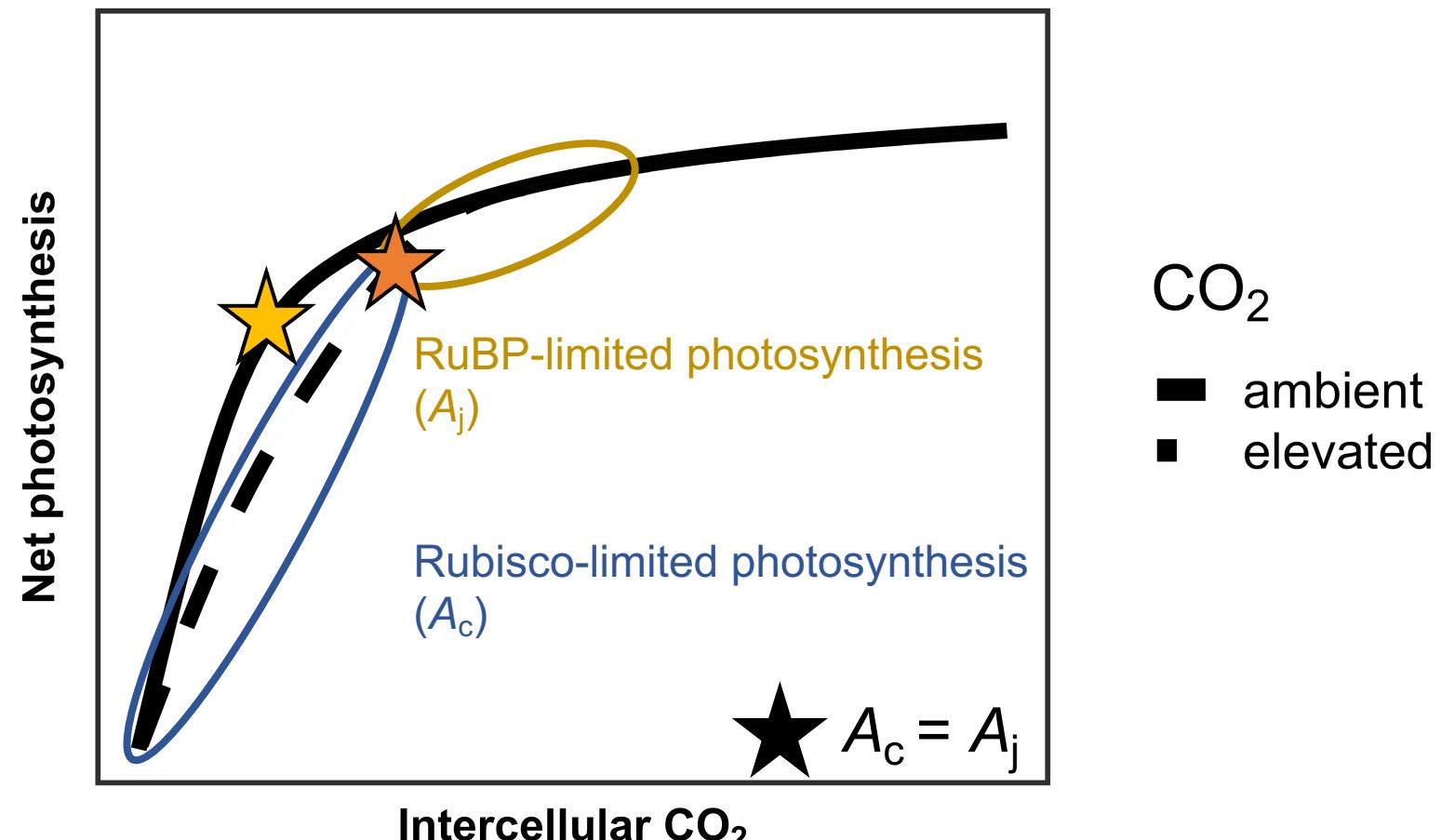
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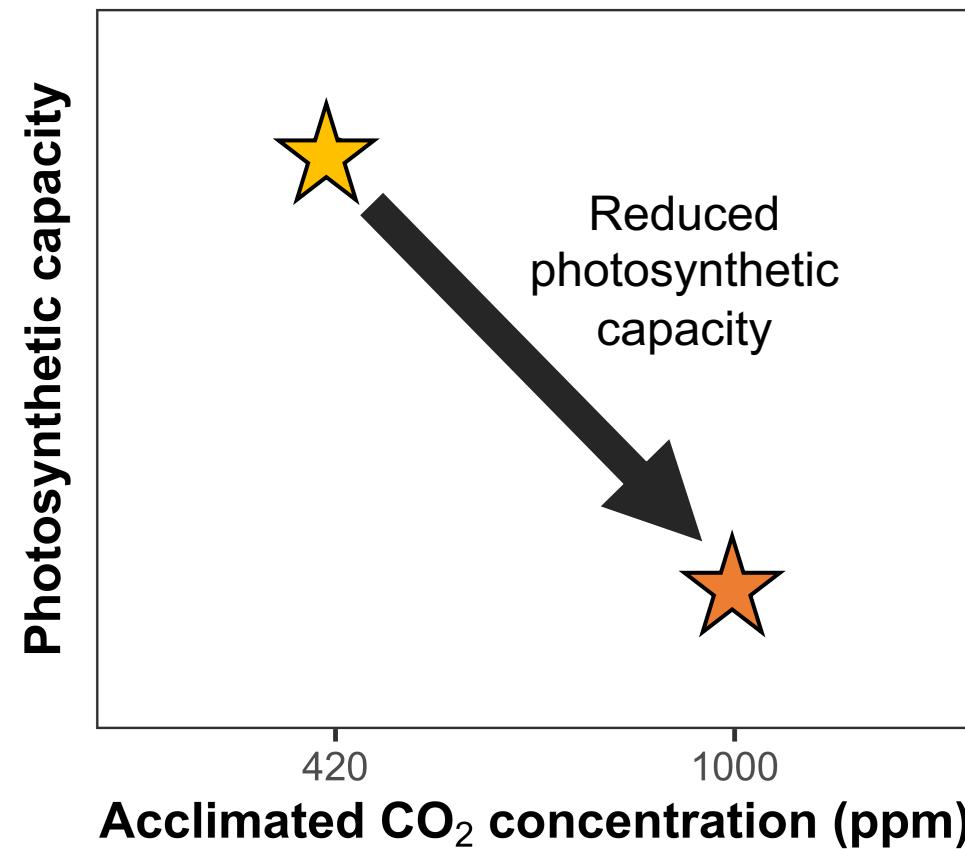
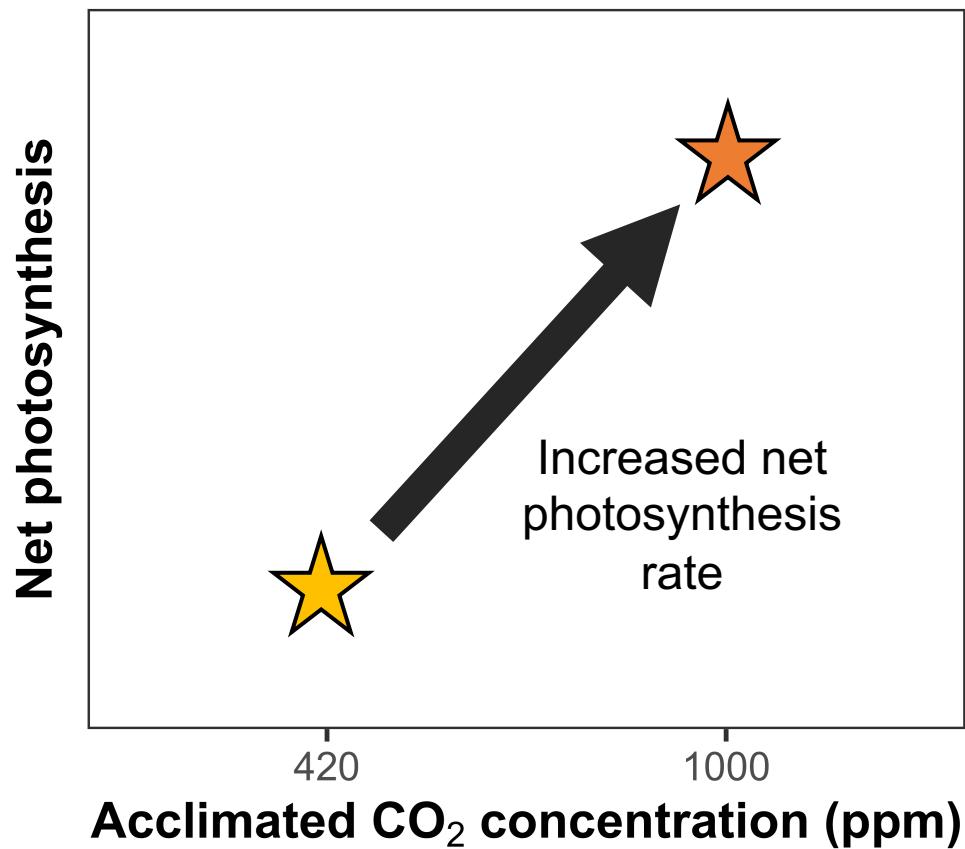
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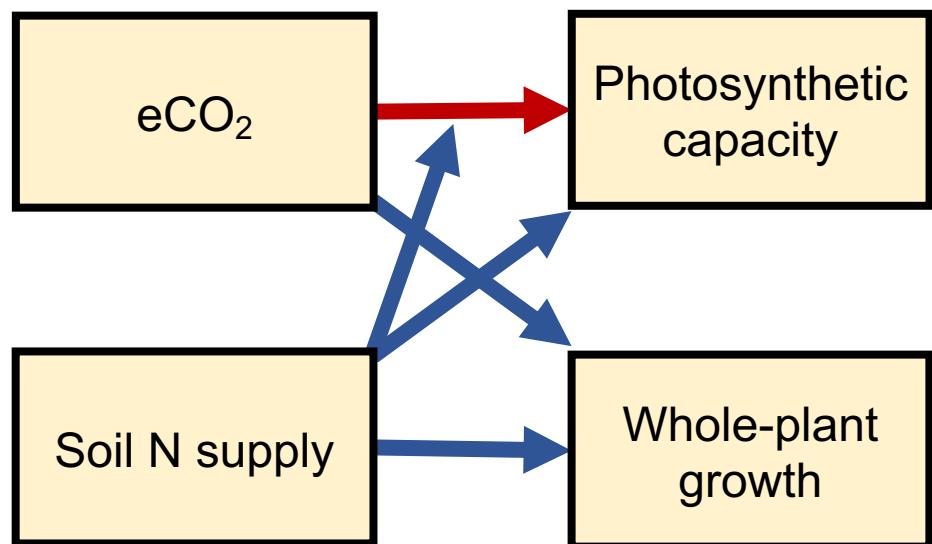
Optimal resource investment to photosynthetic enzymes increases leaf photosynthesis at lower photosynthetic capacity



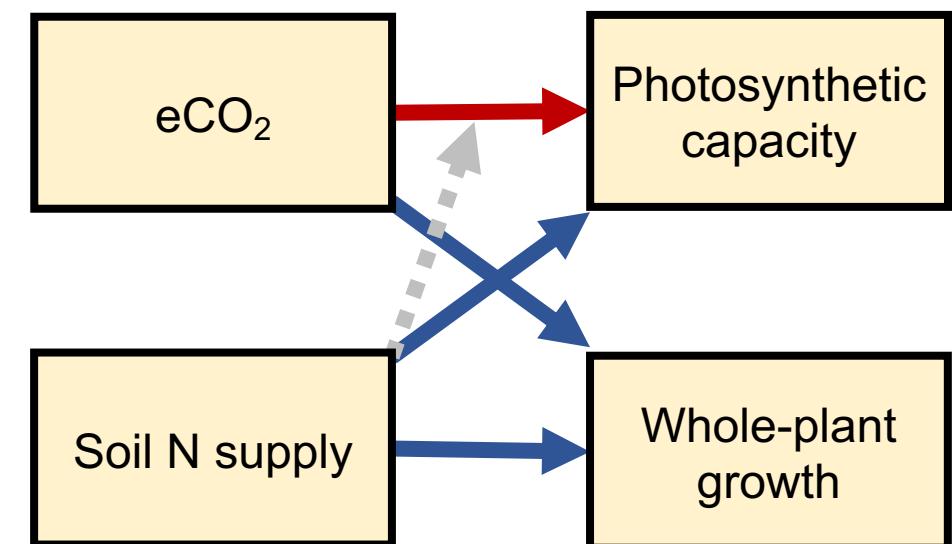
Study Question

How does soil nitrogen availability
modify leaf and whole plant
responses to CO₂?

Nitrogen limitation hypothesis



Optimality hypothesis



- = net positive effect
- = net negative effect
- = null effect

Experiment setup

Acquisition strategy

+ BNF

- BNF

Soil N treatments

0 ppm N

35 ppm N

70 ppm N

105 ppm N

140 ppm N

210 ppm N

280 ppm N

350 ppm N

630 ppm N

CO₂ treatments

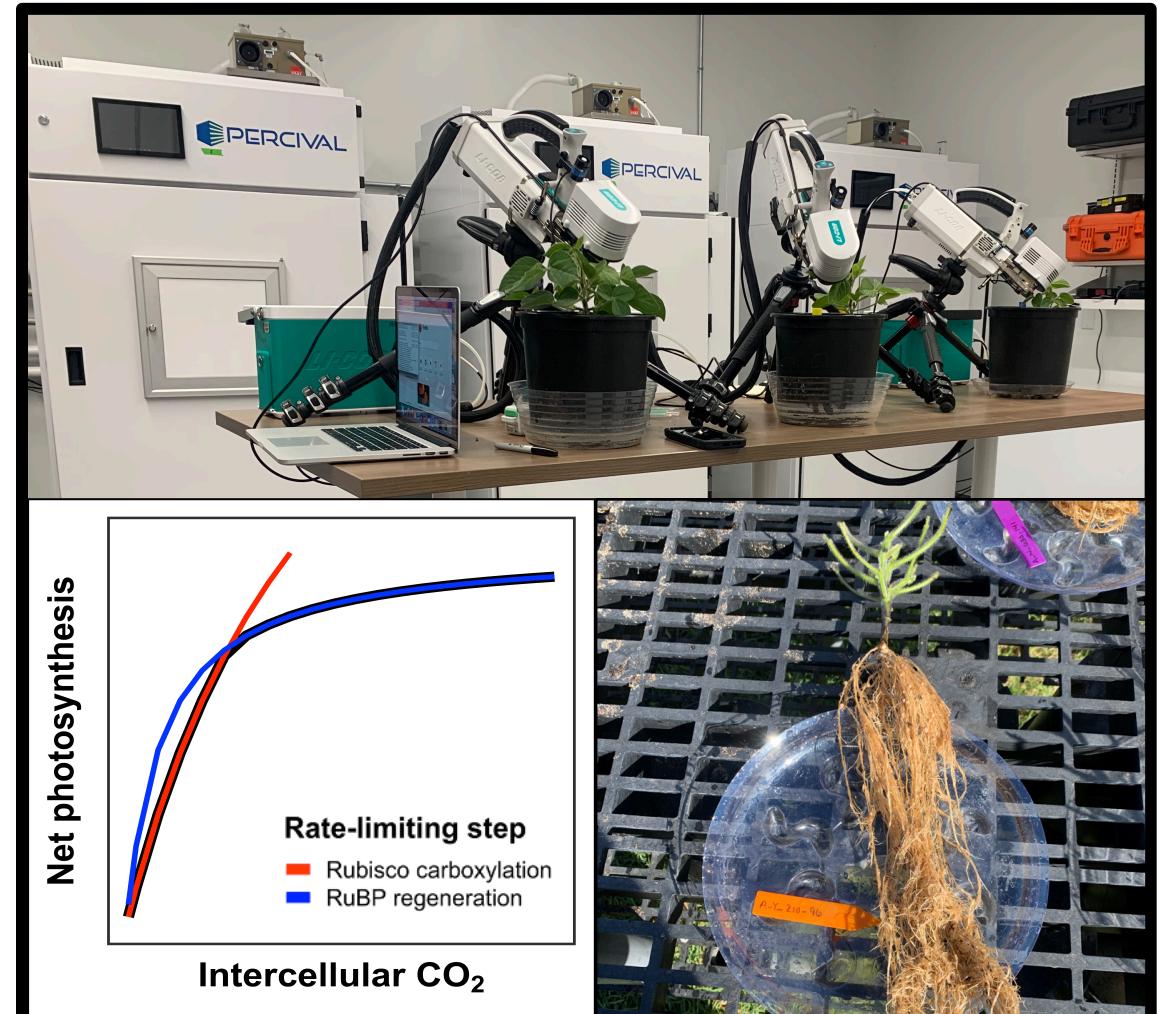
ambient (420 ppm)

elevated (1000 ppm)



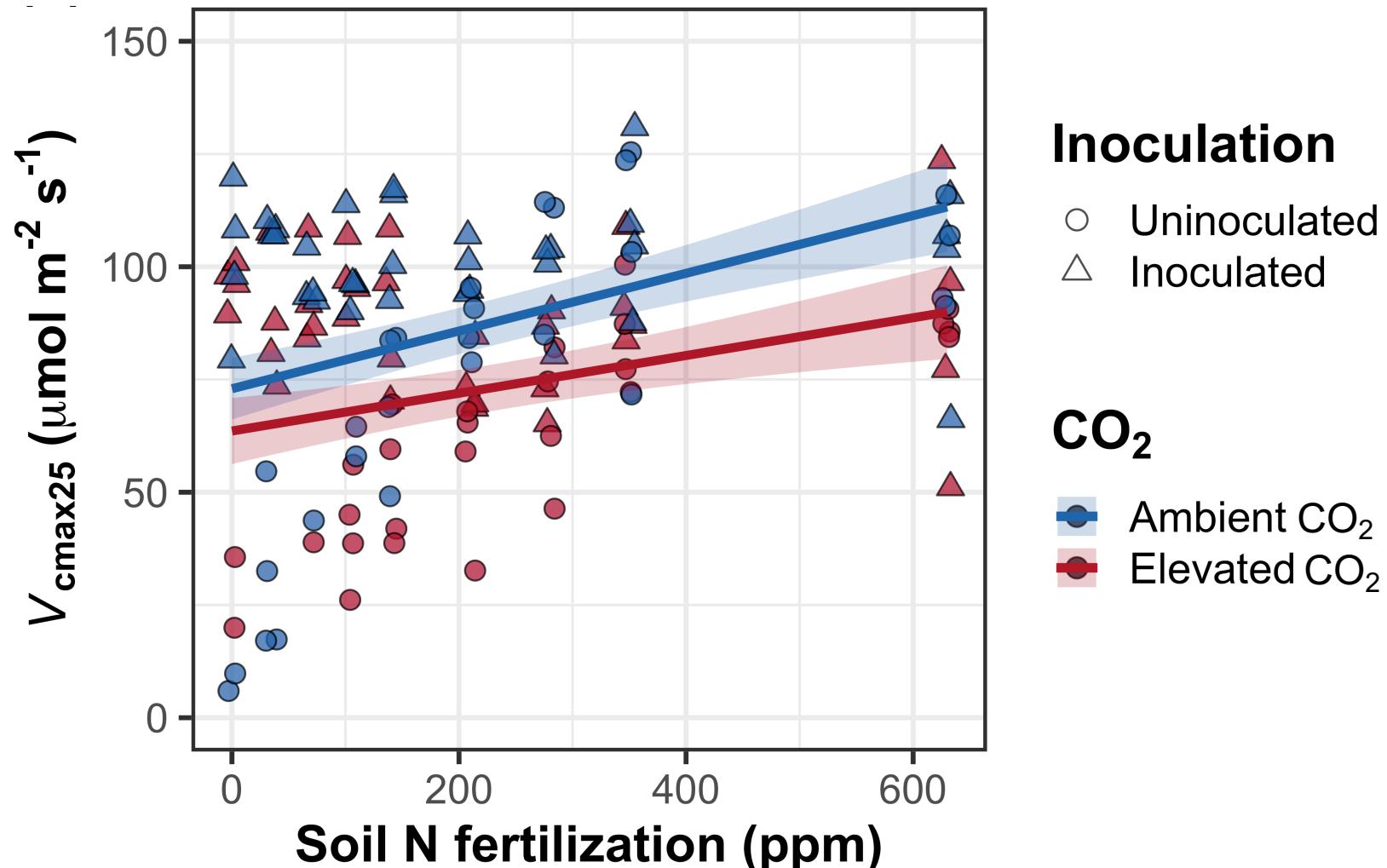
Measurements

- Photosynthetic capacity
 - V_{cmax25}
 - J_{max25}
 - $J_{max25} : V_{cmax25}$
- Total biomass
- % leaf N derived from atmosphere



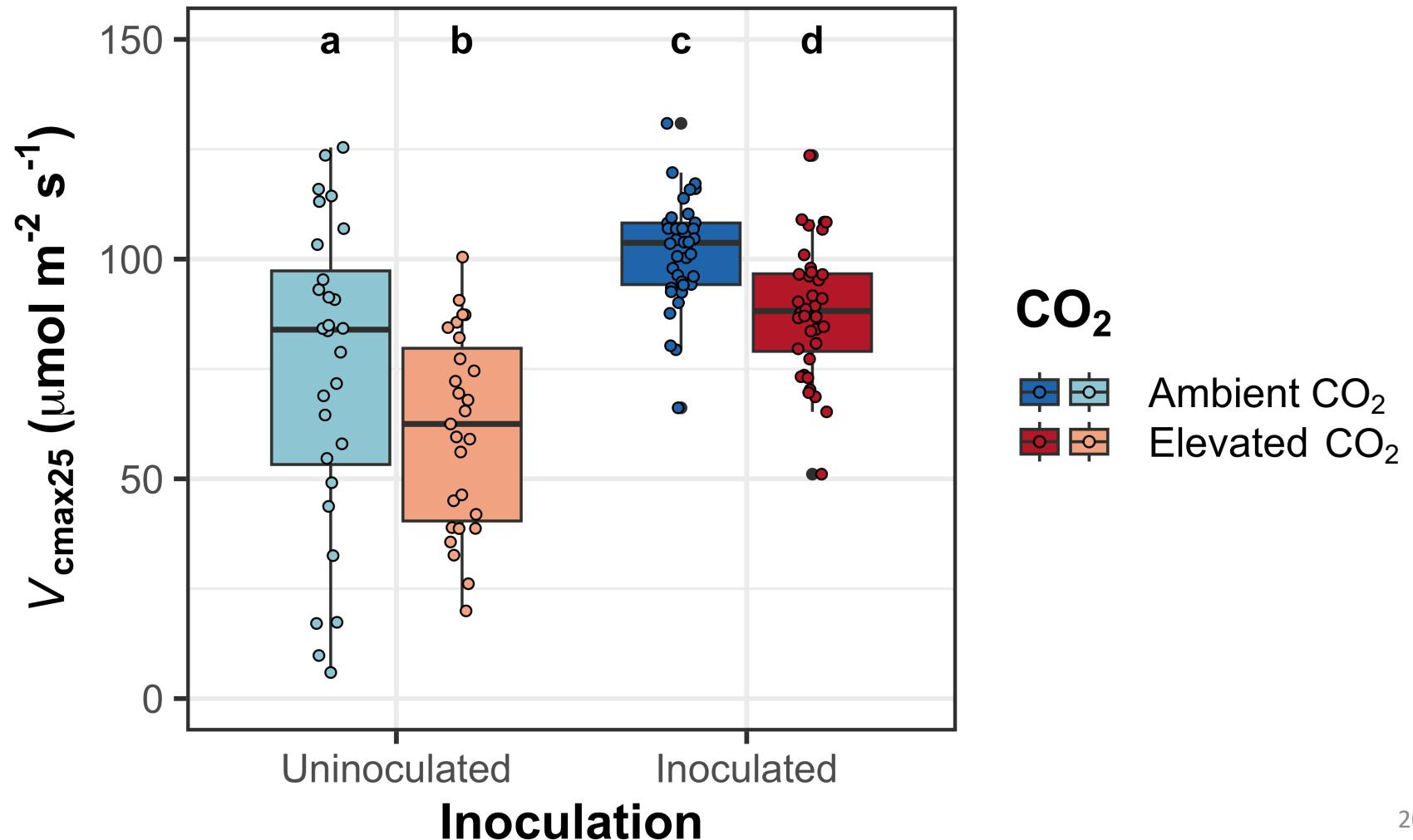
Increasing fertilization did not modify the **reduction** in photosynthetic capacity under elevated CO₂

CO₂: *p*<0.001
Fertilization (N): *p*<0.001
Inoculation (I): *p*<0.001
CO₂*N interaction: NS



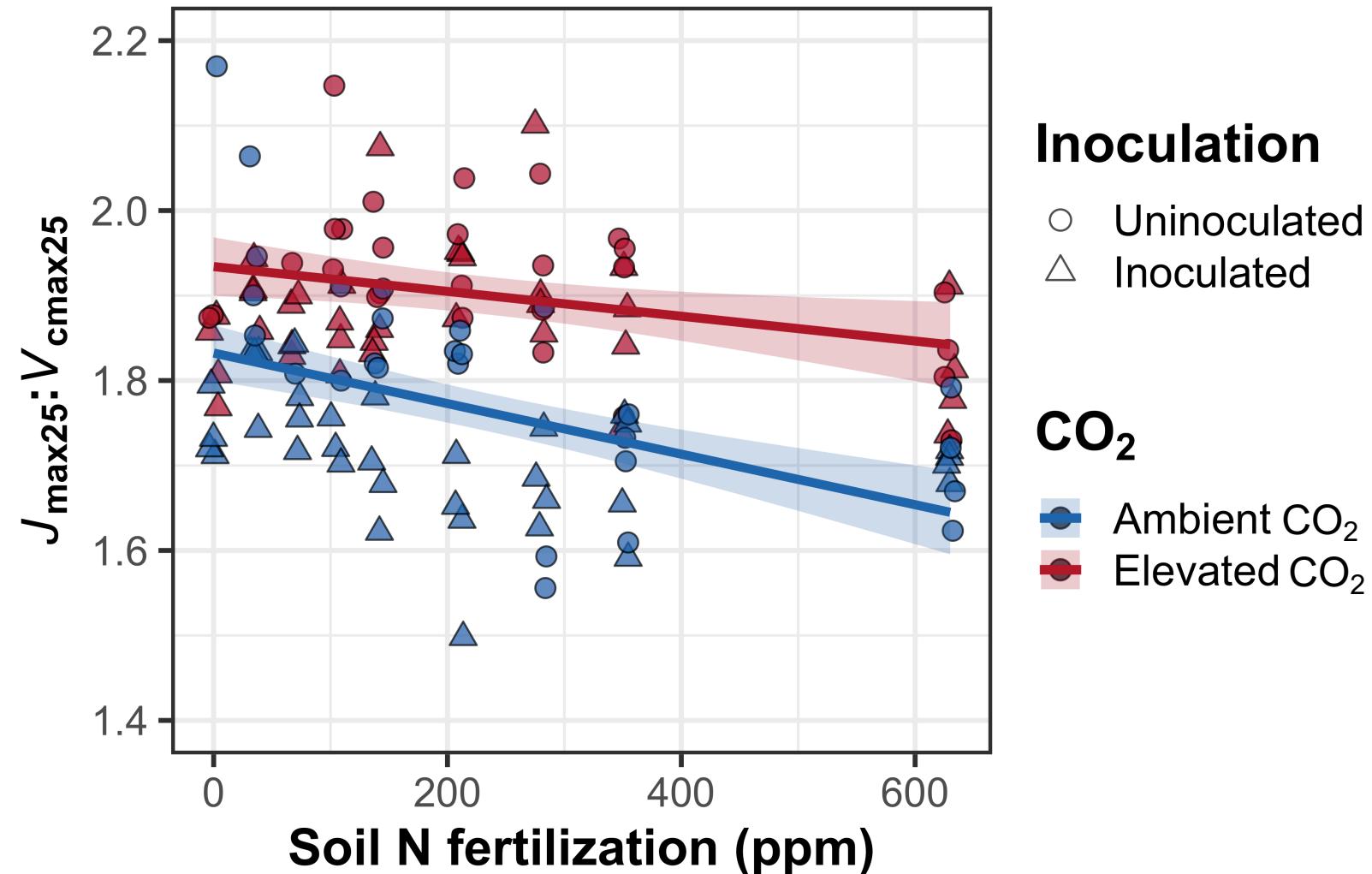
Inoculation also did not modify the **reduction** in photosynthetic capacity under elevated CO₂

CO₂: **p<0.001**
Fertilization (N): **p<0.001**
Inoculation (I): **p<0.001**
CO₂*N interaction: **NS**
CO₂*I interaction: **NS**



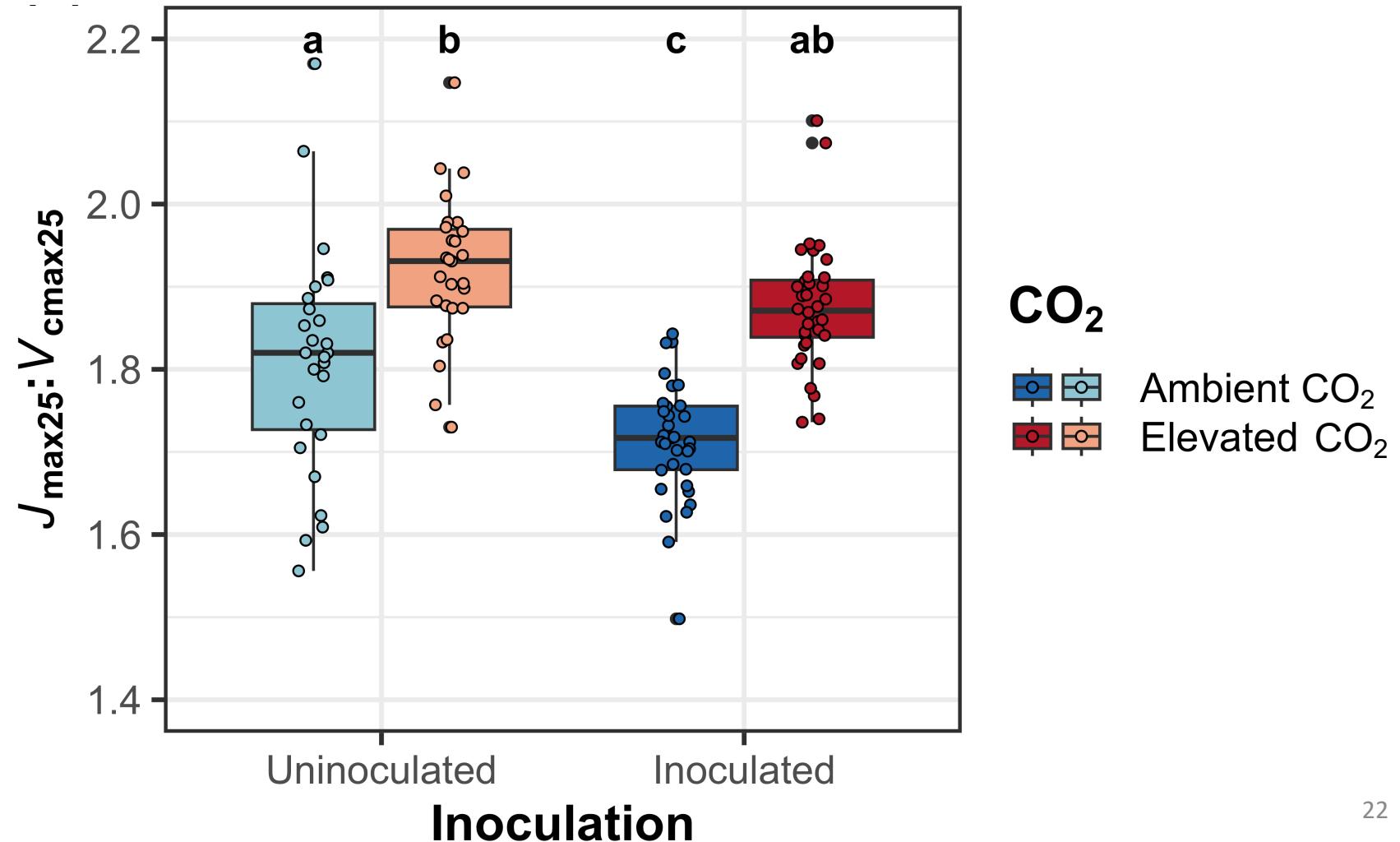
Elevated CO₂ **decreased** V_{cmax25} **more strongly** than J_{max25} . Fertilization did not modify this effect

CO₂: $p<0.001$
Fertilization (N): $p<0.001$
Inoculation (I): $p<0.001$
CO₂*N interaction: NS



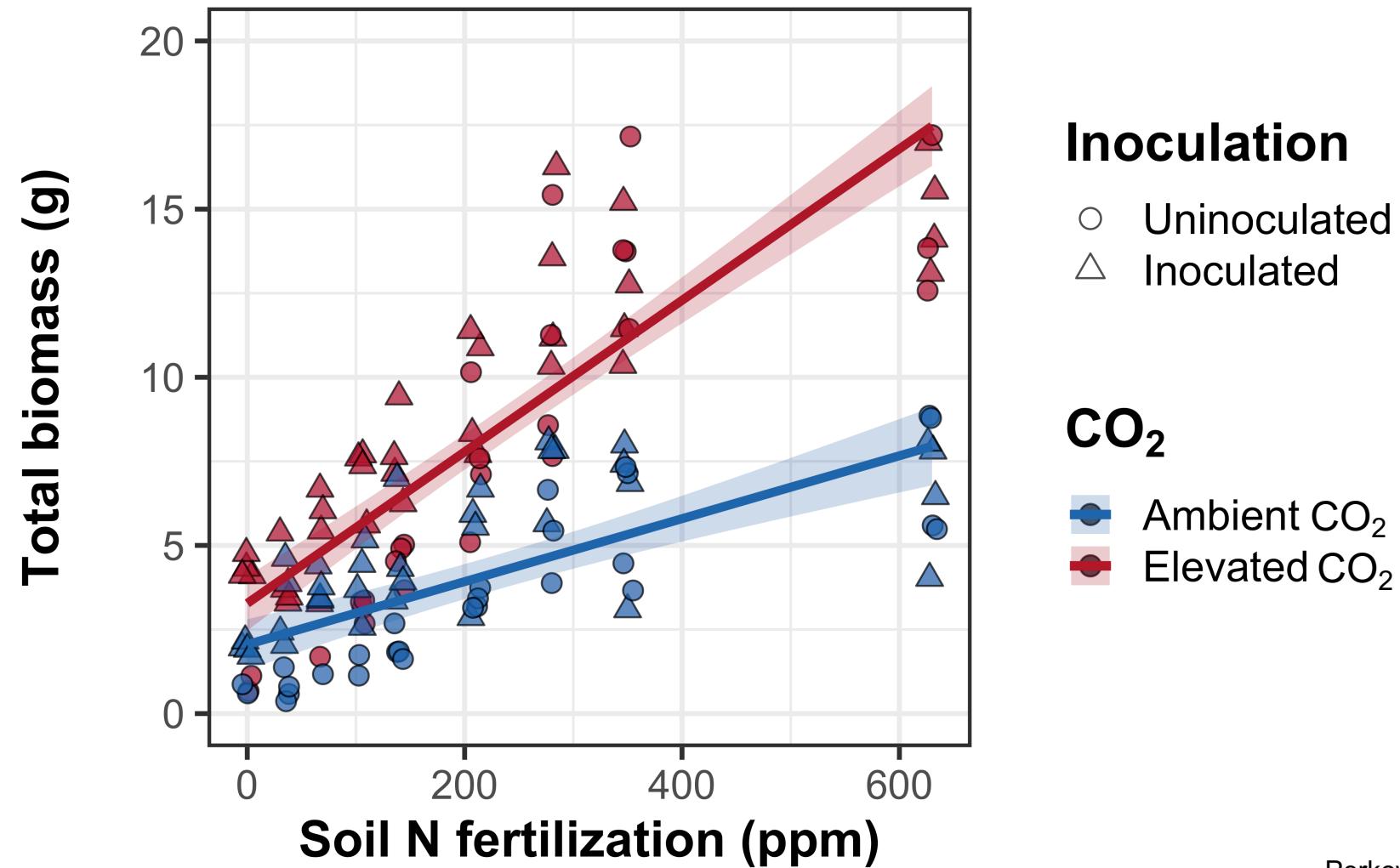
Elevated CO₂ **decreased** $V_{\text{cmax}25}$ **more strongly** than $J_{\text{max}25}$. Inoculation did not modify this effect

CO₂: **$p < 0.001$**
 Fertilization (N): **$p < 0.001$**
 Inoculation (I): **$p < 0.001$**
 CO₂*N interaction: **NS**
 CO₂*I interaction: **NS**



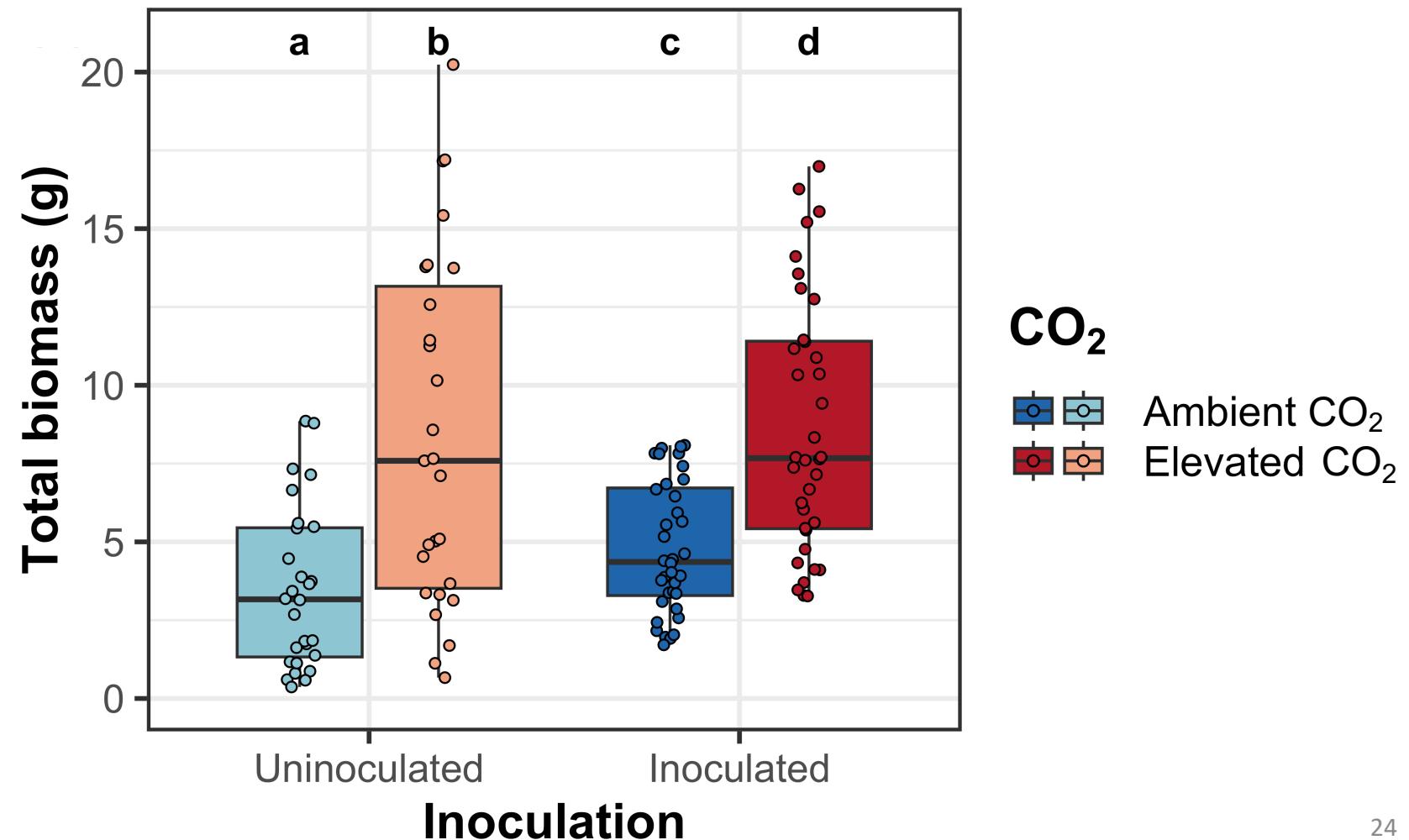
Increasing fertilization **increased** the positive effect of elevated CO₂ on whole-plant growth

CO₂: *p*<0.001
Fertilization (N): *p*<0.001
Inoculation (I): *p*<0.001
CO₂*N interaction: *p*<0.001



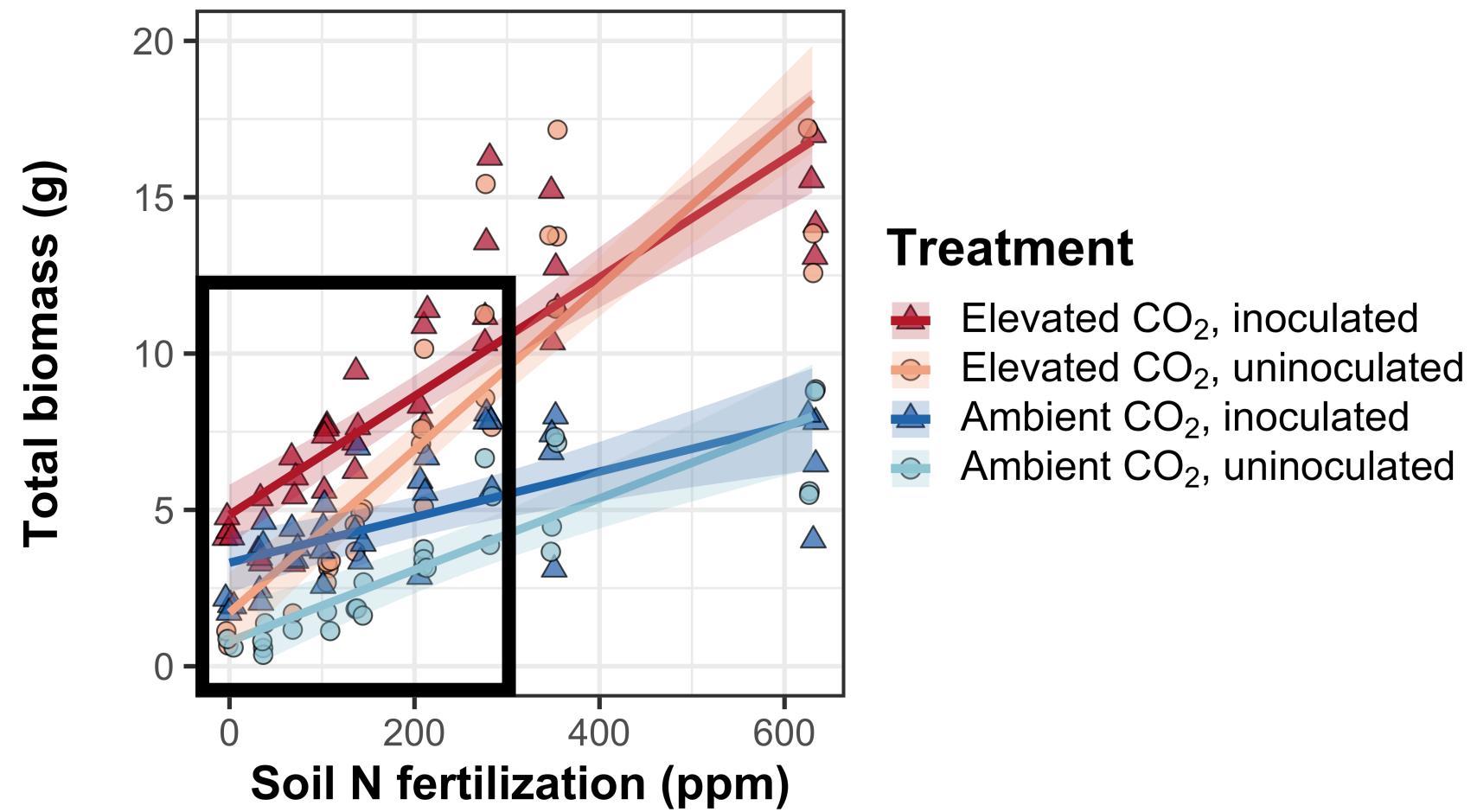
Inoculation did not modify the **positive** effect of eCO₂ on total biomass

CO₂: *p*<0.001
Fertilization (N): *p*<0.001
Inoculation (I): *p*<0.001
CO₂*N interaction: *p*<0.001
CO₂*I interaction: NS



However, inoculated plants had **greater** total biomass under low fertilization

CO_2 : $p<0.001$
Fertilization (N): $p<0.001$
Inoculation (I): $p<0.001$
 $\text{CO}_2 \times \text{N}$ interaction: $p<0.001$
 $\text{CO}_2 \times \text{I}$ interaction: NS

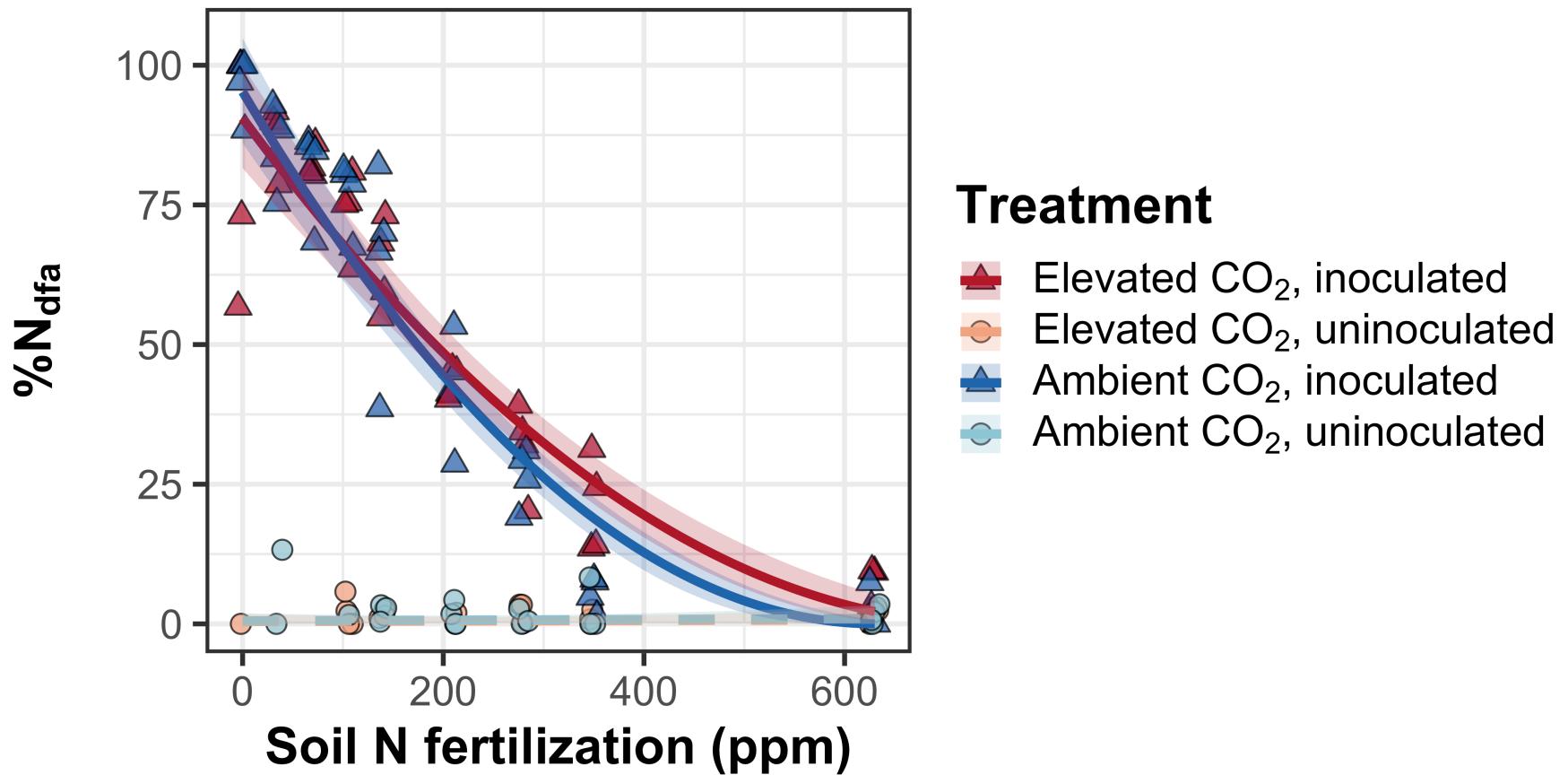


Treatment

- Elevated CO_2 , inoculated
- Elevated CO_2 , uninoculated
- Ambient CO_2 , inoculated
- Ambient CO_2 , uninoculated

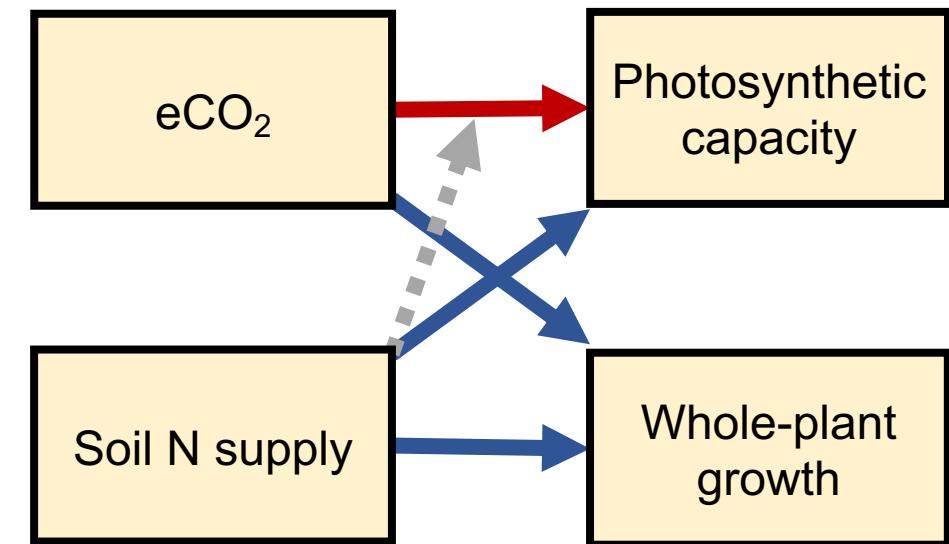
Increasing fertilization **decreased** the percent of leaf nitrogen content derived from the atmosphere

CO₂: NS
Fertilization (N): **p<0.001**
Inoculation (I): **p<0.001**
CO₂*N interaction: NS
CO₂*I interaction: NS

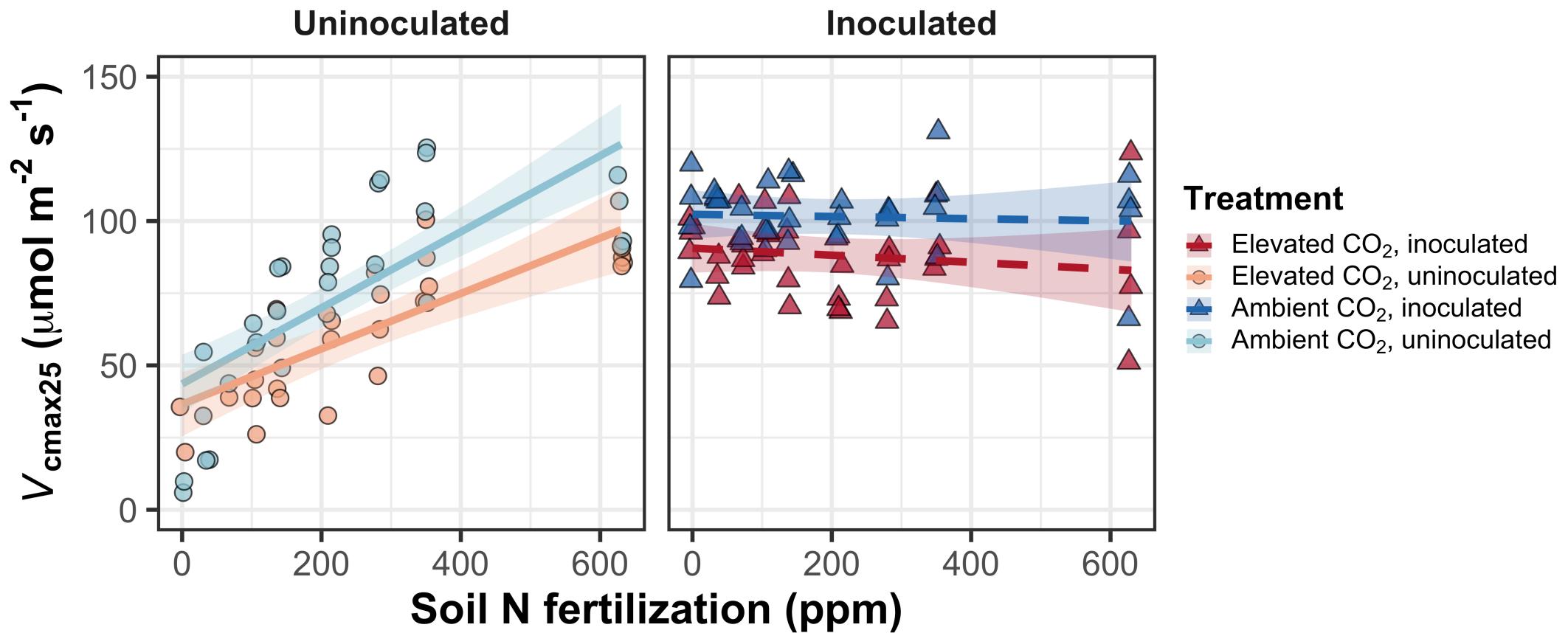


Conclusions

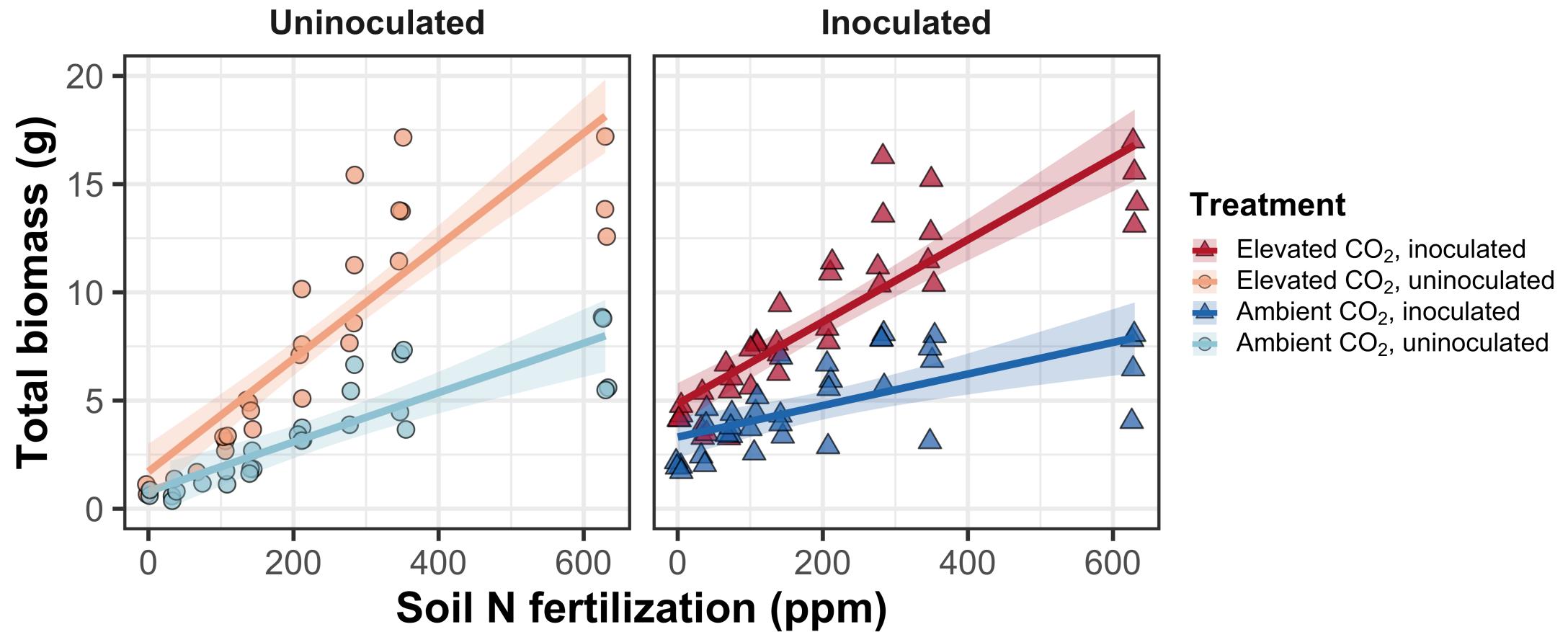
- N demand and supply control plant responses to eCO₂ at different scales
 - N supply → whole-plant response to eCO₂
 - N demand → leaf response to eCO₂



Increasing fertilization **increased** photosynthetic capacity, but only in uninoculated plants

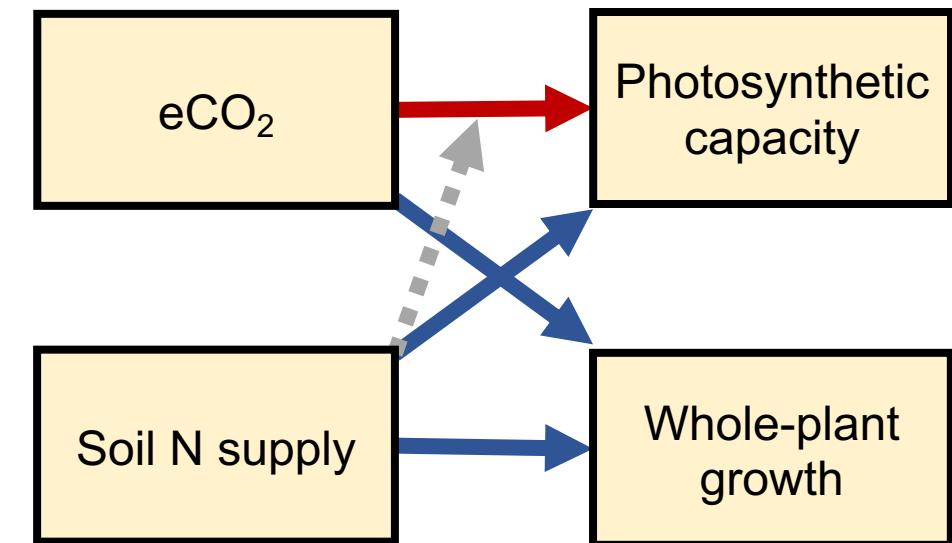


Increasing fertilization **increased total biomass more strongly** in uninoculated plants



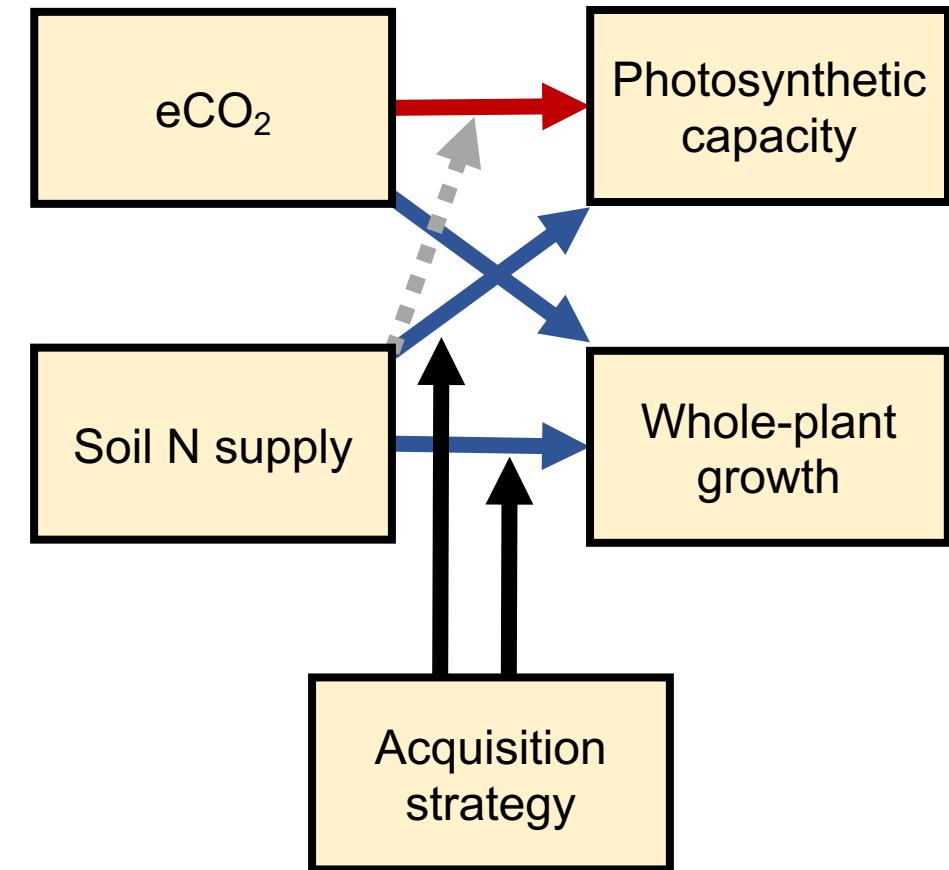
Conclusions

- N demand and supply control plant responses to eCO₂ at different scales
 - N supply → whole-plant response to eCO₂
 - N demand → leaf response to eCO₂



Conclusions

- N demand and supply control plant responses to eCO₂ at different scales
 - N supply → whole-plant response to eCO₂
 - N demand → leaf response to eCO₂
- Plant responses to fertilization are dependent on acquisition strategy



Acknowledgements



Mylea Lovell

TTU Phytotron manager



Alissar Cheaib

Smith Lab Post-doc



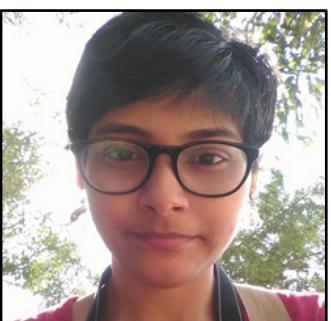
Eve Gray

Smith Lab MS student



Kelly Carroll

Smith Lab Manager



Snehanjana Chatterjee

Smith Lab PhD student



Isa Beltran

Smith Lab MS student



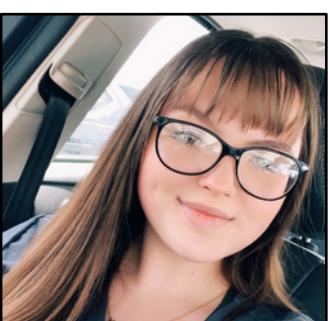
Brad Posch

Former Smith Lab Post-doc



Monika Kelly

Smith Lab MS student



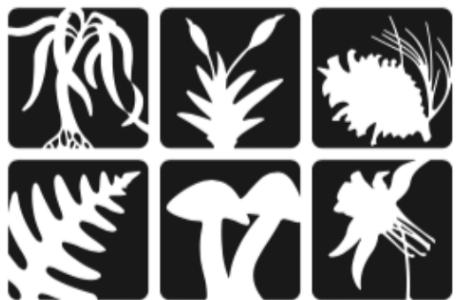
Hannah German

Smith Lab UG student



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Thank you!

