SPRUCE Nitrogen and Phosphorus Budgets

SPRUCE 2025 All Hands Meeting
13 May 2025
Minneapolis, MN

OAK RIDGE National Laboratory

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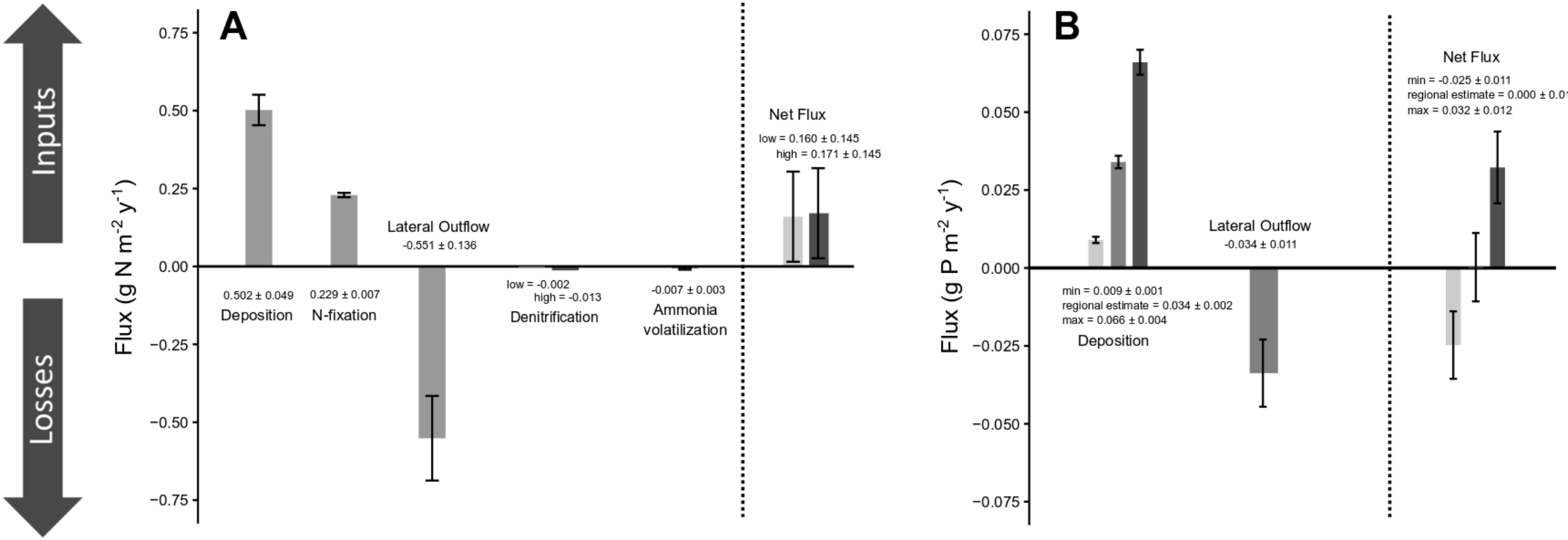
~On behalf of the broader SPRUCE team~

U.S. DEPARTMENT OF ENERGY

Pretreatment N & P Budget



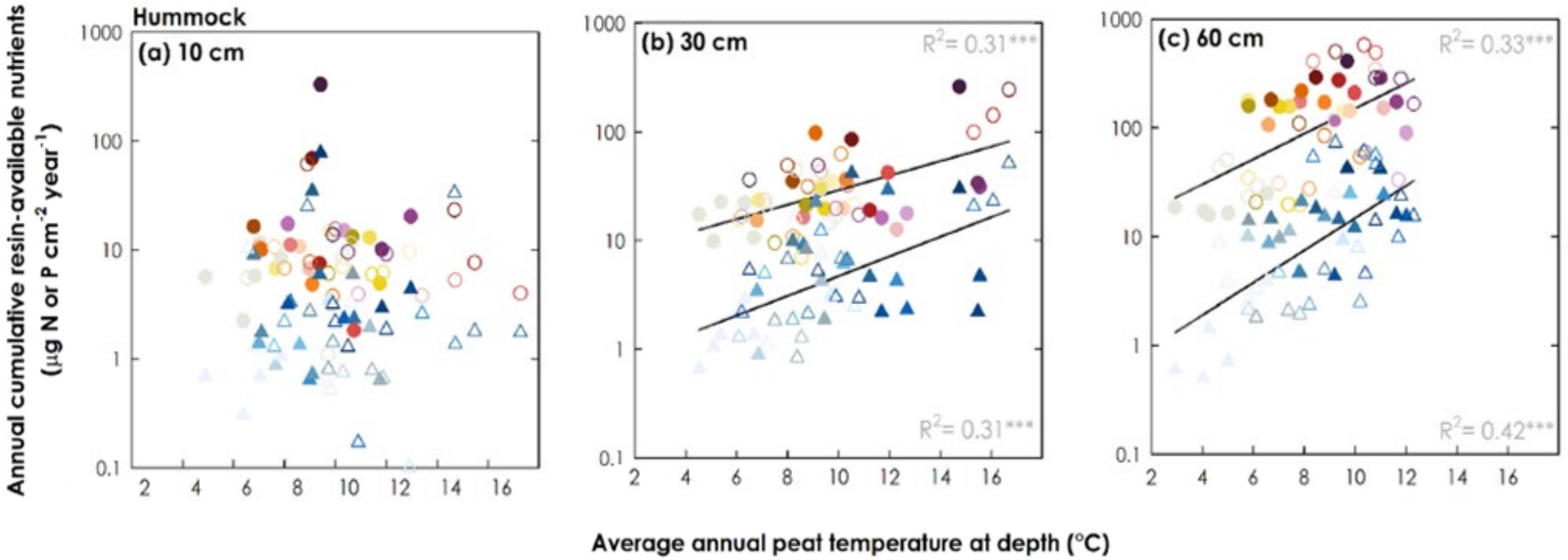
N & P colimitation

N accumulating at ~0.2 g N m^{-2} y^{-1}

Fluxes in/out of vegetation ~10x greater than in/out of ecosystem

Salmon et al. 2021

N & P availability increases with warming



- N and P availability increases with warming, especially below 30 cm
- Increases were concurrent with decline of *Sphagnum* moss
- Later years see **negative** interaction between warming and eCO2 in surface soils

Iversen et al. 2022; Petro et al. 2023

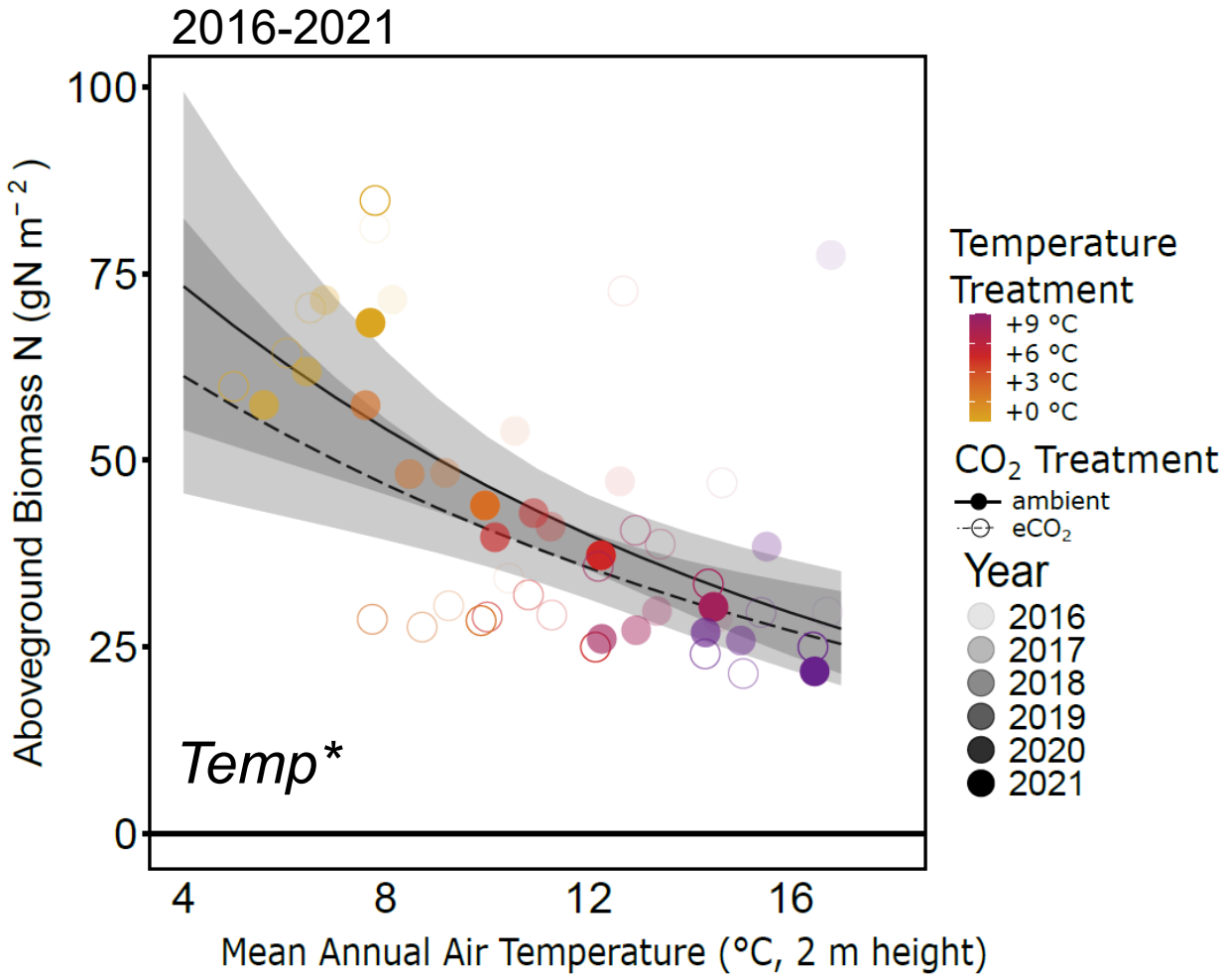
Science Question:

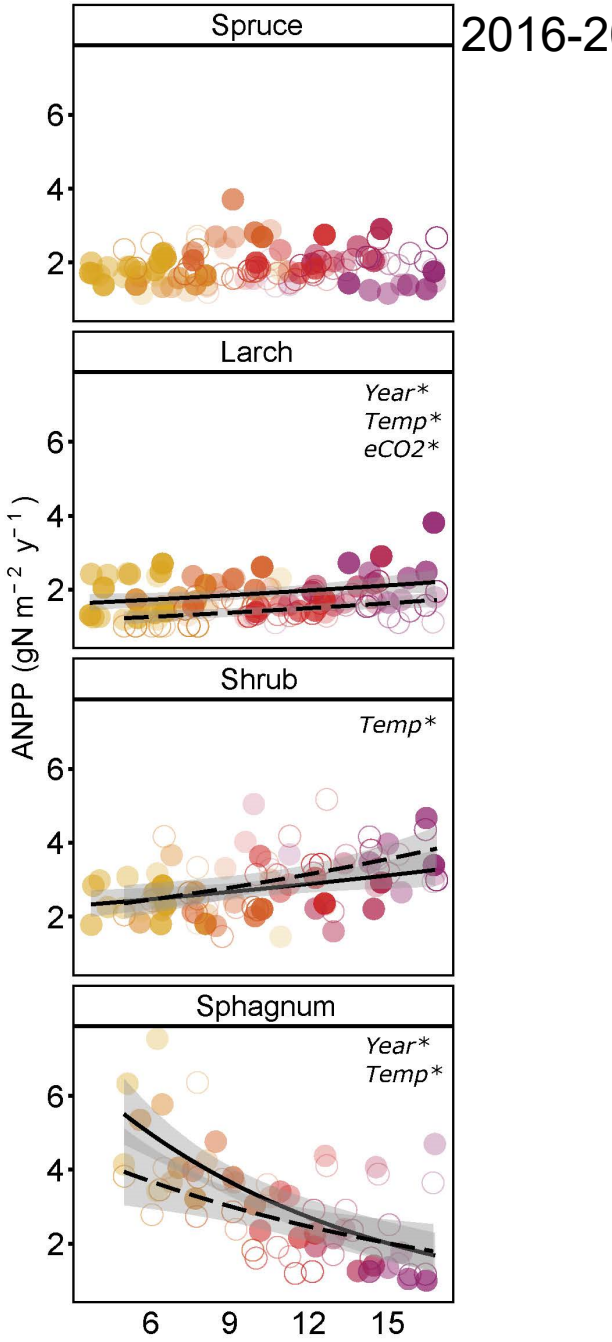
Are plants acquiring more nutrients with warming?

Is there evidence of changing nutrient limitation?

2016-2023
Aboveground Biomass
Aboveground NPP
%CNP
preliminary values

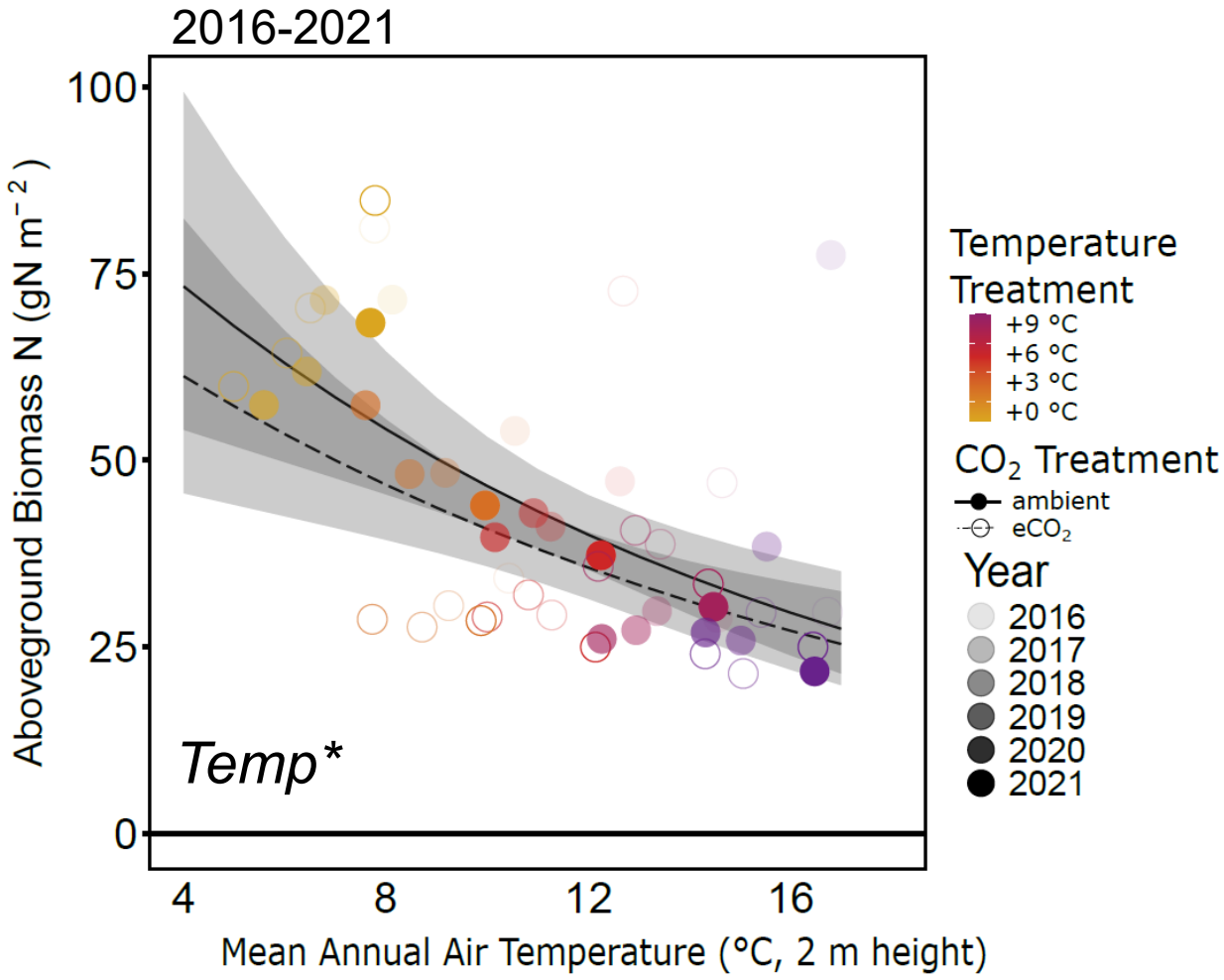
Sphagnum N losses with warming dominate

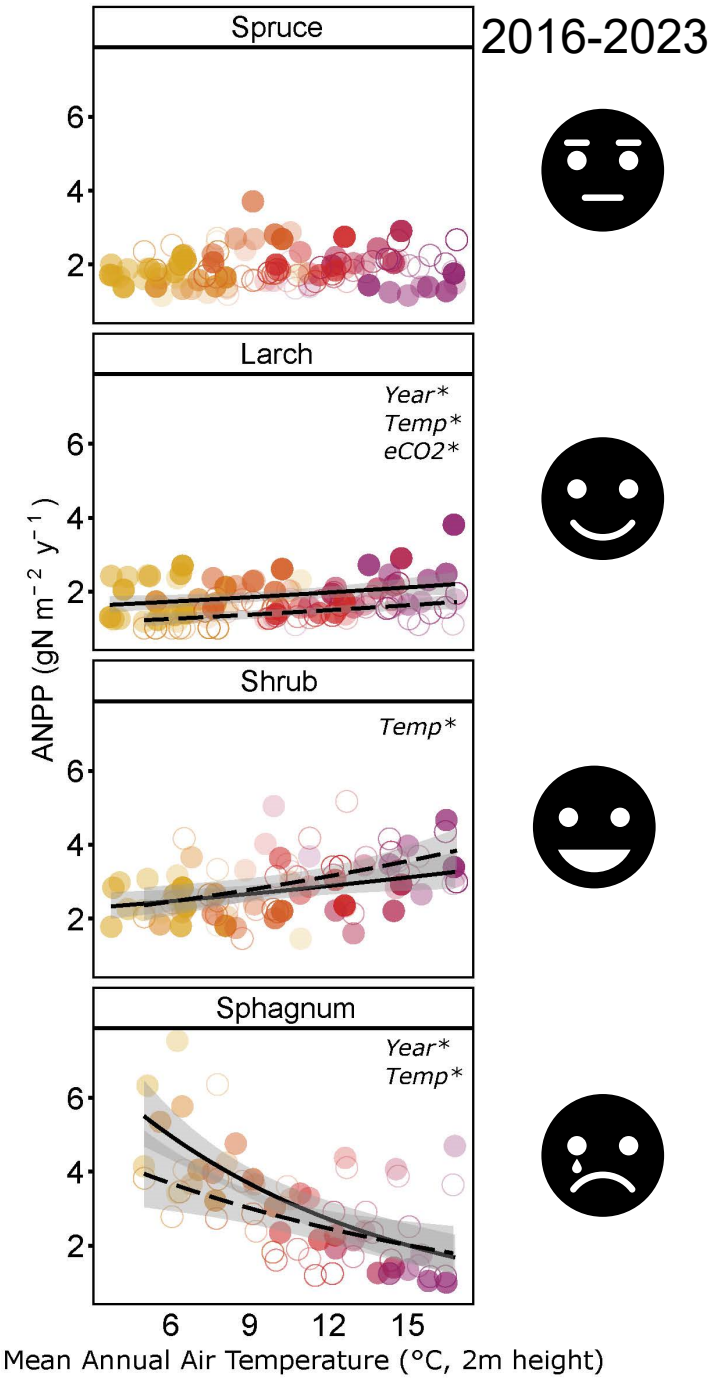




N~ Year + Temp + eCO2 + Temp x eCO2

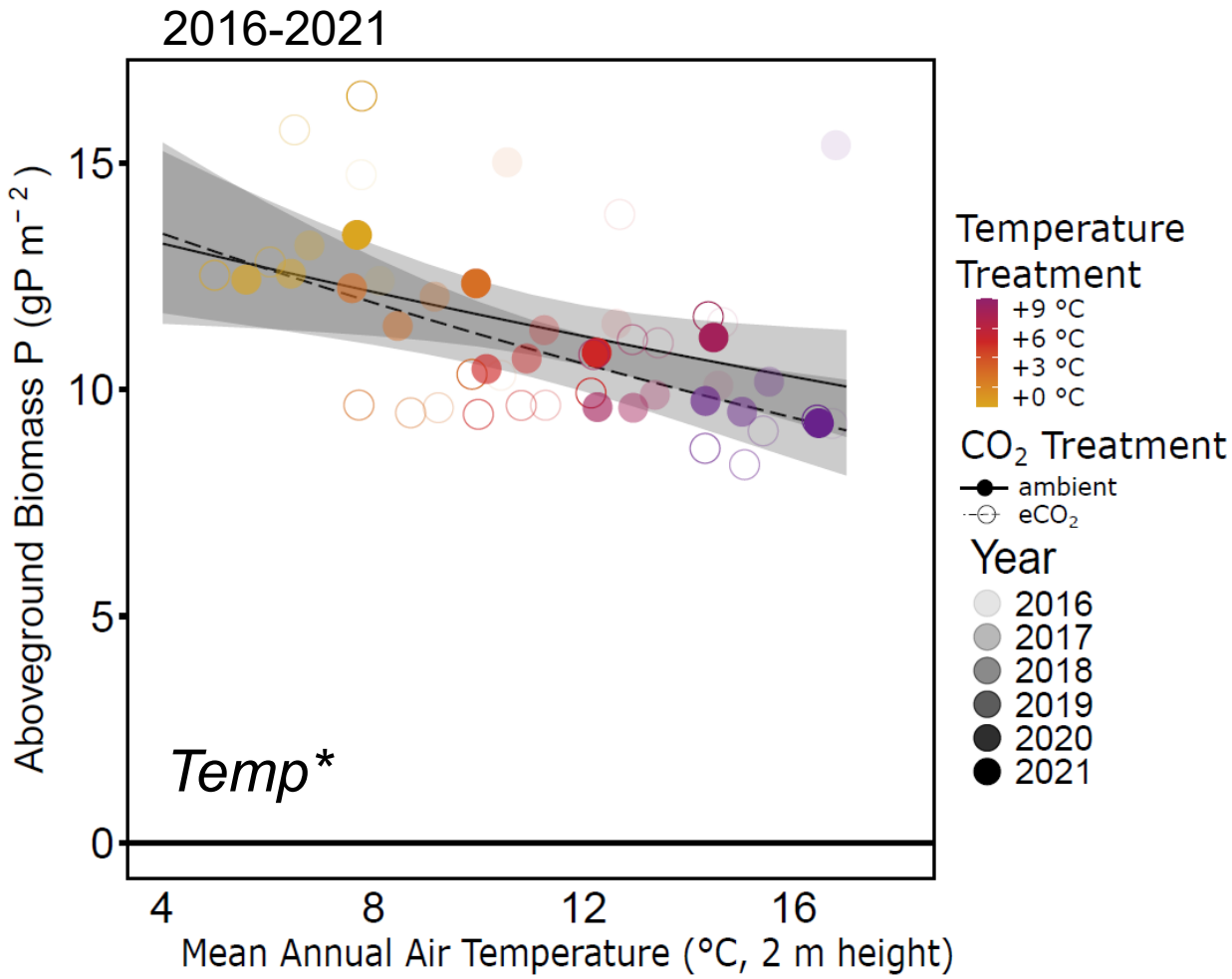
Sphagnum N losses with warming dominate

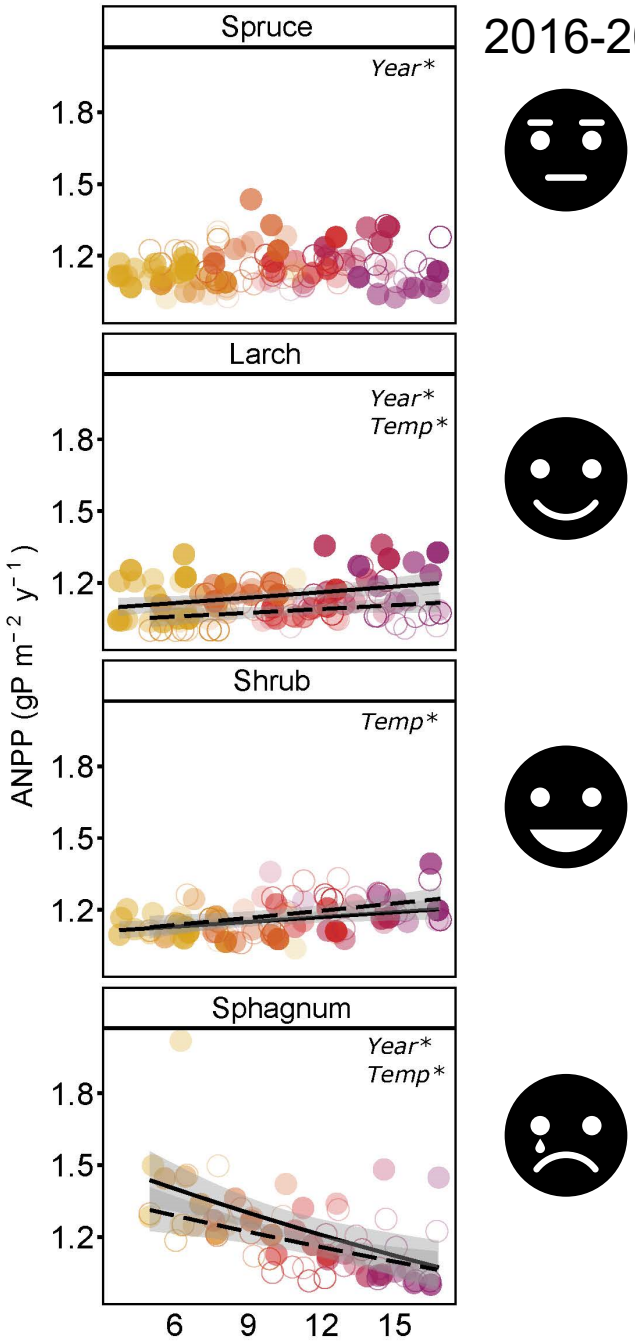




N~ Year + Temp + eCO2 + Temp x eCO2

Sphagnum P losses with warming dominate (less)

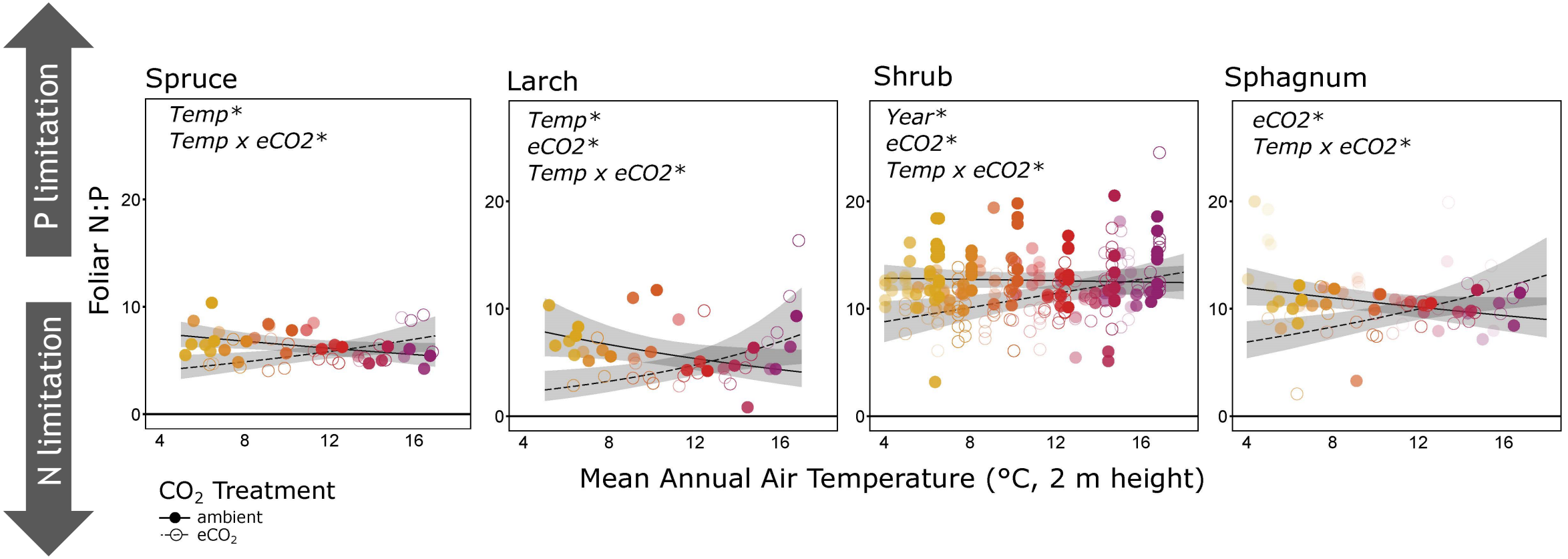




2016-2023

P~ Year + Temp + eCO2 + Temp x eCO2

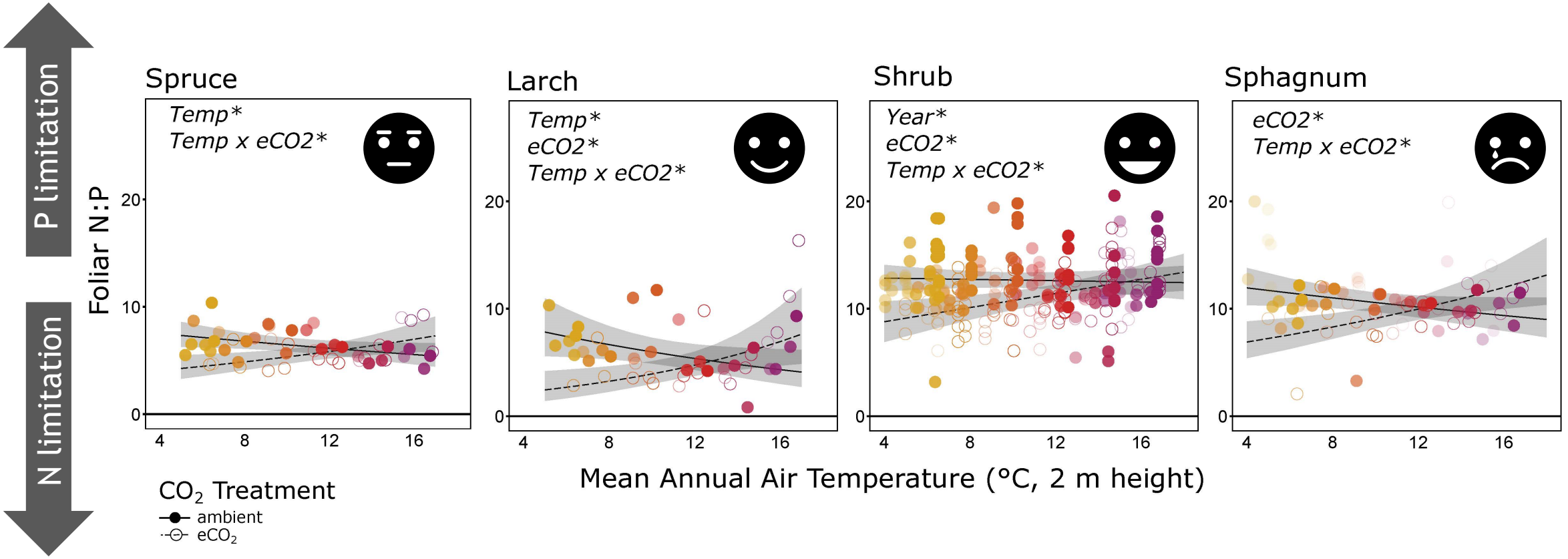
All PFTs show increasing P-limitation with warming & eCO_2



2016-2023

N:P~ Year + Temp + eCO2 + Temp x eCO2 + (1|Plot)

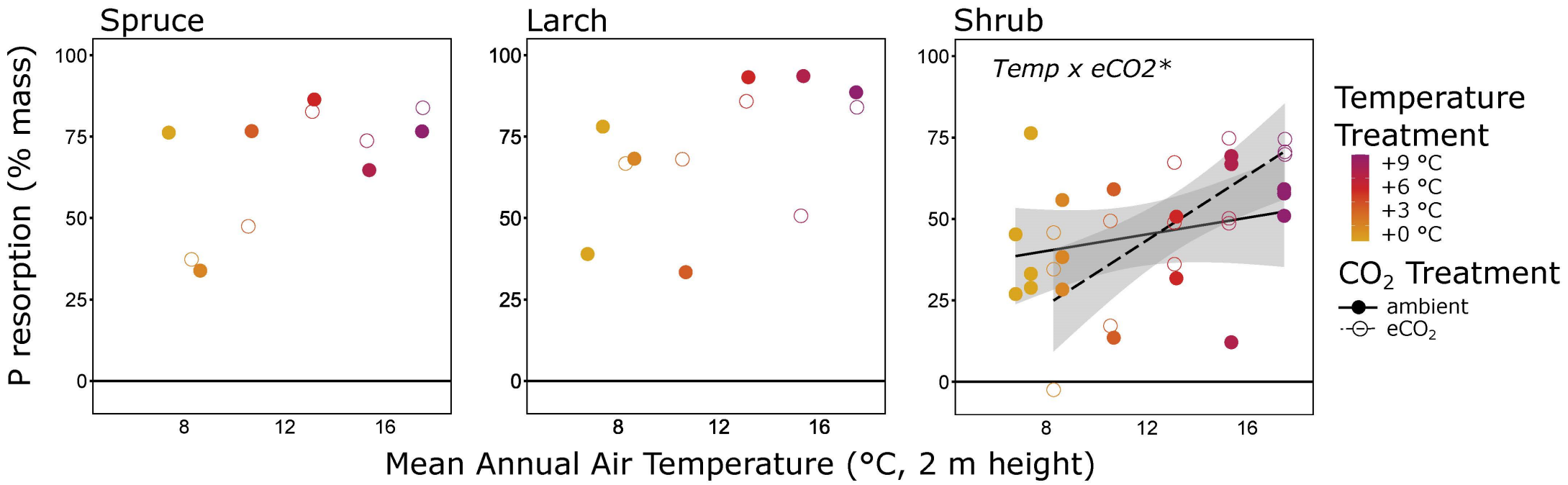
All PFTs are increasingly P-limited with warming & eCO_2



2016-2023

N:P~ Year + Temp + eCO2 + Temp x eCO2 + (1|Plot)

Shrubs are increasingly efficient at resorbing P with warming & eCO_2



2024

P resorption ~ Temp + eCO2 + Temp x eCO2

Warming x eCO_2 interactions

This dataset:

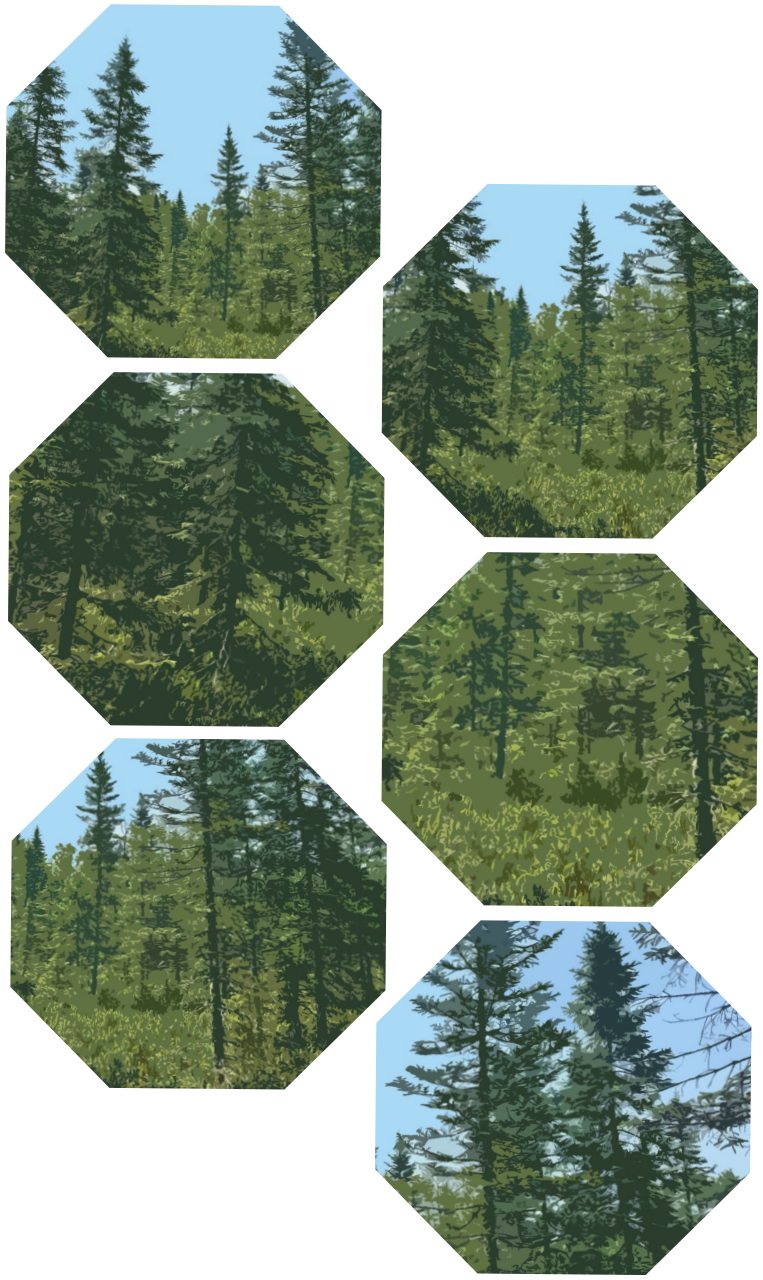
- Increasing P limitation with combined warming and eCO2, not related to ANPP
- Shrubs have increased P resorption efficiency with combined warming and eCO2

Other Insights:

- 2023 Aboveground biomass of shrubs has **positive** interaction between warming and eCO2 (Hanson et al. 2025)
- Fine root pool of shrubs has **positive** interaction between warming and eCO2 (Weber et al. In prep)

Sampling plans

- Sphagnum depth and density
- Litter resorption per unit leaf area
- Cohorts of Spruce needles
- Woody tissue %NP
- Coarse roots allometries
- Fine root productivity, biomass, NP
- Peat NP
- NP in deposition versus outflow
- NP in porewater



Are plants acquiring more nutrients with warming?

- Aboveground biomass N & P pools are decreasing with warming, N is decreasing more than P
- Loss of *Sphagnum* pools and fluxes have not been compensated for by aboveground N & P cycling of other PFTs
- Shrubs and Larch show signs of increasing N & P acquisition warming

Is there evidence of changing nutrient limitation?

- All PFTs show signs of increasing P limitation when warming and eCO2 are combined
- P limitation does not appear to be driven by demand of PFT
- Successful shrubs may be accumulating P and causing P limitation of other PFTs