Does foliar N:P predict nutrient limitation in six northern hardwood species?

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Introduction

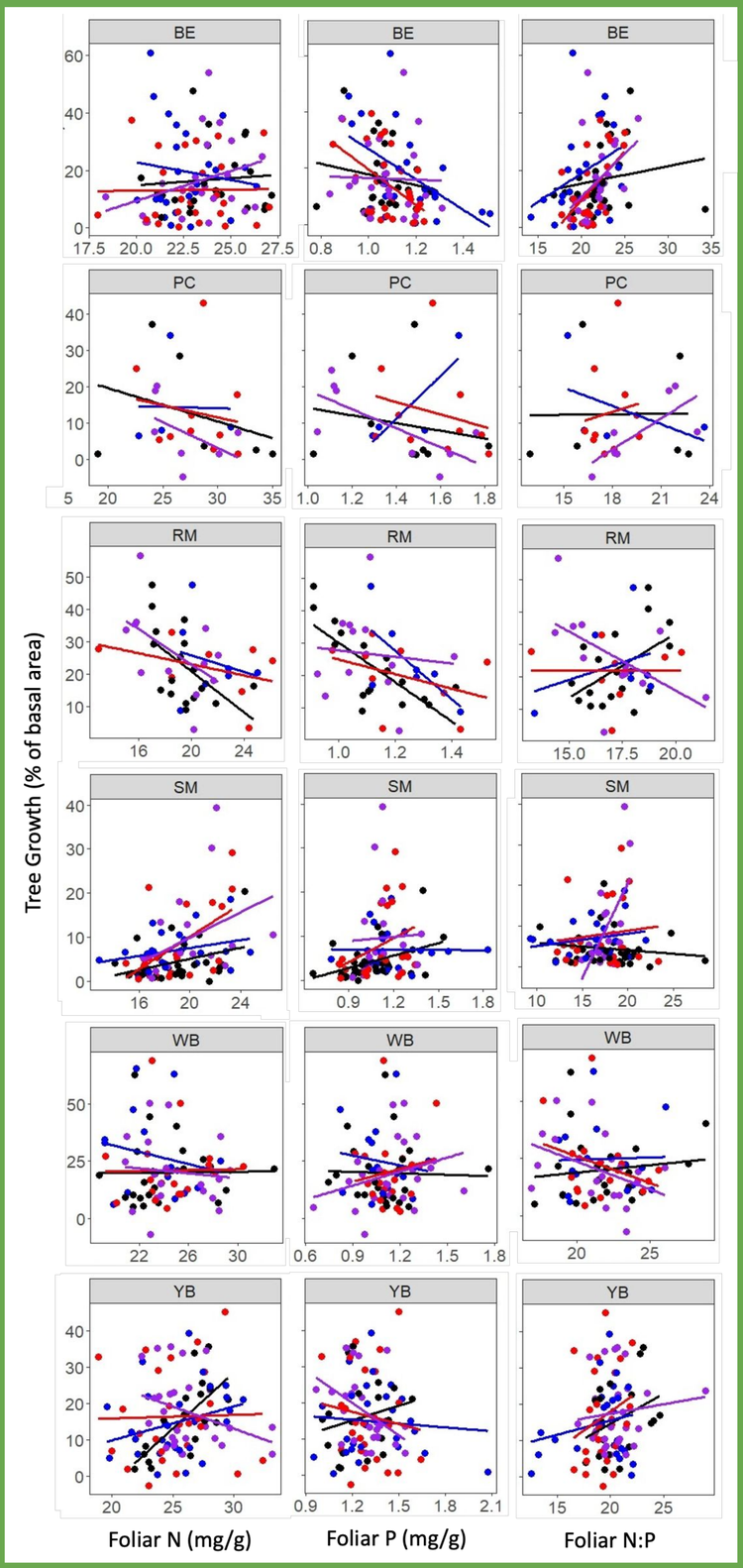
It is convenient to interpret foliar N:P ratios as indicating the relative limitation of plant growth by N versus P. However, tests of these relationships in temperate forests are few, in part because N has been presumed to be limiting, and thus P fertilization trials are rare. Multiple Element Limitation in Northern Hardwood Ecosystems (MELNHE) is a unique full-factorial N by P fertilization study—perhaps the longest-running in a temperate forest anywhere in the world.

The goal of this study was to test whether pre-treatment foliar concentrations of N or P or N:P ratios could predict growth responses to additions of N vs. P, measured in the six dominant hardwood species.

Methods

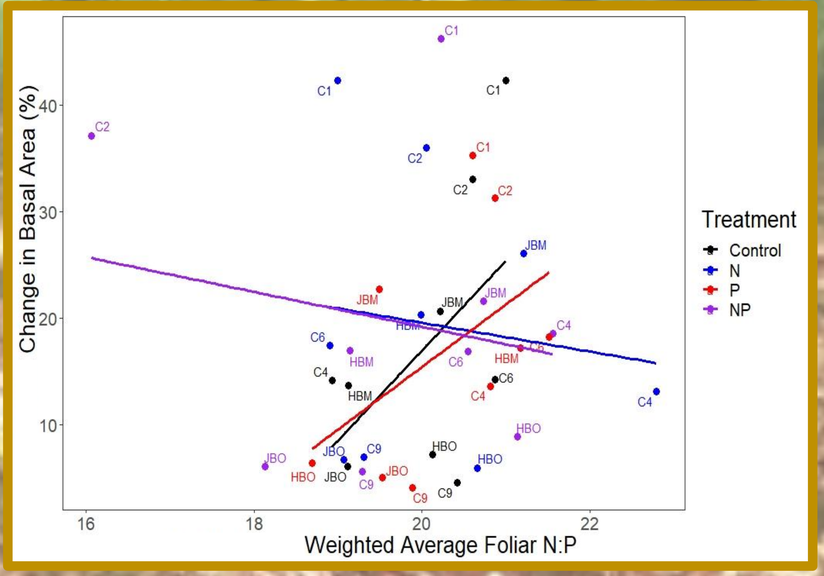
- MELNHE (Multiple Element Limitation in Northern Hardwood Ecosystems) involves 13 forest stands of three age classes distributed across three study sites in the White Mountains of New Hampshire: Hubbard Brook, Jeffers Brook, and Bartlett Experimental Forests. Forests regenerated naturally
- Soils are primarily well drained acid Spodosols of sandy loam texture developed in glacial drift. The climate is humid continental, with temperature and precipitation averaging 5.7°C and 1400mm at HBEF and 4.4°C and 1300 mm at BEF.
- Since 2011 plots measuring 0.09 to 0.25 ha have been treated with N (30 kg N/ha/yr as NH4NO3), P (10 kg P/ha/yr as NaH2PO4), N+P, or left untreated as a control.
- Leaves of the six dominant species were sampled pretreatment, in 2008, 2009, and 2010.
- Trees > 10 cm DBH were inventoried in 2011 and 2015 to obtain tree diameter growth and basal area of the plots.
- We tested the relationship between foliar chemistry and growth response to N and P fertilization, both at the community level, using as predictors the average foliar N, P, or N:P weighted by species basal area in each plot, and also at the tree level, either by species, or all together with species in the model. These models included nutrient treatments in a factorial design, with main effects of N and P addition and their interaction. Plots were nested within stands and stands were nested within site or age class.

Species-Level Foliar N and P Fails to Predict Growth Response to N vs. P Addition



- Trees with high foliar N would be expected to have a higher growth response to P--this appears to be the case for sugar maple, but was not significant overall (P = 0.32).
- Trees with high foliar P should have a higher growth response to N, but the opposite appears to be the case--most N and NP lines slope down to the right (P = 0.02).
- Combining these two sets of expectations, we should see a greater growth response to P where N:P is high (red lines sloping up to the right) and a greater growth response to N where N:P is low (blue lines higher on the left). Neither of these patterns was visually compelling or statistically significant.

Community-Level Predictions are Better



- Using the average foliar N:P of each treatment plot (weighted by species BA of the plot) was better at predicting growth response at the plot level (plot basal area increase). Growth response to P was higher where N:P was high (but similar to controls) and response to N and NP was higher where N:P was low.
- Please comment if you have a suggestion for using these data to identify a threshold N:P predictive of N vs. P limitation. Overall in the MELNHE stands, relative diameter growth was enhanced by P addition, not N addition (Goswami et al. 2018).

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