Ectomycorrhizal fungi and soil nitrogen losses in spruce forests with anthropogenically alleviated nitrogen limitation

Michal Choma
choma@jcu.cz

Karolina Tahovská, Filip Oulehle,
Filip Moldan, Eva Kaštovská
& others

Přírodovědecká fakulta
Faculty of Science

KATEDRA BIOLOGIE EKOSYSTÉMŮ

PŮDNÍ SKUPINA
KBE PřF JU

Ectomycorrhizal symbiosis (ECM)

- >5000 species of ectomycorrhizal fungi (EMF), >8000 plant species (woody)

- exchange of plant assimilates for water and nutrients (N, P)

- mycorrhiza crucial for both partners
  - plants better cope with environmental stress
  - fungi without partner probably unable to complete life cycle

- structures
  - hyphal mantle
  - Hartig's net
  - peripheral (extraradical) mycelium
    - rhizomorphs etc.
    - fruitbody

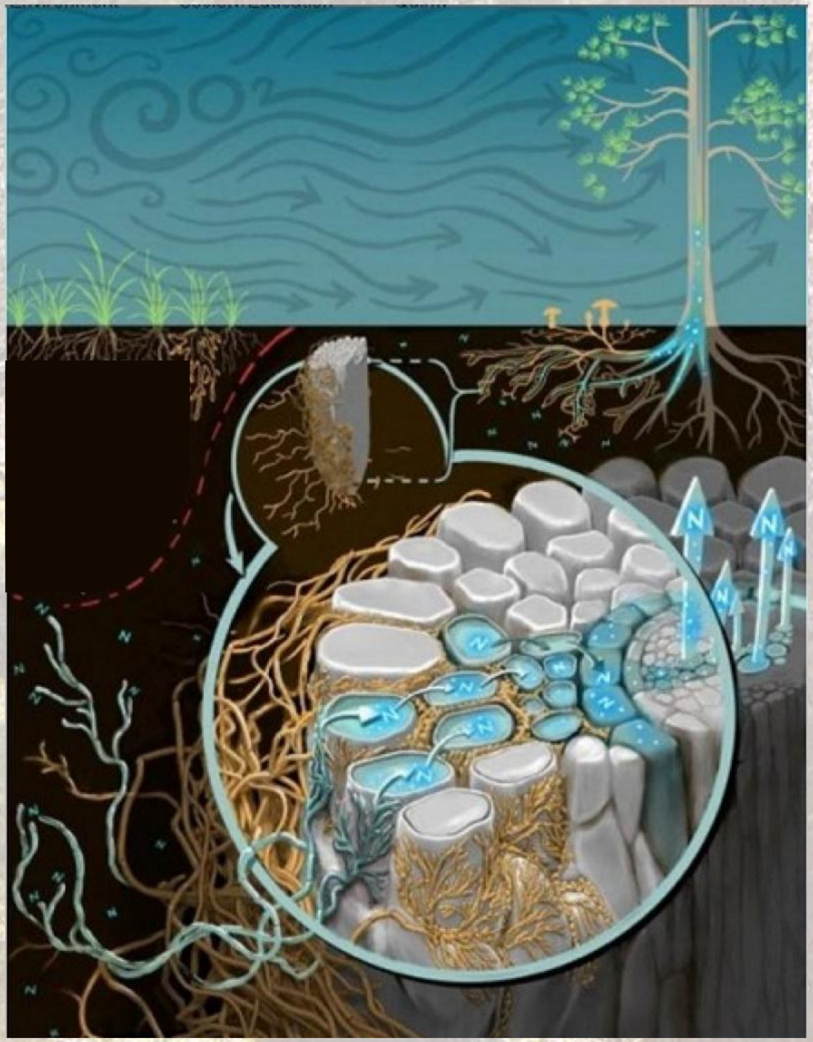


Fig. 1: *Transport of nutrients via mycorrhiza. Author: Victor O. Leshyk*

Function of ectomycorrhizal fungi in forest soils

- ECM independently evolved in > 80 lineages of saprotrophic fungi → functional diversity
- **C cycle**
  - support of primary production
  - redistribution of photoassimilates
  - C sequestration
    - decomposition (enzymes, interaction with saprotrophs)
    - immobilisation to biomass (→ necromass)
- **transformation and immobilisation of nutrients (N)**
  - mobilisation (decomposition, weathering…)
  - immobilisation (fungal and plant biomass)
- other (e.g. ectomycorrhiozosphere effect, ECM networks)

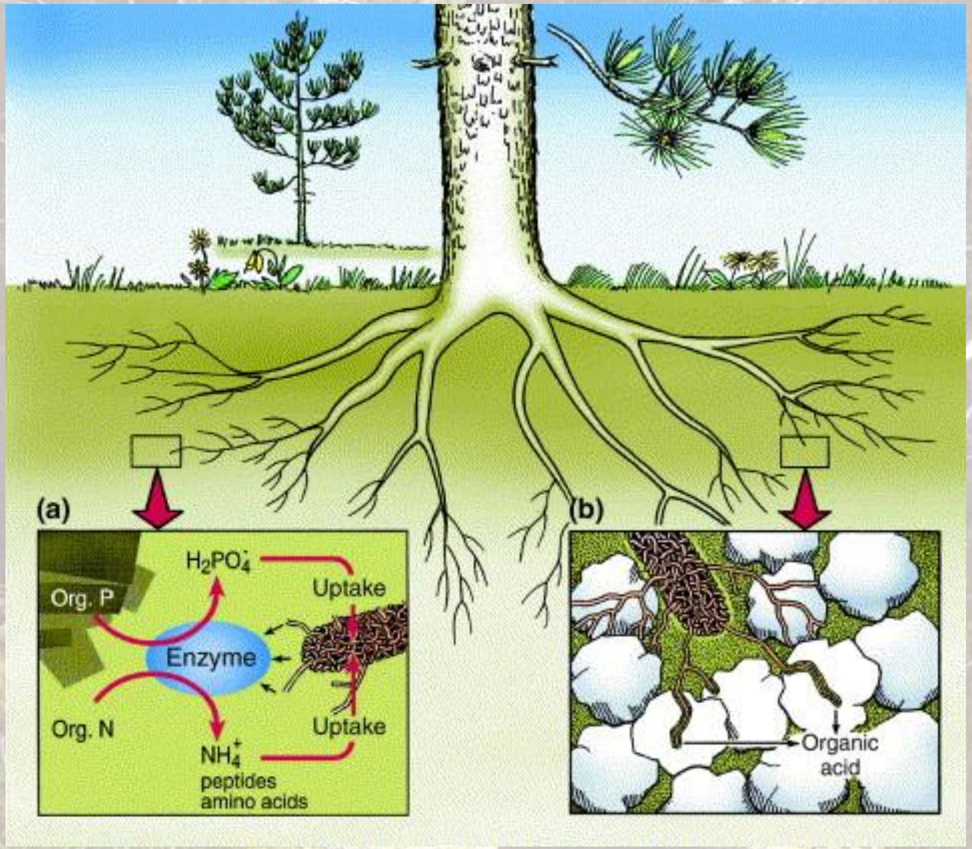
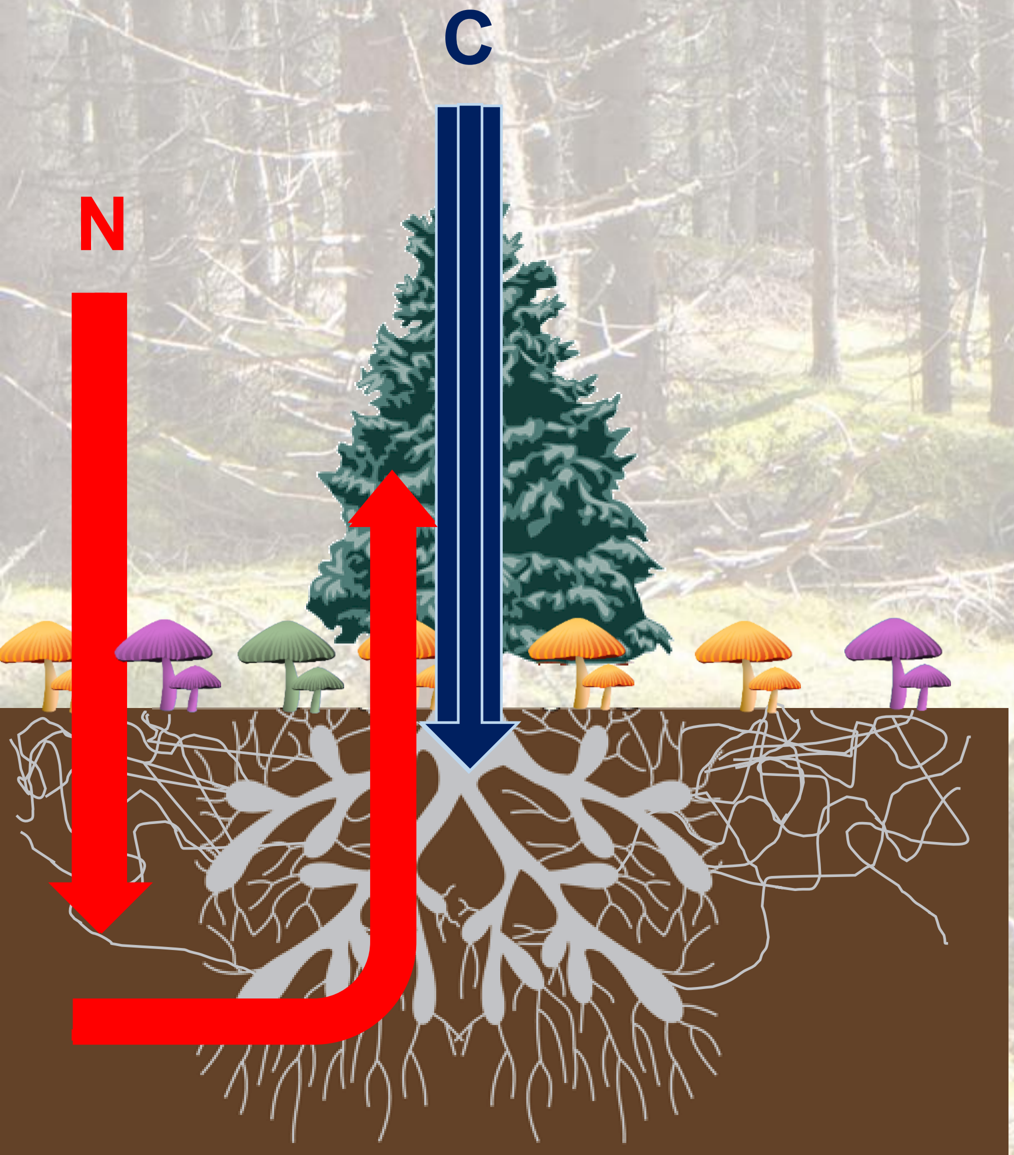


***Fig. 2:** Acquisition of nutrients by ectomycorrhizal fungi – release of a) extracellular enzymes, b) organic acids. Taken from Landeweert et al. 2001,*

Reaction of ectomycorrhizal fungi to increase N availability



In natural conditions ↓ input of N

- plant N limitation, ↑ C flow to roots → EMF
- ↑ biomass of EMF mycelium
- EMF species effective in N acquisition and transport

With increased N input (deposition, fertilization)

- alleviation of plant N limitation, ↓ C flow to roots
- ↓ fruitbodies
- ↓ biomass of peripheral mycelium
- change in species composition

Nitrophobic and nitrophilic species of ectomycorrhizal fungi

- hypothetical concept (Lilleskov et al. 2011)

Nitrophobic EMF
- ↑ mycelium, hydrophobic rhizomorphs, often enzymatic potential
  →↑ C requirements
- medium-distance fringe a long-distance exploration types
- *Cortinarius*, *Suillus*, *Piloderma*

Nitrophilic EMF
- ↓ mycelium, no rhizomorphs
- contact and short-distance explor. t.
- *Lactarius*, *Laccaria*

Many species variable reaction
- e.g. *Russula*

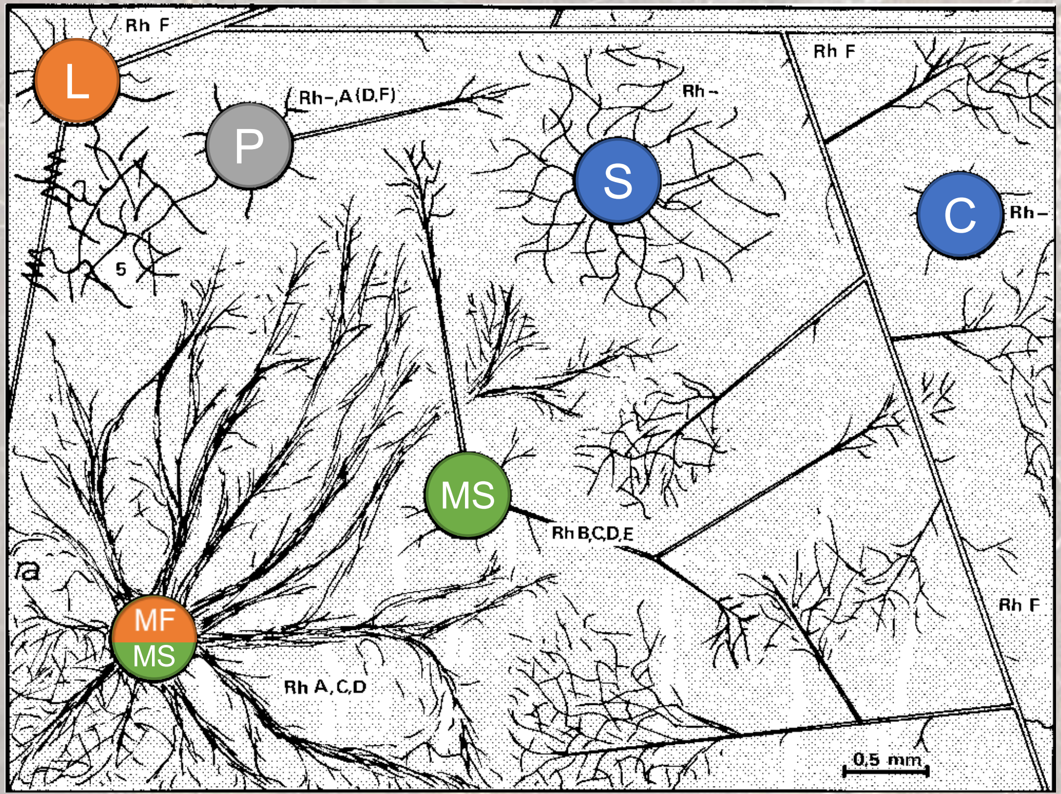


***Fig. 4:** Exploration types of EMF after Agerer (2001).*
- do not form rhizomorphs
  - C: contact, S: short distance
- hydrophilic rhizomorphs
  - MM: medium-distance mat, MS: medium-distance smooth
- hydrophobic rhizomorphs
  - MF: medium-distance fringe, L: long-distance
- P: pick-a-back

Retreat of EMF and/or nitrophobic species
=↓ immobilisation of N in biomass → ↑ N leaching?

Following slides based on:

A subset of results from dissertation thesis

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Indications that long-term nitrogen loading limits carbon resources for soil microbes

M.O. Rappe-George [a,*], M. Choma [b], P. Čapek [b], G. Börjesson [a], E. Kaštovská [b], H. Šantrůčková [b], A.I. Gärdenäs [a,c]

[a] Department of Soil and Environment, Swedish University of Agricultural Sciences, P.O. Box 7014, 750 07 Uppsala, Sweden
[b] Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovská 1760, 370 05 České Budějovice, Czech Republic
[c] Department of Biological and Environmental Sciences, University of Gothenburg, P.O. Box 461, 405 30 Gothenburg, Sweden

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Recovery of the ectomycorrhizal community after termination of long-term nitrogen fertilisation of a boreal Norway spruce forest

Michal Choma [a,*], Martin O. Rappe-George [b], Jiří Bárta [a], Petr Čapek [a], Eva Kaštovská [a], Annemieke I. Gärdenäs [b,c], Hana Šantrůčková [a]

[a] Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovská 1760, 370 05 České Budějovice, Czechia
[b] Department of Soil and Environment, Swedish University of Agricultural Sciences, P.O. Box 7014, 750 07 Uppsala, Sweden
[c] Department of Biological & Environmental Sciences, Gothenburg University, P.O. Box 463, 405 30 Göteborg, Sweden

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Positive response of soil microbes to long-term nitrogen input in spruce forest: Results from Gårdsjön whole-catchment N-addition experiment

Karolina Tahovská [a,*], Michal Choma [a], Eva Kaštovská [a], Filip Oulehle [b,d], Jiří Bárta [a], Hana Šantrůčková [a], Filip Moldan [c,d]

[a] Department of Ecosystem Biology, Faculty of Science & SoWa, University of South Bohemia, Branišovská 31, 370 05, České Budějovice, Czech Republic
[b] Czech Geological Survey, Department of Environmental Geochemistry and Biogeochemistry, Geologická 6, Prague 5, 152 00, Czech Republic
[c] IVL Swedish Environmental Research Institute, Box 53021, SE-400 14, Göteborg, Sweden
[d] Global Change Research Centre of the Czech Academy of Sciences, Czech Academy of Sciences, Bělidla 986-4a, Brno, 60300, Czech Republic

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Research Article

RESEARCH ARTICLE

Bacteria but not fungi respond to soil acidification rapidly and consistently in both a spruce and beech forest

Michal Choma[1,*,†], Karolina Tahovská[1], Eva Kaštovská[1], Jiří Bárta[1], Michal Růžek[2,3] and Filip Oulehle[2]

[1]Department of Ecosystem Biology, Faculty of Science, University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic, [2]Czech Geological Survey, Department of Environmental Geochemistry and Biogeochemistry, Geologická 6, Prague 5, 152 00, Czech Republic and [3]Department of Physical Geography, Faculty of Science, Charles University, Albertov 6, 128 43 Prague, Czech Republic

Overview of experimental sites

***Tab. 1:** Research sites – basic overview*

	Stråsan (ST)	Gårdsjön (GA)	Načetín (NAC)
Current N deposition (kg N ha^{-1} y^{-1})	3	9	30
N deposition change compared to 1990	no	slight ↓	slight ↓, recovery from N saturation
Experimental N addition (kg N ha^{-1} y^{-1})	34	40	50
Experiment duration (years)	46	24	4

What did we study in these spruce forests

- organic horizon (F+H)
  - soil DNA, fungal ITS sequencing, identification of EMF, exploration types
  - soil biochemistry: pH; water-extractable, total and microbial C a N; extracellular enzymatic activity
- leaching of NO_3^- (lysimeters / monitoring of catchment outflow)
- others

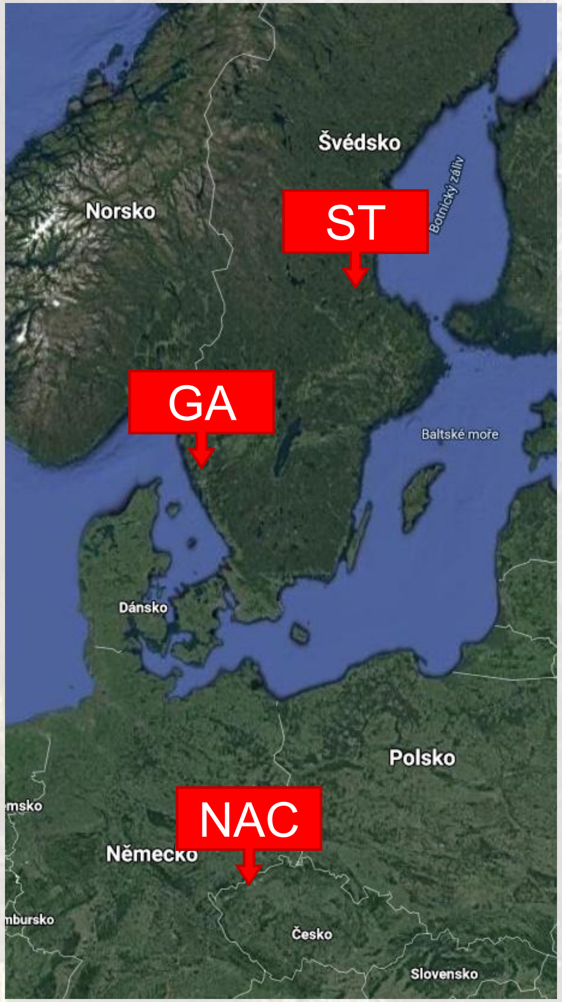
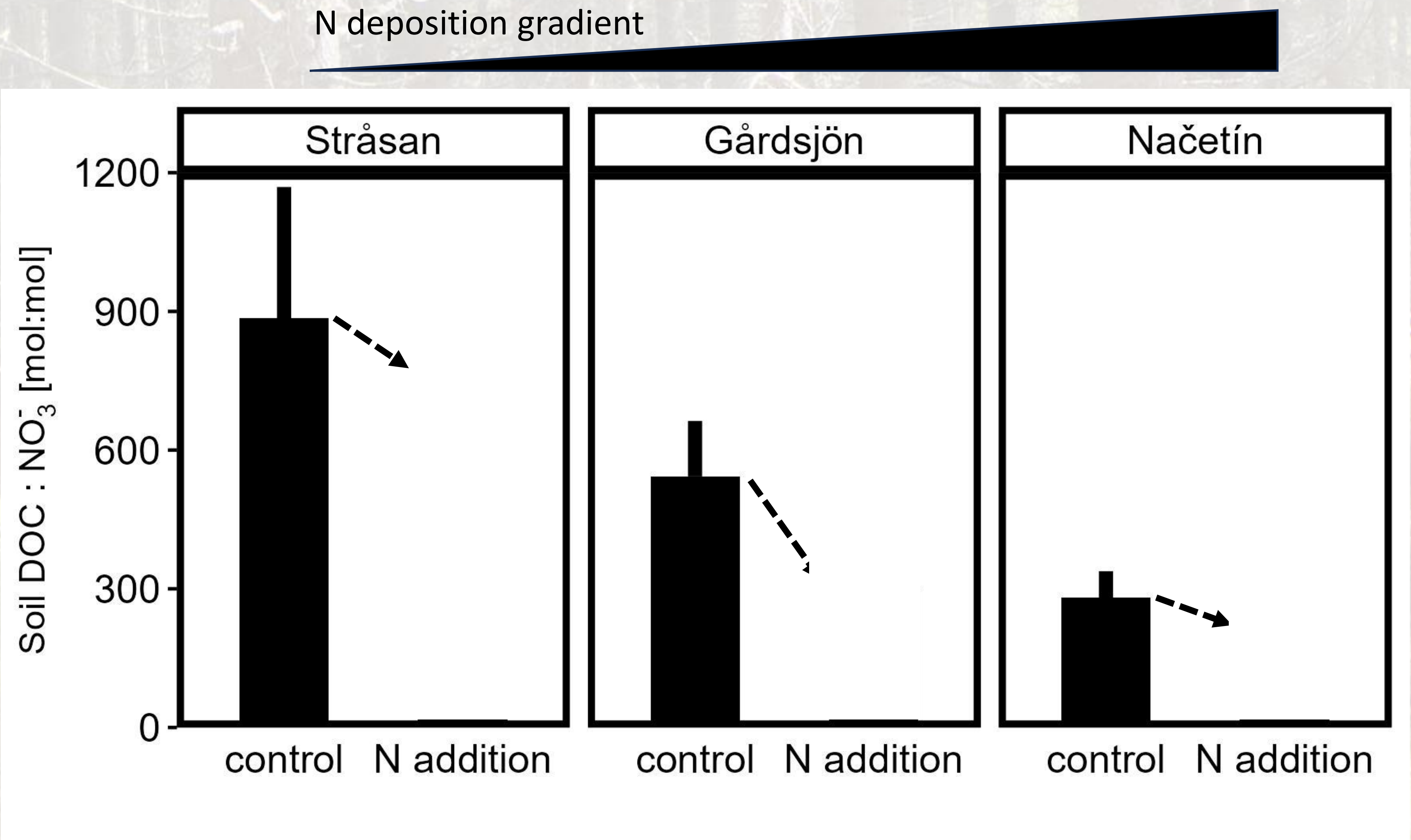
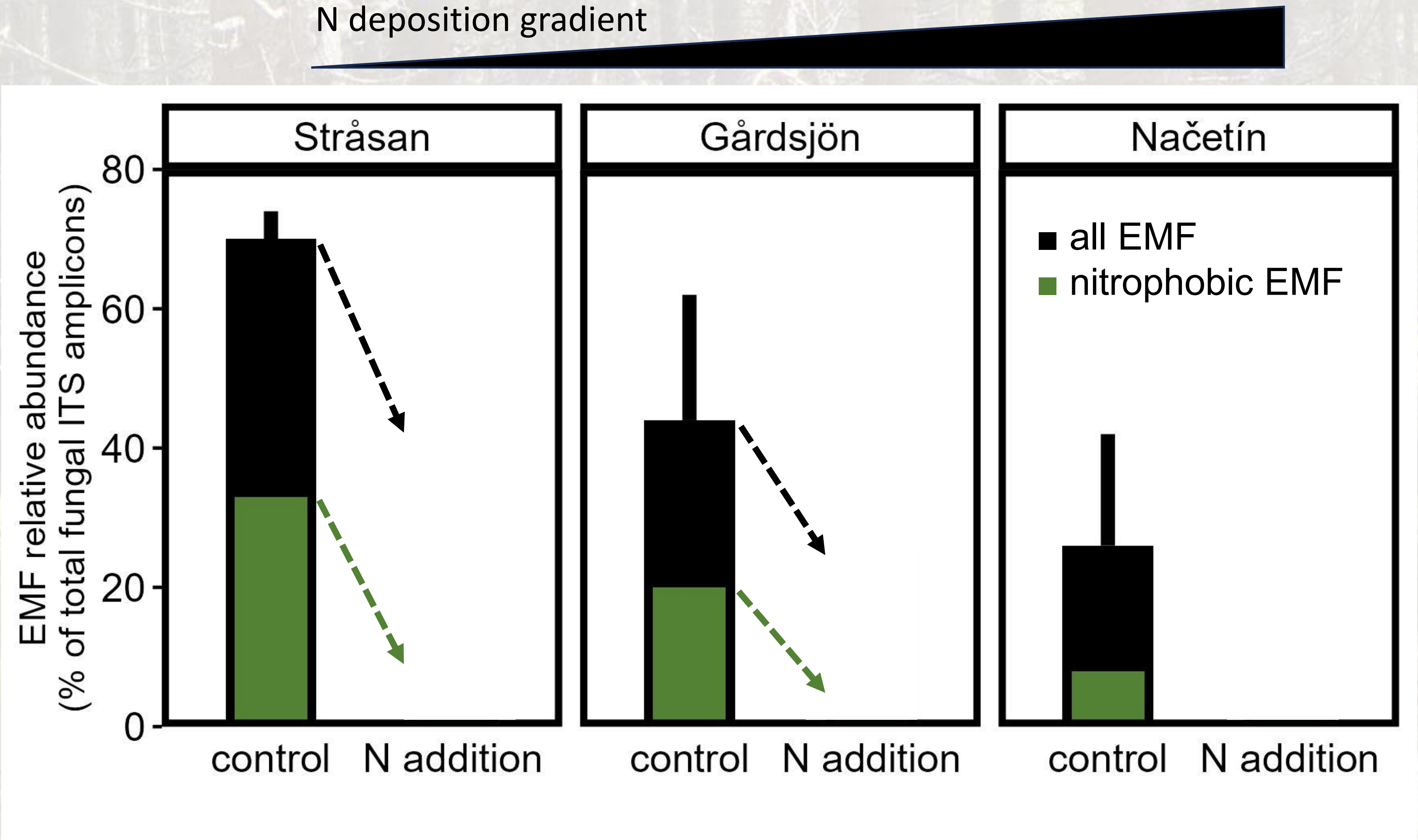


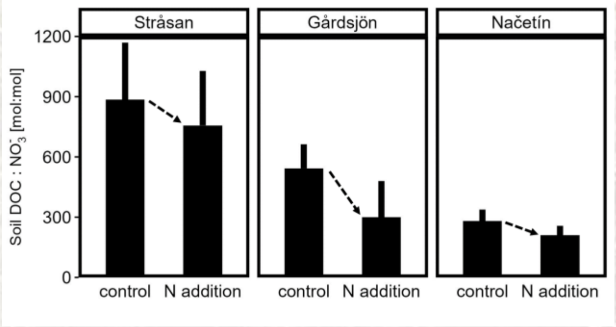
***Fig. 5:** Geographical location of sites.*
Background: GoogleMaps.

N input increased N availability (!)

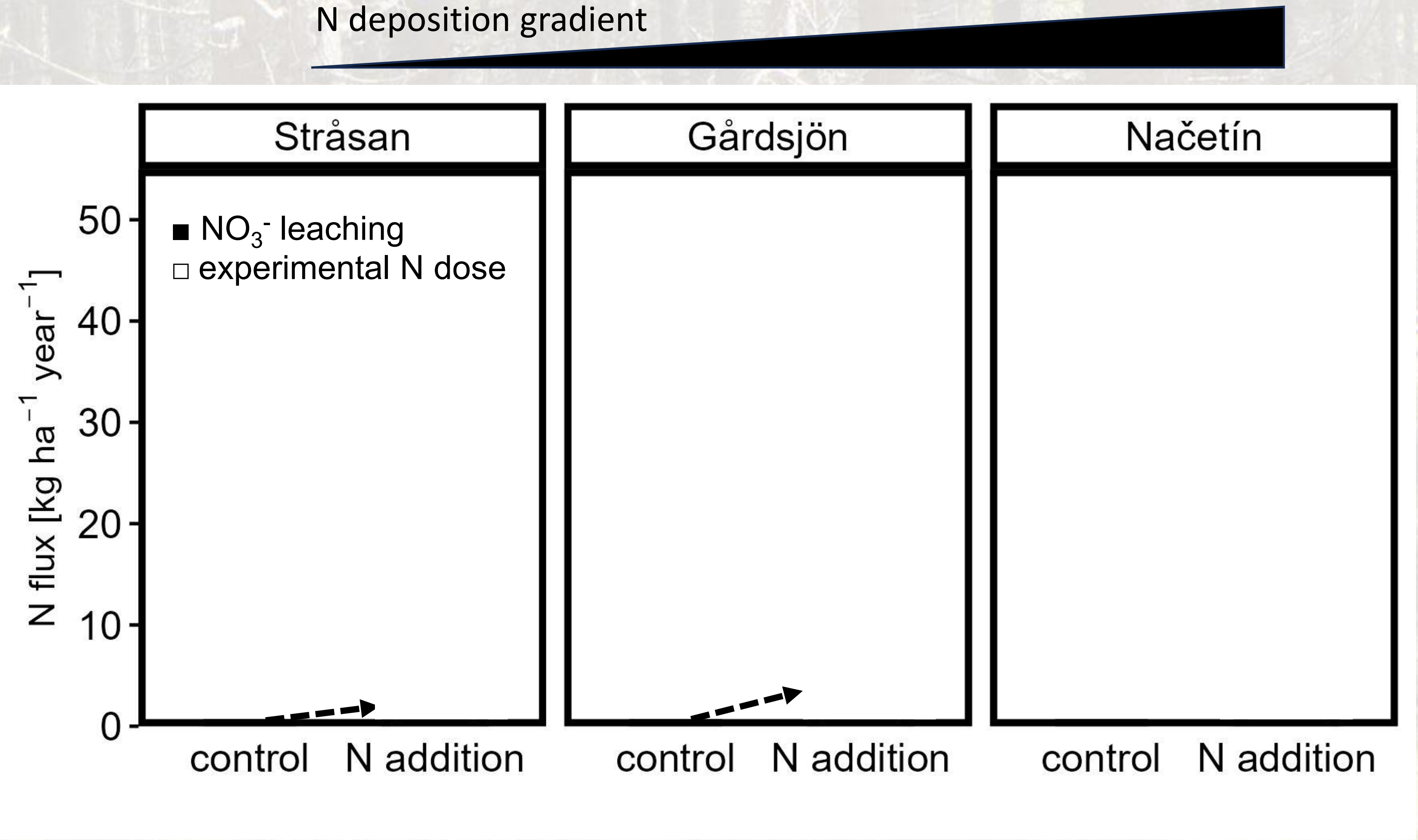


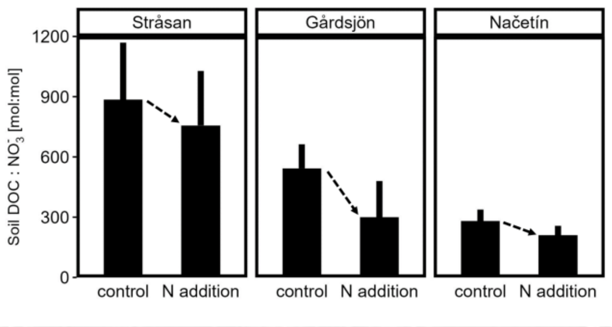
As a consequence, (nitrophobic) EMF retreated

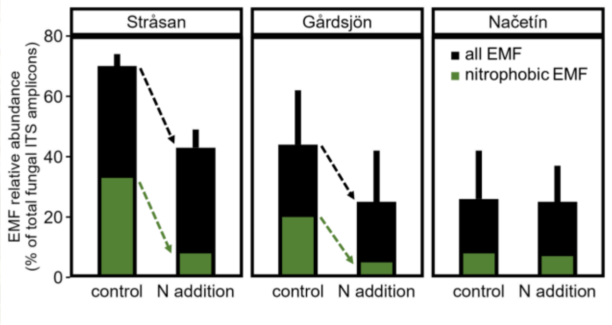




Leaching of nitrates







Take-home

Long-term N enrichment increased soil N availability, which resulted in retreat and composition changes of EMF.

Evident on both N deposition gradient and experimental N addition.

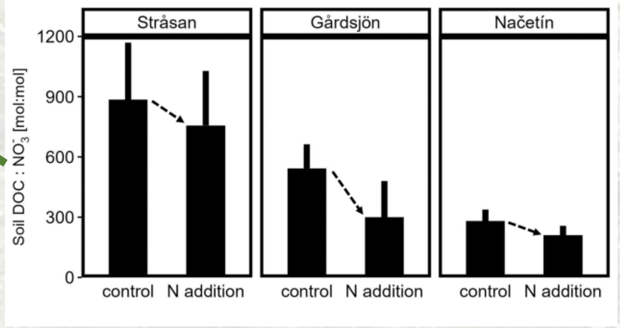
Experimental N addition increased soil nitrate leaching. Nevertheless, this increase accounts only to a fraction (< 10 %) of total N added.

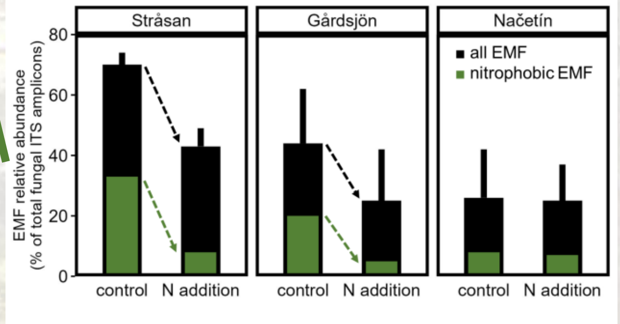
Forest ecosystems are resilient and can maintain low levels of N leaching despite changes in EMF community.

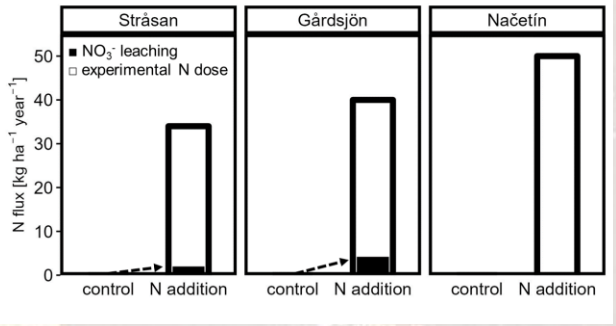
(= EMF are not irreplaceable and the most important in N retention)

- accumulation in plant biomass (↑ growth, ↑ N enrichment)
- sequestration of N in SOM (↑ soil N, ↓ SOM C:N)
- effective use by adapted microbiome (saprotrophs, faster growing groups, change in enzymatic activity)

Unless additional stress occurs, such as acidification…







Thank you for attention!

Have a feeling that it was too much simplified?

You’re right! If interested in details, read more: