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Can Canopy Uptake Influence Nitrogen Acquisition and Allocation by Trees?

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Nitrogen (N) fertilization due to atmospheric deposition of anthropogenic nitrogen (N_{DEP}) may explain some of the net carbon (C) sink (0.6-0.7 Pg y^{-1}) in temperate forests, but estimates of the additional C uptake due to atmospheric N additions ($\Delta C \Delta N$) can vary by over an order of magnitude ($\sim$ 5 to 200 $\Delta C \Delta N$). High estimates from several recent studies [e.g. Magnani (2007), Nature 447 848-850], deriving $\Delta C \Delta N$ from regional correlations between N_{DEP} and measures of C uptake (such as eddy covariance -derived net ecosystem production, or forest inventory data) contradict estimates from other studies of ^{15}N tracer applications added as fertilizer to the forest floor. A strong $\Delta C \Delta N$ effect requires nitrogen to be efficiently acquired by trees and allocated to high C:N, long-lived woody tissues, but these isotope experiments typically report relatively little ($\sim$ 20 %) of ^{15}N added is found above-ground, with < 5 % of the total ^{15}N applied found in wood. Consequently the high correlation-derived $\Delta C \Delta N$ estimates are often attributed to co-variation with other factors across the range of sites investigated.

However ^{15}N-fertilization treatments often impose considerably higher total N loads than ambient N_{DEP} and almost exclusively only apply mineral ^{15}N treatments to the soil, often in a limited number of treatment events over relatively short periods of time. Excessive N deposition loads can induce negative physiological effects and limit the resulting $\Delta C \Delta N$ observed, and applying treatments to the soil may ignore the importance of canopy nitrogen uptake in overall forest nutrition. As canopies can directly take up nitrogen, the chronic, (relatively) low levels of ambient N_{DEP} inputs from pollution may be acquired without some of the effects of heavy N loads, obtaining this N before it reaches the soil, and allowing canopies to substitute for, or supplement, edaphic N nutrition. The strength of this effect depends on how much N uptake can occur across the canopy under field conditions, and if this extra N supplies growth in woody tissues such as the stem, as well as the canopy.

To test these ideas, we applied a low ($\sim$ 2.5 % above ambient N_{DEP}) ^{15}N treatment to *Picea sitchensis* saplings, targeting the soil or the canopy in monthly fertilizations for 16 months, and investigating ^{15}N return in different age classes of biomass and over time. While soil-targeted deposition treatments agreed well with existing knowledge of N partitioning from this source, we could infer 2-3 times more ^{15}N was retained above-ground in canopy-targeted treatments, including a relative increase in ^{15}N allocation to stem and woody biomass when compared to the soil treatment. These results suggest that existing forest ^{15}N-fertilization experiments could under-estimate the overall $\Delta C \Delta N$ effect of atmospheric deposition.