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 foliar nutrients 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
    - $Efficiency = \frac{Element_{green} - Element_{litter}}{Element_{green}} * 100$
    - Expressed as percentage
- Importance:
  - Nutrient cycles and, therefore, the productivity of natural ecosystems can be altered by human activities, such as pollution and fertilization.
  - Attempts to link resorption of a nutrient with availability of that nutrient have yielded mixed results.
  - It is likely that multiple element limitation is driving resorption.
  - Resorption of P was previously shown to depend upon the availability of both N and P in these stands.

Objectives

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

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Site Background

- Eight mid-aged and mature replicate 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:
  - 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*) from the mature stands

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

Statistical:
- ANOVA for a split-split-plot design:
  - Whole plot factor = age in a CRD
  - Split plot factor = N x P factorial
  - Split split plot factor = species

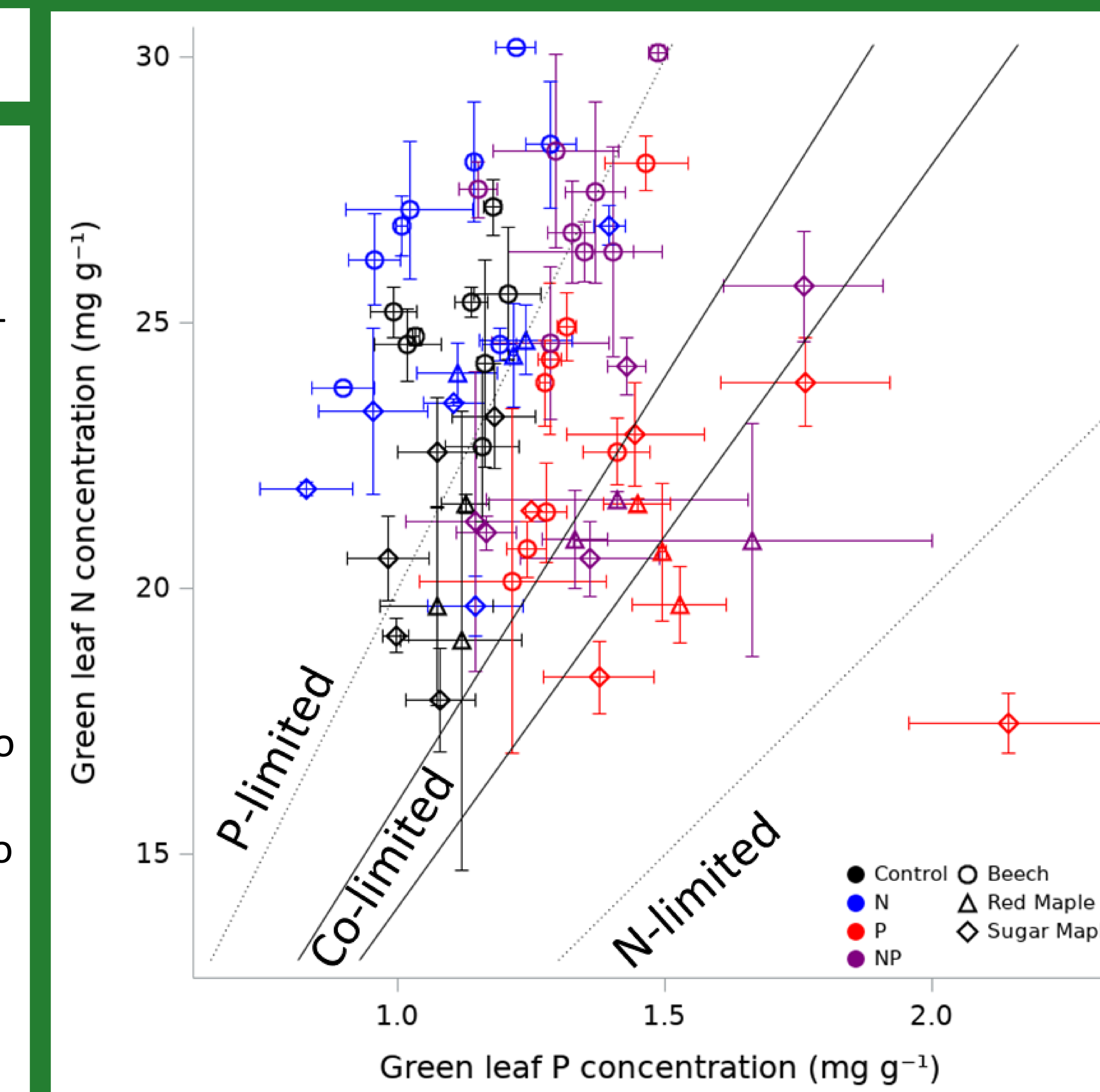


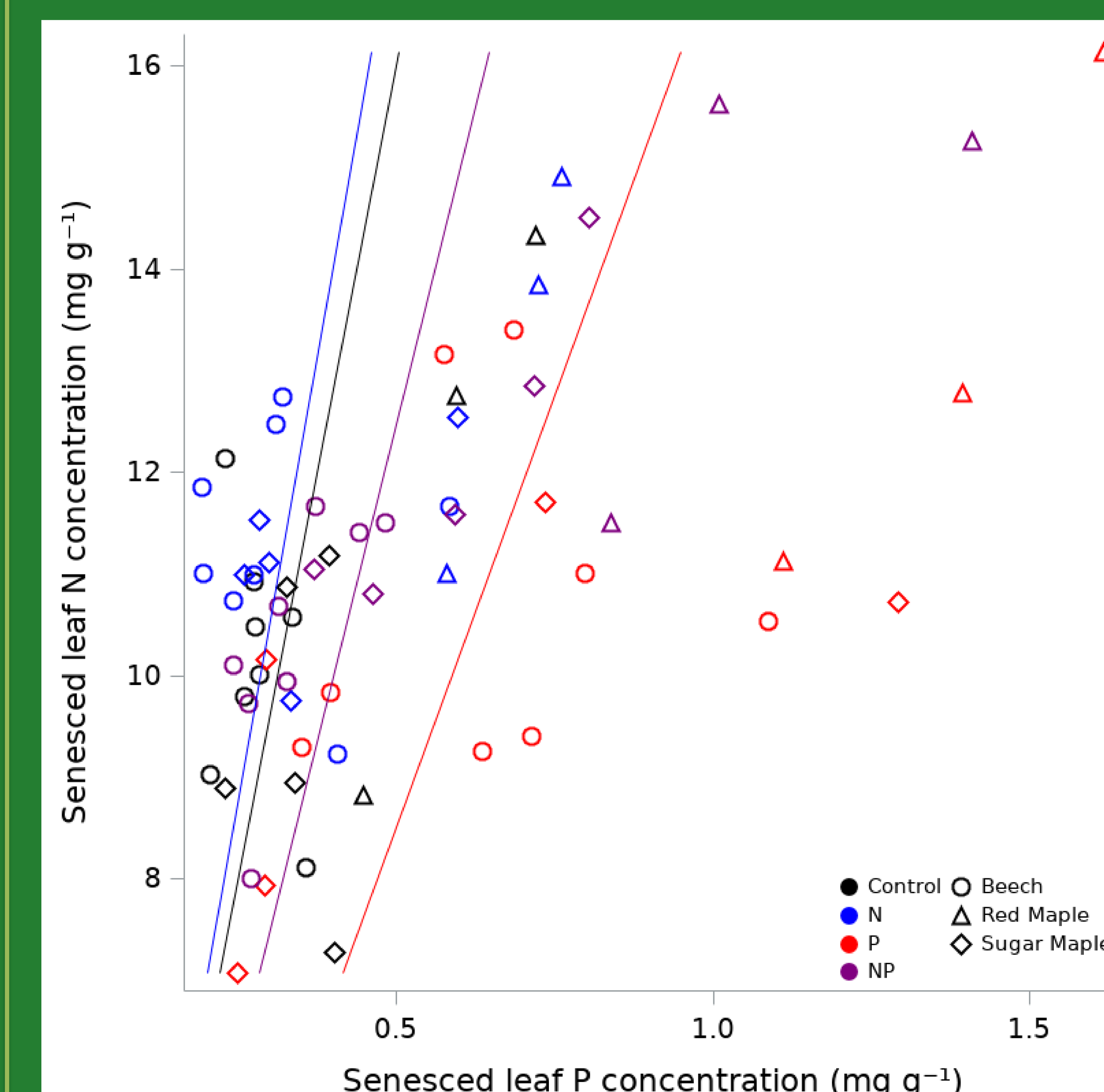
Conclusions

- Our results show a greater response to P treatment than to N treatment in these P-limited stands.
- We can also see the influence of species-specific nutrient demands, possibly a consequence of successional stage.
- By manipulating N and P availability, we can observe greater effort allocated to acquisition of the more limiting nutrient.

Green Leaf Concentrations

- Each point represents the species mean in a treatment plot (n=3).
- The solid and dotted lines delineate co-limitation between N:P of 14-16 and 10-20, respectively.
- Adding P increased green leaf P by 29% (p<0.001), resulting in a shift towards co-limitation.
- When N was added, green leaf N increased by 11% (p<0.001) and green leaf P decreased by 4% (p=0.02), pushing our P-limited stands further into P limitation.
- Adding N and P together generally led to a shift towards co-limitation.
- The three species differed in their N:P ratios (p<0.001), but age was not a significant factor (p=0.46).





Litter Concentrations

- Each point shows plot-wide litter N and P concentrations for each species. Solid lines give the mean litter N:P ratio for each treatment across 8 stands.
- P concentrations in the P and NP plots were significantly higher than in the control (p=0.03).
- Trees were 9% less proficient at N resorption with N treatment (p=0.03).
- Red maple was 19% less proficient at N resorption (p<0.001) and more than 50% less proficient at P resorption (p<0.001) than beech or sugar maple, and had the lowest litter N:P ratio (p<0.001).
- All species had lower litter N:P ratios in the P and NP plots compared to the control.

Resorption Efficiency (RE)

- Each point is the plot-wide N and P RE for each species. The dotted line is the 1:1 line. Solid lines give the mean N:P RE ratio for each treatment across 8 stands.
- Surprisingly, there was no effect of N addition on N or P RE. This may be a result of N saturation in this ecosystem.
- P addition resulted in a 10% decrease in N RE (p=0.06) and a 32% decrease in P RE (p<0.001).
- Red maple had significantly lower N and P RE than sugar maple or beech (p<0.001); this may be related to successional stage since age was not a significant factor.
- For red maple, P RE was only 2.2% in the P plots, possibly a sign of luxury consumption of P.