

N deposition and bryophyte responses in boreal background forests

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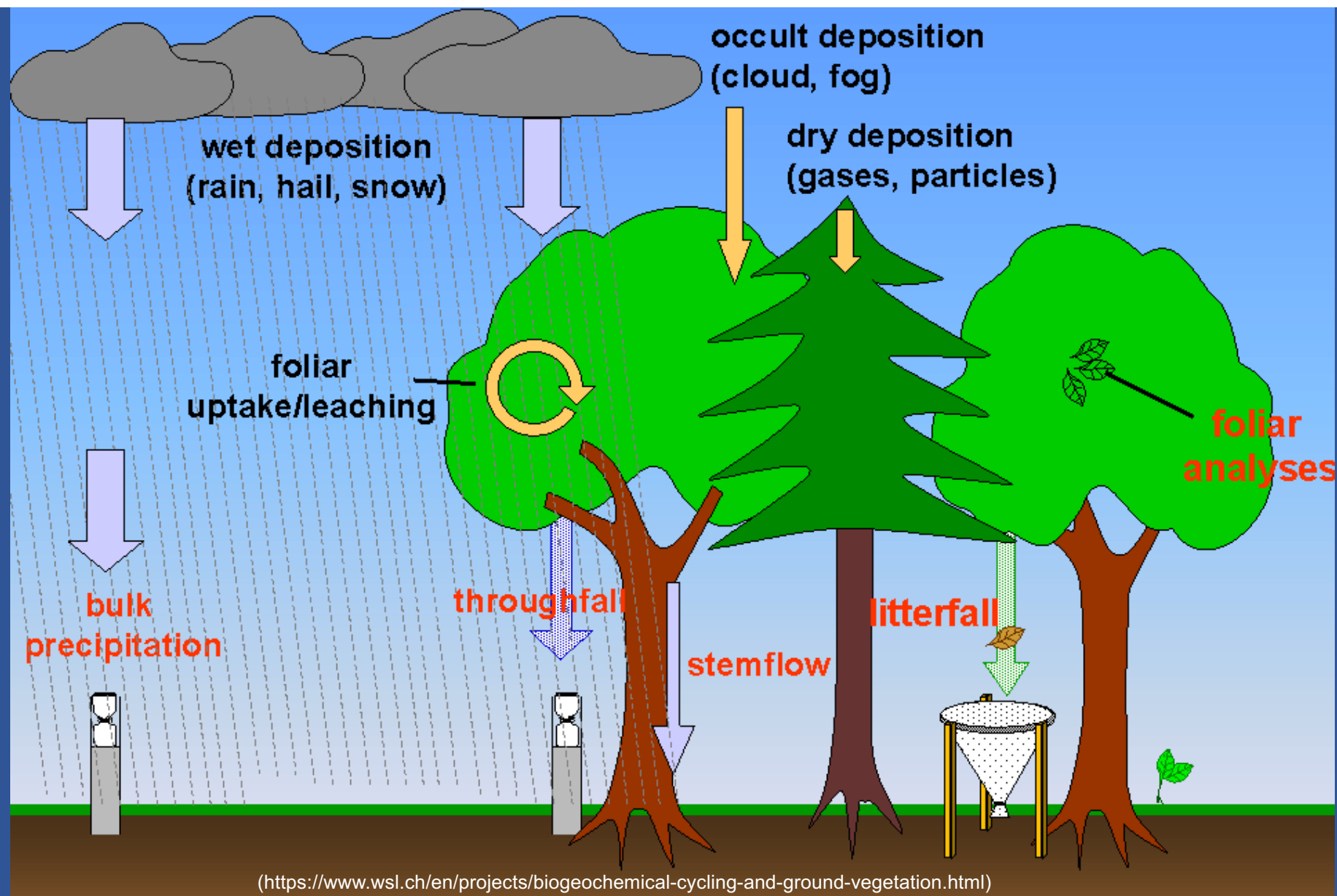
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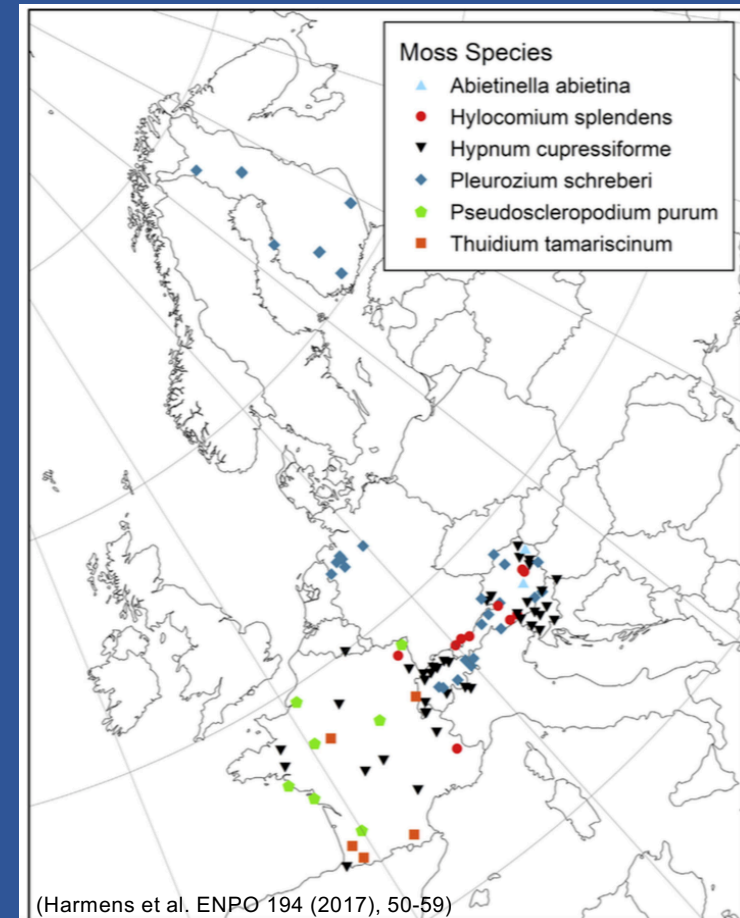
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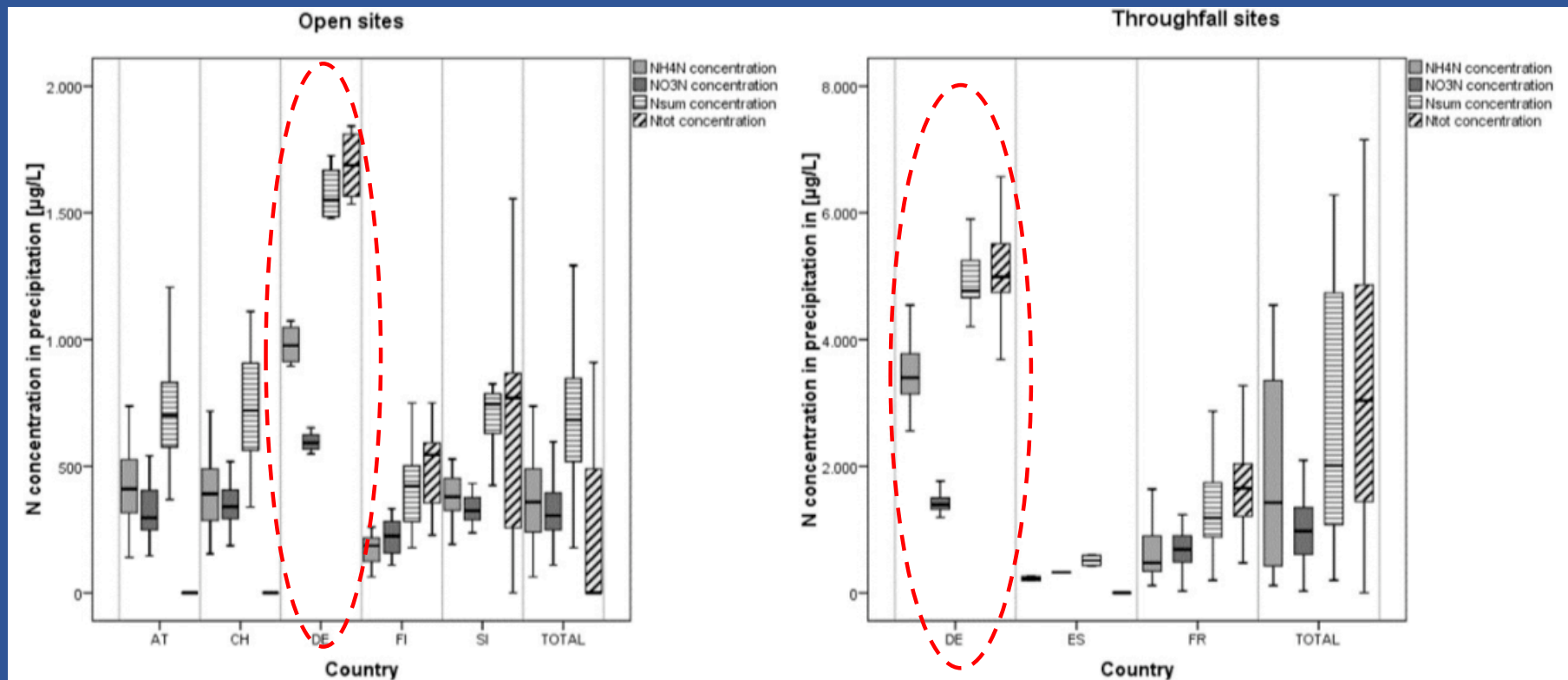
AIMS

- investigate and model relationships between moss N_{tot} concentration and N deposition at boreal background sites ($< 5 \text{ kg N ha}^{-1} \text{ yr}^{-1}$)



AIMS

- compare the relationships at open plots (bulk deposition, BD) vs. forest plots (throughfall, TF) including different N fractions in deposition (total N, NH_4^+ -N, NO_3^- -N and DON)



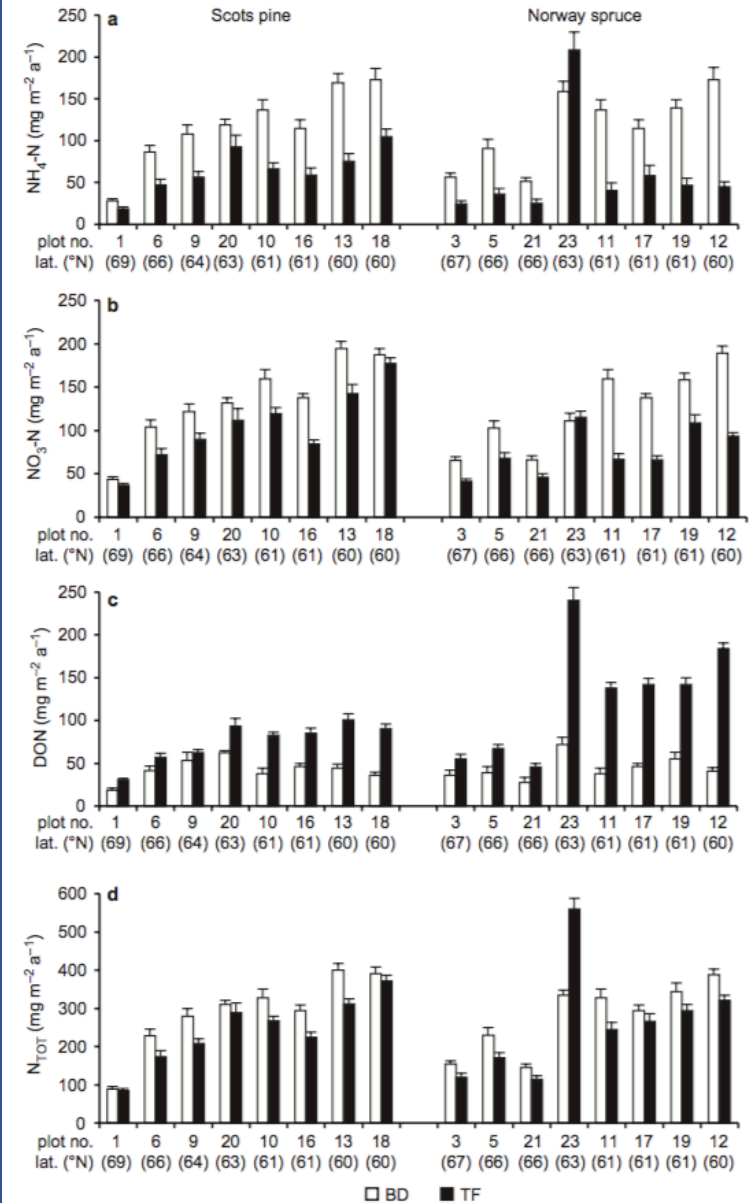
(Meyer et al. STOTEN 538
(2015), 600-610)

HYPOTHESIS

- moss N_{tot} forest plots > open plots due to canopy drip of N, especially that of DON, given that the assimilation cost of organic N (amino acids) is expected to be lower than that of inorganic N

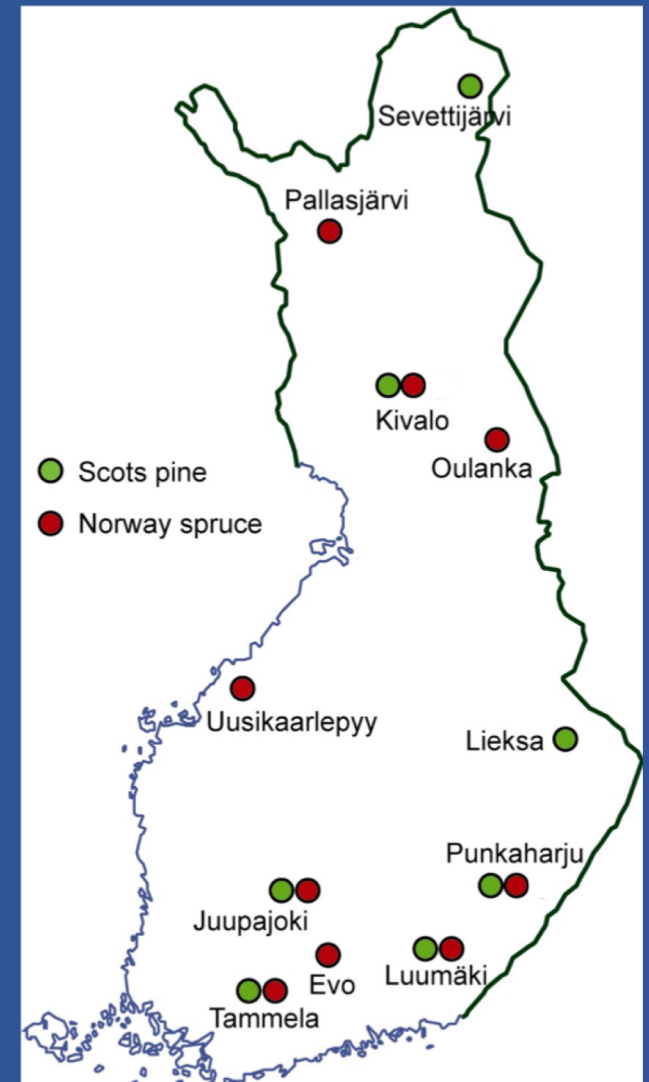


(Mustajärvi et al. BER 13 (2008), 3-21)

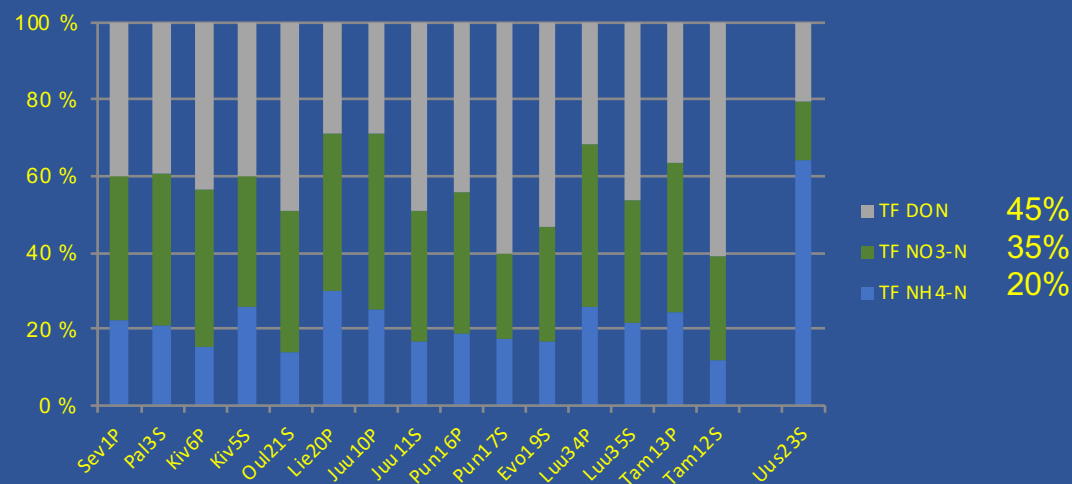
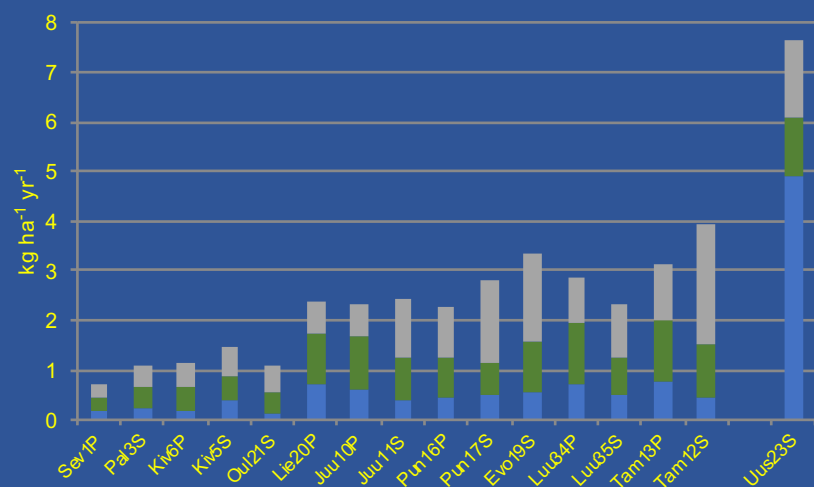
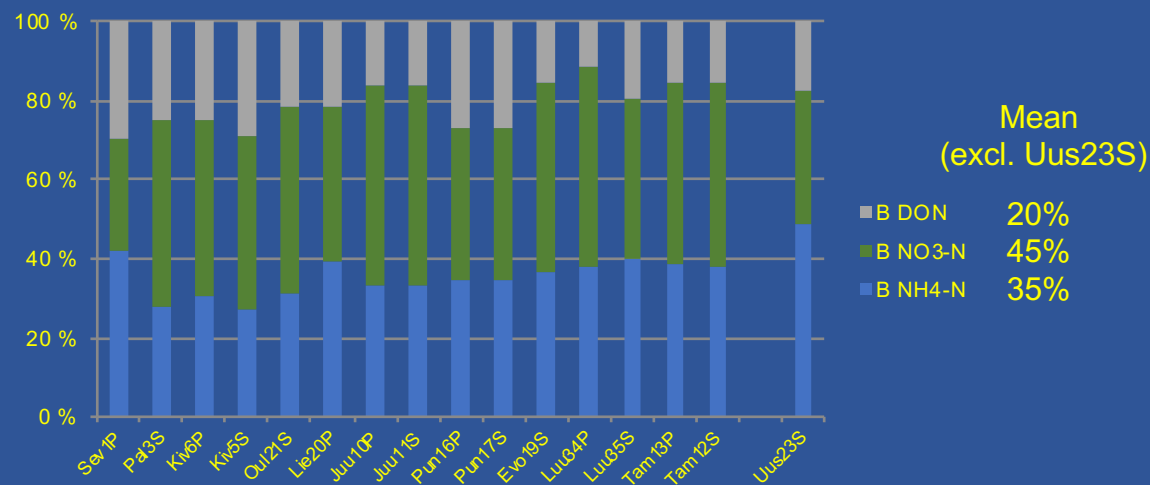
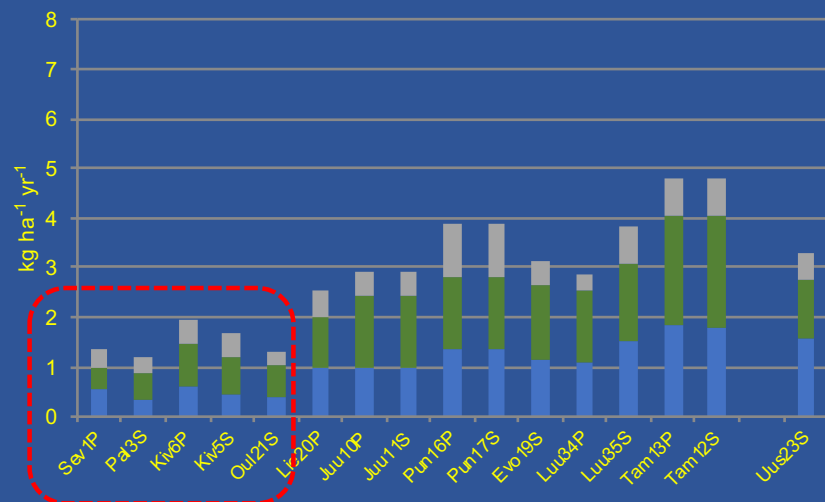


MATERIAL AND METHODS

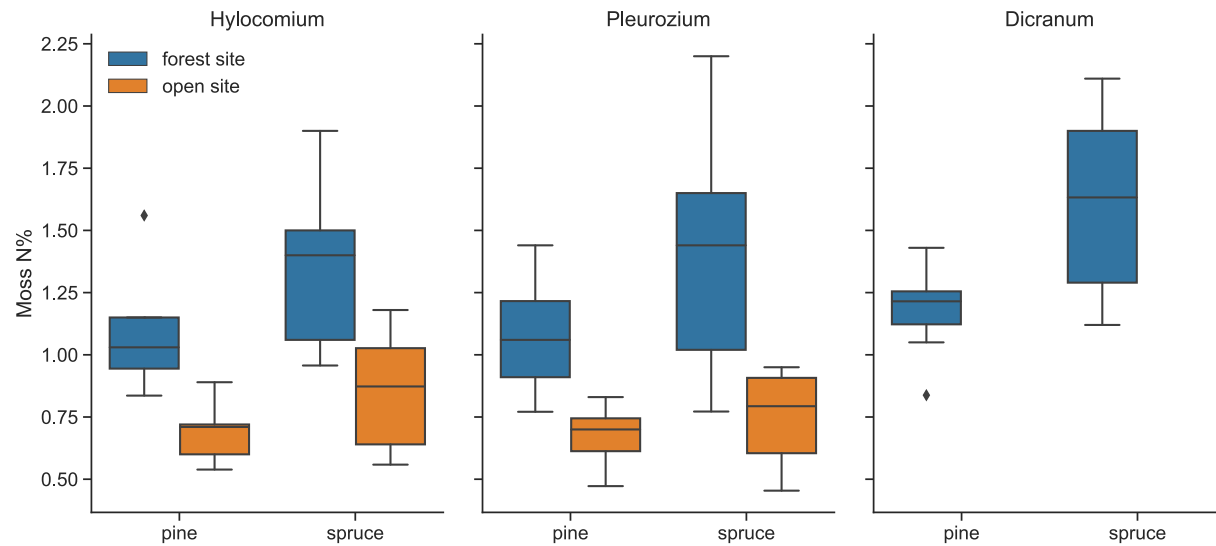
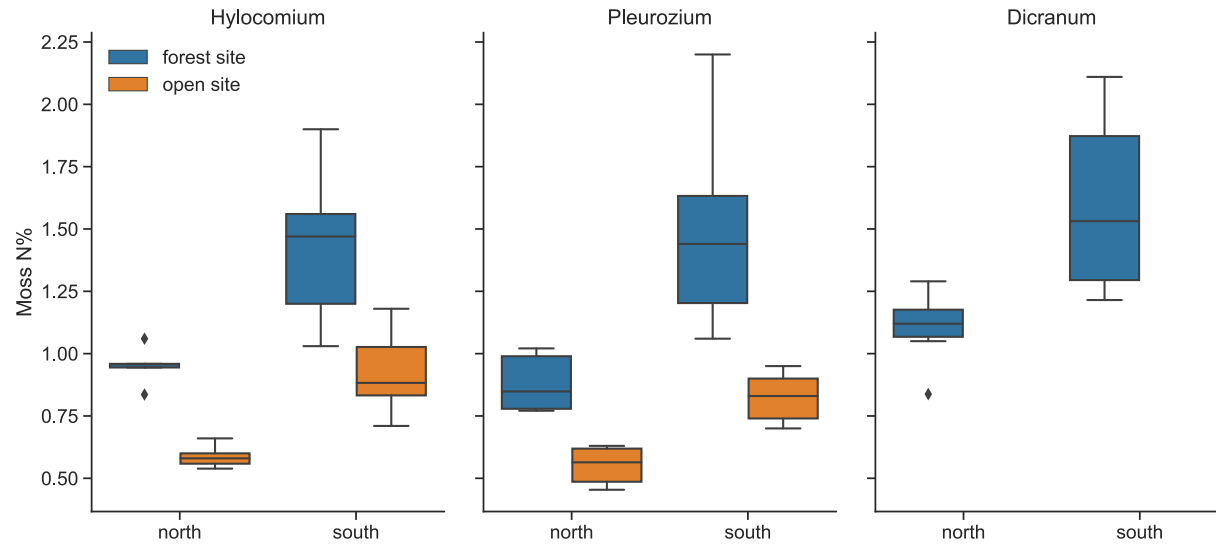
- ICP Forests Level II stands: 11 BD plots in forest openings and 16 TF plots in 2009; 12 TF plots in 2002-2003
- Note: Uusikaarlepyy locates near a fox farm
- deposition and moss chemistry
- *Hylocomium splendens*, *Pleurozium schreberi*, *Dicranum* sp.
- south-north climatic gradient
- Scots pine (*Pinus sylvestris*) vs. Norway spruce (*Picea abies*) canopy effect



RESULTS – N deposition (2007-2009 means)



P = Scots pine, S = Norway spruce



RESULTS – Moss N_{tot}

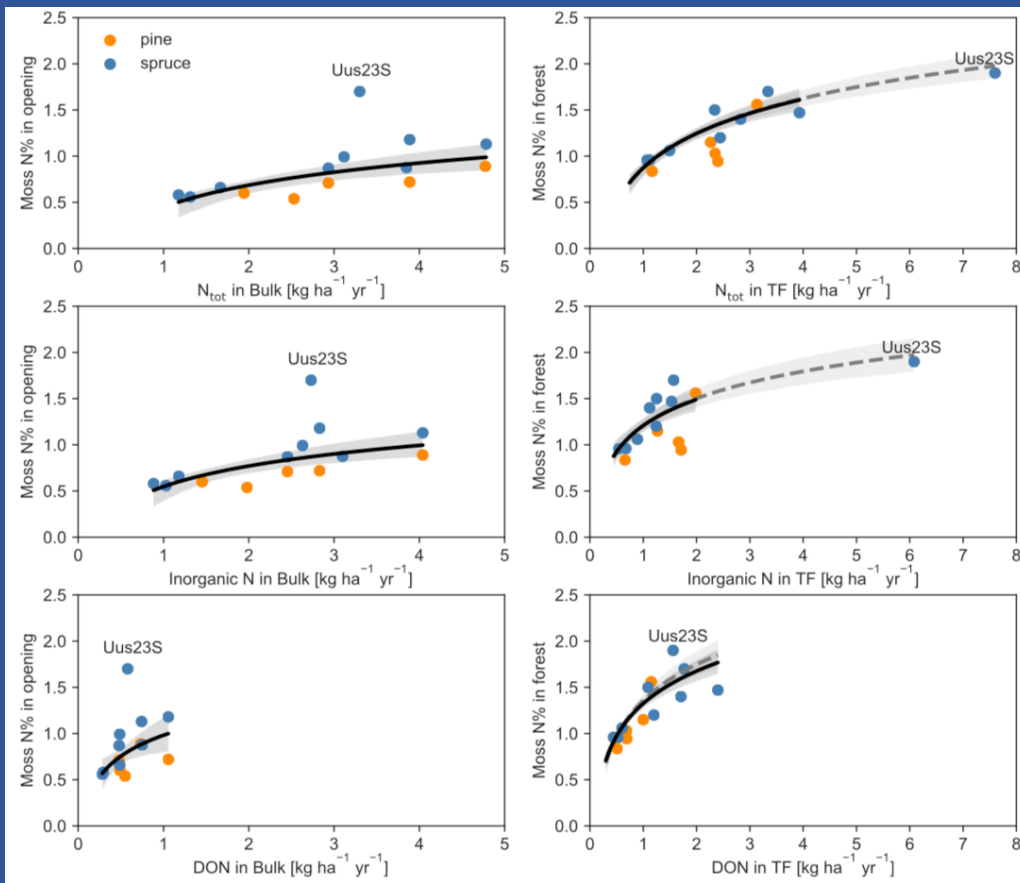
south > north

forest > opening

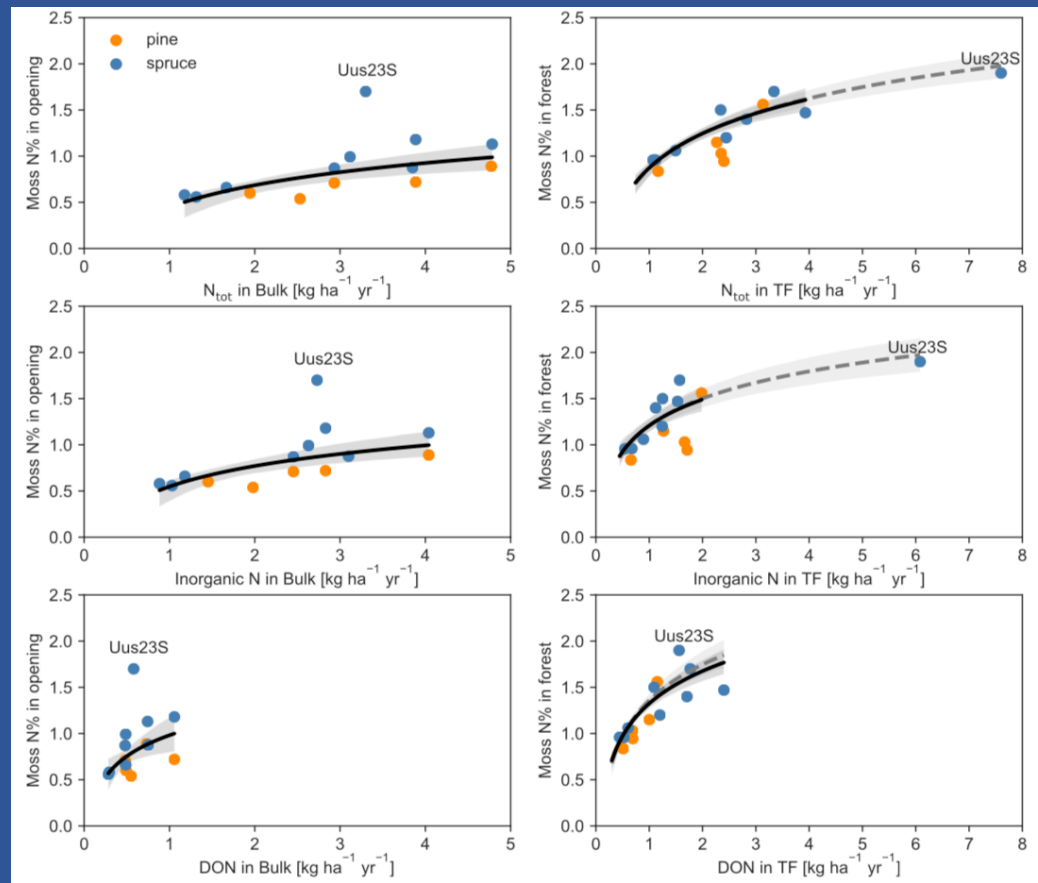
spruce > pine

RESULTS – Moss N_{tot} in relation to deposition N form

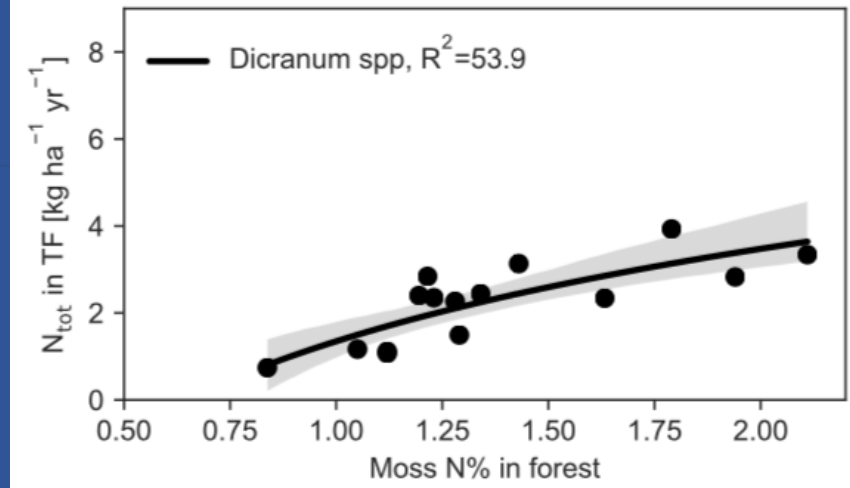
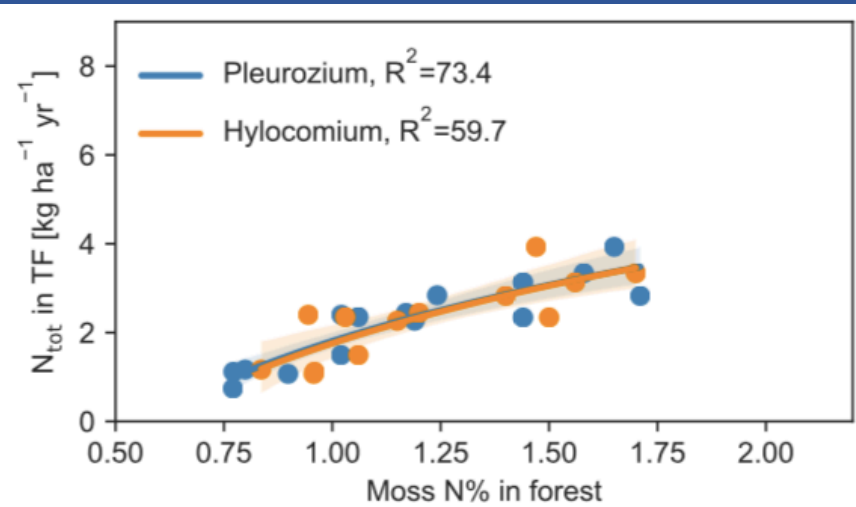
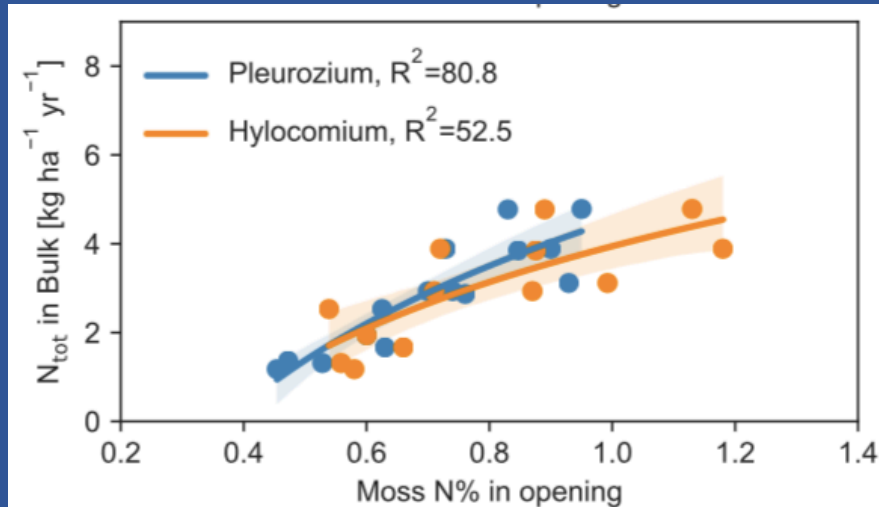
Hylocomium



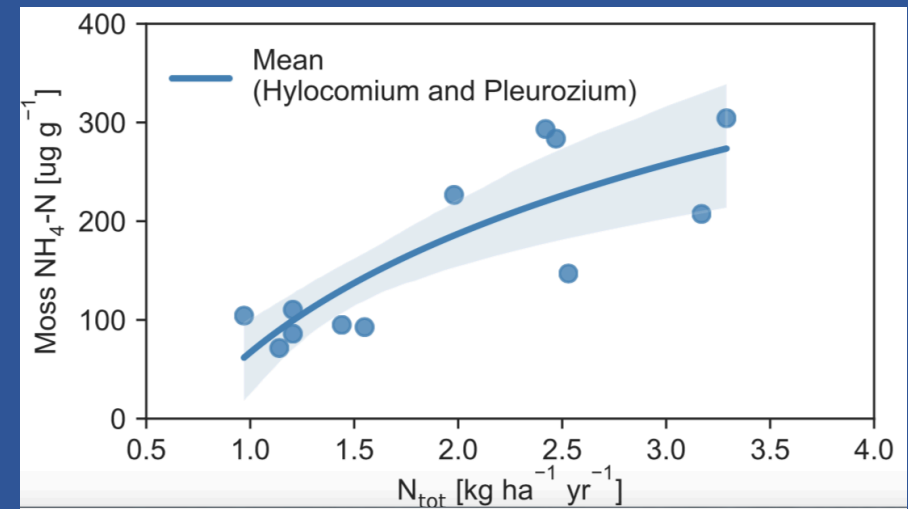
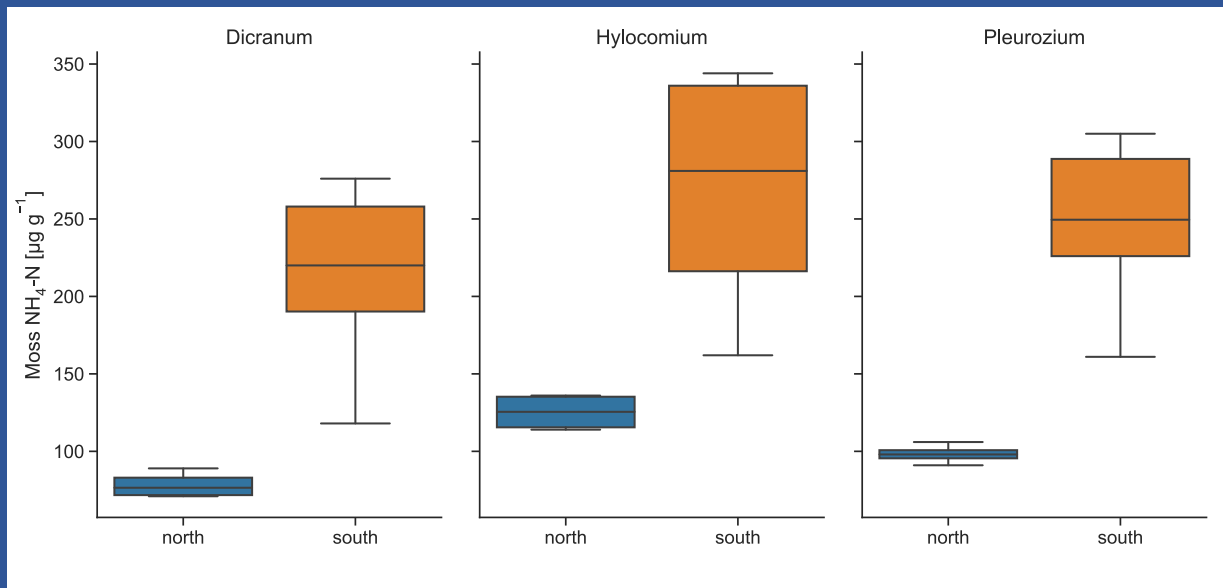
Pleurozium



RESULTS – Modelling N deposition using moss N_{tot}



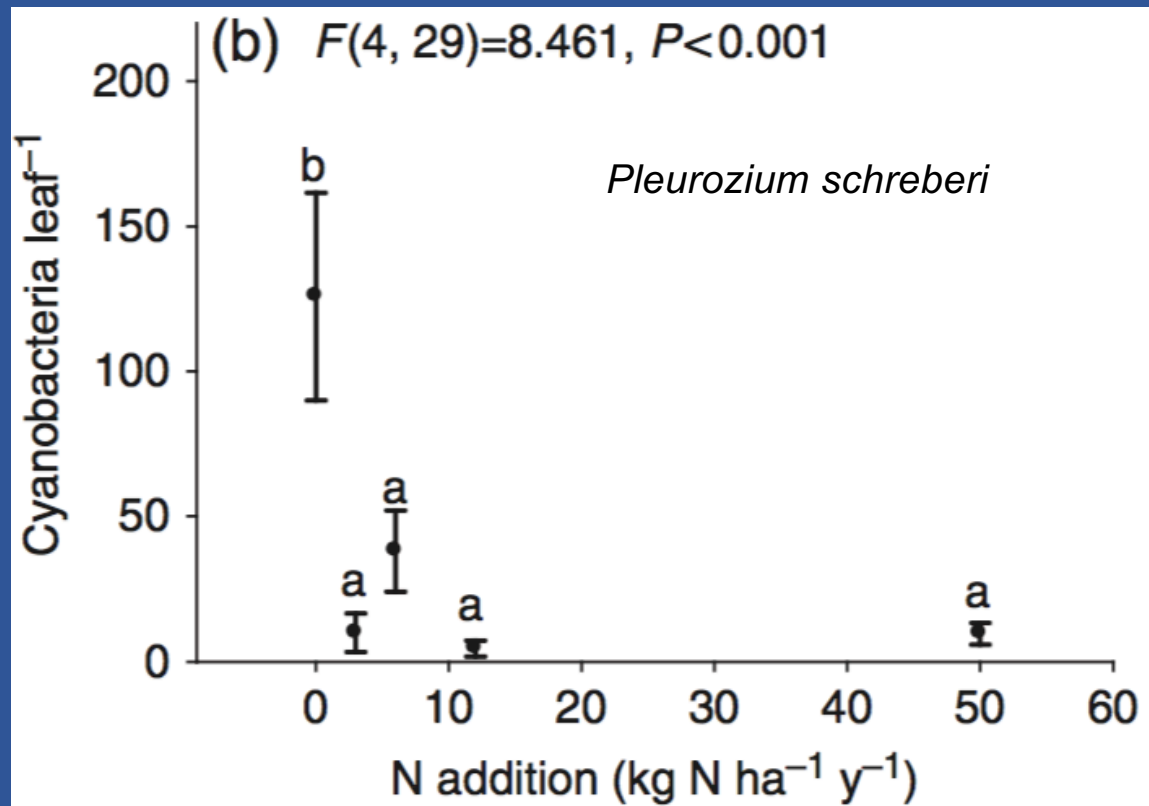
RESULTS – Moss free $\text{NH}_4\text{-N}$ concentration in south vs. north and in relation to TF N_{tot} deposition



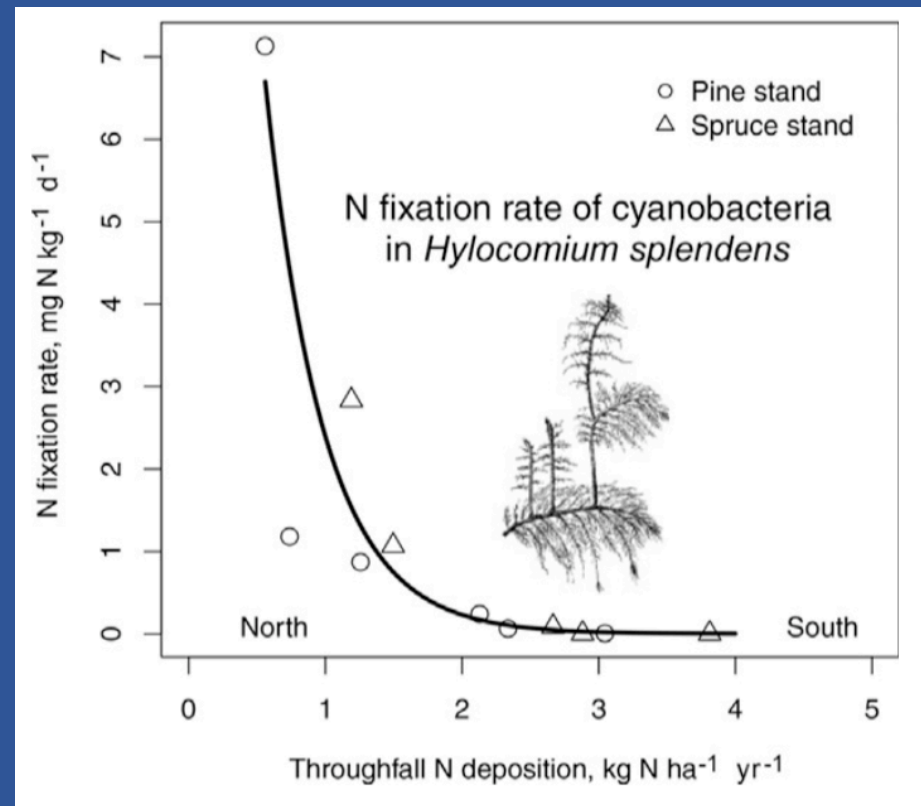
CONCLUSIONS FROM THIS STUDY

- Tree canopies took up/retained both NH_4^+ and NO_3^- , and released DON
- Inorganic N of BD explained all variation in moss N_{tot} in forest openings, while DON was also needed to explain moss N_{tot} forest plots
- 3–4 kg N_{tot} ha⁻¹ yr⁻¹ causes N saturation in mosses, as seen as asymptotic form of their N_{tot} response curves and accumulation of free $\text{NH}_4\text{-N}$ in moss tissues

RESULTS FROM OTHER STUDIES - Biological N fixation in relation to N supply



(Gundale et al. GCB 17 (2011), 2743-2753)



(Salemaa et al. STOTEN 653 (2019), 995-1004)

Critical levels and loads of reactive N compounds for biological N fixation and biodiversity?

Table III.1: Critical levels for SO₂ (µg m⁻³) by vegetation category.

Vegetation Type	Critical level SO ₂ [µg m ⁻³]	Time period
Cyanobacterial lichens	10	Annual mean
Forest ecosystems*	20	Annual mean and Half-year mean (October-March)
(Semi-)natural	20	Annual mean and Half-year mean (October-March)
Agricultural crops	30	Annual mean and Half-year mean (October-March)

*The forest ecosystem includes the response of the understorey vegetation.

(UNECE Mapping Critical Levels for Vegetation)

United States Forest Service: Oligotrophs (e.g. *Lobaria pulmonaria*) are most abundant under 0.5 to 4.2 kg N/ha/yr and are increasingly difficult to find as deposition increases above 4.2.

(http://gis.nacse.org/lichenair/?page=e_sensitivity)

N critical load for *Lobaria pulmonaria* 3 kg N/ha/yr

(http://nadp.slh.wisc.edu/conf/2018/pptpdf/1852_geiser.pdf)



(https://www.fs.fed.us/wildflowers/plant-of-the-week/lobaria_pulmonaria.shtml)

AIR QUALITY AND DEPOSITION IN PALLAS, FINNISH LAPLAND

Air quality ($\mu\text{g m}^{-3} \text{ yr}^{-1}$)

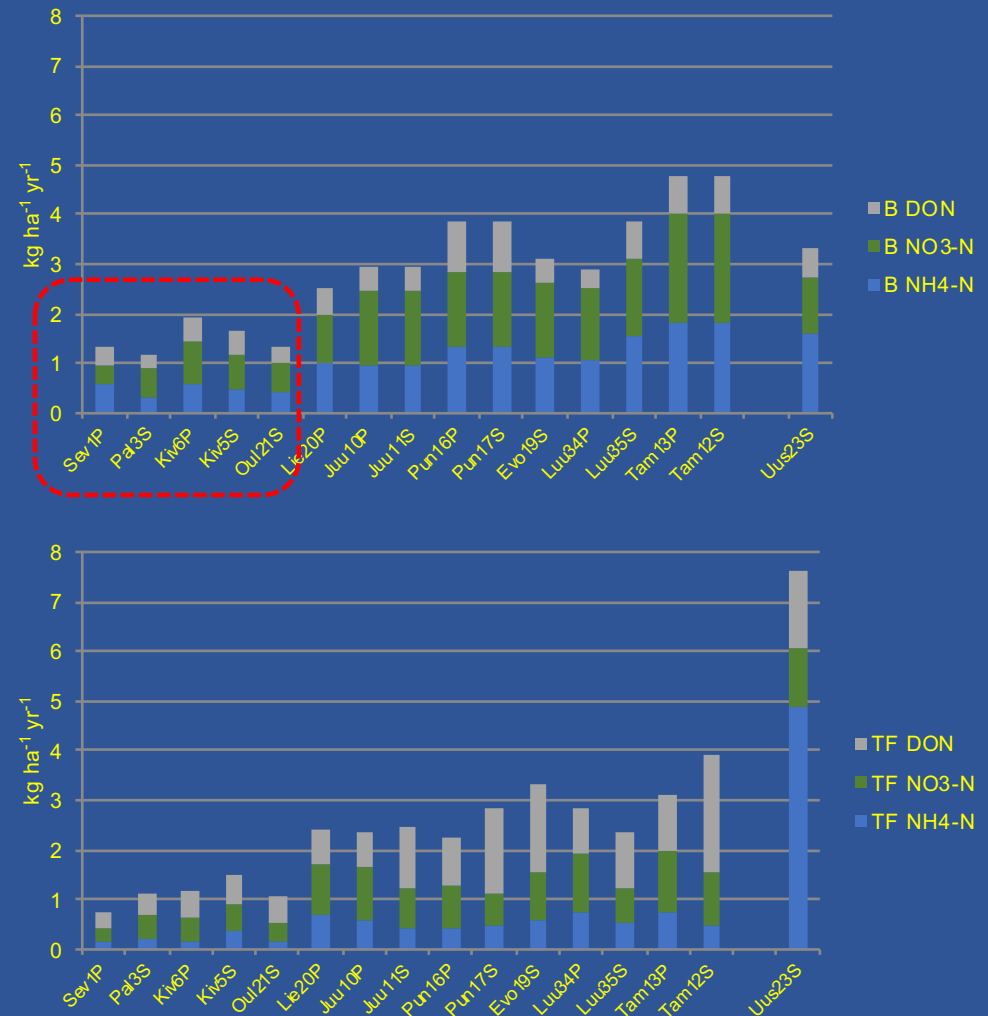
NO_2	0.3-1.1
$(\text{HNO}_3 + \text{NO}_3^-) - \text{N}$	0.05
$(\text{NH}_3 + \text{NH}_4^+) - \text{N}$	0.10-0.30

Bulk deposition ($\text{kg ha}^{-1} \text{ yr}^{-1}$)

$\text{NO}_3^- - \text{N}$	1
$\text{NH}_4^+ - \text{N}$	0.5

N in precipitation (mg l^{-1})

$\text{NO}_3^- - \text{N}$	0.1-0.15
$\text{NH}_4^+ - \text{N}$	0.05-0.10



P = Scots pine, S = Norway spruce

A close-up photograph of a dense carpet of green moss. The moss consists of many small, pointed leaves that are a vibrant green color. Interspersed among the green leaves are several thin, reddish-brown stems that stand out. The overall texture is very fine and detailed, with many small gaps and overlaps between the moss leaves.

THANK YOU!

(Photo Hannu Nousiainen)