Alder strategies for phosphorus assimilation across a boreal forest successional sequence

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INTRODUCTION
Rates of carbon cycling and NPP in boreal forests are heavily dependent on inputs of biologically fixed N from Alnus tenuifolia. N-fixing species, including alder have exceptionally high demands for phosphorus (P) and N-fixation rates have been shown to respond positively to P fertilization. One strategy that alder uses to meet its P requirements is to associate with ectomycorrhizal fungi (EMF), which produce surface bound enzymes that mobilize organic and recalcitrant P forms.

HYPOTHESIS
N-fixation inputs across the landscape are controlled by the ability of alder to assimilate P through associations with EMF species of varying capacities to mobilize P. Because the forms and availability of P are known to change throughout forest succession and between soil horizons, we expected to see parallel shifts in EMF communities and function at these same scales.

METHODS
• Soil cores (n=30) were collected from the base of alder genets in early (alder-willow), mid (balsam poplar) and late (white spruces) successional stands (20m X 20m plots) along the Tanana River floodplain in mid-August 2009
• Cores were split into organic and mineral fractions
• Cores were stored on ice and alder roots were removed from cores within 2-3 hours
• Single healthy mycorrhizal tips (n = 7 tips/core) were excised from root systems under 10-40x magnification

RESULTS
• All enzymes activities were positively inter-correlated across stages and horizons (all P<.001); the strongest of these relationships was between acid phosphatase and phosphodiesterase (P<.001, R² = 0.32) (Fig. 2)
• Enzyme activities were ~double in late compared to early and mid-succession (all P<.001) (Fig. 3)
• Higher acid phosphatase in organic vs. mineral soils (P<.001) (Fig. 4)
• Stage by horizon interactions:
  - Acid phosphatase (P<.01) activity was higher on tips from organic verses mineral horizons (P<.001) in early succession
  - Phosphodiesterase (P<.001) activity was higher on tips from organic horizons of early (P<.05) and mid (P<.10) successional stands, but lower in organic horizons of late succession (P<.01)

CONCLUSIONS
• Functional traits of individual EMF species vary between soil horizons and throughout succession
• High activities of enzymes that mineralize complex forms of organic P in late successional white spruce sites are likely related to the more recalcitrant forms of organic matter found in these soils

FUTURE WORK
• Enzyme activities are being matched with digital estimates of root tip surface area
• Automated ribosomal intergenic spacer analysis (ARISA) is being used to analyze fungal ITS DNA sequences isolated from individual alder root tips for community analysis and paired with enzyme activity
• Forms and availability of P are being quantified using Hedley fractionation method
• Measures of plant N:P balance: foliar nutrient analyses and leaf resorption – from trees above where soil cores were taken

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