Soil Extracellular Enzyme Activities from a Post-harvest, Climate Manipulation Experiment

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Introduction & Background
Forest harvest often results in loss of soil C and N. Climate change may exacerbate post-harvest C and N losses from the soil. We designed an experiment to test this. We have previously reported that climate manipulation affected soil C and N fluxes, but found unexpected results (See Table).

Research Questions
Do shifts in C- and N-acquiring enzymes help explain previously reported unexpected soil C and N results?

What soil C and N metrics are best predicted by soil extracellular enzyme activity?

Methods & Materials
Forest Regeneration and Climate Experiment
Located at Penn State University’s Stone Valley Forest, in Huntington County Pennsylvania. A 2 ha mixed-deciduous forest was whole-tree harvested in August 2007.

After harvest, four treatments were applied to harvested forest plots (4 replicates of each treatment):

- Pre-Harvest: Treatments Begin
- Harvest: Treatments Begin
- 1 yr after Harvest

Soil Enzyme and Biogeochemical Measurements
Soil samples were collected every season and assayed for six extracellular enzyme activity (EEA) using para-nitrophenyl (hydrodrolases) and L-DOPA (oxidoreductases) substrates. The following enzymes activities were quantified: β-1,4-glucosidase (BG), cellobiohydrolase (CBH), leucine aminopeptidase (LA), alcohol acetylglucosaminidase (NAG), peroxidase (PER), and polyphenol oxidase (POO). The methods used were based on Sinsabaugh et al. (1999).

Soil enzyme ratios were used to interpret shifts in substrate supply and demand (Sinsabaugh 2008, 2011). EEE/EnTot is LBG/NNAG or labile C over labile N. EEE/EnTot is LN/NAG or labile C over labile recalcitrant C. EEE/EnTot is LN/NAG or labile N over total C. Additional measures included gravimetric water content, soil organic matter by loss on ignition, total C; and N; extractable organic C (WEOC); NH4-N; potentially mineralizable N in a 365-day incubation (PMN365); 3 potentially mineralizable C pools of labile (PMC), intermediate (PMC) and recalcitrant (PAMC).

Below: EEA over three years of the experiment. In a repeated measures ANOVA there was a significant warmed*wetted effect (p = 0.029) on BG and warmed effect (p=0.007) on NAG. In 2009 LA activity showed the warm treatment to the fastest 5 EEA.

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Below: principal components analysis of soil EEAs from spring (O2), summer (C), and fall (N). The vectors represent soil C and N metrics that best explained (p < 0.05) the variation in the EEA: Water-extractable organic C (WEOC), total nitrogen (ToN), and carbon-to-nitrogen ratio (CN).

Soil metrics and ecological enzyme ratios. Values significant (p < 0.05) are shown in bold. The N-acquiring to other enzymes (EEA/EnTot) were increased by single-factor treatments compared to the ambient treatment (warmed p = 0.023, wetted p = 0.025).

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References: