Partitioning the influence of soil N, mycorrhizae, and foliar N uptake on foliar $\delta^{15}N$ patterns

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Introduction

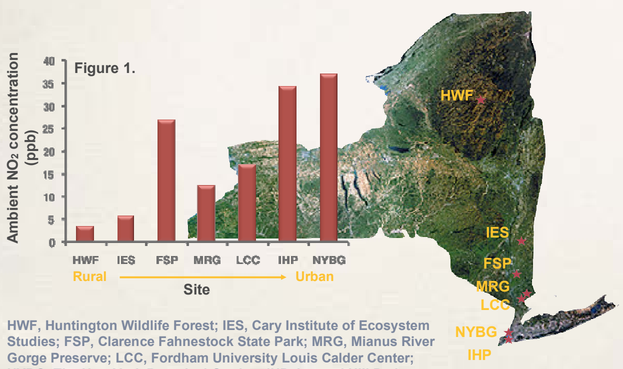
- Vegetation is an important sink for atmospheric reactive N in N limited systems and direct foliar uptake may be a significant pathway for the acquisition of plant-available N.
- A proxy for atmospheric reactive N would be useful to estimate the magnitude of this uptake pathway.
- N stable isotope ratios ($^{15}N/^{14}N$) are useful tools because plant-available N sources often have different isotopic N compositions ($\delta^{15}N$). However, the mechanisms driving differences in foliar $\delta^{15}N$ patterns are still unresolved.
- Foliar $\delta^{15}N$ primarily reflects the integration of soil solution $\delta^{15}N$, direct foliar N uptake, within-plant fractionations, and fractionation due to mycorrhizae.

Objective

Estimate the influence of soil $\delta^{15}N$, mycorrhizae, and foliar N uptake on foliar $\delta^{15}N$ patterns of several tree species along a gradient of increasing atmospheric NO_2 concentration in New York State (Fig. 1)

We addressed these questions using two approaches:

1. Estimate the influence of mycorrhizal fractionation on foliar $\delta^{15}N$ in red maple seedlings using a ***potted plant study*** where the influence of mycorrhizae was eliminated using fungicide
2. ***Field measurements*** of foliar and soil $\delta^{15}N$ along a gradient of atmospheric nitrogen dioxide (NO_2) concentration



HWF, Huntington Wildlife Forest; IES, Cary Institute of Ecosystem Studies; FSP, Clarence Fahnestock State Park; MRG, Mianus River Gorge Preserve; LCC, Fordham University Louis Calder Center; NYBG, The New York Botanical Garden; IHP, Inwood Hill Park

I. Potted Plant Study

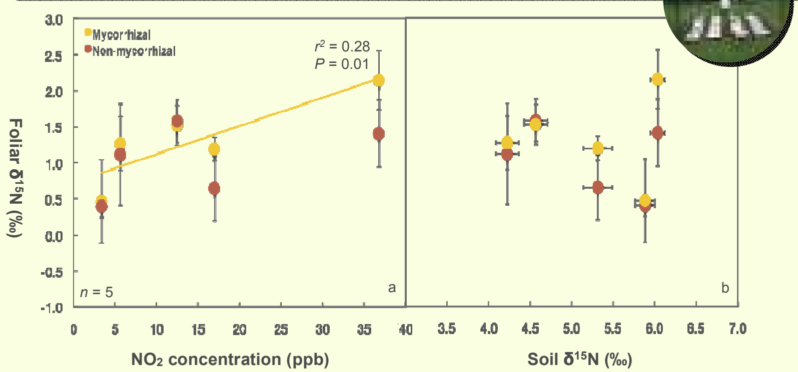


Figure 2. Relationship between foliar $\delta^{15}N$ and average atmospheric NO_2 concentration (a) and bulk soil $\delta^{15}N$ (b) in red maple seedlings with (yellow) and without (red) mycorrhizae. We observed a positive correlation between foliar $\delta^{15}N$ and increasing NO_2 concentration in red maple seedlings with mycorrhizae, but when mycorrhizae were inhibited with fungicide this relationship no longer existed. Also, the presence of mycorrhizae did not significantly alter foliar $\delta^{15}N$. Data are means ± 1 SE.

II. Field Measurements

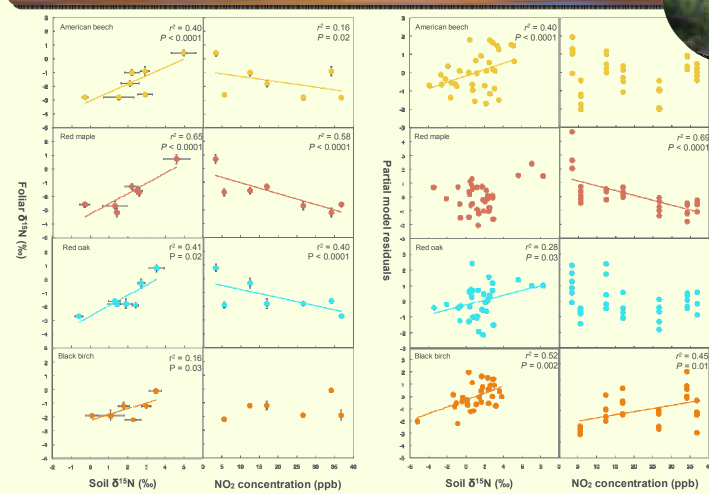


Figure 3. Relationship between foliar and bulk soil $\delta^{15}N$ across a gradient of atmospheric NO_2 concentration in adult trees (left panels) and the partial residual plots for the predictor variables included in the multiple regression model predicting foliar $\delta^{15}N$ (right panels). We found strong relationships among soil $\delta^{15}N$, NO_2 concentration, and foliar $\delta^{15}N$ with varying strength across species (red maple > red oak > American beech > black birch). Multiple regression analysis revealed that for some species the average NO_2 concentration explained significant additional variation after site level bulk soil $\delta^{15}N$ was accounted for in the model. Data are means ± 1 SE (n = 20).

III. Evidence for foliar N uptake?

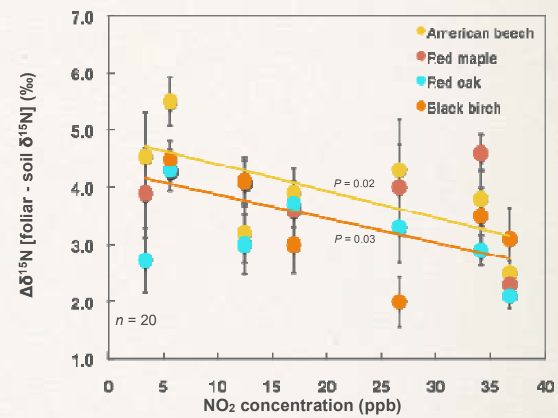


Figure 4. Relationship between $\Delta\delta^{15}N$ (absolute difference between soil and foliar $\delta^{15}N$) and atmospheric NO_2 concentration. Data are means ± 1 SE. The *a priori* prediction was a divergence between soil and foliar $\delta^{15}N$ would increase at sites with a higher potential for foliar uptake. However, this was not the observation. Soil $\delta^{15}N$ tended to increase across the gradient (i.e., driving this relationship in the opposite direction). There are two other possibilities: (1) even though soil $\delta^{15}N$ cannot explain the trend, differential rates of mineralization/nitrification across the gradient may lead to differential soil solution $\delta^{15}N$ helping to drive this pattern, and (2) fractionation events influencing ^{15}N during NO_2 assimilation (diffusion, enzymatic fixation, etc.) are unknown. Thus, the influence of foliar uptake in this context is poorly constrained and, depending upon the $\delta^{15}N$ of the pathway, could generate this pattern.

Conclusions

- Trends in foliar $\delta^{15}N$ found across sites with increasing atmospheric NO_2 concentration in red maple seedlings and in adult trees of American beech, red maple, red oak, and black birch
- Effect of mycorrhizae on foliar $\delta^{15}N$ minimal in this system
- Results suggest direct foliar N uptake of atmospheric reactive N deposition has an influence on foliar $\delta^{15}N$ in several species and can be detected using natural abundance $\delta^{15}N$ measurements of plant and soil material.

Acknowledgements

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