Foliar Analysis of Four Northern Hardwood Species Indicates Nutrient Limitation

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INTRODUCTION

- Foliar nutrient concentrations are used to indicate tree growth, soil fertility and forest health. Responses to fertilization suggest an important parameter in the assessment of the nutritional status of forests because the addition of fertilizer to improve forest productivity can affect the quality and quantity of foliage.
- Unlike techniques based on a single measure of nutrient concentration, vector analysis allows for a simultaneous comparison of plant growth, nutrient concentration, and nutrient content in an integrated graphic format. It can distinguish dilution effects, nutrient imbalances and element interactions through interpretation, independent of predetermined critical levels or ratios.

OBJECTIVES

- Determine the effects of nutrient additions (N, P, and N+P) on nutrient status of green leaves of American beech, pin cherry, white birch and yellow birch.
- Use vector analysis to detect dilution effects, nutrient imbalances and element interactions of the four hardwood species in response to nutrient additions.




SITE DESCRIPTION

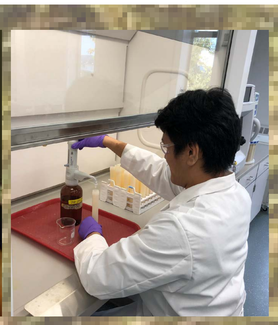
- Nine stands, located in HBEF, BEF and Jeffers Brook of NH, have primarily well drained acid Spodosols (Haplorthods) of sandy loam texture developed from glacial till. Temperature and precipitation average 5°C and 1400 mm per year (Fig 1).
- Nitrogen (30 kg N/ha/yr as NH_4NO_3), phosphorus (10 kg P/ha/yr as NaH_2PO_4), and N+P (same amount) were applied annually to plots beginning in spring 2011 (Fig 2)

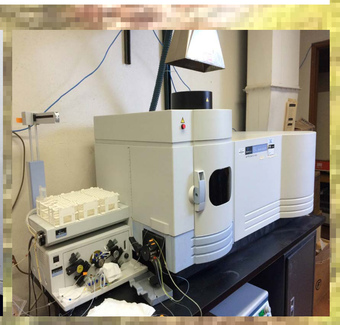
SAMPLING METHOD

- Green leaves of American beech (*Fagus grandifolia*), pin cherry (*Prunus pensylvanica*), white birch (*Betula papyrifera*) and yellow birch (*Betula alleghaniensis*) were collected at the end of the growing season in 2016.
- All leaf samples were oven-dried at 60°C to constant mass and ground using a wiley mill before passing through a 60-mesh screen.

CHEMICAL ANALYSES

- Foliar N concentrations were determined with a FlashEA 1112 analyzer (Thermo Scientific). Foliar P concentrations were determined with an Optima 5300 DV ICP-OES (Perkin-Elmer) after samples were ashed and hot plate-digested with 6N nitric acid.



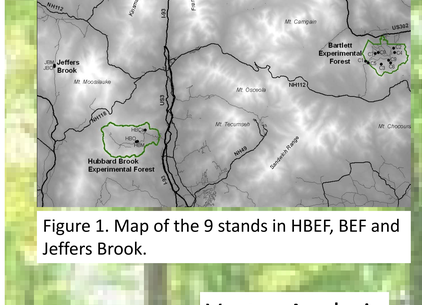


Figure 1. Map of the 9 stands in HBEF, BEF and Jeffers Brook.

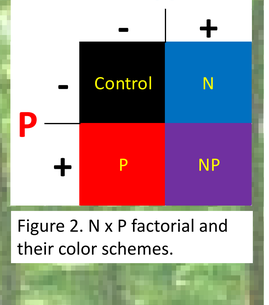


Figure 2. N x P factorial and their color schemes.

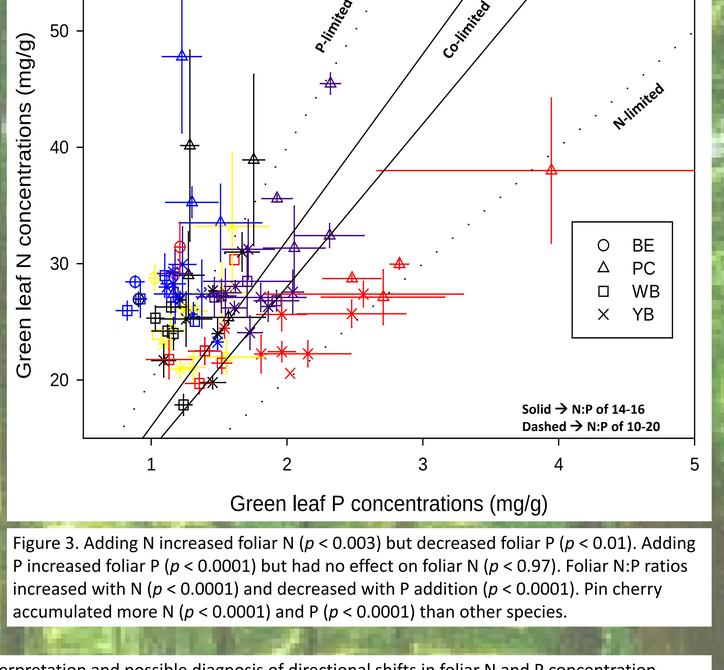


Figure 3. Adding N increased foliar N ($p < 0.003$) but decreased foliar P ($p < 0.01$). Adding P increased foliar P ($p < 0.0001$) but had no effect on foliar N ($p < 0.97$). Foliar N:P ratios increased with N ($p < 0.0001$) and decreased with P addition ($p < 0.0001$). Pin cherry accumulated more N ($p < 0.0001$) and P ($p < 0.0001$) than other species.

Vector Analysis

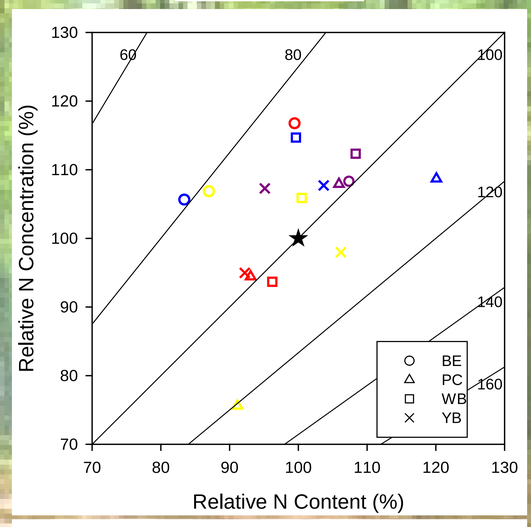


Figure 4. Relative foliar N responses (concentration and content) to nutrient addition by species. Diagonal lines represent relative mass.

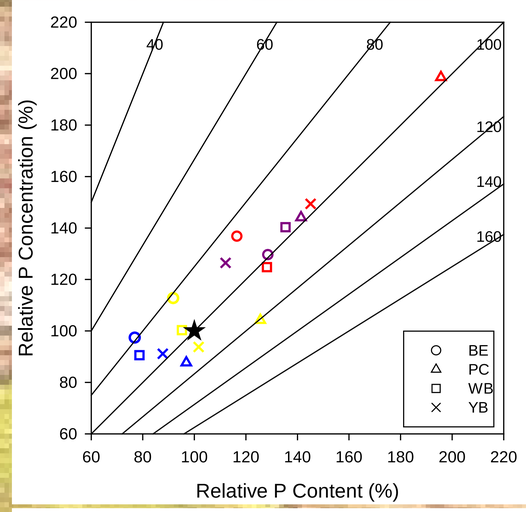


Figure 5. Relative foliar P responses (concentration and content) to nutrient addition by species.

Table 1. Interpretation and possible diagnosis of directional shifts in foliar N and P concentration, content and dry weight.

	Treatment	American beech	Pin cherry	White birch	Yellow birch
N	N	Excess (Toxic)	Deficiency (Limiting)	Excess (Toxic)	Excess (Toxic)
	P	Excess (Toxic)	Excess (Antagonistic)	Excess (Antagonistic)	Excess (Antagonistic)
	NP	Excess (Toxic)	Excess (Toxic)	Excess (Toxic)	Excess (Toxic)
	Ca	Excess (Toxic)	Excess (Antagonistic)	Excess (Toxic)	Dilution (Non-limiting)
P	N	Deficiency (Limiting)	Deficiency (Limiting)	Deficiency (Limiting)	Deficiency (Limiting)
	P	Excess (Toxic)	Lux. Consump. (Non-toxic)	Lux. Consump. (Non-toxic)	Lux. Consump. (Non-toxic)
	NP	Lux. Consump. (Non-toxic)	Lux. Consump. (Non-toxic)	Lux. Consump. (Non-toxic)	Excess (Toxic)
	Ca	Excess (Toxic)	Deficiency (Limiting)	Excess (Antagonistic)	Dilution (Non-limiting)

Discussions

- Foliar N:P ratios were in P-limited range in the control and N plots (Fig 3).
- Vector analysis showed slightly different results than the single measure of nutrient concentration (Figs 4 & 5 and Table 1).
- N is not limiting in the N plot ($p < 0.05$) and in the NP plot ($p < 0.05$). But, P is limiting in the control and N plots.

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