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Contrasting effects of long term vs short term N addition on foliar CO2 exchange parameters of two common Arctic peat land plant species

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The productivity of Arctic peatlands is generally limited by cold temperatures, short growing seasons and low nitrogen (N) supply. However, due to increased deposition rates as a consequence of anthropogenic activity, as well as through higher mineralization rates following climate warming, the N availability in the Arctic ecosystems is expected to increase. In fertilizer experiments, higher N availability is known to increase primary production as well as the leaf area index. Furthermore, N addition changes species composition: shrub cover typically increases while bryophyte cover decreases. Less is known, however, about the effects of N addition on the leaf CO_2 exchange parameters. Previous N addition experiments in Arctic peat lands (lasting 1-4 years) showed some increases in the leaf level net C-uptake, though this response was inconsistent among species. It is also unclear whether this response can be extrapolated to a prolonged period of elevated N supply ($>$ 20 years). Moreover, less is known about whether and how the investment of N in different components of the photosynthetic apparatus changes following short or long term N addition. The latter is of particular interest, since in many vegetation models or upscaling exercises the parameters determining leaf level C-uptake are scaled by the amount of foliar N.

The aims of our study were (1) to investigate the effects of short and long term N addition on the foliar CO_2exchange parameters of Arctic peat land species, and (2) to determine relative N investment in different parts of the photosynthetic apparatus after short and long term N addition. We compared the carboxylation efficiency of Rubisco (V_{cmax}), electron transport capacity (J_{max}), dark respiration (R_d), chlorophyll content and total foliar N of sun lit leaves from two species after short term (6 weeks), and longer term (4 years and 21 years) N (and P) addition. The species included were *Betula nana* and *Eriophorum vaginatum* and the experiments were carried out in moist acidic tussock tundra in Northern Alaska, near the Toolik Lake field station.

(1) For both *B. nana* and *E. vaginatum* no significant differences in $V_{cmax}$and J_{max} were observed after short and long term N addition. In contrast, R_d was significantly higher in both species after 24 years of N addition, but not in the shorter term treatments. (2) For *E. vaginatum*, the N content did not change greatly after short or long term N addition, and hence no significant differences in partitioning of N to the photosynthetic parameters were found. For *B. nana*, however, the foliar N was increased by 20 to 50% as a consequence of 6 weeks to 24 years of N addition, respectively. In other words, for *B. nana* the photosynthetic N use efficiency decreased with increasing N availability. The amount of chlorophyll increased only for *B. nana* in the 6 weeks N addition treatment.

Overall, these results show that the effects of N addition on plot level productivity observed in other studies are not a consequence of changes in the photosynthetic capacity per unit leaf area. It also implies that species from N-limited areas like Arctic peatlands might already optimize their photosynthetic capacity and that the photosynthetic capacity: N ratio is flexible within one species. Finally, the R_d results showed that some effects of increased N addition can only be observed after more than two decades of fertilisation, which underlines the importance of long term ecological experiments.