# Foliar Nutrient Concentrations and Resorptions of Northern Hardwood Species in an N x P Manipulation Study

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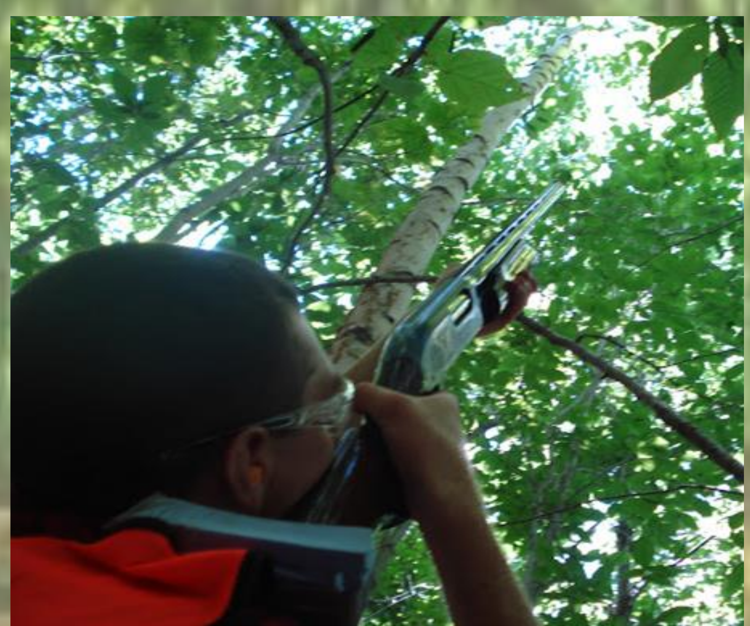
## Introduction

- Temperate forests on glaciated soils are generally thought to be nitrogen-limited, but increases in atmospheric nitrogen (N) deposition have altered their biogeochemistry, increasing N availability relative to phosphorus (P). Long-term NxP manipulations in this biome are needed to test for N vs. P limitation or co-limitation.
- Foliar nutrient concentration is an important indicator of plant nutrient status.
- Foliar nutrient resorption is mechanism for nutrient conservation whereby nutrients are retranslocated from senescing leaves. The timing senescence reflects the balance between continuing to photosynthesize and risking winter damage.
- The Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) project was established to study N and P acquisition and limitation through a series of nutrient manipulations in northern hardwood forests.

## Research Questions

- How are foliar nutrient concentrations of northern hardwood species affected by nutrient additions N and P?
- What nutrient is limiting in the MELNHE stands?
- How is the timing of foliar nutrient resorption affected by nutrient additions?



## Site Description

- Ten stands, located in Hubbard Brook Experimental Forest (HBEF), Bartlett Experimental Forest (BEF) and Jeffers Brook (JB) of central New Hampshire, have primarily well drained acid Spodosols (Haplorthods) of sandy loam texture developed in glacial. The climate is humid continental, with an annual temperature and precipitation averaging 5.7°C and 1400mm at HBEF and 4.4°C and 1300 mm at BEF.
- N (30 kg N/ha/yr as $NH_4NO_3$), P (10 kg P/ha/yr as $NaH_2PO_4$), and N+P (at the same rates) were applied annually to plots beginning in spring 2011. A single application of calcium (1150 kg Ca/ha as $CaSiO_3$) was applied in 2011.

## Sampling Method

- We collected green leaves of American beech (*Fagus grandifolia*), pin cherry (*Prunus pensylvanica*), white birch (*Betula papyrifera*) and yellow birch (*B. alleghaniensis*) at the end of the growing season in 2016.
- We collected fresh litter of red maple (*Acer rubrum*) and sugar maple (*A. saccharum*), in addition to the aforementioned species, in traps four times over the course of litterfall.

## Data Analysis

- We tested for NxP treatment effects on green leaves by using a linear mixed-effects model and performing analysis of variance (ANOVA) along with species and stand age, where stand nested within stand age and site was considered a random effect. Collection date was added when looking at variations over time. All statistical analysis and graphs were done using lme4 and ggplot packages in R (v. 3.4.3).

Table 1. Species of green leaves$^{G}$ and fresh litter$^{L}$ collected in ten MELNHE stands.

| Site | Stand | Stand Age | Species |
|---|---|---|---|
| BEF | C1 | Young | A. beech$^{G+L}$, P. cherry$^{G+L}$, R. maple$^{L}$, W. birch$^{G+L}$, Y. birch$^{L}$ |
| | C2 | Young | A. beech$^{L}$, P. cherry$^{L}$, R. maple$^{L}$, W. birch$^{L}$, Y. birch$^{L}$ |
| | C4 | Mid-aged | P. cherry$^{G}$, W. birch$^{G}$, Y. birch$^{G}$ |
| | C6 | Mid-aged | A. beech$^{L}$, P. cherry$^{G}$, R. maple$^{L}$, S. maple$^{L}$, W. birch$^{G+L}$, Y. birch$^{G+L}$ |
| | C8 | Mature | Y. birch$^{G}$ |
| | C9 | Mature | A. beech$^{L}$, S. maple$^{L}$, Y. Birch$^{G+L}$ |
| HBEF | HBM | Mid-aged | W. birch$^{G}$, Y. birch$^{G}$ |
| | HBO | Mature | Y. Birch$^{G}$ |
| JB | JBM | Mid-aged | P. cherry$^{G}$, W. birch$^{G}$, Y. birch$^{G}$ |
| | JBO | Mature | Y. Birch$^{G}$ |

P and other elements were analyzed by Optima 5300 DV ICP-OES (Perkin-Elmer) following an acid-digestion.

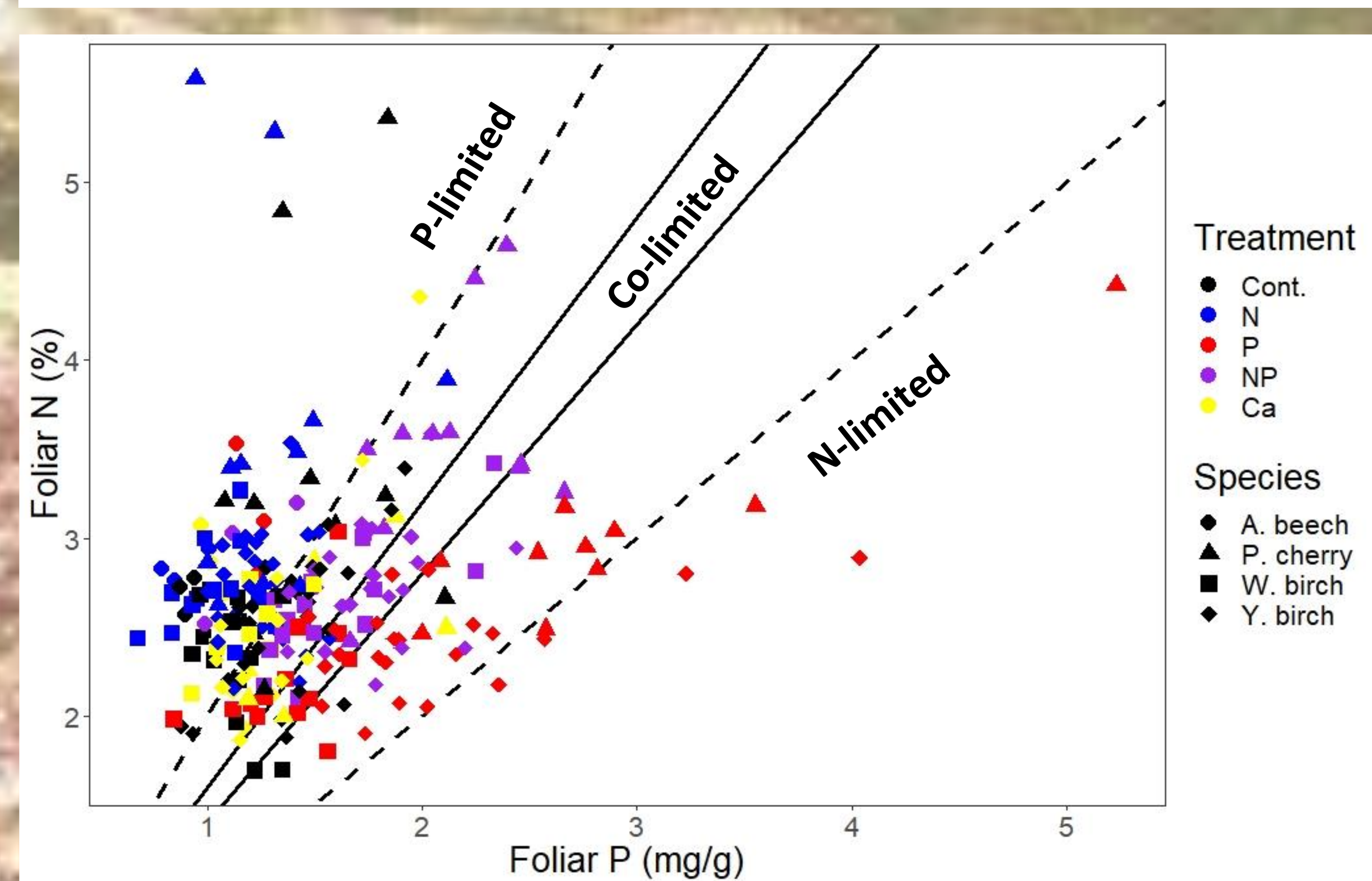




Fig 1. Adding N increased foliar N ($p < 0.01$) but decreased foliar P ($p < 0.01$), shifting towards P-limitation. Adding P increased foliar P ($p < 0.001$), shifting towards N-limitation. Pin cherry accumulated more N and P than other species ($p < 0.001$). The solid and dotted lines delineate co-limitation between N:P of 14-16 and 10-20, respectively.

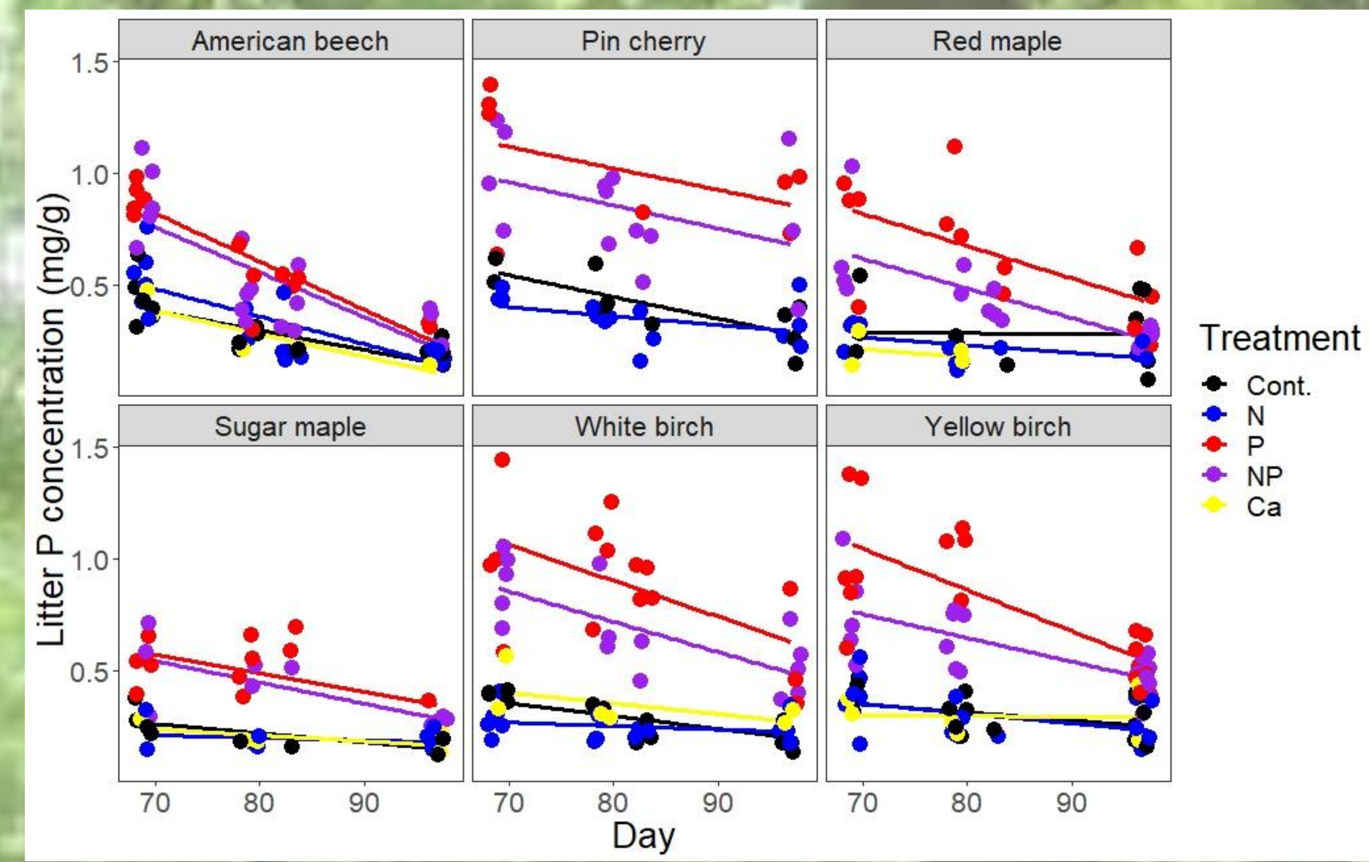




Fig 2. Litter P was higher with P addition ($p < 0.01$) and pin cherry exhibited the highest litter P concentrations ($p < 0.01$).

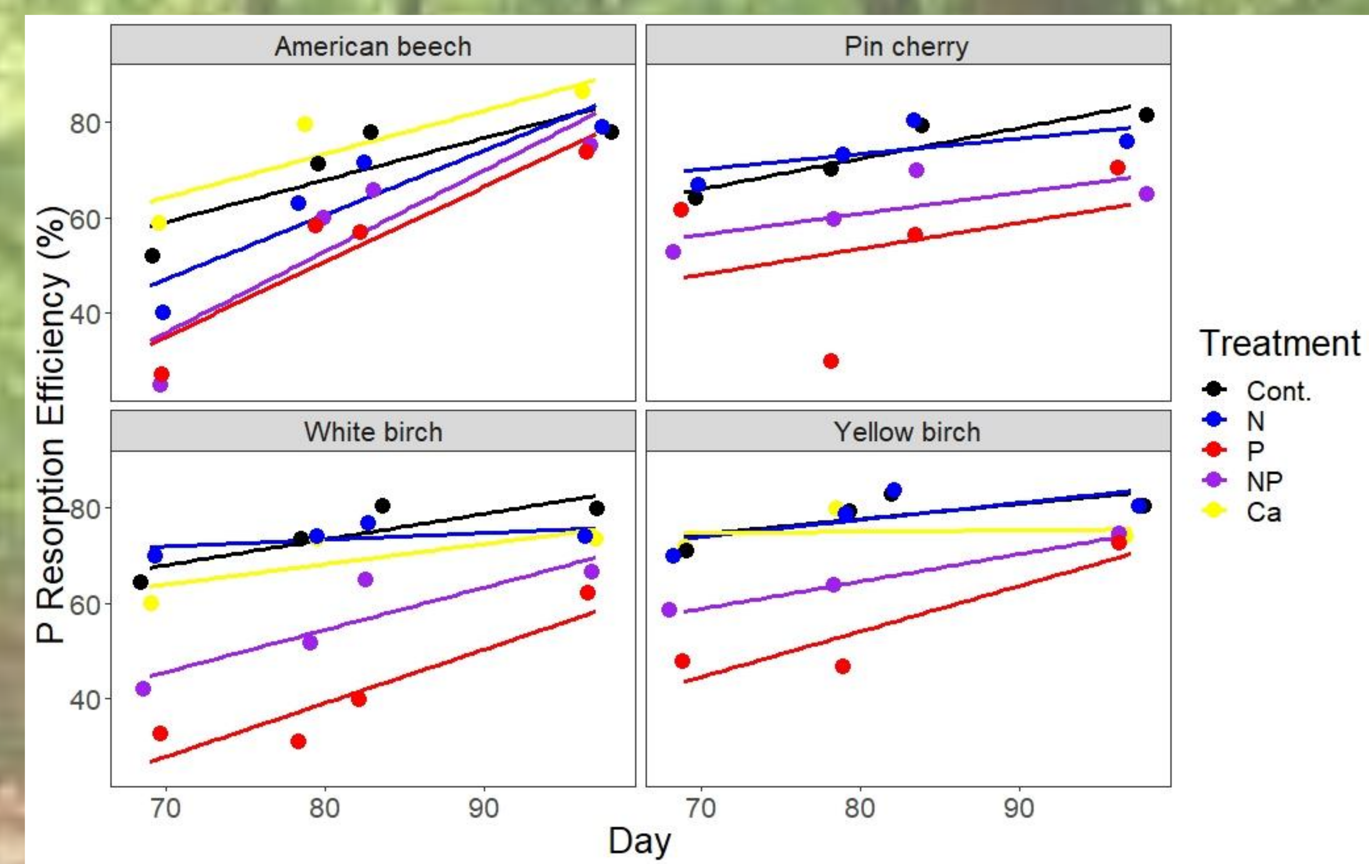




Fig 3. P resorption efficiency increases over time. P resorption efficiency was lowest under P addition.

## Summary

- Foliar concentrations of N and P suggest P limitation, although these forests have been presumed to be N limited.
- Pin cherry, an early successional species, had the highest N and P concentrations in foliage and litter.
- As expected, adding N increased foliar N and adding P increased foliar P. But adding N decreased foliar P.
- P resorption efficiency was lower under P addition. Results for N resorption efficiency are forthcoming.
- P resorption proceeds over the course of litterfall. Stay tuned for results for N resorption over time.

## Conclusion

- Decades of anthropogenic N deposition may have shifted these forests to P limitation; tree diameter growth also responded more to P than to N addition (Goswami, 2018).

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