

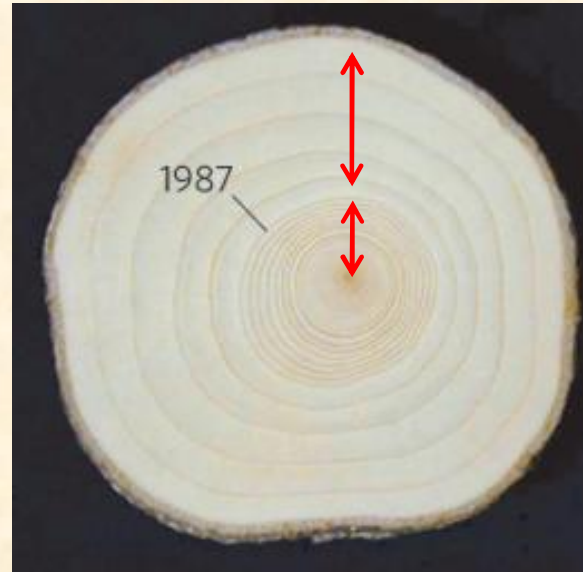
A photograph of a boreal forest. The ground is covered in a thick, vibrant green carpet of feathermoss. Tall, slender evergreen trees stand in the background, their trunks visible through the canopy. The lighting is soft, suggesting an overcast day. The overall scene is a lush, green forest floor.

Nitrogen Fixation in Boreal Feathermoss Communities

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Boreal Forest N Limitation

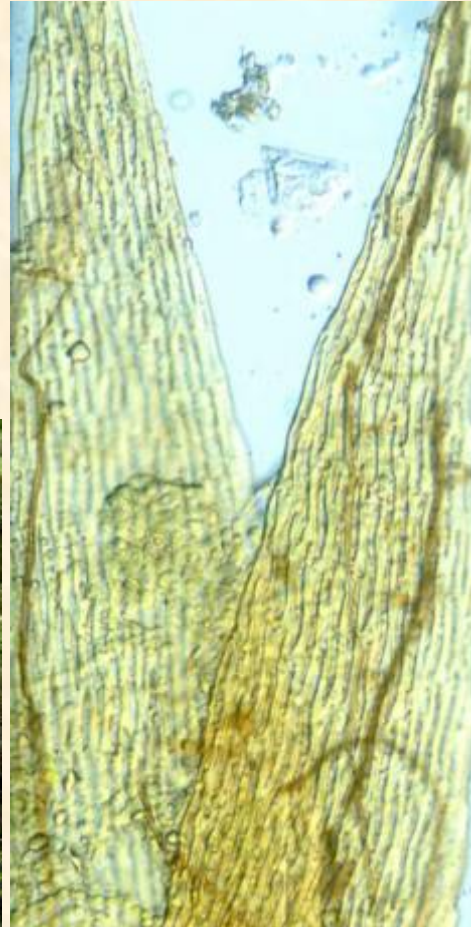


After N fertilization

Before N fertilization

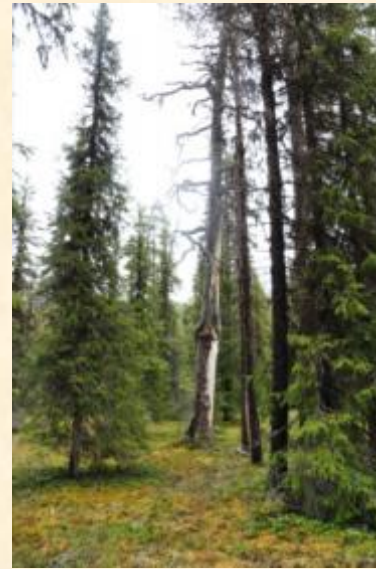
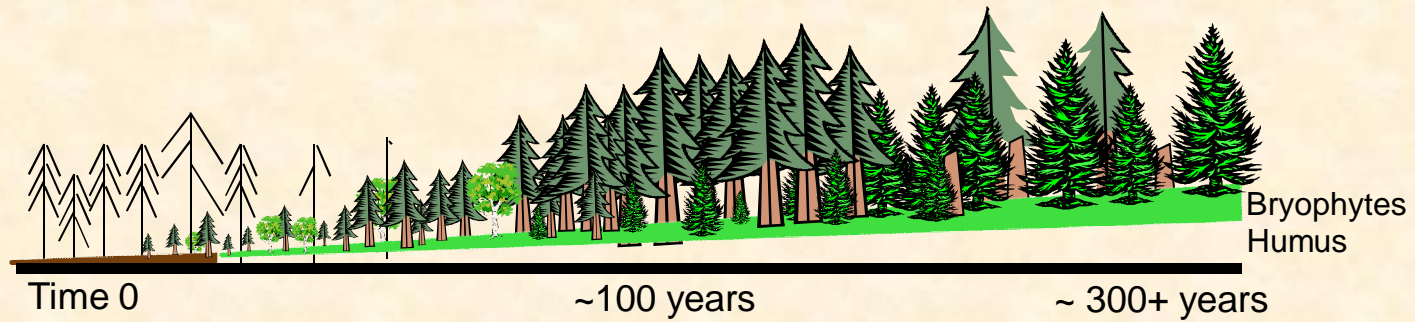
Photo by Sune Linder, in Högberg, 2007, Nature

Feathermoss-Cyanobacteria



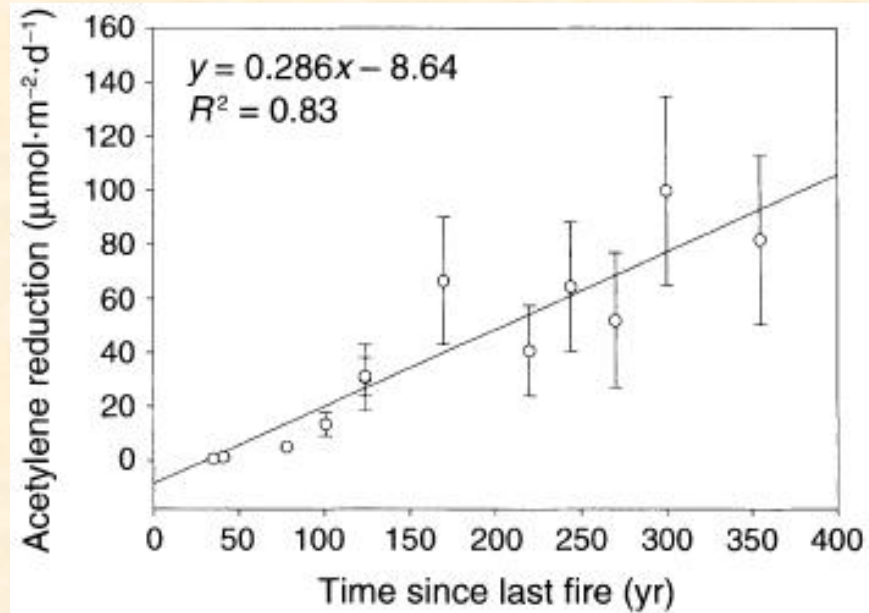
DeLuca, Zackrisson, Nilsson, Sellstedt, Nature, 2002

2y Succession



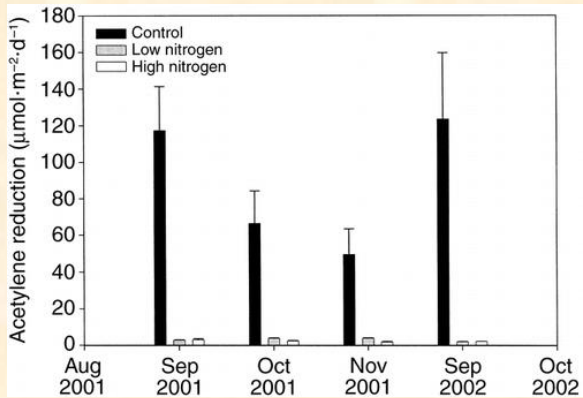
N-fixation and 2y succession

Zackrisson, DeLuca, Nilsson, Sellstedt, Berglund, 2004, Ecology

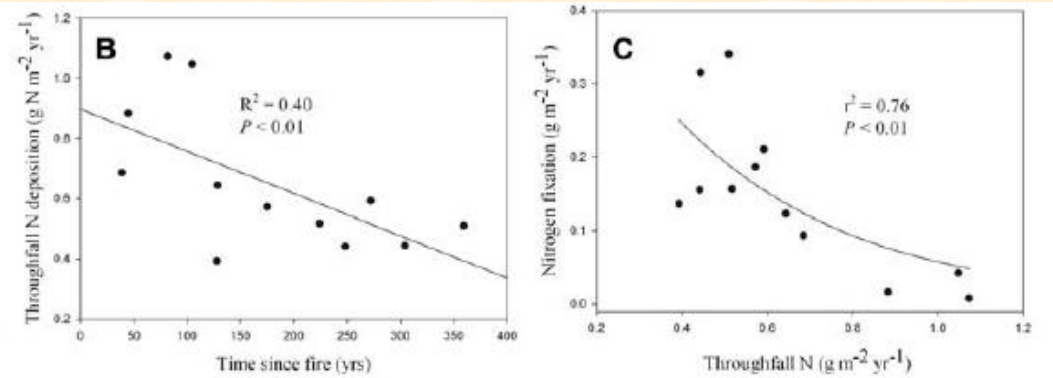


N-Cycle Feedbacks

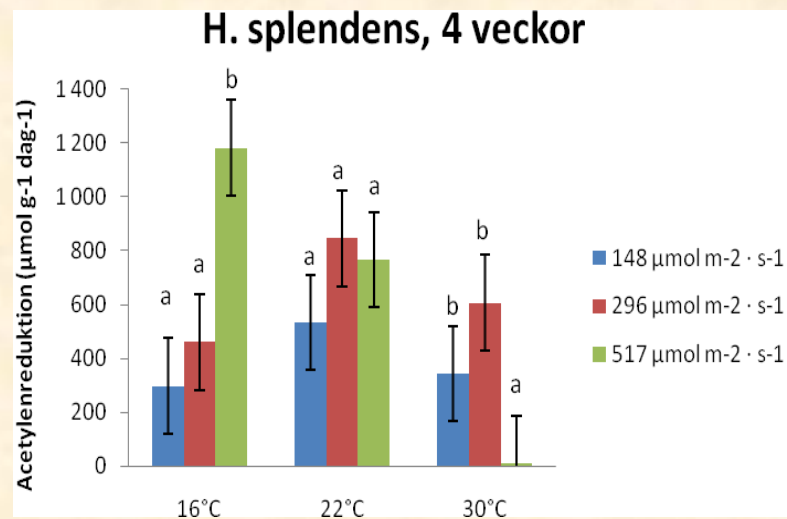
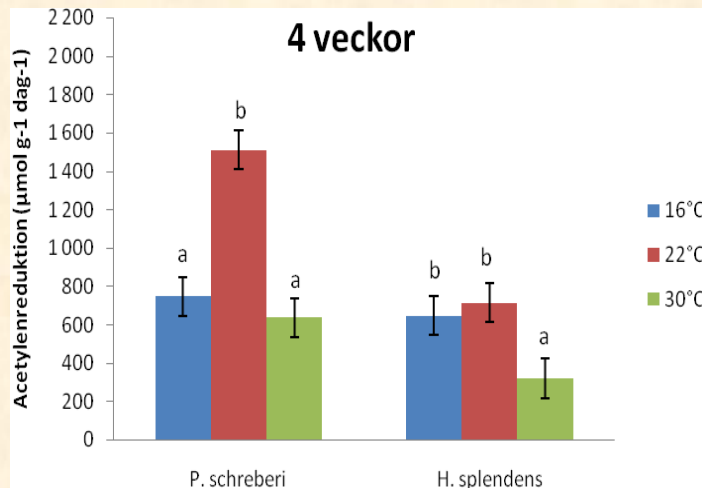
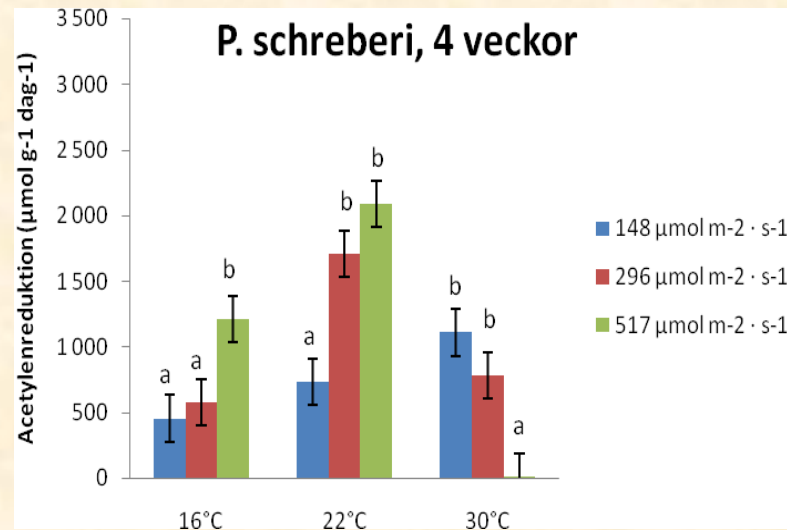
Zackrisson, et al. 2004, Ecology



DeLuca, Zackrisson, Gundale, Nilsson 2008, Science

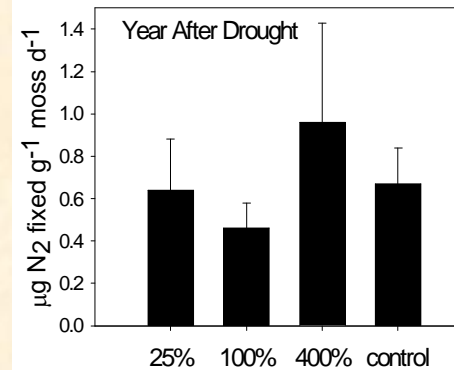
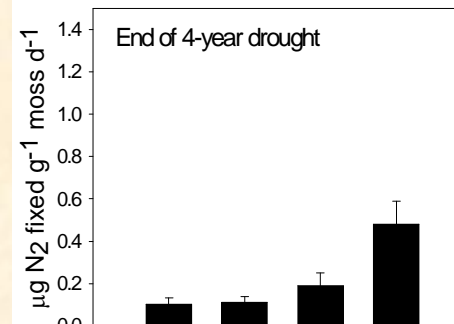
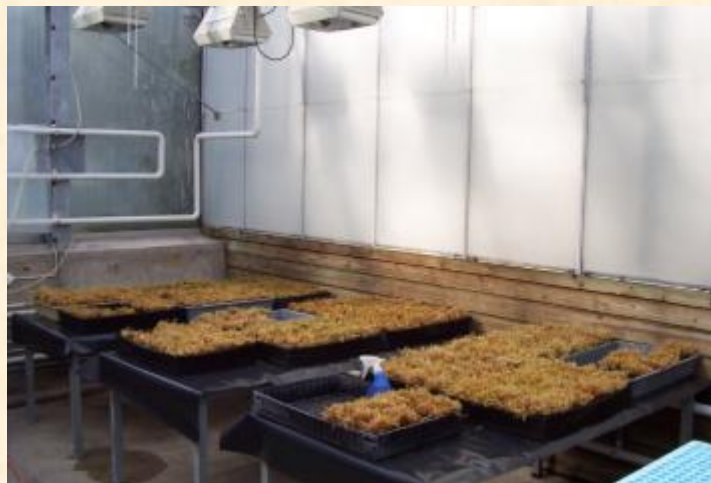
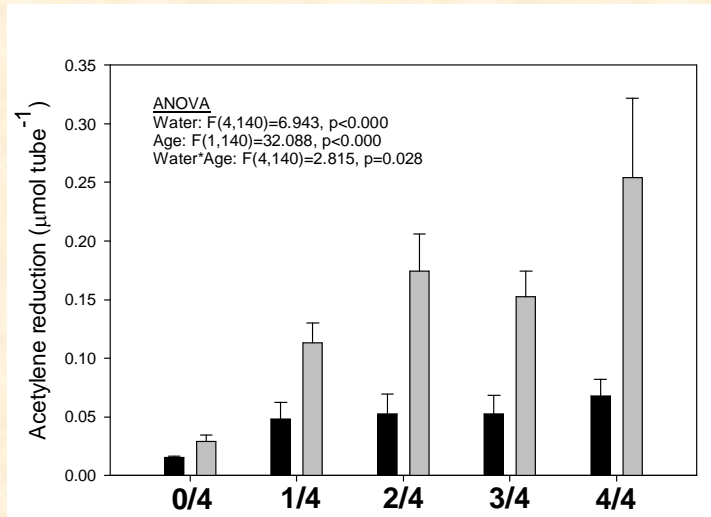


Abiotic: Light and Temperature



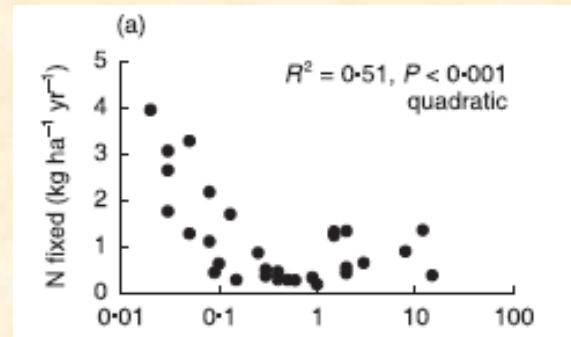
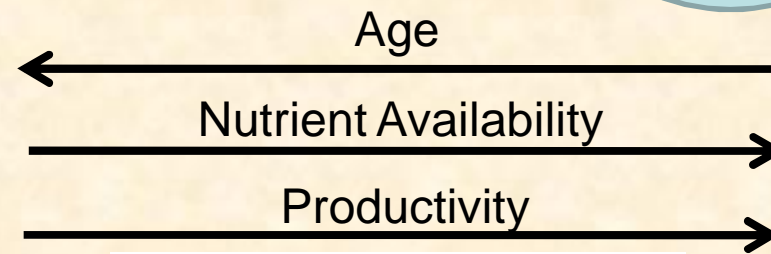
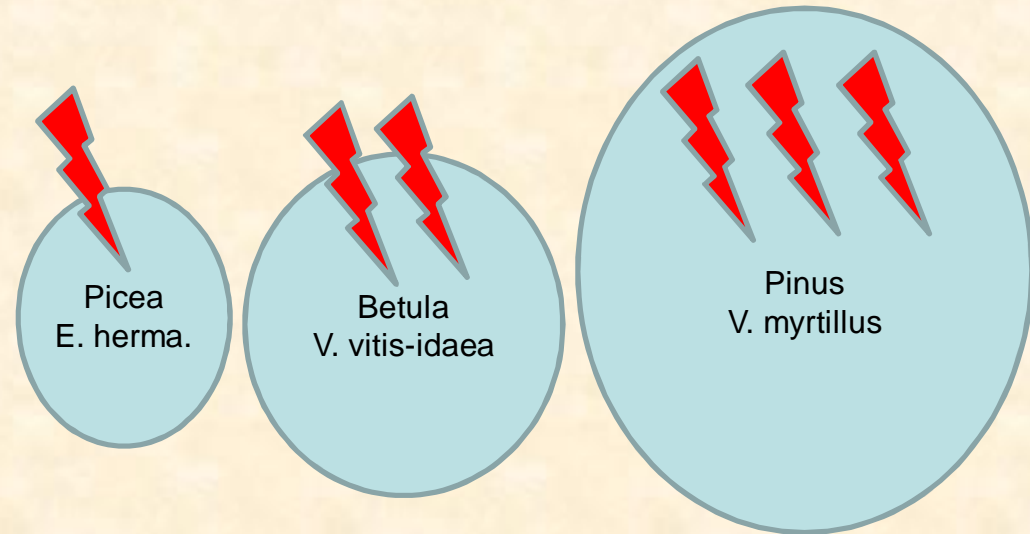
Abiotic controls: Water

Gundale, Gustafsson, Nilsson, CJFR 2009



Gundale and Nilsson, In prep

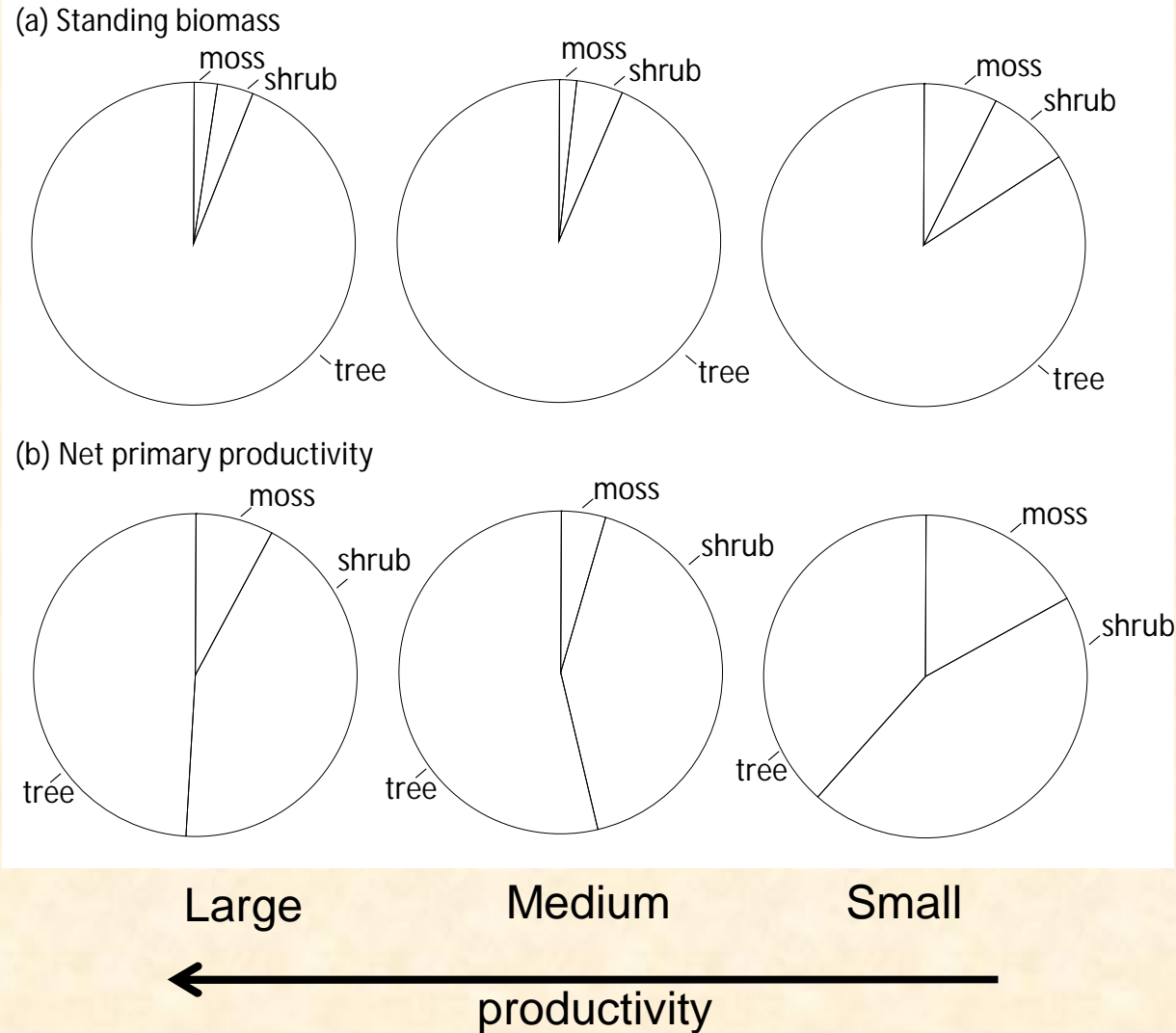
Vascular Plant Interactions



Lagerström et al 2007, Functional Ecology

Bryophyte Biomass and NPP

Wardle, Jonsson, Bansal, Bardgett, Gundale, and Metcalfe, In Review



Bryophyte-Vascular Plant Interactions

Shrub Species removal:

+/- *V. myrtillis*

+/- *V. vitis-idaea*

+/- *E. hermaphraditum*

Functional Group Removal:

+/- shrubs

+/- tree roots

+/- bryophytes



Positive Interactions!

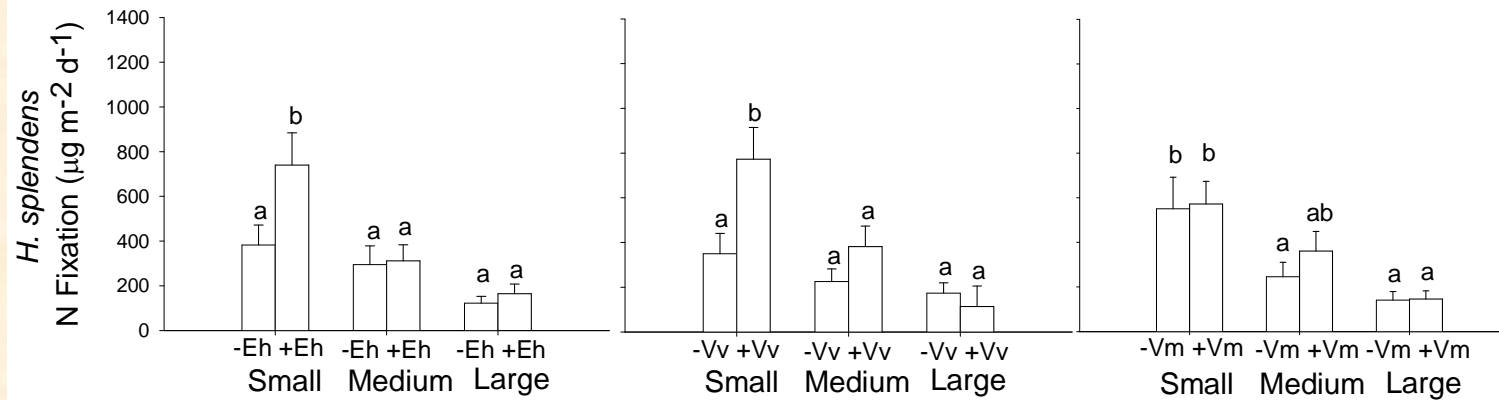
+/- Eh



+/- Vv



+/- Vm

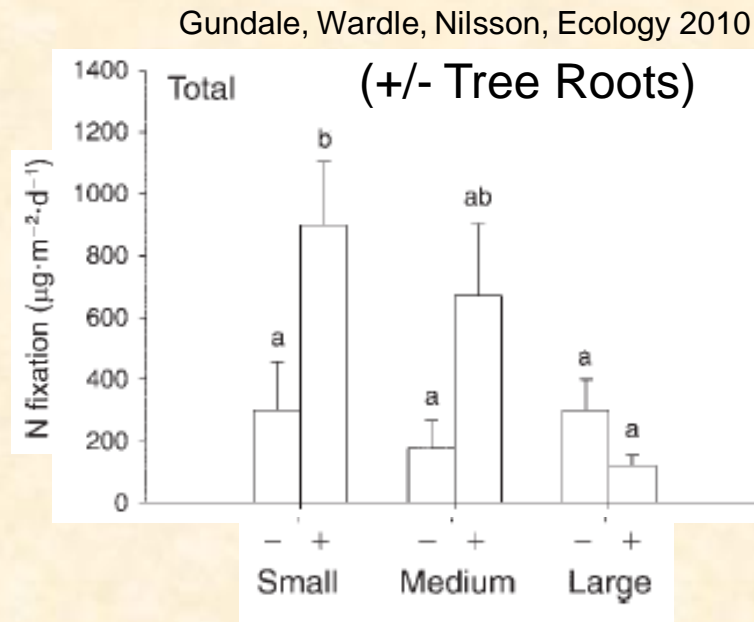


Gundale, Wardle, Nilsson, Ecology, 2010

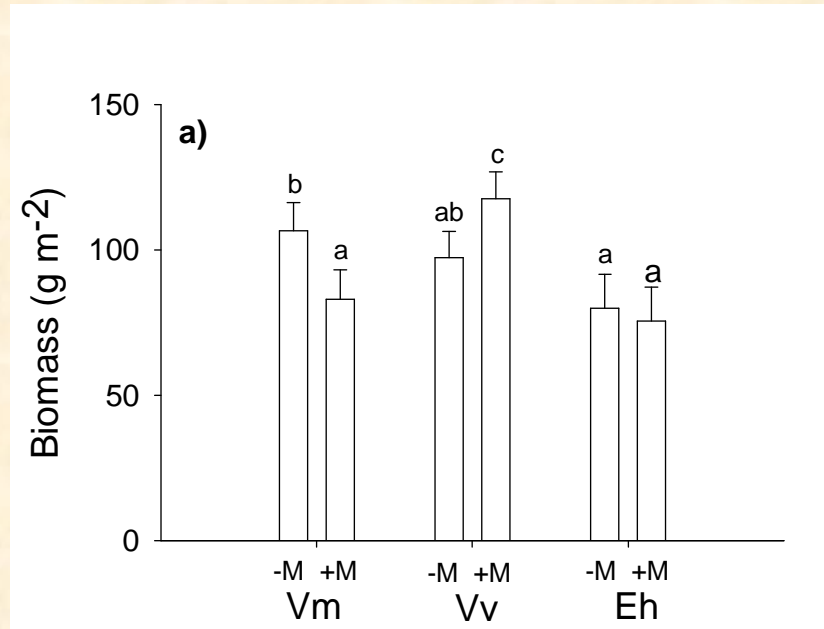
More Positive Interactions!



Shrub removal nearly significant: $p=0.073$



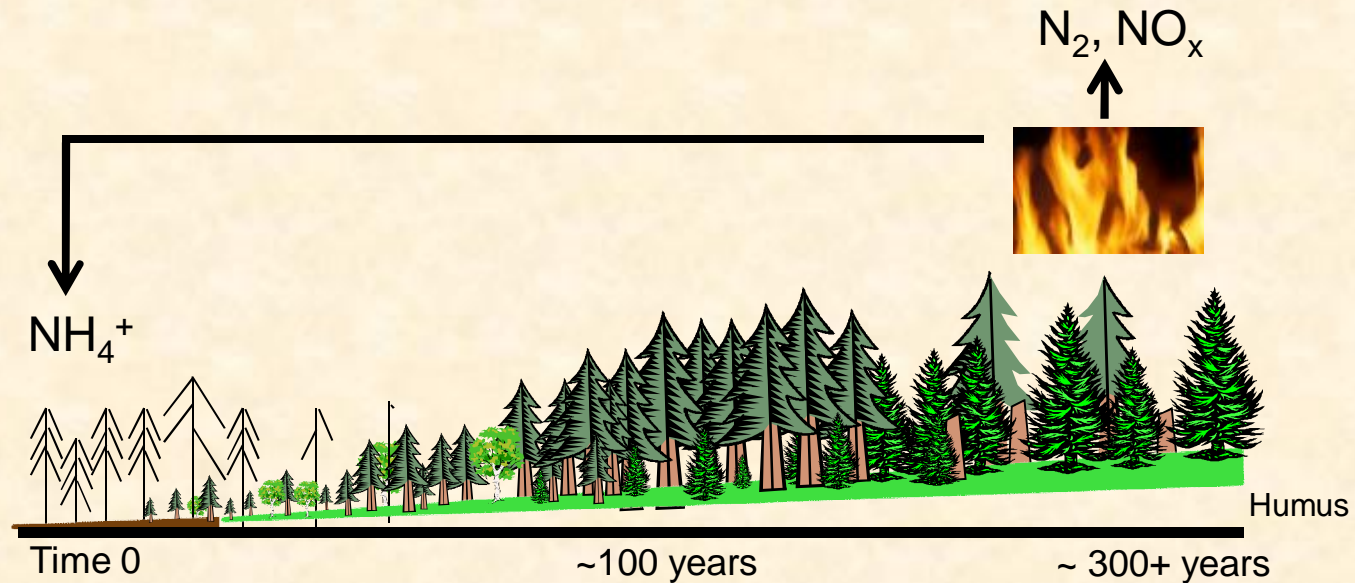
Reciprocal interactions!



Gundale, Hyodo, Nilsson & Wardle, In Prep

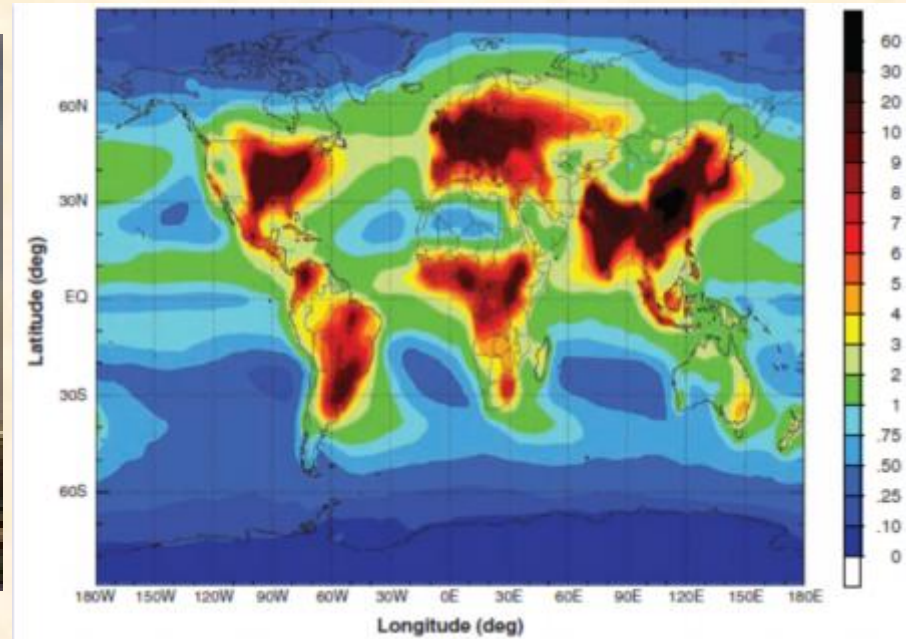


N-fixation and 2y Succession



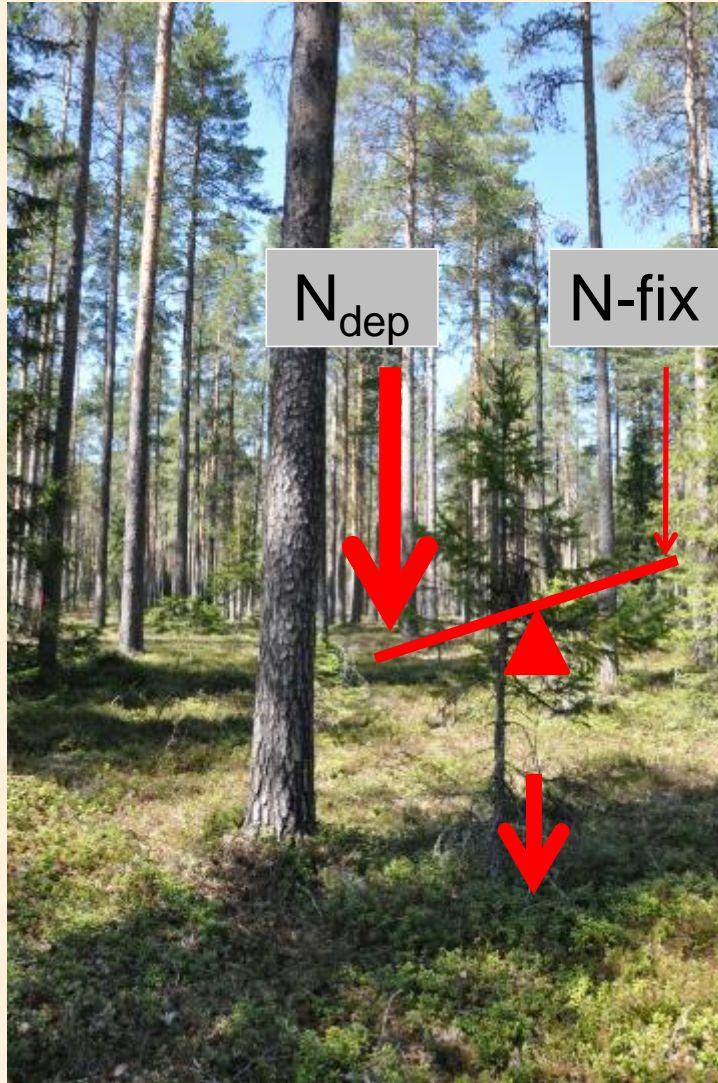
- N-fixation supports bryophyte productivity AND slow growing vascular plant species
- N-fixation indirectly supports high productivity through the fire cycle

N Deposition and Bryophytes



Galloway *et al.* Science 2008

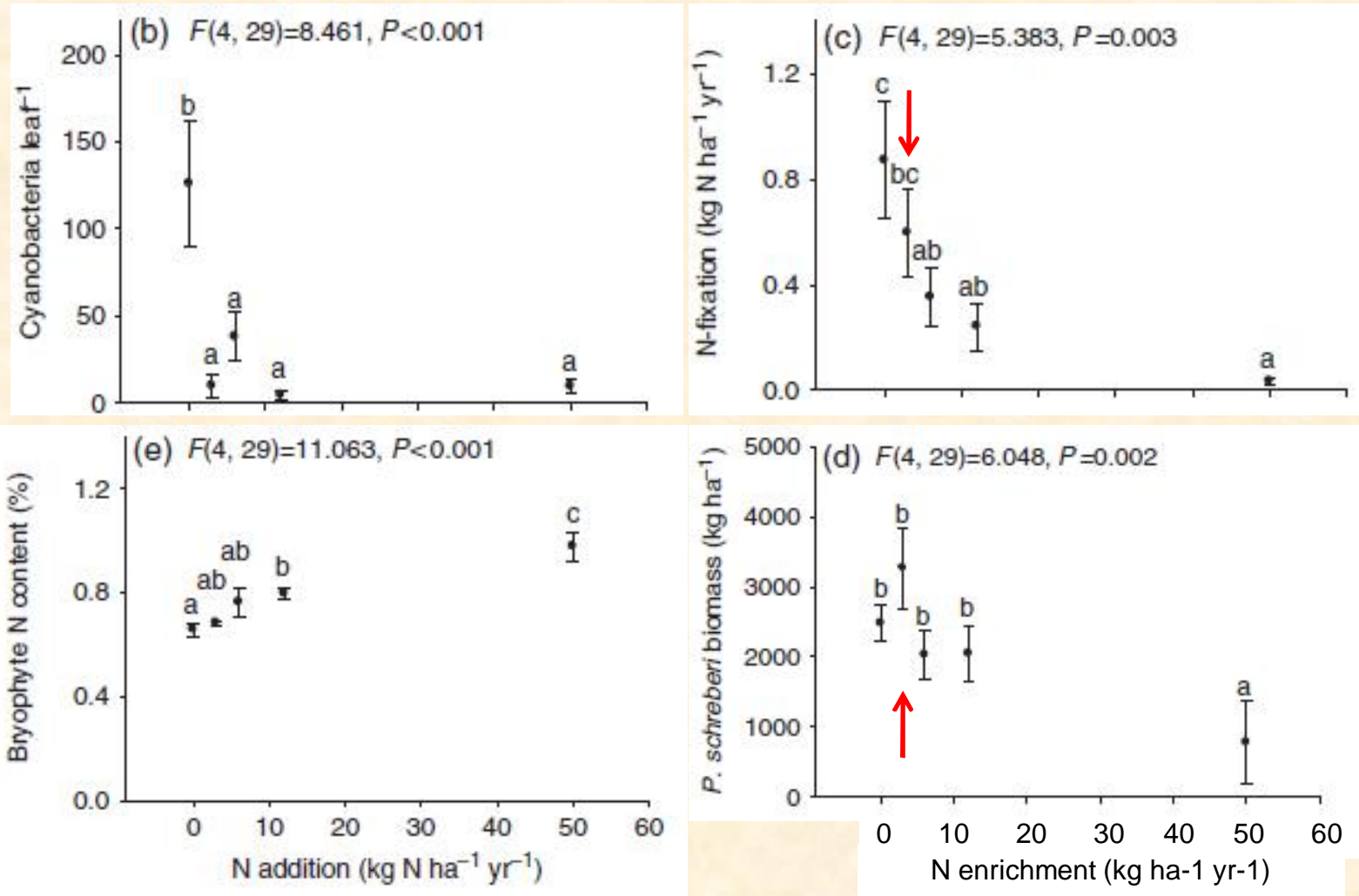
"Bryophyte Effect"



Experimental Design

- NH_4NO_3 since 2005 (4 years).
- 0, 3, 6, 12, 50 $\text{kg ha}^{-1} \text{ yr}^{-1}$.
- 0.1 ha plots
- N=6 replicates

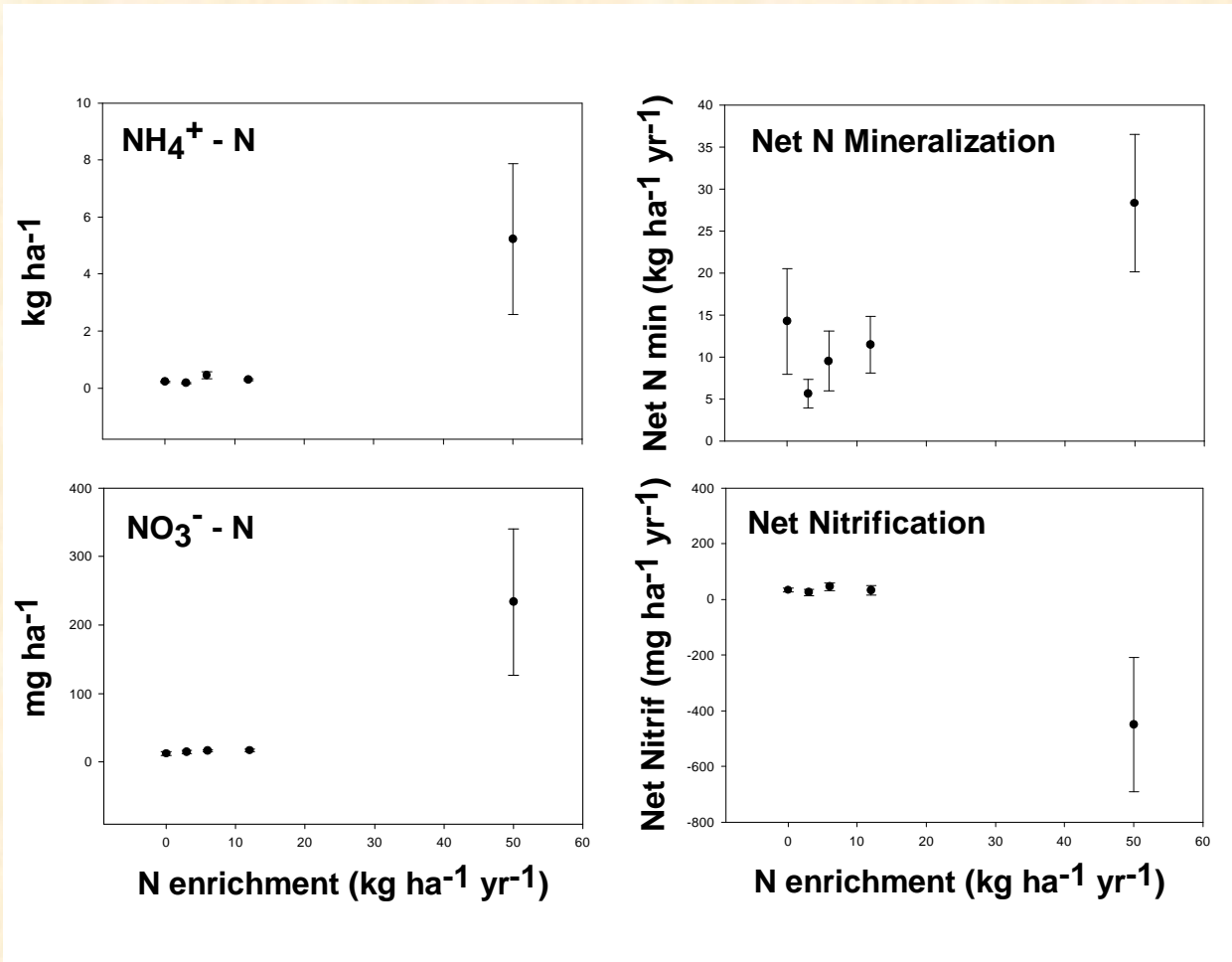
Bryophyte-Cyano Response



Bryophyte N Budget

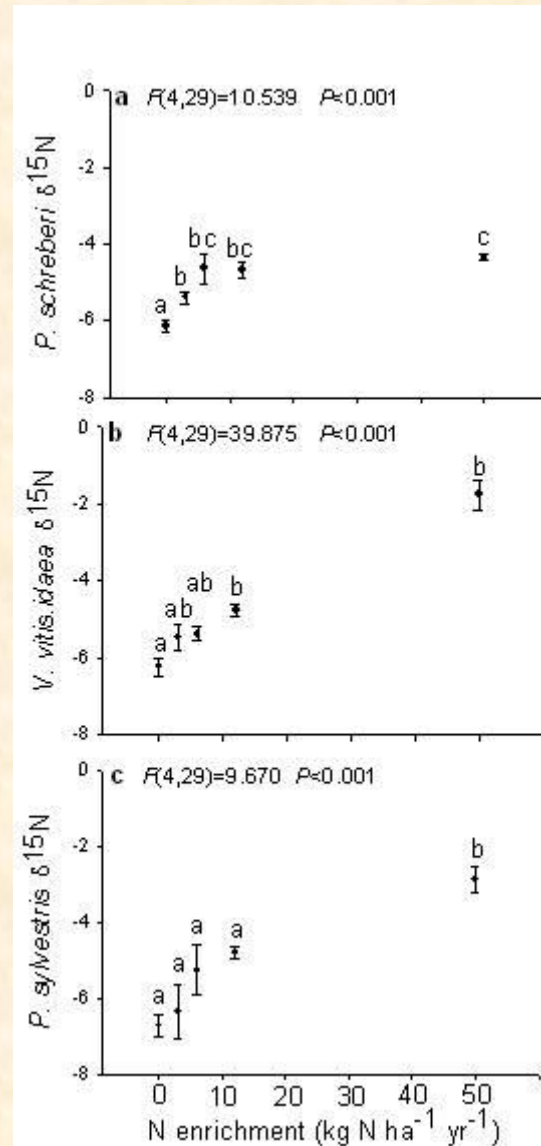
	3 kg ha ⁻¹ yr ⁻¹	50 kg ha ⁻¹ yr ⁻¹
Total N (x 4 years)	12	200
<i>P. schreberi</i> N	5.7	-8.8
N-fix offset	1.1	3.4
Total	6.8	-5.4
	56.7%	-2.7%

Soil Response

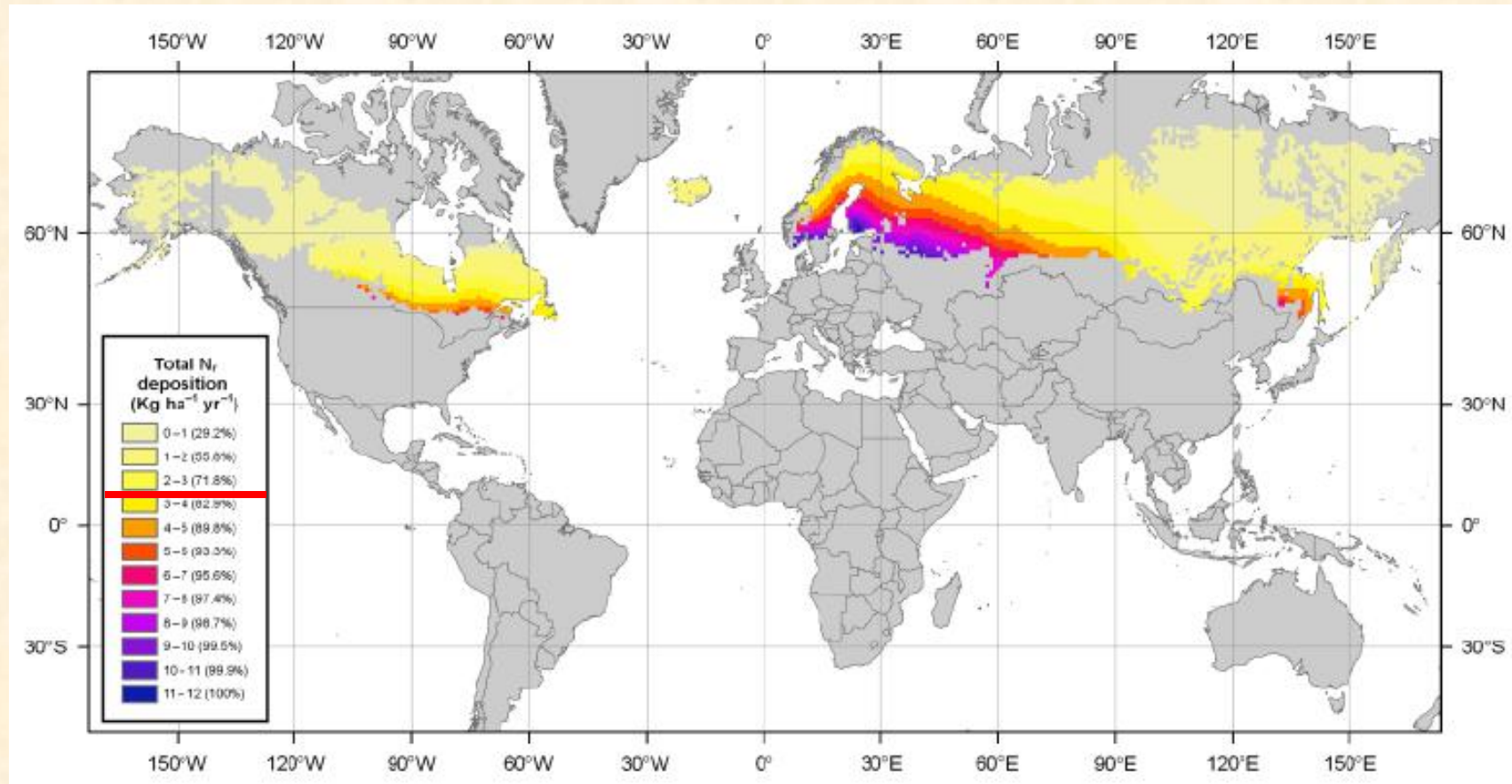


Tree Aquisition?

Fertilizer
 $\delta^{15}\text{N} = 1.81$



Results in Context



Gundale et al, 2011 Global Change Biology. Figure derived from Dentener et al., Global Biogeochemical Cycles 2006.

Summary

- N-fixation shows a different relationship with productivity than in temperate ecosystems.
- N-fixation appears to directly supports bryophyte productivity AND indirectly specific vascular plants.
- Bryophytes control low-level inputs of atmospheric N deposition.

Collaborators: Tom DeLuca, David Wardle, Marie-Charlotte Nilsson, Annika Nordin and Anders Jäderlund.

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