Foliar N and P concentrations and resorption indicate P limitation in a northern hardwood forest

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Background

- Resorption:
  - Process by which trees translocate nutrients from tissues prior to senescence
  - Important nutrient conservation mechanism
- Ways to measure:
  - Proficiency:
    - Concentration to which nutrients are reduced in leaf litter
  - Efficiency:
    - Ratio of green leaf concentrations to the amount resorbed (expressed as percentage)
    - $Efficiency = \frac{Element_{green} - Element_{litter}}{Element_{green}} * 100$
- Why it matters:
  - Nitrogen (N) and phosphorus (P) are most limiting nutrients to plant growth
  - Attempts to link resorption of a nutrient with availability of that nutrient have yielded mixed results
  - Possibility that trees are co-limited by multiple elements so that resorption of, e.g., N, depends on availability of both N and P
  - Co-limitation may occur at multiple scales
  - Resorption of P was previously shown to depend upon the availability of both N and P in these forests

Objectives

- Compare green leaf and litter N and P concentrations and resorption efficiency
  - What can green leaf concentrations tell us about limitation?
  - Is relative resorption related to limitation status?
  - Can we see N and P interactions in resorption?
  - How does resorption and limitation differ among species, site, and age class?

Site Background

- Four mid-aged and four mature stands in three sites (Bartlett Experimental Forest [BEF], Hubbard Brook [HB], Jeffers Brook [JB] in the White Mountains, NH
- Four 50x50m (BEF) or 30x30m (HB and JB) plots, fertilized annually since 2011 with either:
  - N (30 kg N ha^{-1} y^{-1} as NH_4NO_3), P (10 kg P ha^{-1} y^{-1} as NaH_2PO_4) , N and P together (same rates), or no treatment

Methods

Field:

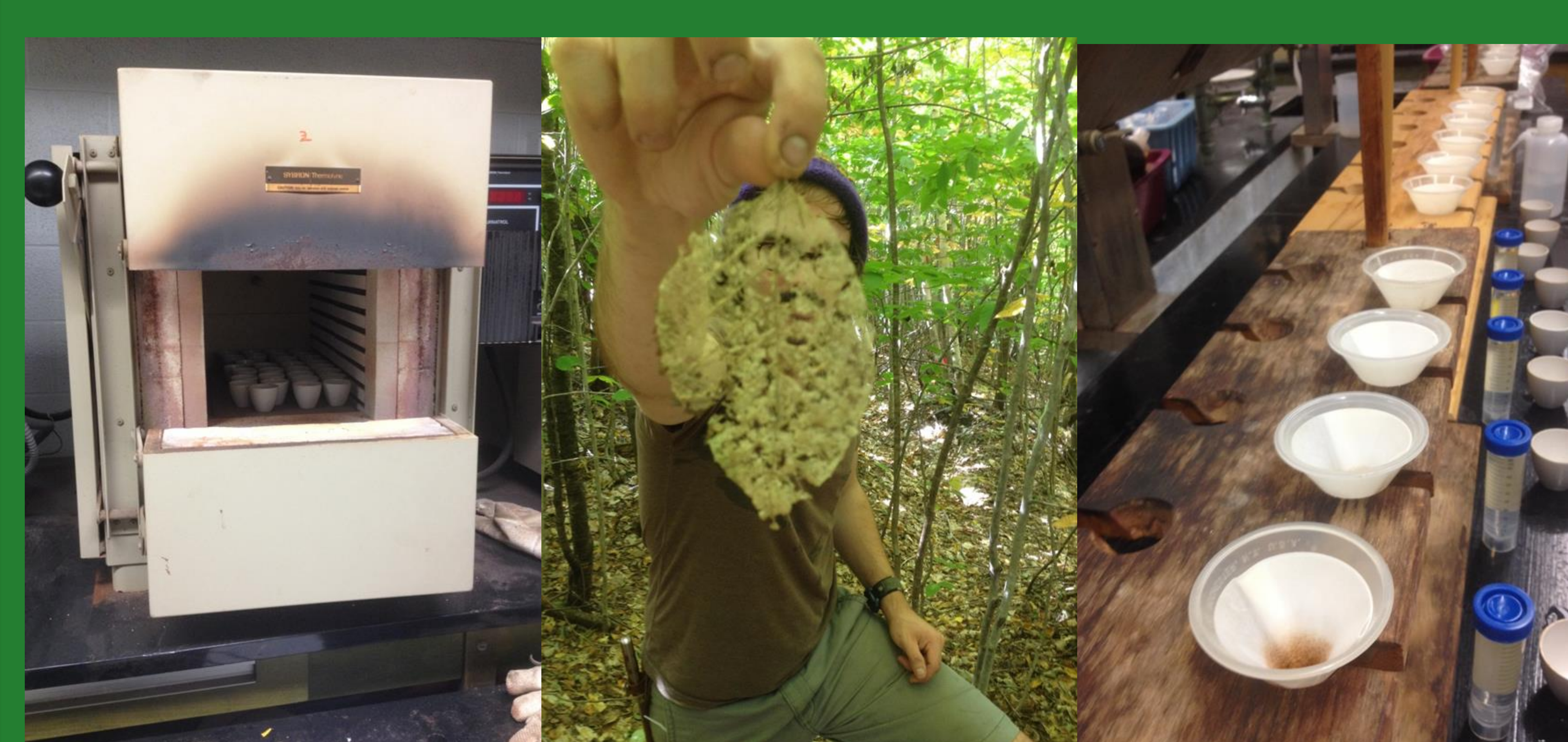
- We collected green leaves in August and leaf litter in October from:
  - American beech (*Fagus grandifolia)* in all stands
  - Red maple (*Acer rubrum)* in mid-aged stands
  - Sugar maple (*A. saccharum*) in the mature stands

Lab:

- All leaves oven dried at 60°C to constant mass and ground
- For N concentrations:
  - Dry combustion in a CN analyzer
- For P concentrations:
  - Ashing, hot-plate digestion, ICP-OES

Statistical:

- ANCOVA for a randomized complete block design:
  - Covariate = pre-treatment (2008-2010) values
  - Blocking factor = stand nested within age and site
  - Other predictor variables = age; site; factorial of N treatment, P treatment, and species



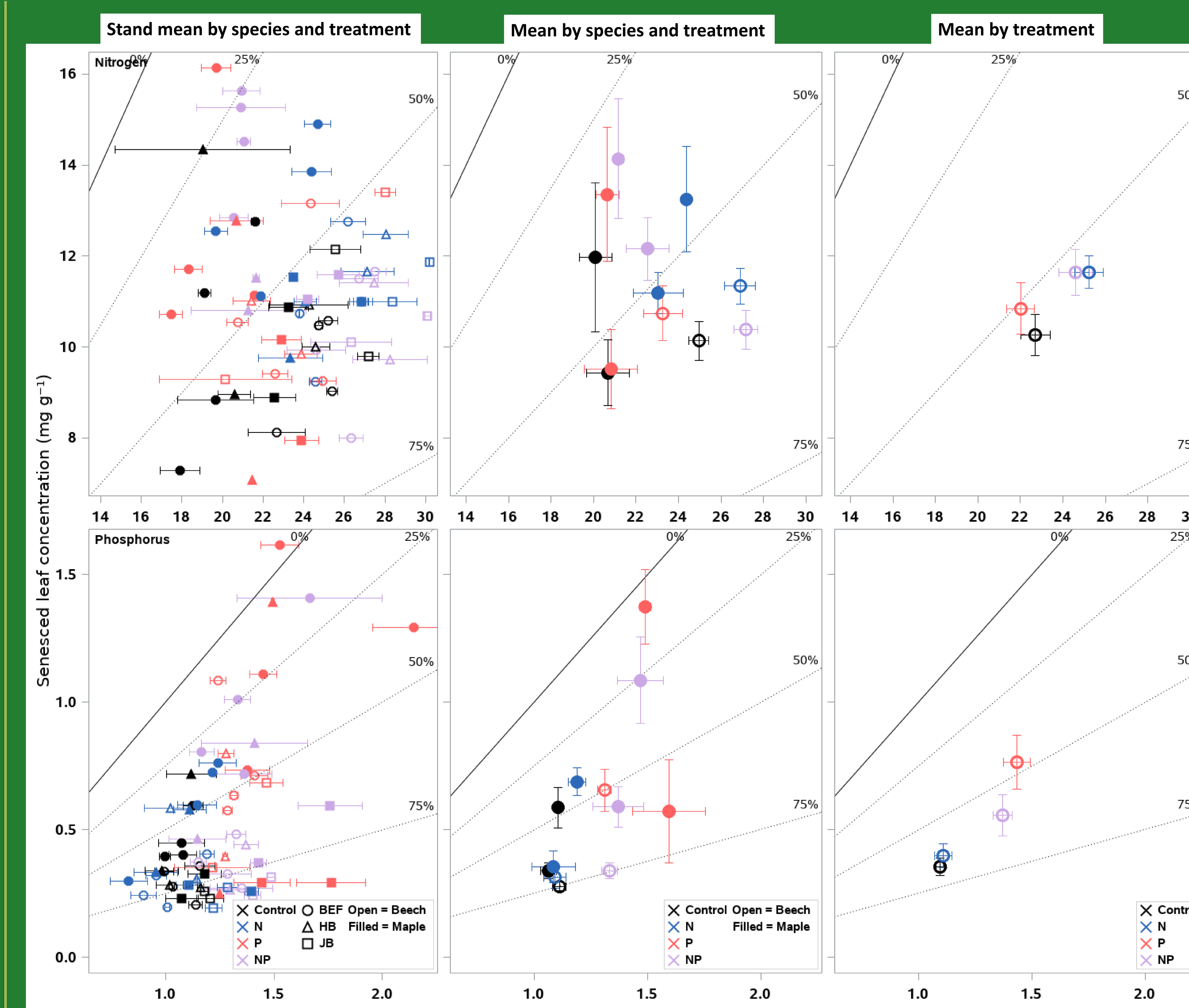


Fig. 1

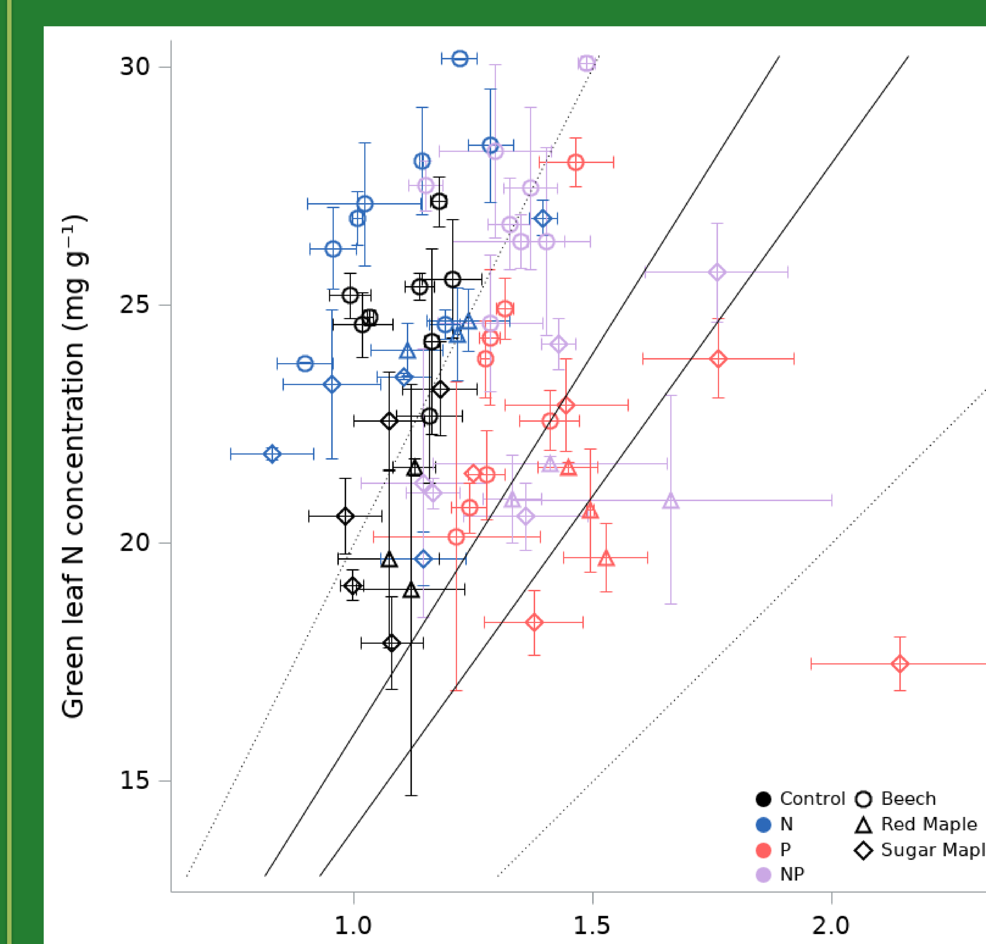


Fig. 2

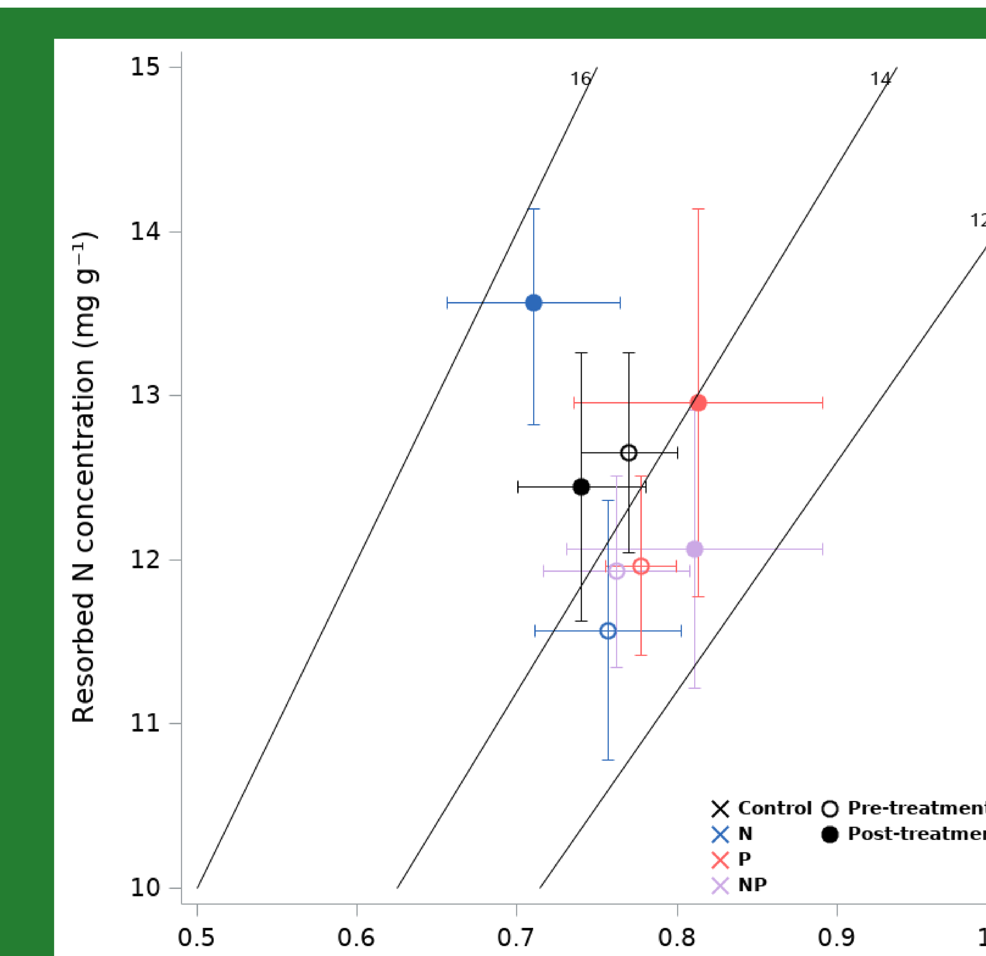


Fig. 3

Results and Conclusions

- These stands were assumed to be N-limited, but appear to be P-limited based on N:P ratios (Fig. 2) and a greater response to P than to N (Fig. 1)
- By manipulating N and P availability, we can observe greater effort allocated to acquisition and conservation of the more limiting nutrient(s)
- Surprisingly, nutrient conservation through resorption was highest at the most fertile site (JB; Fig. 1)
- We can also see the influence of species-specific nutrient demands (Figs. 2 and 3) – is this a consequence of successional stage? Phylogeny?
- Future ideas to investigate: the N:P ratio of the concentration resorbed by trees was remarkably consistent between stands pre- and post-treatment and among treatments both pre- and post-treatment (Fig. 3). Is this an example of a stoichiometric control on resorption?

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