Reduced N in precipitation as N source for boreal bryophytes

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Overview of presentation

- What we knew already 50 years ago
- Gaps in knowledge
- Results from monitoring of precipitation N in boreal forest
- Results from bryophyte N uptake experiments in boreal forest
- Ecological and physiological responses of bryophytes to increasing N input
- Recovery of bryophytes follwing decreased ecosystem N input
- Take home message!

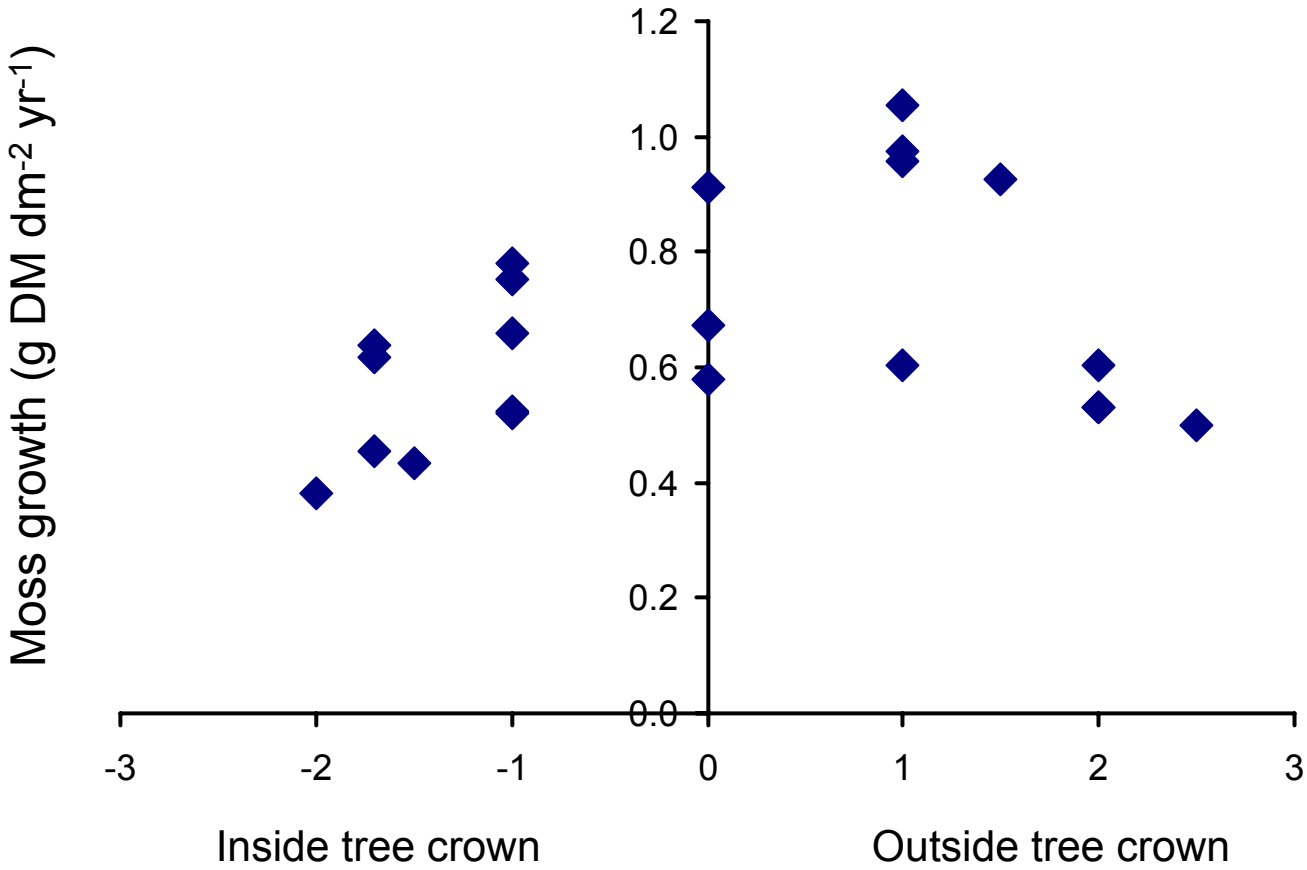
The annual N uptake of a boreal forest moss carpet is 7 - 10 kg N ha^{-1}

(Romell, 1939)

”The nitrogen nutrition of forest mosses may thus appear at first to be rather mysterious.”

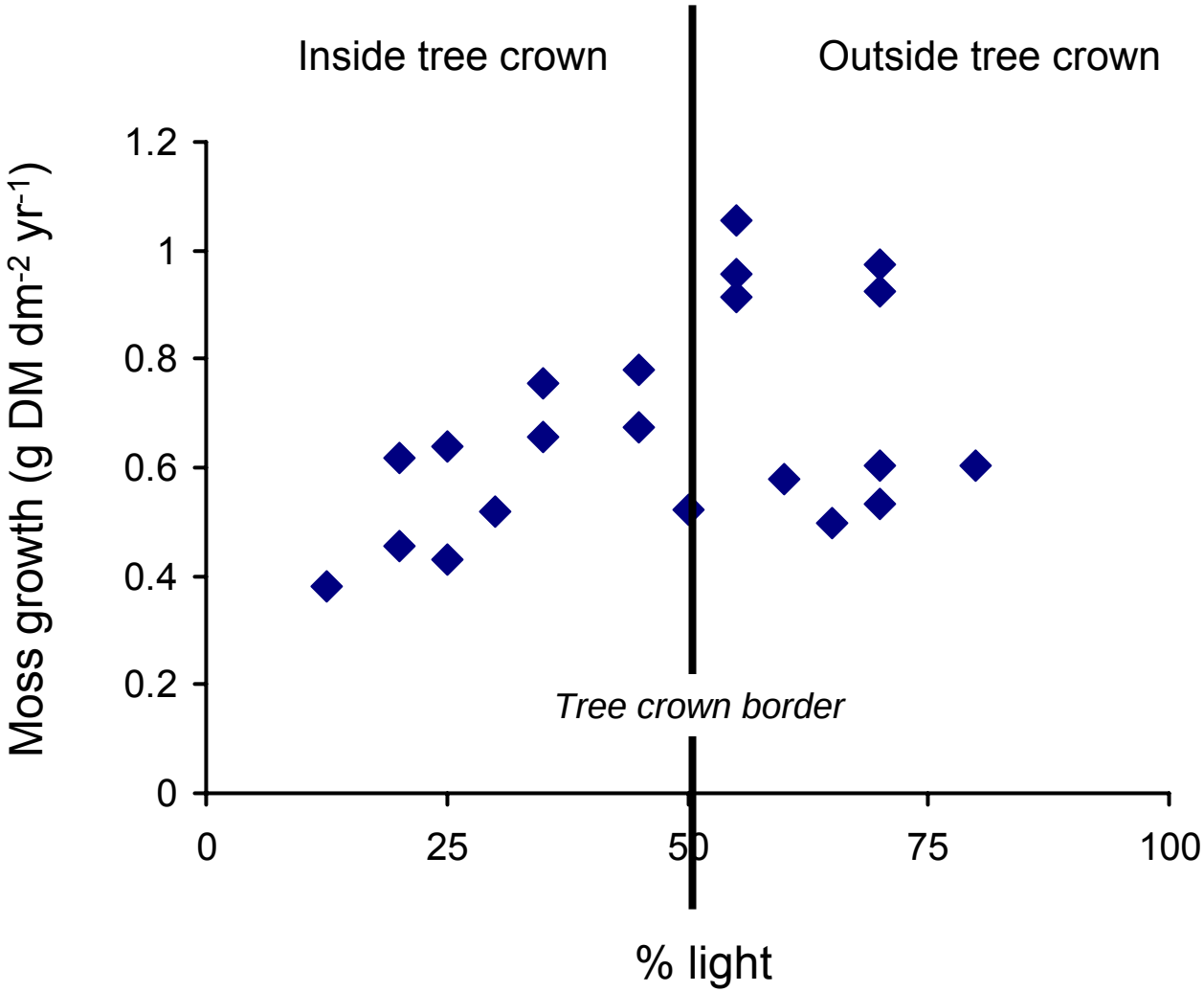
Carl-Olof Tamm, 1953

Annual moss growth in relation to the tree canopy



(Modified from Tamm, 1953)

Annual moss growth in relation to light availability



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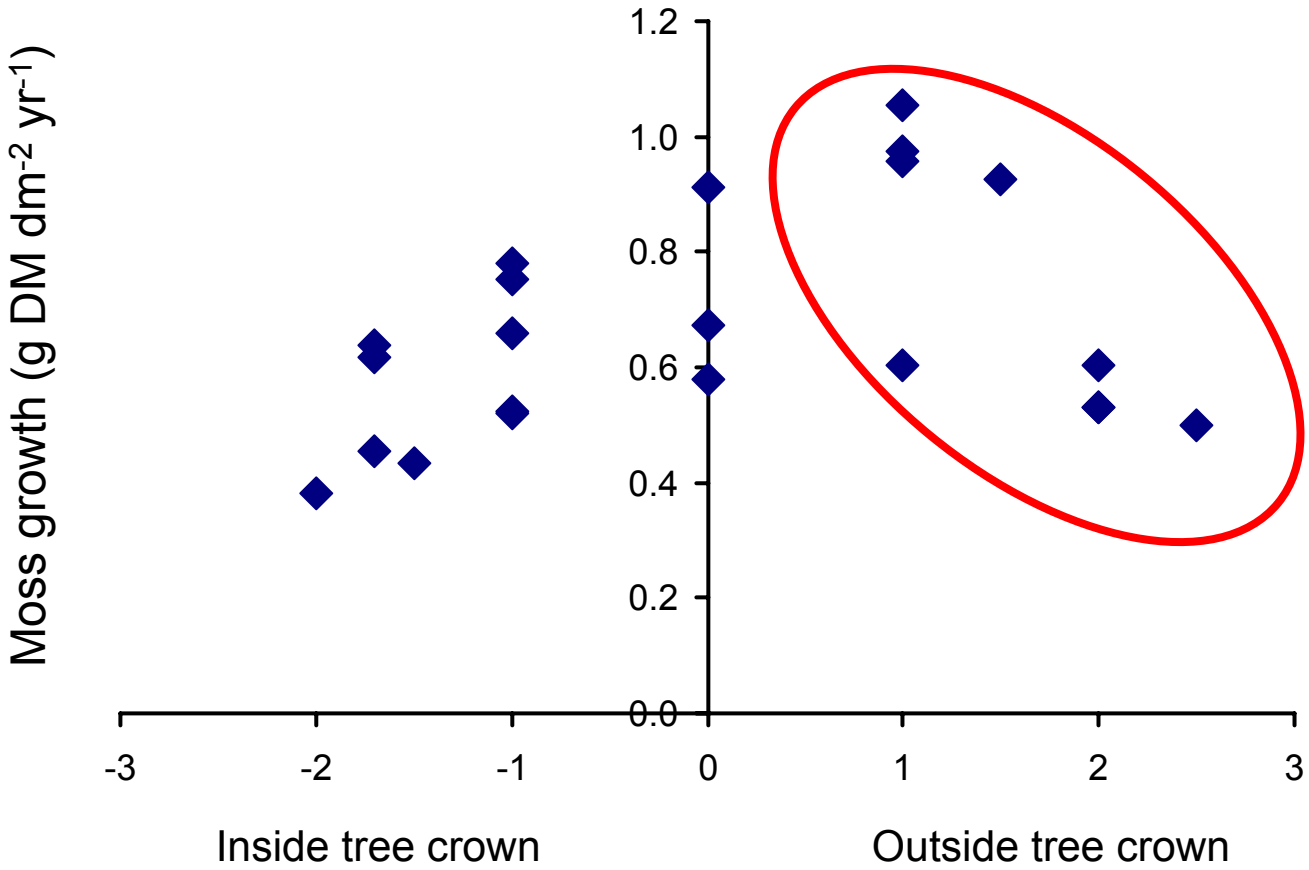
Annual moss growth in relation to the tree canopy



(Modified from Tamm, 1953)

Sources of N for boreal moss carpets;

- Tree and litter leachate
- Atmospheric dust and salt spray
- Air ammonia

(Tamm, 1953)

Current knowledge of N sources for boreal forest mosses;

- N_2-fixation in symbiosis with cyanobacteria
(DeLuca et al. 2002 in Nature)
- Efficient N recycling and acropetal transport
(for example Eckstein 2000 in J. of Ecology)
- Precipitation

”Of great interest is the possible release of organic compounds containing N as large amounts of organic matter are carried down with the rain. However, we do not know how much of this N – if there is any – is available to the mosses.”

Carl-Olof Tamm, 1953

Gaps in knowledge;

1. Is precipitation a significant source of organic N to forest mosses?

2. What is the capacity of mosses to take up different N forms from precipitation?

3. Can mosses access N deposited with snow?

Study area

- Boreal forest in north Sweden
- Background N deposition 2 – 3 kg N ha^{-1} yr^{-1}

Study species - *Hylocomium splendens*

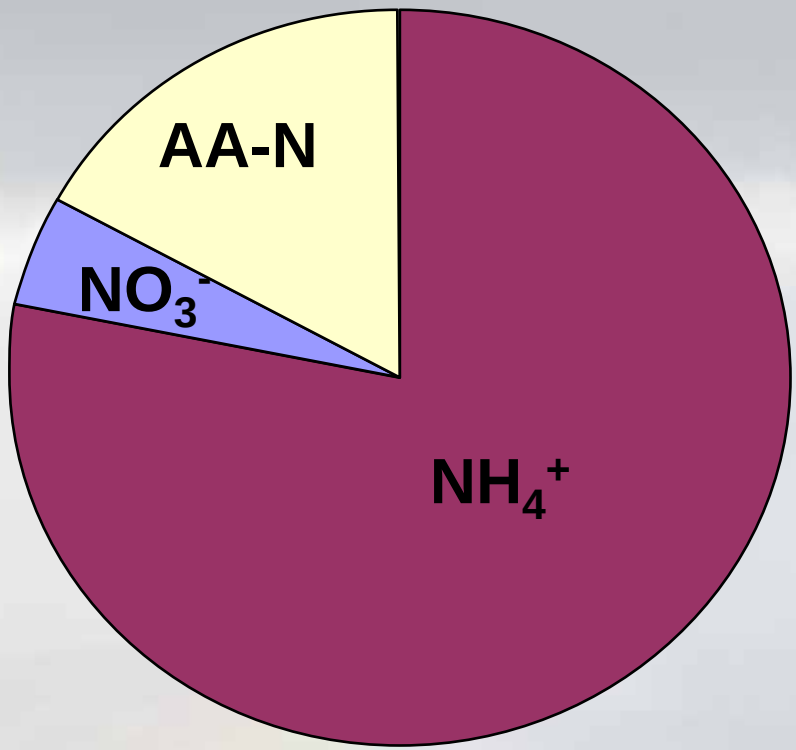
Precipitation collection

Rain in containers with acid holding solution

Snowmelt water from teflon lysimeters installed under the snow

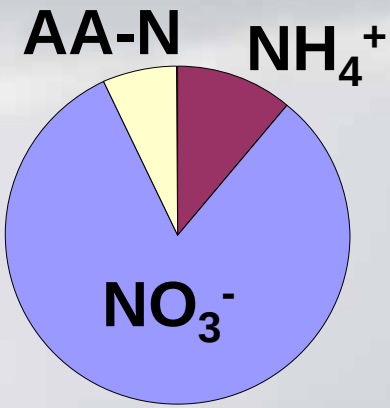
Results from monitoring of (throughfall) precipitation in boreal forest

Rain



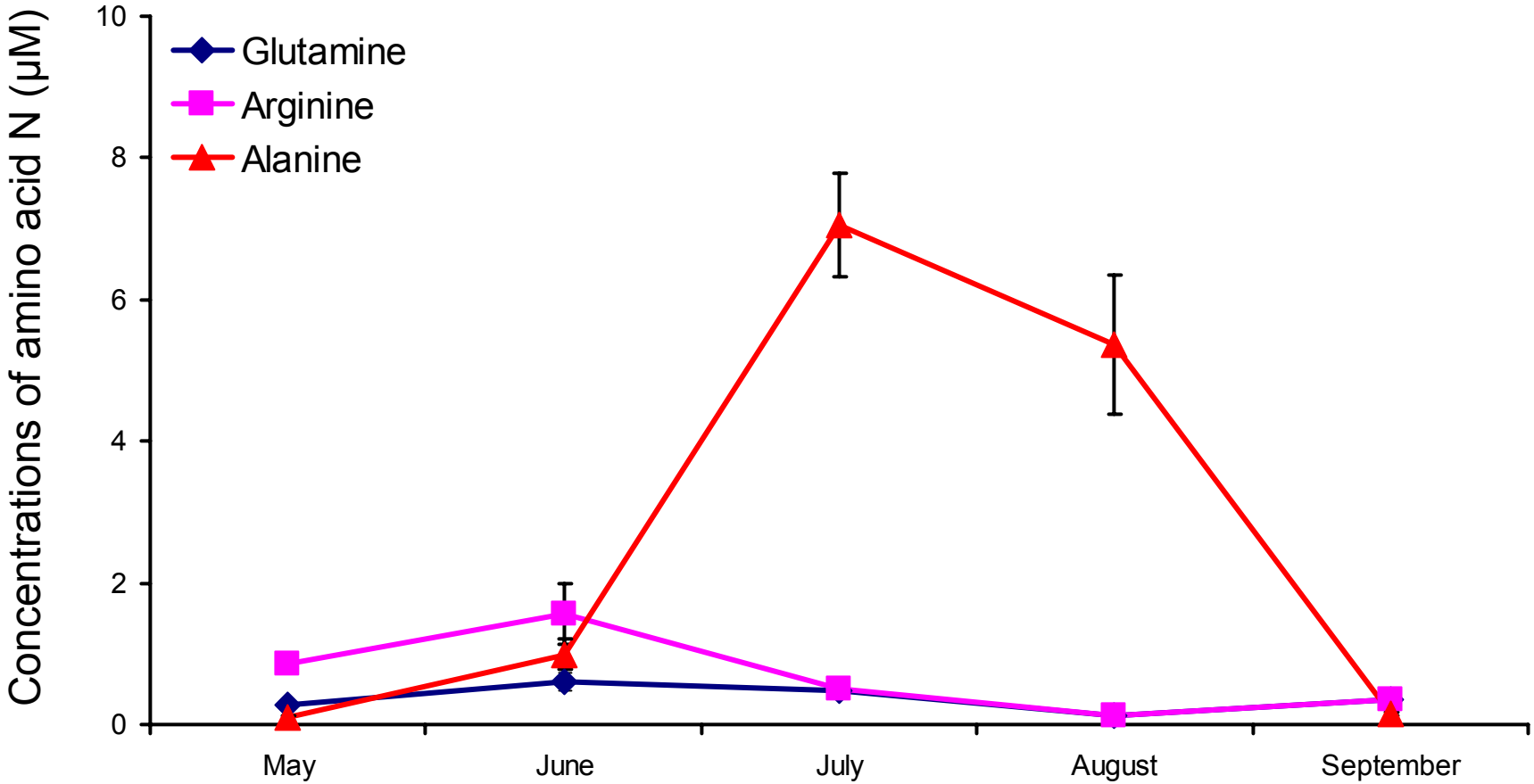
2 kg N ha^{-1}

Snow



0.2 kg N ha^{-1}

Rainwater (throughfall) concentrations of amino acid N

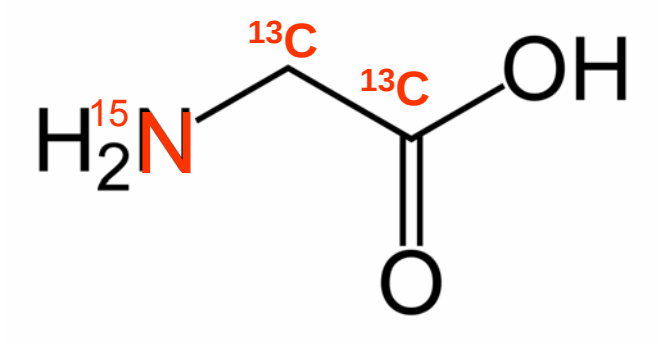


^{15}N-^{13}C labeling experiments to study moss N uptake

Artificial rainwater;

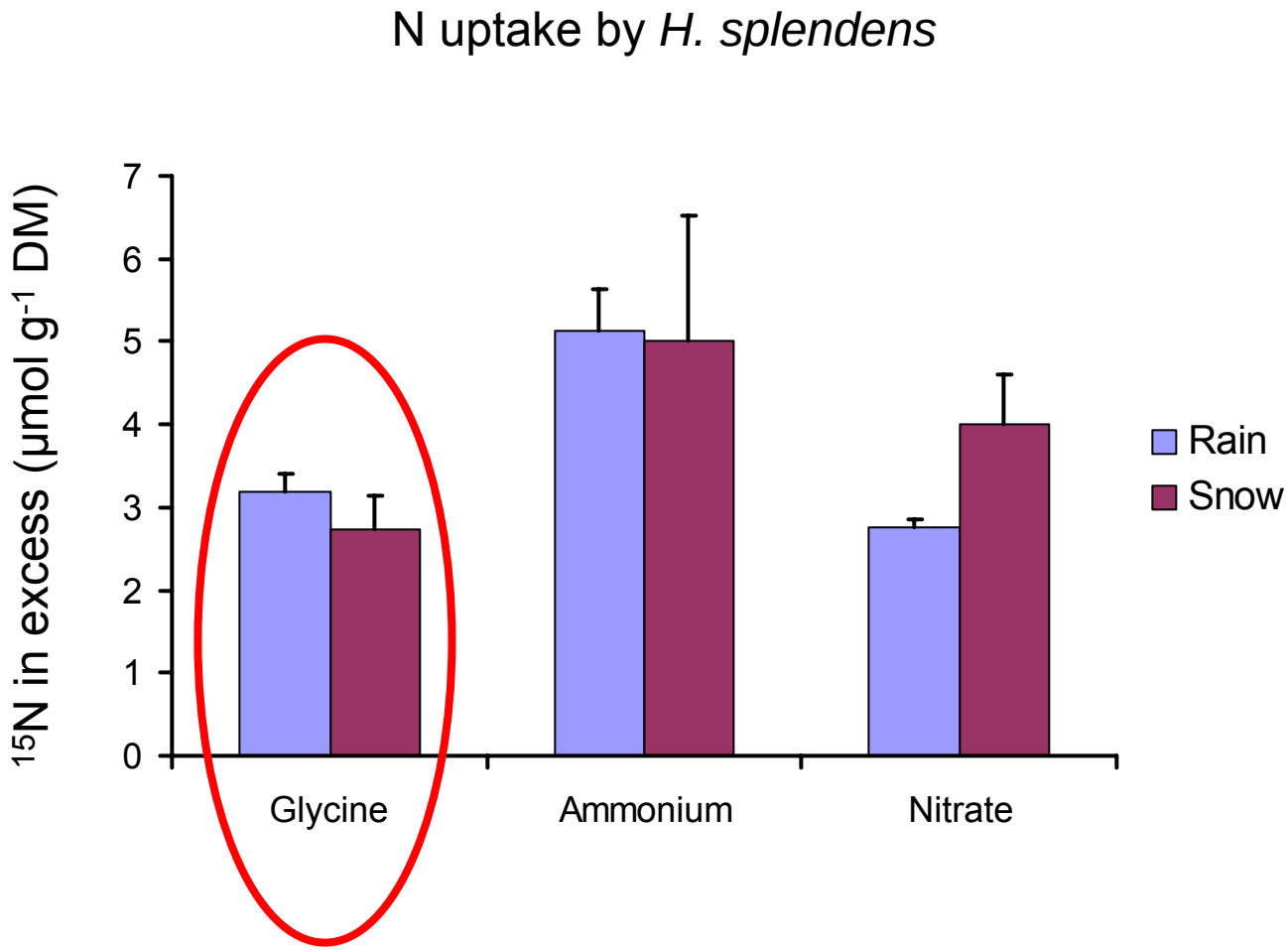
20 µM glycine-N
20 µM NH_4^+
20 µM NO_3^-
Micronutrients
pH 6.0

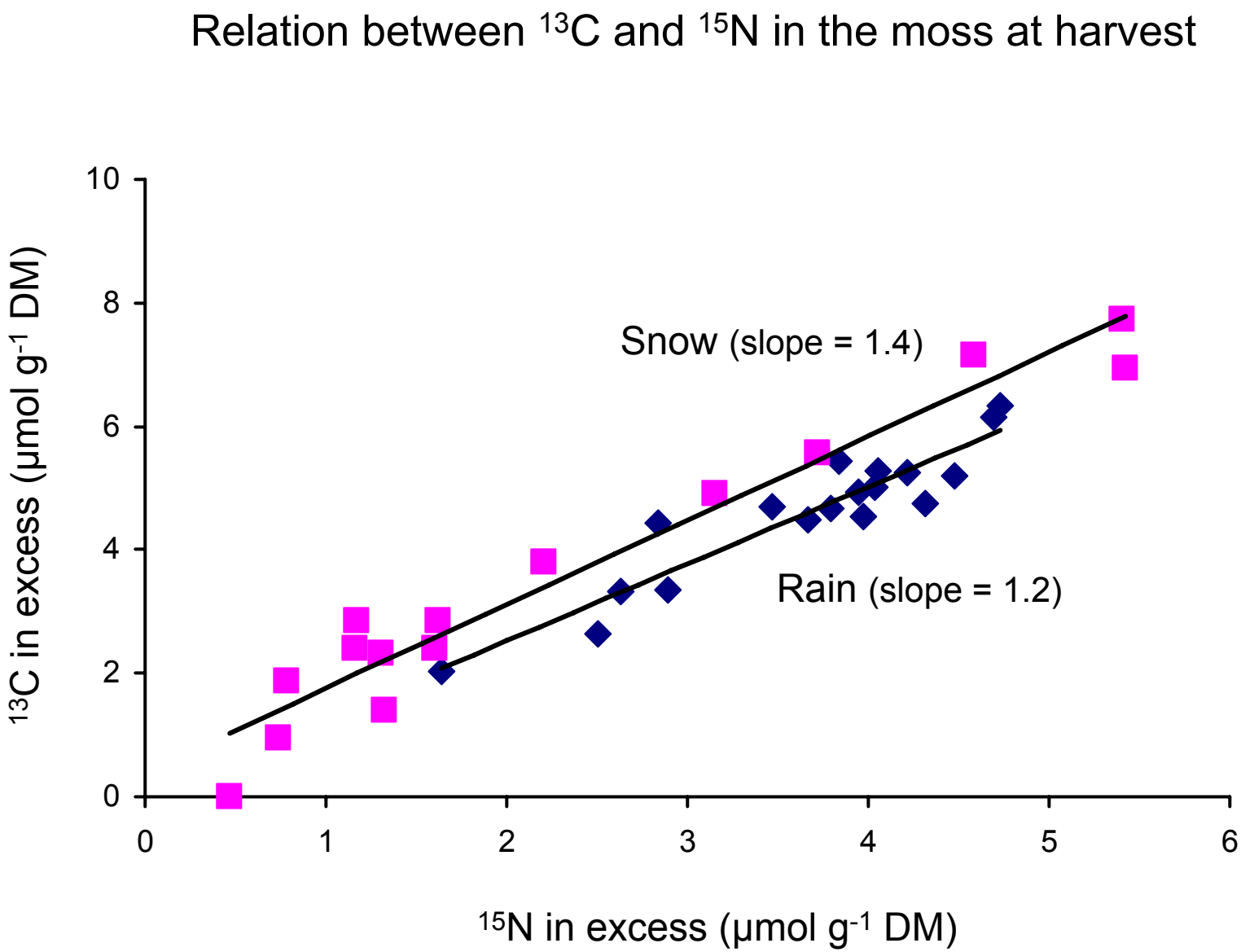
Glycine



Rain – applied by regular spraying events during 2 weeks time

Snow – solution watered on top of snowpack prior to snowmelt


N uptake by *H. splendens*
^{15}N in excess (µmol g^{-1} DM)
7
6
5
4
3
2
1
0
Glycine
Ammonium
Nitrate
Rain
Snow


Relation between ^{13}C and ^{15}N in the moss at harvest
^{13}C in excess (µmol g^{-1} DM)
^{15}N in excess (µmol g^{-1} DM)
Snow (slope = 1.4)
Rain (slope = 1.2)
0
2
4
6
8
10
0
1
2
3
4
5
6

Conclusion: Precipitation in boreal forest contains a significant fraction of amino acid N which bryophytes can access. Amino acids thus contributes both N and C to bryophytes.

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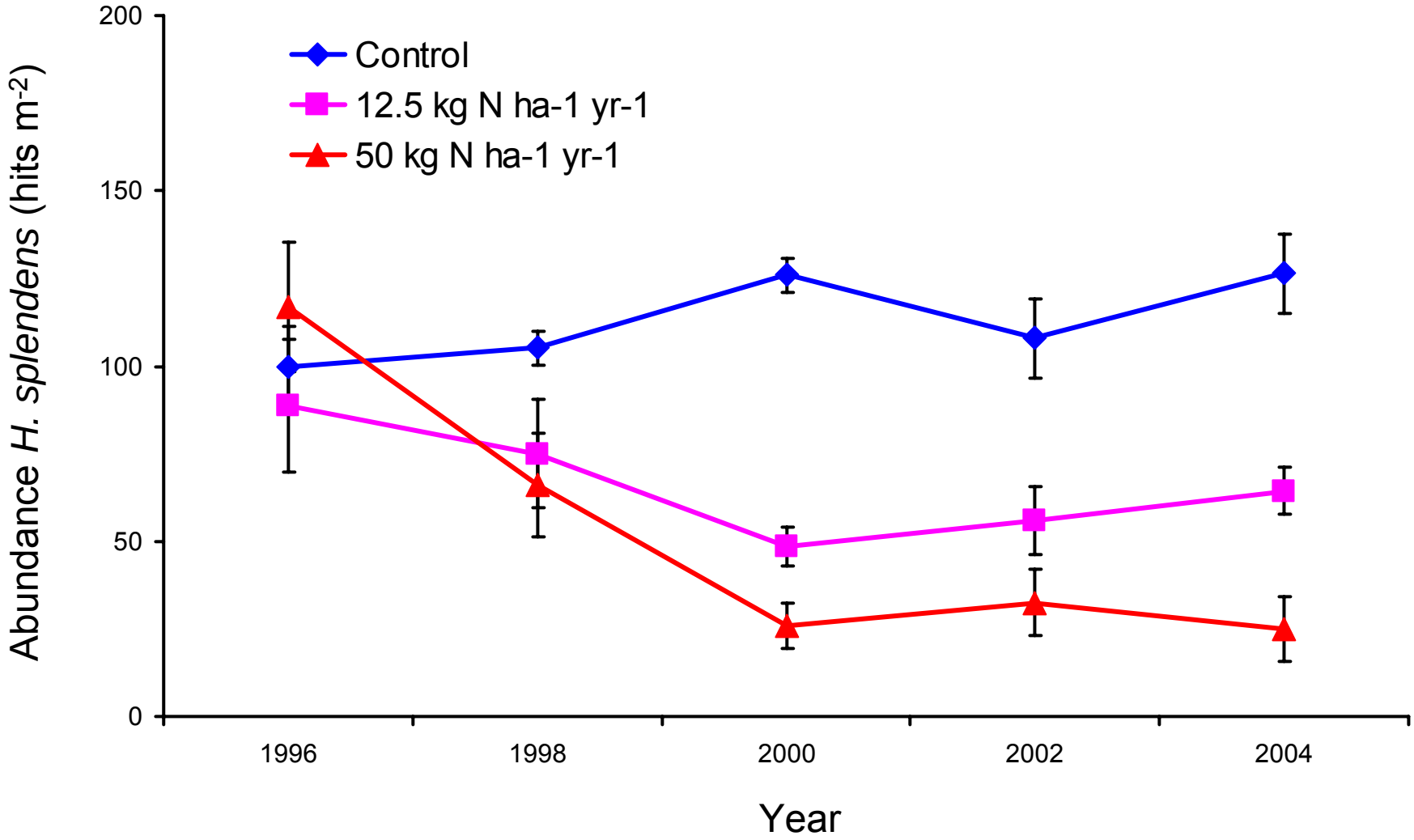
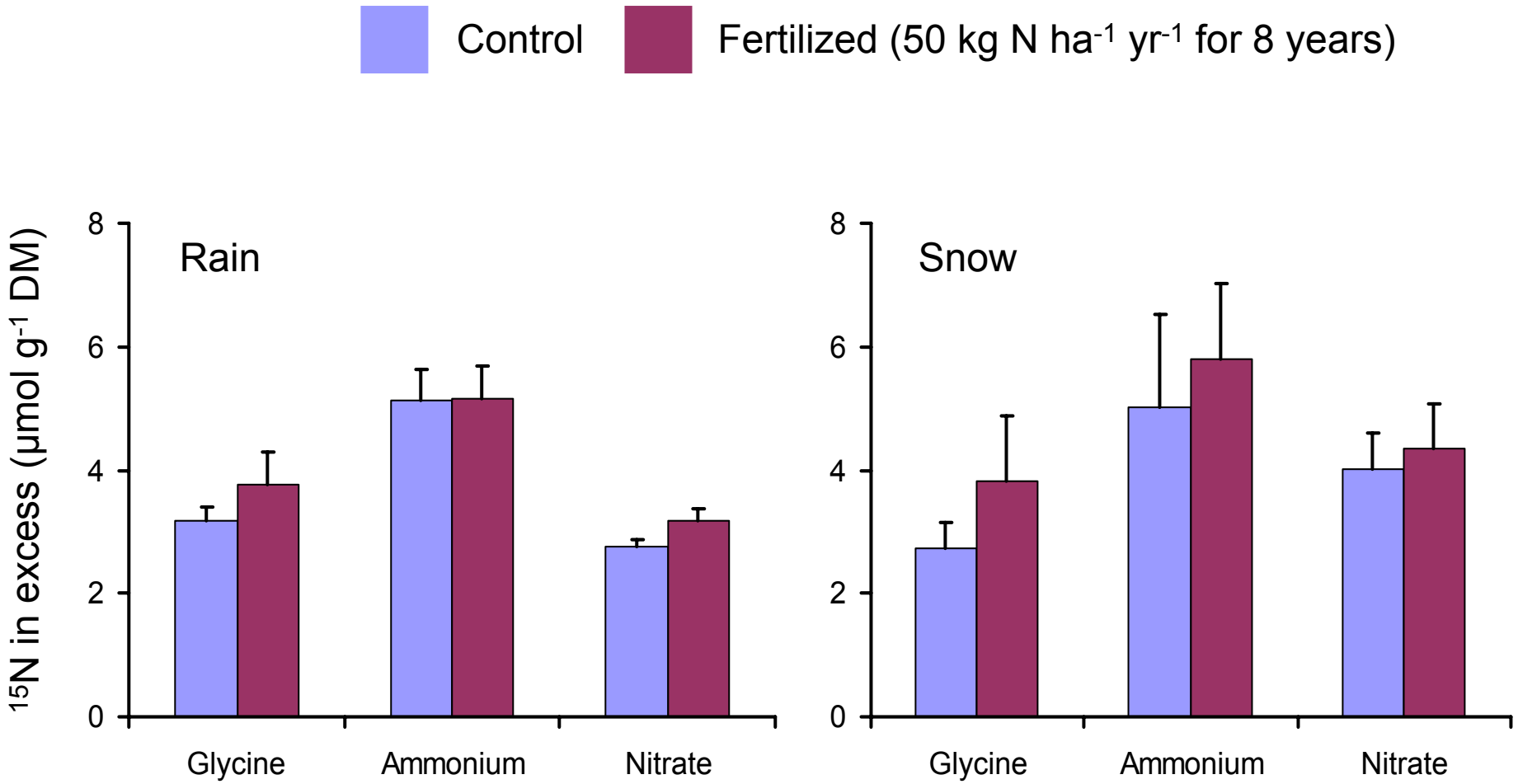
Abundance of *H. splendens* in a N addition experiment



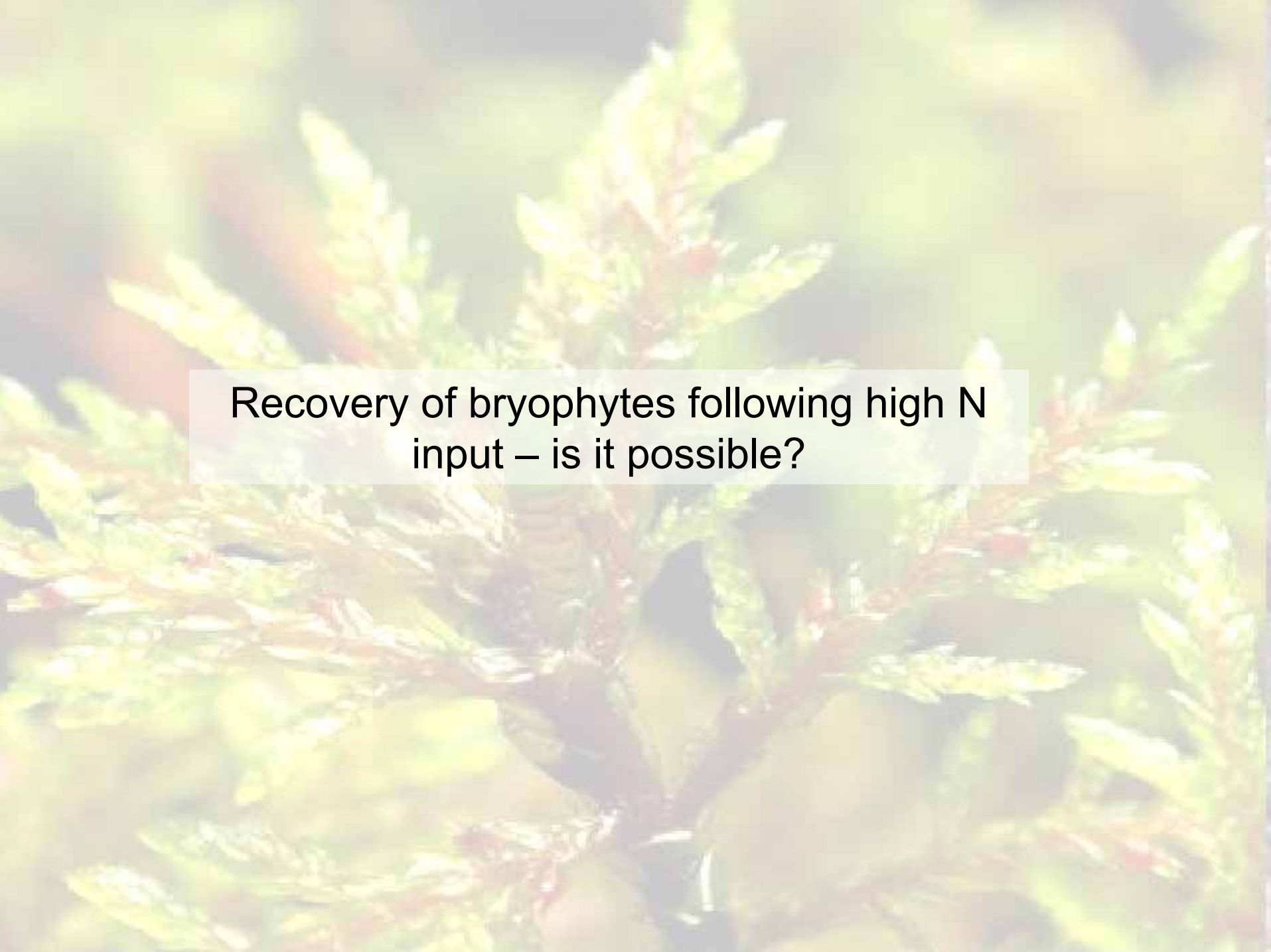
Physiological changes in the moss in response to fertilization;

	Control	Fertilized
Total N (mg N g^{-1} DM)	8.4 ± 0.4	18.7 ± 1.0
Amino acid N (mg N g^{-1} DM)	0.5 ± 0.1	1.7 ± 0.2

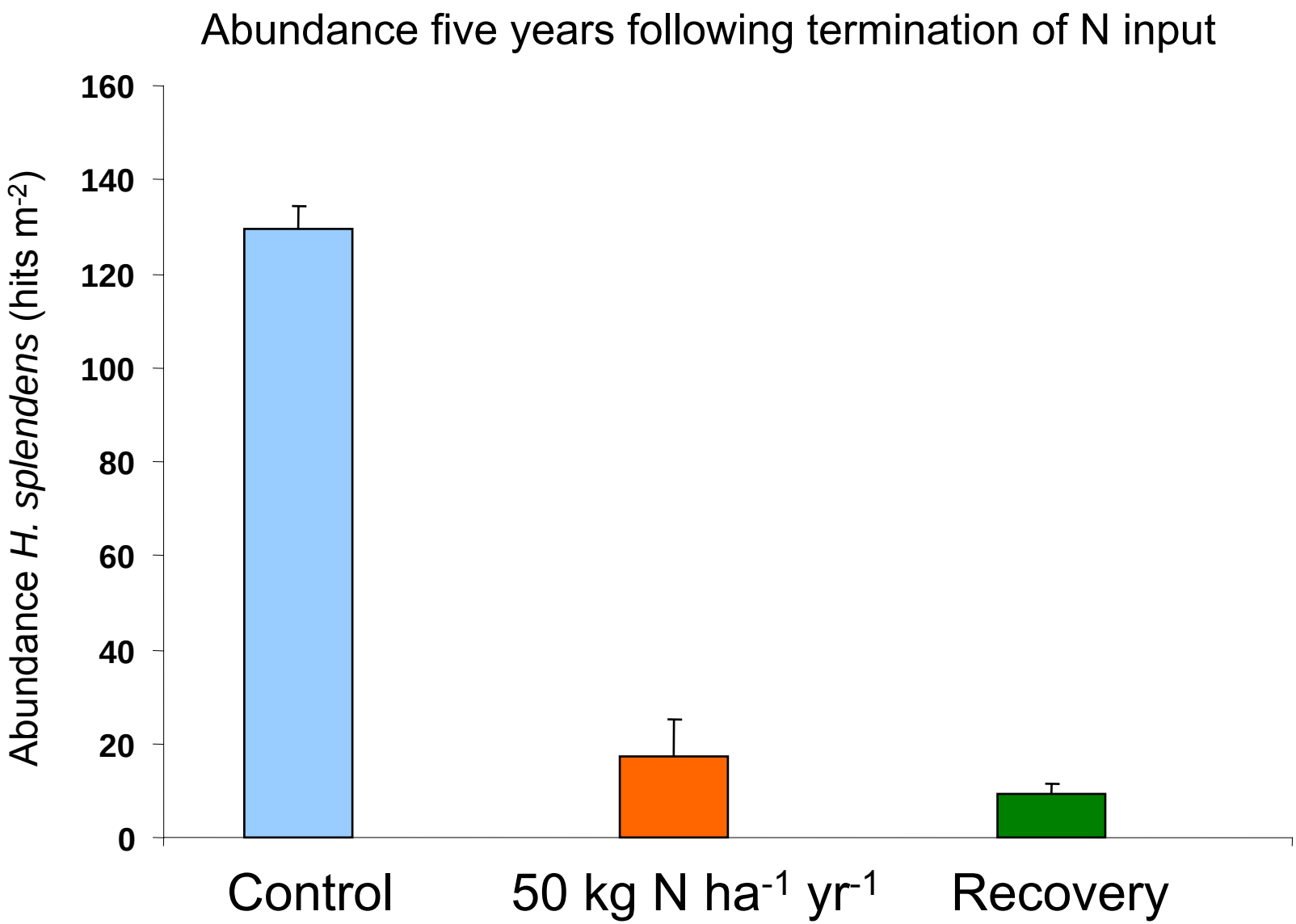
No difference in uptake between N treatment plots



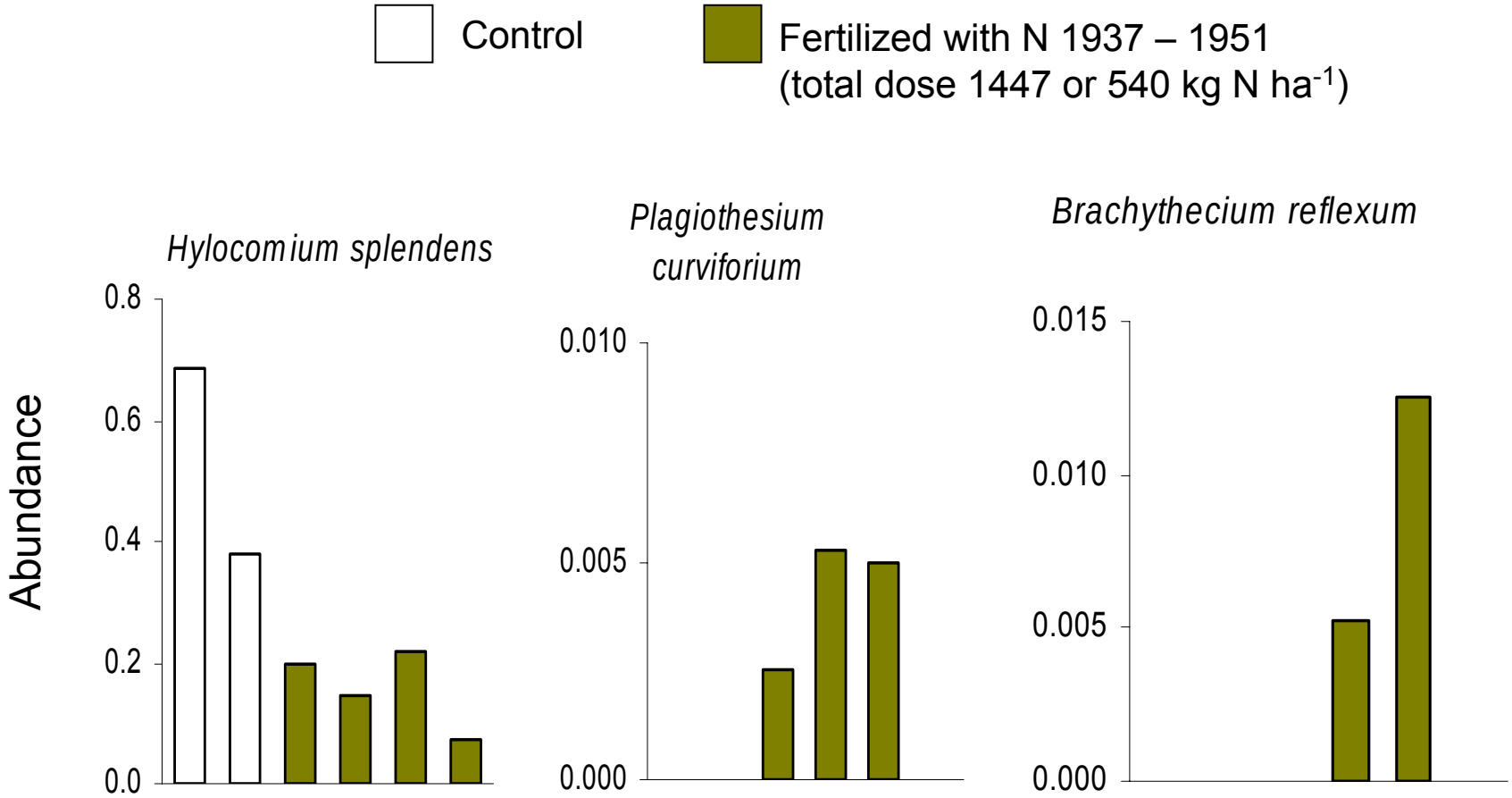
Conclusion: The lack of down regulation of N uptake appear to be one important mechanism explaining decreased bryophyte ground cover under increasing N supply.



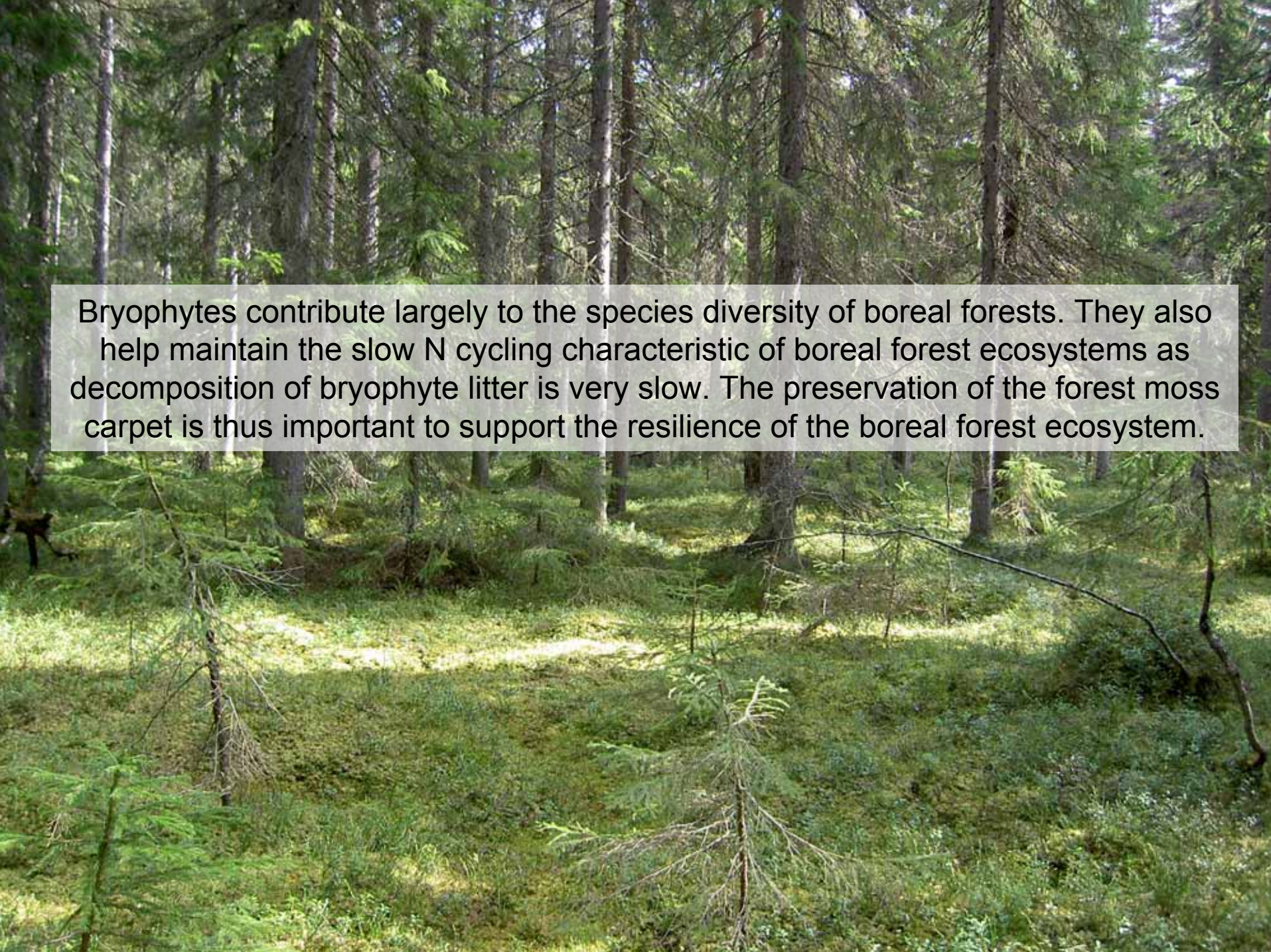
Recovery of bryophytes following high N input – is it possible?


Abundance five years following termination of N input
Abundance H. splendens (hits m-2)
160
140
120
100
80
60
40
20
0
Control
50 kg N ha-1 yr-1
Recovery

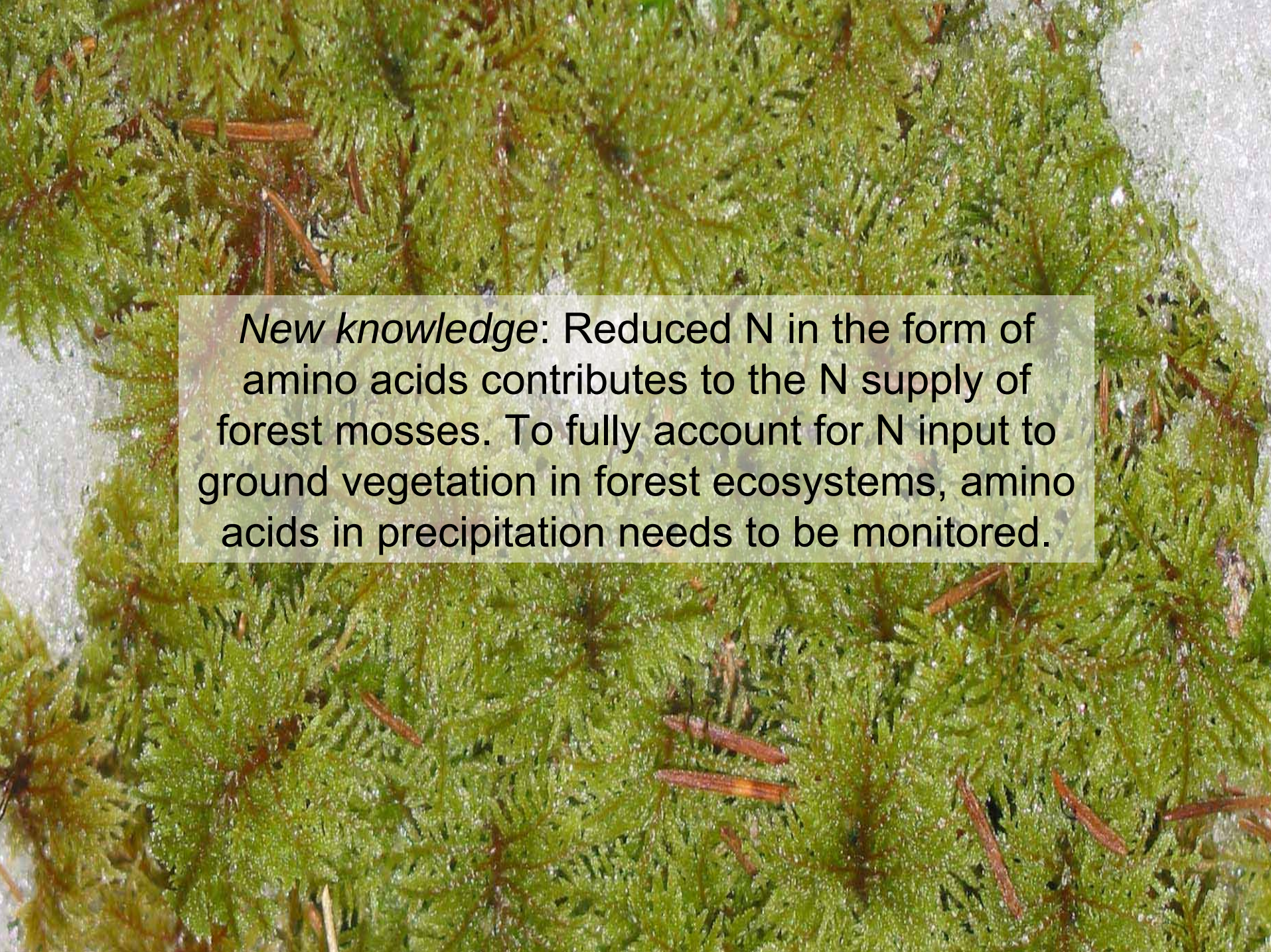
50 years after terminated N fertilization



(Data from Strengbom et al. 2001 in Funct. Ecol.)



Bryophytes contribute largely to the species diversity of boreal forests. They also help maintain the slow N cycling characteristic of boreal forest ecosystems as decomposition of bryophyte litter is very slow. The preservation of the forest moss carpet is thus important to support the resilience of the boreal forest ecosystem.



New knowledge: Reduced N in the form of amino acids contributes to the N supply of forest mosses. To fully account for N input to ground vegetation in forest ecosystems, amino acids in precipitation needs to be monitored.