SFB 607 *Growth and Parasite Defense – Competition of Resources in Economic Plants from Forestry and Agronomy*

Technische Universität München

Effects of elevated ground-level ozone on acquisition and cycling of nitrogen in a mixed stand of mature *Fagus sylvatica* and *Picea abies*

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Introduction

When studying the effects of elevated ground-level ozone [O_3] on the competitiveness of trees, the interaction in the plant-mycorrhiza-soil system is important. In the free-air ozone fumigation experiment at "Kranzberger Forst" (SE-Germany) it was shown that enhanced O_3 concentrations reduces density and turnover rates of fine roots in European beech (*Fagus sylvatica* L.). Moreover, the mycorrhiza population was changed in beech and Norway spruce (*Picea abies* L. [Karst.]).

To test whether these belowground responses affected the acquisition of nitrogen [N], the same 60-70 yrs old beech and spruce trees exposed to double-ambient ($2xO_3$) or ambient ($1xO_3$) ozone concentrations were labelled with $^{15}NH_4{}^{15}NO_3$ (98 atom%, 1 m² of soil surface each) over a period of three weeks in 2005. Aboveground plant organs were sampled during two vegetation periods after labelling, while roots, mycorrhiza and soil were sampled once, at the end of the experiment.

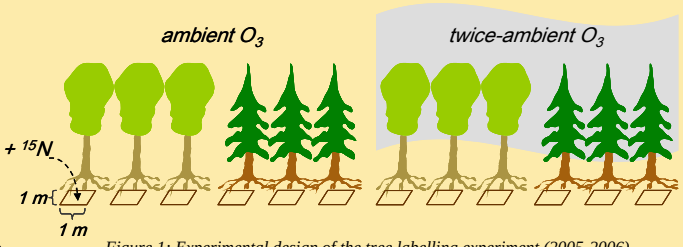

Figure 1: Experimental design of the tree labelling experiment (2005-2006)

Winter 2006	*Fagus sylvatica*		*Picea abies*	
	$1xO_3$	$2xO_3$	$1xO_3$	$2xO_3$
^{15}N recovery per tree [%]	26 ± 8	21 ± 6	29 ± 17	19 ± 3
^{15}N recovery in soil per 1m²-plot [%]	24 ± 1	36 ± 11	30 ± 2	39 ± 4
Total tree biomass [kg]	432 ± 102	599 ± 199	630 ± 67	460 ± 87
Total N per tree [g kg^{-1}]	2 ± 0.1	2 ± 0.1	3 ± 0.2	2 ± 0.3 **

Table 1: ^{15}N recovery, total N and biomass per tree. Values as means ±SE, with n=3 trees. Levels of significance between ozone treatments at $P < 0.05$ (*), 0.01 (**) or 0.001 (***).

Results

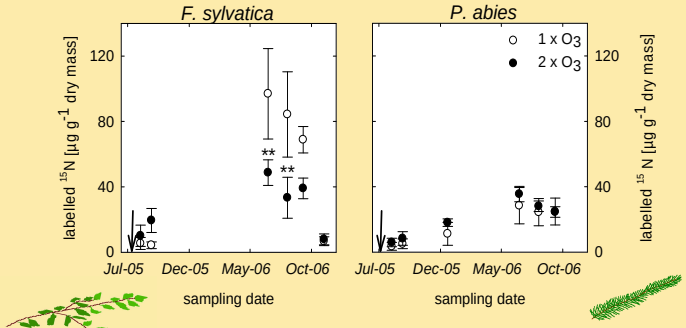

Figure 2: Labelled ^{15}N in beech leaves and current-year spruce needles of sun foliage throughout 1 ½ growing seasons. November data represent leaf litter. Values as means ± SE, n=3 trees. Arrows indicate the time of labelling. Levels of significance between ozone treatments at $P < 0.05$ (*), 0.01 (**) or 0.001 (***).

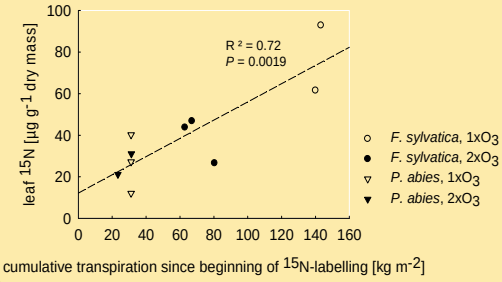

Figure 3: Correlation between cumulative transpiration per unit of leaf area since beginning of the ^{15}N-labelling in July 2005 through September 2006 and labelled ^{15}N in sun crown leaves or current-year needles in Sept. 2006. Each data point represents an individual tree.

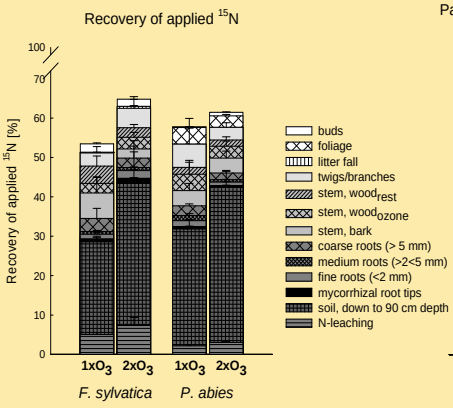

Figure 4: Recovery of ^{15}N in tree and soil compartments 16 months upon ^{15}N-label application (after beech leaf fall). Values as means ±SE, with n=3 trees. Recovery in below-ground compartments is referred to the 1 m² plots down to 90 cm depth.

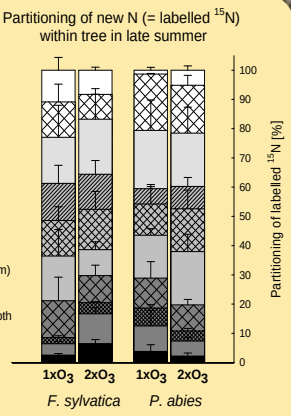

Figure 5: Partitioning of labelled ^{15}N in trees in late summer. Values as means ±SE, with n=3 trees.

Summary & Conclusions

- While about 25-40 % of the applied ^{15}N was immobilized in the soil, the label could be pursued in the system components (*Fig.4*).
- In foliage, ^{15}N accumulation increased from 2005 to 2006 (*Fig.2*), although the variance was high both between and within the trees. ^{15}N-uptake in beech was reduced under $2xO_3$ and was correlated to transpiration (*Fig.3*). In contrast, ^{15}N-uptake in spruce needles was not affected by $2xO_3$, whereas total N was reduced in needles and twigs (data not shown).
- On whole-tree level, ^{15}N recovery tended to be reduced under $2xO_3$ in both species, and total N status in spruce was significantly lowered (*Tab. 1*).
- Partitioning of the newly acquired N (= labelled ^{15}N) within tree was similar between species and ozone treatments. However, under $2xO_3$, the proportion of new N was increased in fine roots and mycorrhiza of beech, but decreased in medium roots in spruce (*Fig.5*).

→ Thus, our results indicate that high O_3 doses reduce both, uptake and transport of N in mature trees, with beech being stronger affected than spruce. Scaled up from trees to the stand, the relatively moderate O_3 effects on tree level may in long-term alter the N cycle on stand level, e.g. through higher N availability in the soil (Fig. 6).

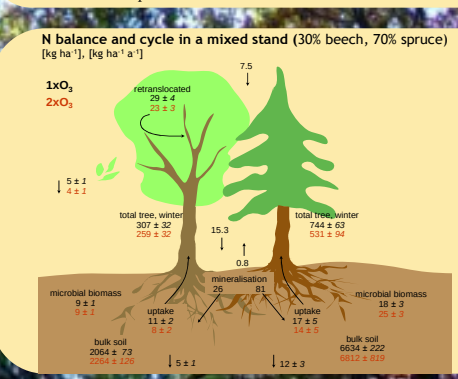

*Figure 6: N balance and cycle of the study site [kg N ha^{-1}] as a mixed stand of beech (30 % of basal tree area) and spruce (70 %) under **$1xO_3$** (black numbers) and **$2xO_3$** (red numbers). Arrows indicate flows [kg N ha^{-1} a^{-1}]. Values as means ±SE, with n=3-5 trees.*

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