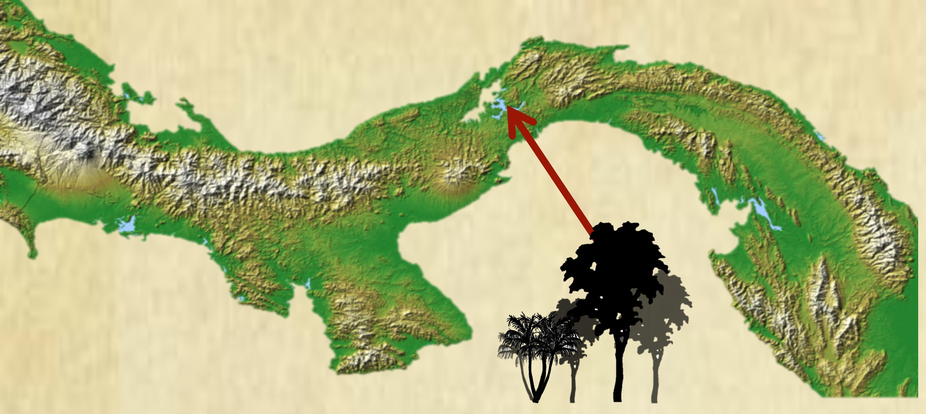

$\delta^{15}N$ Values in Leaves and Soils of Boreal and Tropical Fertilization Experiments

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Introduction

Ecosystem ecologists and biogeochemists have sought to use nitrogen isotope ratios (^{15}N:^{14}N represented as standardized $\delta^{15}N$) as integrative metrics of ecosystem N cycling yet have been hampered by the possibility of multiple simultaneous explanations for plant patterns. For instance, it remains uncertain whether environmental or genetic and physiological factors interact to control variation in foliar $\delta^{15}N$ values, the most common measurement.

Furthermore, it remains to be seen if fertilization alters plant $\delta^{15}N$ values in predictable ways that may be realistic proxies for future growth conditions under increased deposition, mineralization, or disturbance events.

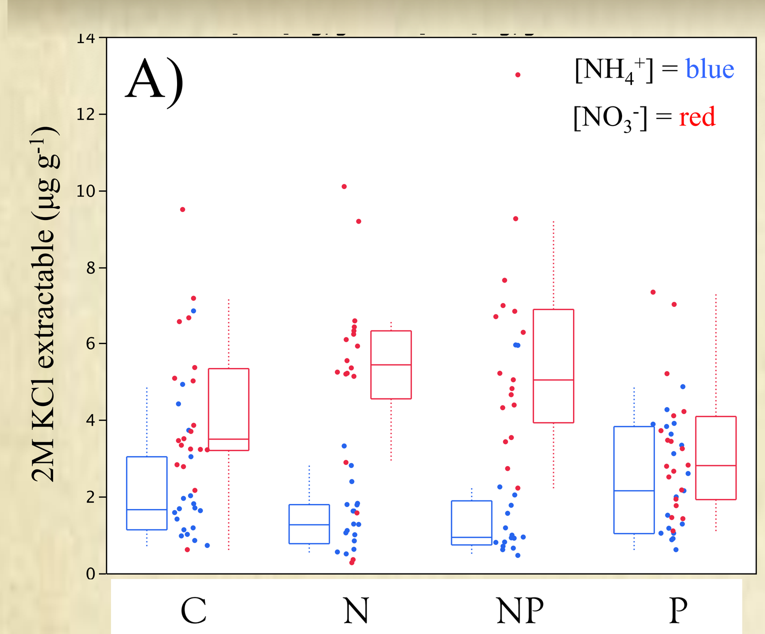
Main Questions

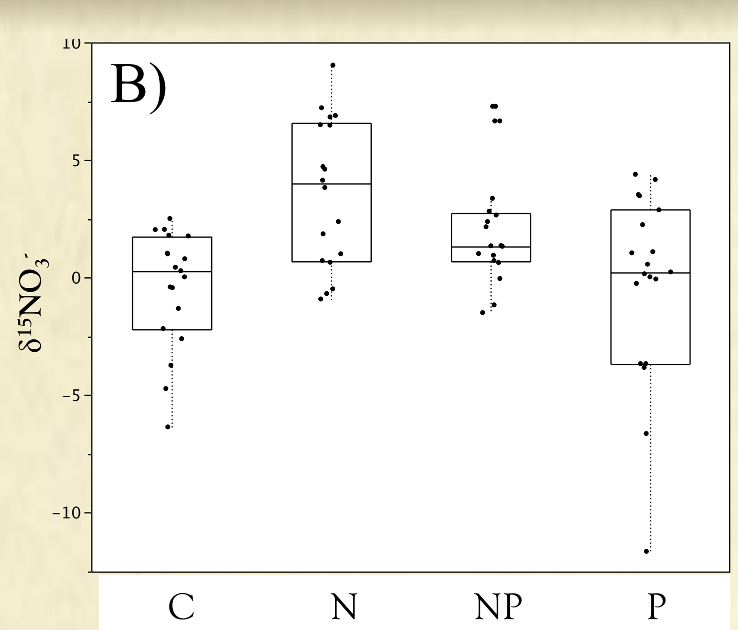
Can plant $\delta^{15}N$ values be reliably used as a N-cycle integrator, like C:N:P ratios, to predict changes in soil fertility or plant productivity?

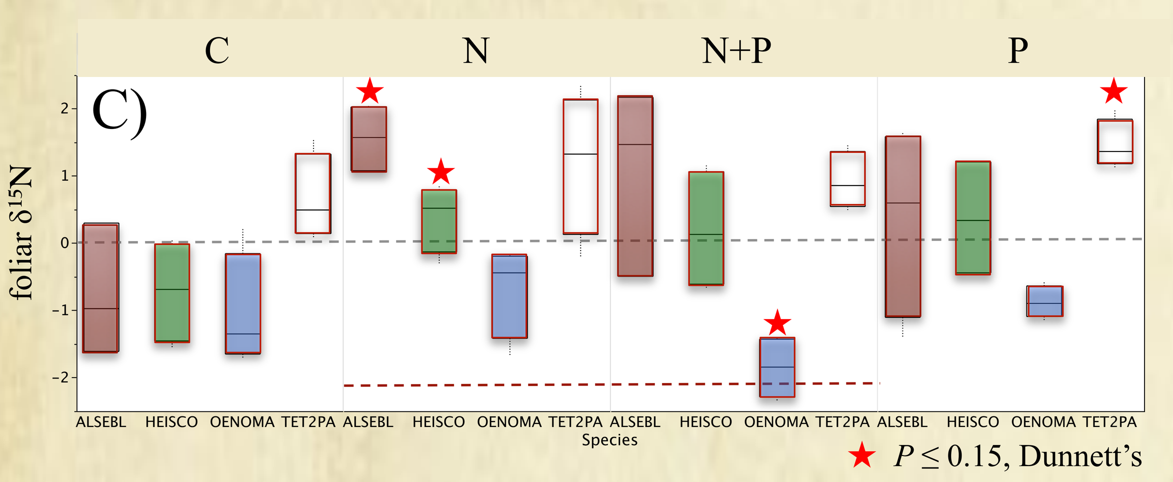
How do ecosystem $\delta^{15}N$ values from fertilization experiments compare to patterns from natural boreal and tropical forests?

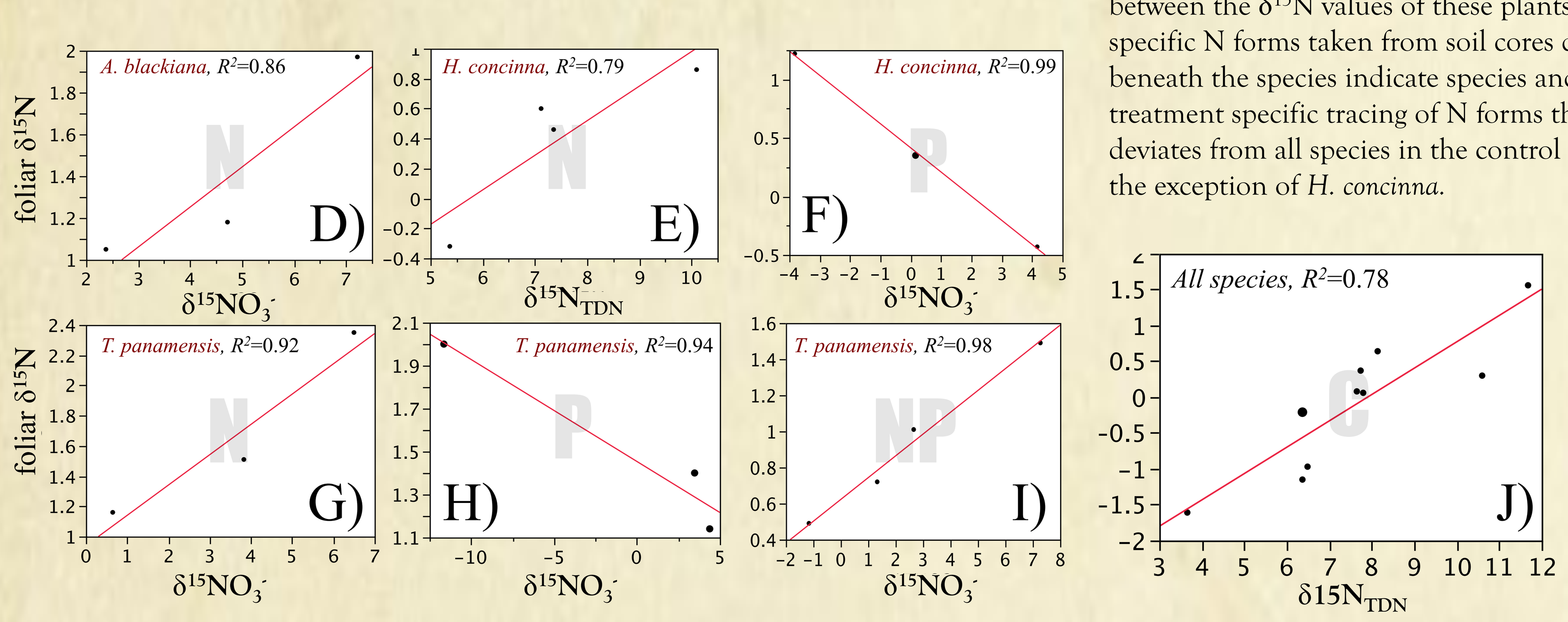
How do we separate sources from pathways of N-cycling in order to understand plant $\delta^{15}N$ values ?

Panamá Results





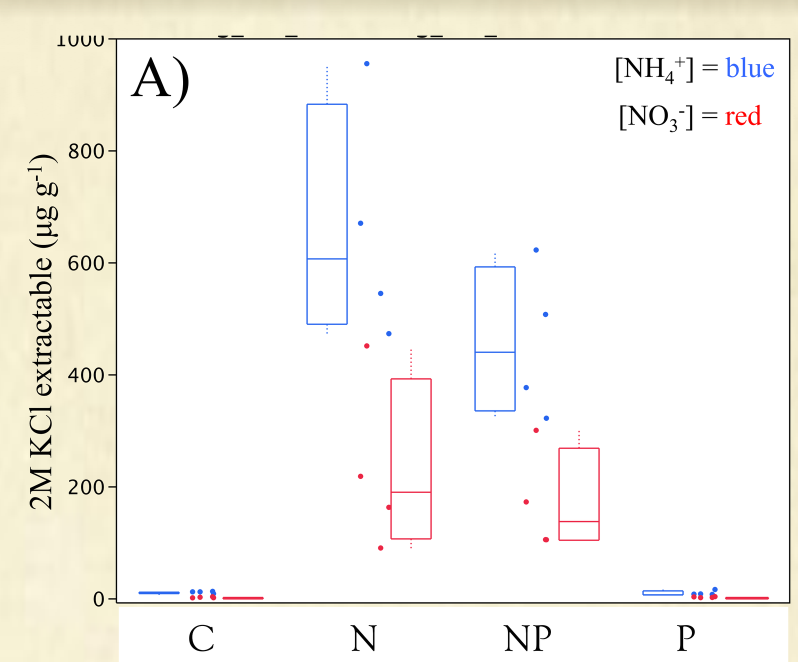


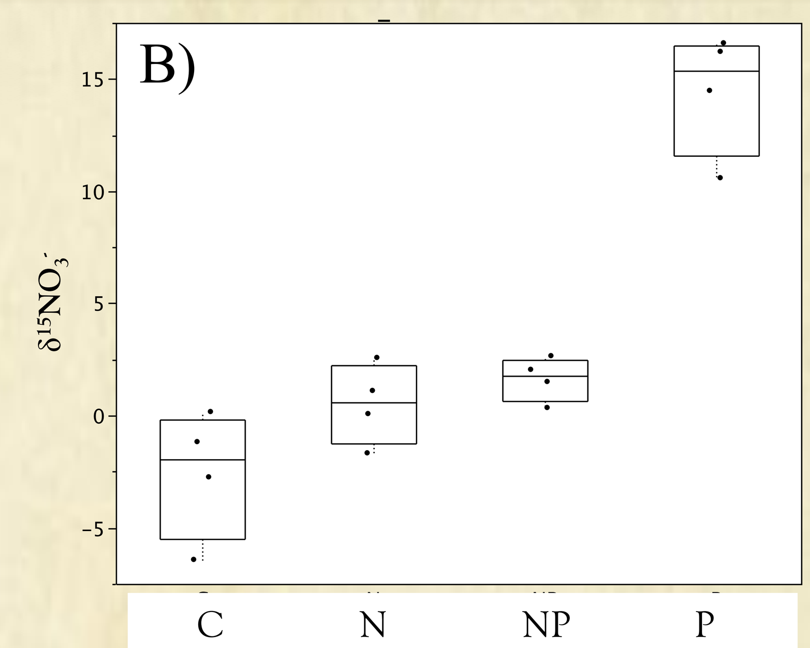


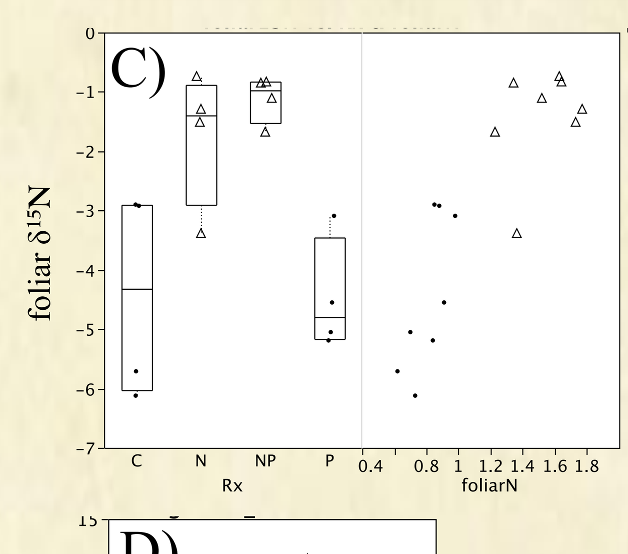
PANAMA RESULTS

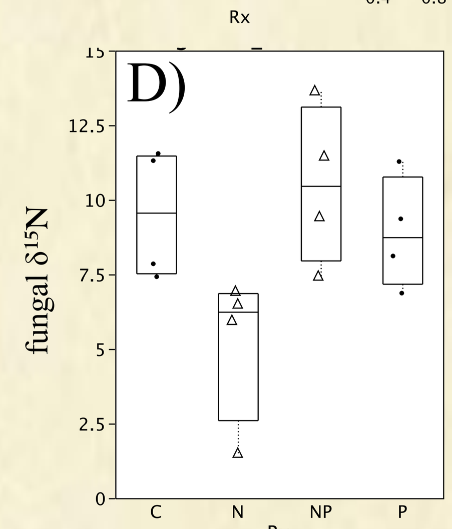
A) Salt extractable NO_3^- was significantly higher in both N and NP treatments. *B*) $\delta^{15}NO_3^-$ values from ion exchange resins were significantly enriched in the N and NP treatments. C) Foliar $\delta^{15}N$ values were significantly enriched in *Alseis blackiana, Heisteria concinna* in the N treatments and *Tetragastris panamensis* in the P treatment, whereas *Oenocarpus mapora* was depleted in the NP treatment. *D*) Significant relationships between the $\delta^{15}N$ values of these plants in and specific N forms taken from soil cores directly beneath the species indicate species and treatment specific tracing of N forms that deviates from all species in the control plot with the exception of *H. concinna.*

Alaska Results









ALASKA RESULTS

A) Salt extractable pools of NH_{4+} and NO_3^- were significantly higher in both N and NP treatments. *B*) $\delta^{15}NO_3^-$ values from ion exchange resins were significantly enriched in the P treatment only and less variable in the N and NP treatments. C) Foliar $\delta^{15}N$ values were significantly enriched in both the N and NP treatments as was foliar N concentrations. *D*) $\delta^{15}N$ values of ectomycorrhiza (ECM) fungi were significantly depleted in the N treatment only. *E*) Synthesis of findings and isotope mixing model solutions (see below) suggest the patterns are caused be a declining dependence on ECM fungi for soil N forms and a switch to direct root uptake of the mineral forms of N resulting from fertilization.

3 pool N source:

$$\delta^{15}N_{available} = f_{DON} \bullet \delta^{15}N_{DON} + f_{NH4} \bullet \delta^{15}N_{NH4} + f_{NO3} \bullet \delta^{15}N_{NO3}$$

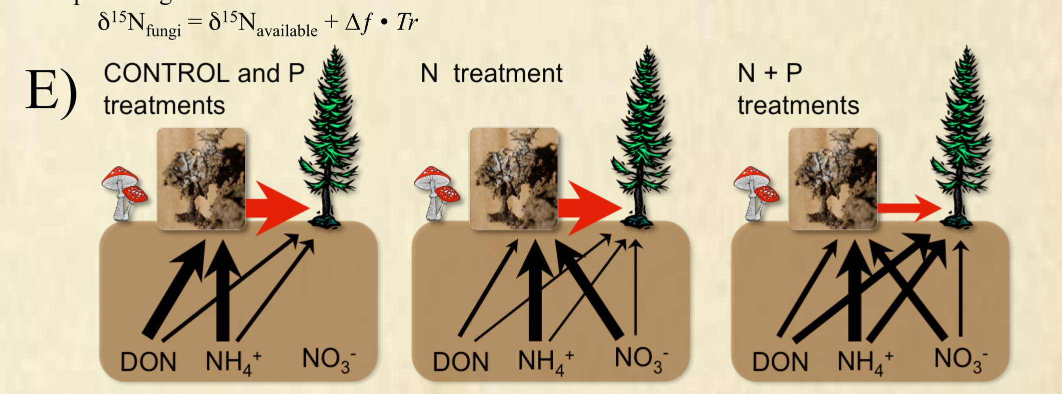
$$\delta^{15}N_{available} = (1 - Tr) \bullet \delta^{15}N_{fungi} + Tr \bullet \delta^{15}N_{transfer}$$

2 pool plant mixture:

$$\delta^{15}N_{root} = \delta^{15}N_{available} - \Delta f \bullet (1 - Tr) \bullet f$$

2 pool fungal mixture:

$$\delta^{15}N_{fungi} = \delta^{15}N_{available} + \Delta f \bullet Tr$$



Methods

Alaska: Fertilization of 16 plots began in 2002, sampled in 2007. Single doses of pelletized $NH_4^+NO_3^-$ (N), ortho-PO_4^- (P), both (N+P), or none (C), annually at a level of 200, in year 1, or 100 kg ha⁻¹ yr⁻¹, in subsequent years, per nutrient. *Picea mariana* was sampled in triplicate from each plot at the height of needle expansion.

Panamá: Fertilization of 16 40×40m plots began in 1998, sampled in 2011. Four doses of coated urea as ($(NH_2)_2CO$), 125 kg N ha⁻¹ yr⁻¹, phosphorus as triple superphosphate ($Ca(H_2PO_4)_2.H_2O$) 50 kg P ha⁻¹ yr⁻¹, both, or none. Canopy heights are to 40 and the forest is possibly >200 years old. *Alseis blackiana, Heisteria concinna, Oenocarpus mapora,* and *Tetragastris panamensis* canopy leaves were shot in triplicate in all plots where posible.

Sampling: $\delta^{15}N$ values were measured using persulfate oxidation coupled to the denitrifier method. $\delta^{15}N$ values of total dissolved N were measured from five 15×4.2 cm cores extracted with 2M KCl the day of sampling at the height of the growing season (*Alaska*) or beginning of the rainy season (*Panamá*). NH_4^+ and NO_3^- $\delta^{15}N$ values measured from ion exchange resin bags incubated for 4 (*Panamá*) to 8 (*Alaska*) weeks.

Conclusions

Fertilization experiments exhibit biome-specific effects on plant $\delta^{15}N$ values. In the tropics plants simply trace sources and in boreal forest they reflect the waning influence of ectomycorrhizal fungi. Fertilization produces an excess of labile NO_3^-, regardless of soil type or climate, and this causes significant enrichment of the remaining $\delta^{15}NO_3^-$. If this metric is to be regarded as a useful integrator of increasing N availability these artifacts must be seen to occur in natural ecosystems that have undergone environmental changes or increased N deposition as well.

What is surprising is that it was P in boreal and N in tropical forests that triggered these effects. This runs counter to established theory. Echoing other recent assessments, the idea that N is in excess of plant demands in the tropics and boreal forests are strictly N limited is not supported.

Acknowledgments

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