ICP Forests

Impact of pollen on throughfall biochemistry in European temperate and boreal forests

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Objectives

The objective of this study is to assess the qualitative and quantitative impact of pollen/flowering on throughfall (TF) deposition fluxes in temperate and boreal deciduous and coniferous forests.

Materials and methods

1) Dissolution experiment

- A 7-day dissolution experiment was conducted with bud scales and flower stalks of *Fagus sylvatica*, pollen of *F. sylvatica* , *Quercus robur*, *Betula pendula*, *Pinus sylvestris*, *Pinus nigra*, *Picea abies* and sterilized pollen of *B. pendula*. Per treatment 50±0.52 mg was added to 200 mL nitrate (NO_3^--N) solution (11.3 mg N L^{-1}) and we took 15 mL samples for chemical analysis after 2, 24, 48, 72, 96 and 168 hrs.

2) Interannual study

- We analysed the relationship between long-time monitoring data of TF deposition fluxes from 98 Level II monitoring plots of the ICP Forests and airborne pollen concentrations (Seasonal Pollen Integral, SPIn) from nearby aerobiological monitoring stations (Fig. 1) with generalized additive mixed models (GAMM) for potassium (K^+), nitrate, ammonium (NH_4^+-N), dissolved organic carbon (DOC) and dissolved organic nitrogen (DON), e.g.:

  $TF\ K^+_{pollen} = s(SPIn, bs="cr", k=3) + VarIdent(Country)$
- Sites were grouped according to dominant tree genus: *Fagus*, *Quercus*, *Pinus* and *Picea.* The 3 mixed stands were included in 2 groups.
- Per site the period with pollen in TF samples (arbitrary 2 months) was selected based on daily airborne pollen concentrations available for a limited number of sites and TF data (Table 1).
- The contribution of pollen to TF fluxes (absolute and in % of annual mean) was calculated and compared:

  $INPUT_{pollen}$ = *TF two months pollen distribution period – TF (previous + following month)*

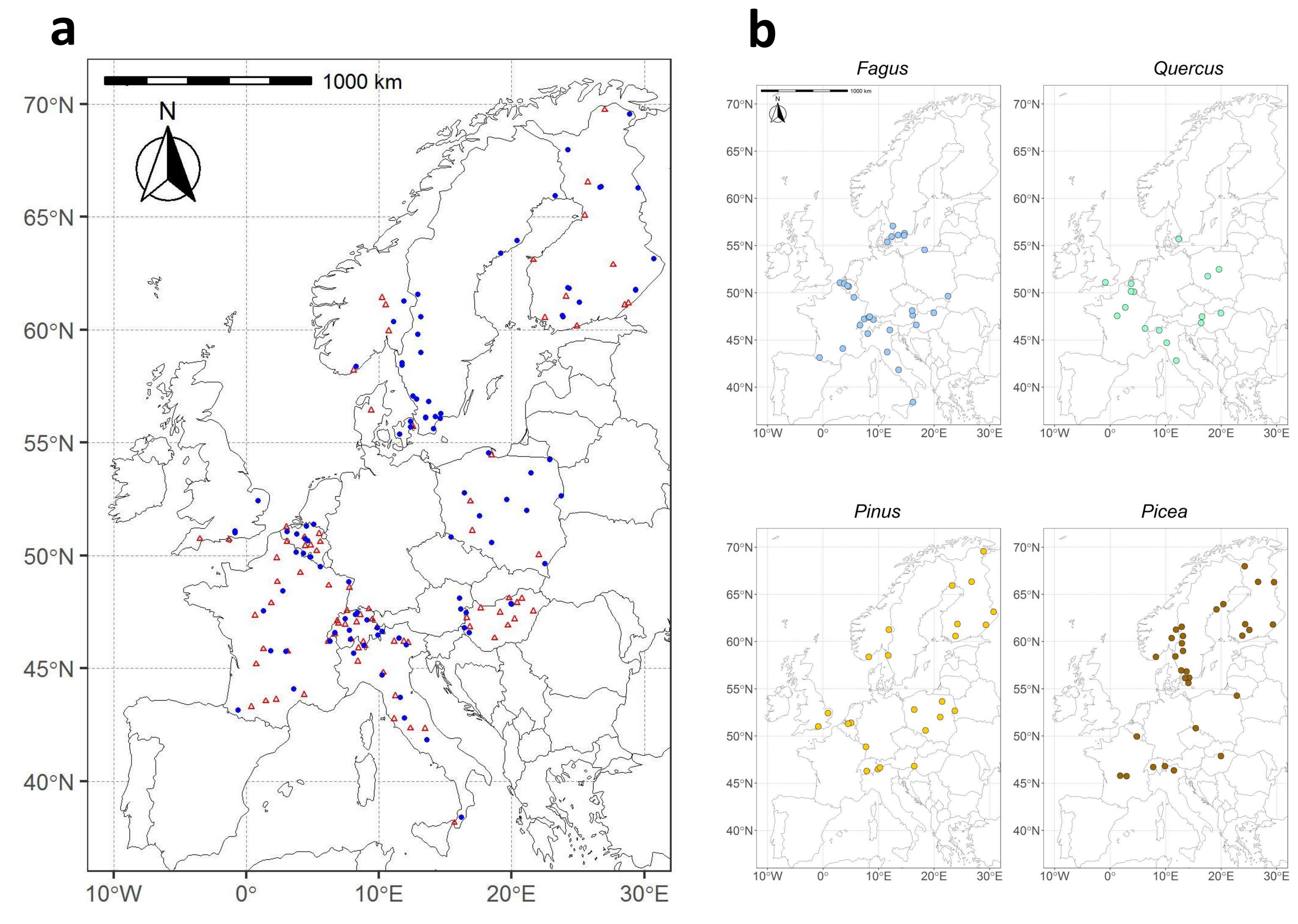

Fig. 1 **a)** Map of ICP Forests Level II plots (blue dots) and aerobiological monitoring stations (red triangles). **b)** Maps of Level II plots for the tree genera.

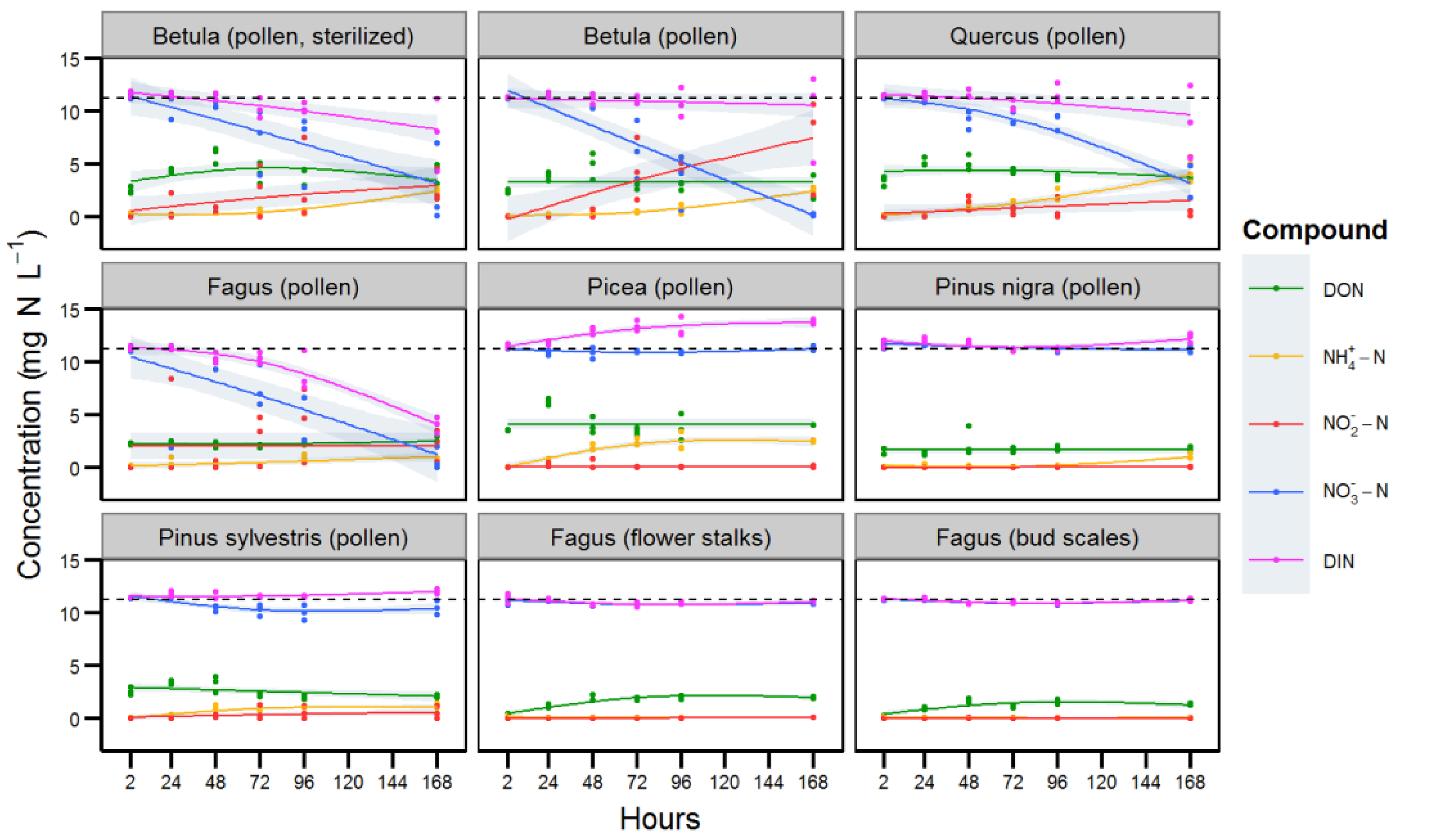

Fig. 2 Volume corrected changes in the concentration of nitrogen species during the experiment for the different treatments (mg N L^{-1}).

Preliminary results

1) Dissolution experiment

- Pollen released K^+, phosphate, DOC, DON and small amounts of sulphate, sodium and calcium (not shown). About 10-20% of organic matter dissolved (Fig. 6).
- NO_3^--N gradually disappeared in samples with pollen from deciduous trees, reducing dissolved inorganic nitrogen (DIN), while NH_4^+-N and (instable) nitrite (NO_2^--N) increased (Fig. 2).
- The contribution of bud scales and flower stalks to TF fluxes was limited to some K^+ and DON.

2) Interannual study

- Pollen contributed to TF most in *Quercus* > *Fagus* > *Pinus* > *Picea* stands (Fig. 3). Differences might be related to pollen reactivity and the amount of pollen distributed (Fig. 5).
- For *Fagus*, a mast flowering species, input from pollen was higher in years with SPIn > 80% of mean (Fig. 4).
- Pollen 'eats' about 2-3% of annual TF NO_3^--N deposition. More than indicated by the experiment, this was also observed for *Pinus* and *Picea*, presumably due to admixture of broadleaved pollen.
- In *Quercus* stands, more than 10% of annual TF K^+, NH_4^+-N and DON might derive from pollen/flowering.
- For *Fagus*, the modeling analysis broadly confirmed the results of the experiment, but model uncertainty was high for more sparse higher values of SPIn (Fig. 7). For *Quercus, Pinus* and *Picea* models were not always valid because pollen is dispersed each year, making it difficult to show the relationship.

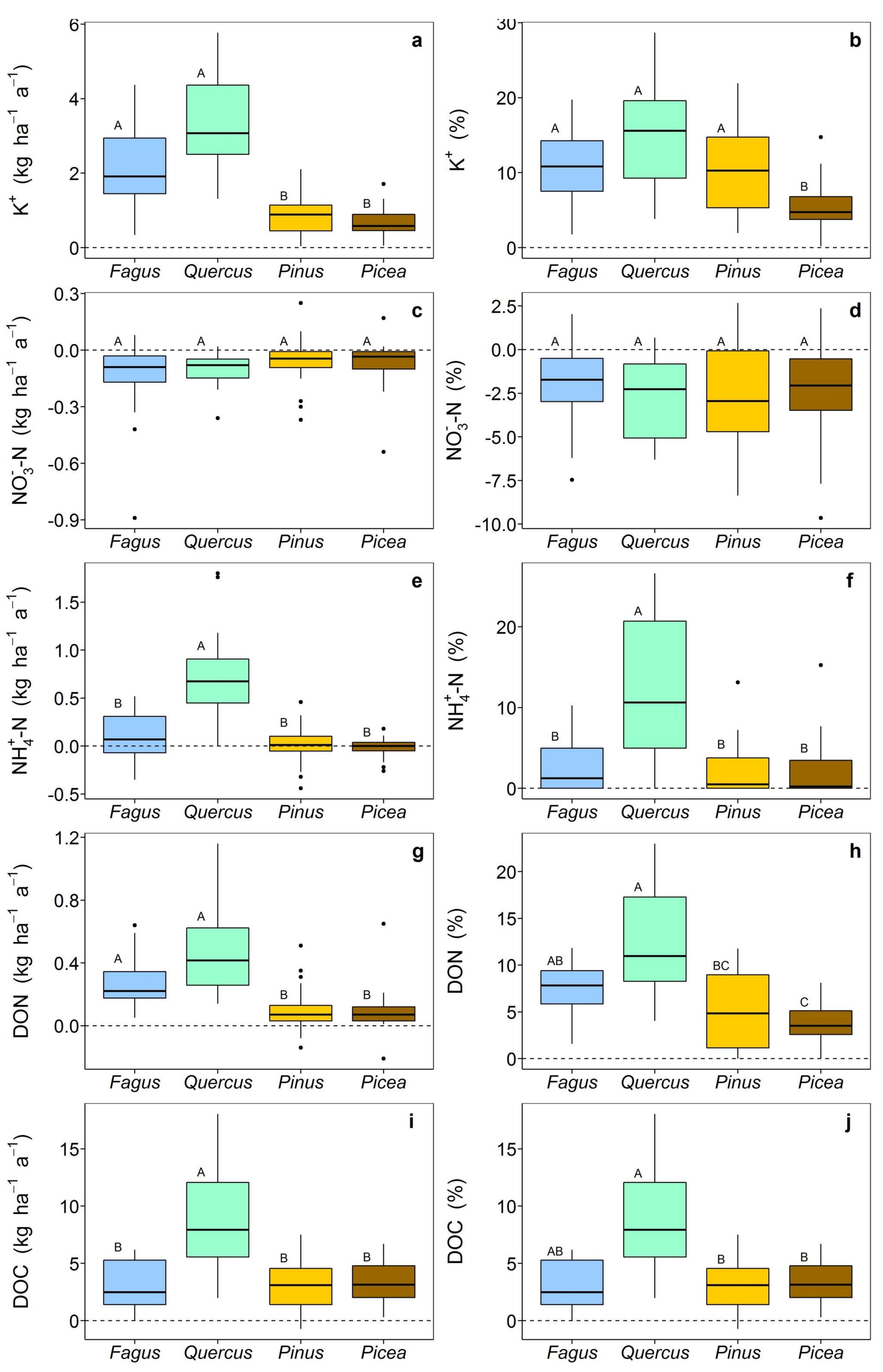

Fig. 3 Contribution of pollen to TF deposition in kg ha^{-1} a^{-1} (left) and as a percentage of mean annual TF (right) for the four tree genera. Capital letters indicate groups with significantly different mean ($p < 0.05$).

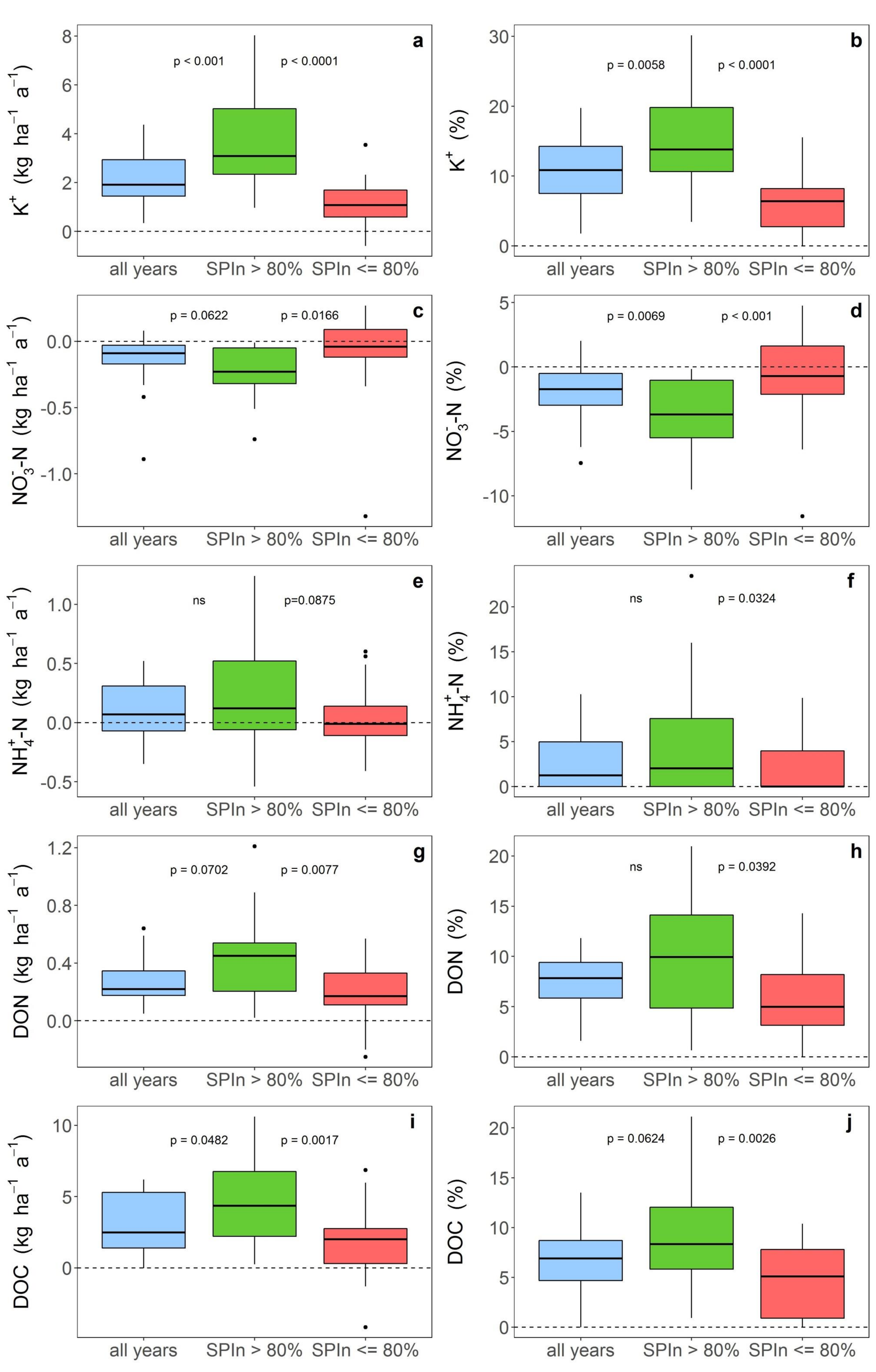

Fig. 4 Contribution of *Fagus* pollen (all years, SPIn > 80% of mean, SPIn <= 80% of mean) to TF deposition in kg ha^{-1} a^{-1} (left) and as a percentage of mean annual TF (right).

Discussion

- During the experiment DIN was reduced, presumably because it was lost as gaseous nitric oxide (NO). NO is a key signalling molecule involved e.g., in pollen germination and pollen tube growth (Domingos et al., 2015). Our results suggest that NO is produced via the nitrate reductase pathway.
- The production of NH_4^+-N might be the result of enzymatic degradation of amino acids as observed in the nectar of certain plants (Prŷs-Jones and Willmer, 1992).

Table 1 Periods selected for calculation of pollen contribution and modelling (number of Level II plots per tree genus) based on pollen and TF data.

	1 Apr-31 May	15 Apr-15 Jun	1 May-30 Jun	15 May-15 Jul	1 Jun-31 Jul	Total
Fagus	24	5				29
Quercus	13	3				16
Pinus		4	10	6	4	24
Picea		4	9	14	5	32

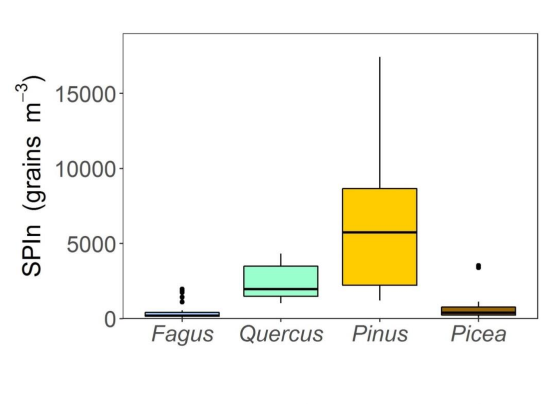

Fig. 5 Mean annual SPIn per plot for the tree genera (from nearby stations).

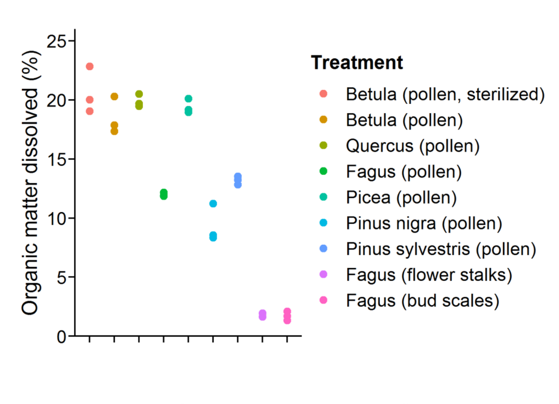

Fig. 6 Total percentage of OM dissolved per treatment (n = 3 repetitions).

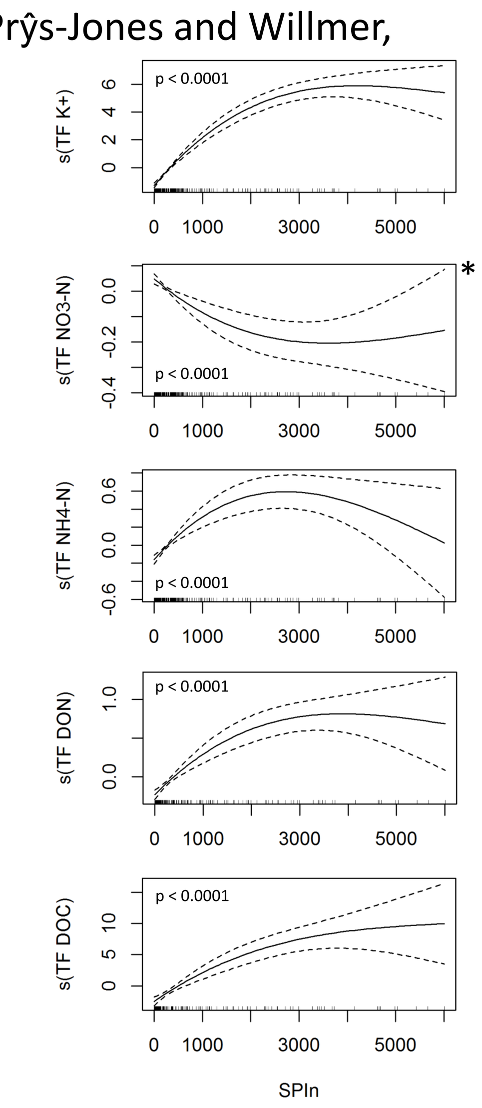

Fig. 7 GAMM models for studied parameters in function of SPIn for *Fagus*.
*: 15 April – 15 May

Preliminary conclusions

- Pollen is an overlooked factor in forest nutrient cycling, particularly for K^+, DOC, DON, NO_3^--N, NH_4^+-N and phosphate.
- Pollen might induce complex canopy N transformations.
- Sampling interval length might affect measured TF fluxes of individual N compounds.

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