

# FERTILIZATION AND THROUGHFALL REDUCTION EFFECTS ON SOIL RESPIRATION AND LITTER DECOMPOSITION AS MEDIATED BY EXTRACELLULAR ENZYME ACTIVITY



Kristin M. McElligott\*, John R. Seiler, and Brian D. Strahm  
 Department of Forest Resources and Environmental Conservation, Virginia Tech  
 \*kmc2@vt.edu



## Background

- ❖ Soil and litter contain the largest pool of organic carbon (C) in the terrestrial biosphere.
- ❖ Heterotrophic soil respiration is among the largest fluxes in the terrestrial C cycle, and ultimately constrains ecosystem C storage.
- ❖ Forest fertilization and altered precipitation regimes are expected to influence decomposition dynamics and soil respiration, thereby ultimately affecting the net C balance of forest ecosystems.
- ❖ Decomposition of organic matter in soil is mediated by extracellular enzymes that are produced primarily by soil fungi and bacteria. Enzyme activity measurements represent microbial activity and thus are widely used as sensitive indicators of environmental change.
- ❖ Enzyme production and activity is dependent on the microbial community composition and organic matter abundance and quality. Potential enzyme activity is highly influenced by forest nutrient management, and physical and chemical characteristics of soil.

## Research Questions

In this study, we will explore how the soil microbial processes linked to decomposition in a mid-rotation loblolly pine stand might change with fertilization and reduced throughfall. We will address four questions important for predicting potential alterations in microbially mediated processes that determine whether C is lost to the atmosphere as heterotrophic respiration or retained in the soil:

- 1) How do the interactive effects of fertilization and throughfall reduction alter extracellular enzyme activity and litter quality?
- 2) How are enzyme activities related to patterns of litter decomposition and respiration?
- 3) How does litter quality influence enzyme activity?
- 4) What is the contribution of litter respiration to total soil respiration?

We expect that: (1) fertilization will increase the abundance of C-degrading enzymes but decrease the abundance of N- and P-degrading enzymes; nutrient limited microbes will reallocate their resources to obtain C, and (2) reduced throughfall will inhibit potential enzyme activities in unfertilized, and to a lesser extent, fertilized plots; enzyme activity may be decoupled from moisture availability when nutrients are limited.

## Research Approach



**Figure 1.** The research site is located in an 11-year-old loblolly pine stand (A) in the Appomattox Buckingham State Forest, VA (Tier III site) with fertilization, throughfall exclusion (B), and litter exclusion treatments (C).



**Figure 2.** Soil and litter respiration measurements will be taken concurrently with soil, litter, and duff enzyme activity, nutrient content, and C chemistry sample collection.

**Table 1.** Key enzymatic reactions include those involved in the degradation of cellulose and lignin, those that hydrolyze reservoirs of organic N such as proteins, chitin, and peptidoglycan, and those that mineralize P from nucleic acids, phospholipids and other ester phosphates. Activity can be used to infer shifts in microbial demand for carbon (including labile versus recalcitrant forms), nitrogen, and phosphorus.

| ID  | Enzyme                     | Process  |
|-----|----------------------------|--|
| NAG | N-acetyl-β-glucosaminidase | Depolymerization of N from SOM; chitin degradation |
| POX | polyphenol oxidase         | Depolymerization of N from SOM; lignin degradation |
| BG  | β-glucosidase              | C degrading; sugar degradation                     |
| CHB | β-D-cellubiosidase         | C degrading; cellulose degradation                 |
| AP  | phosphatase                | Phosphorus mineralization                          |
| AG  | α-glucosidase              | C cycling activities; sugar degradation            |
| XYL | β-xylosidase               | C cycling activities                               |
| LAP | leucine aminopeptidase     | N cycling activities; protein degradation          |
| PER | peroxidase                 | Lignin degradation                                 |

- ❖ This study will be located at the Virginia PINEMAP Tier III site in an 11-year-old loblolly pine stand with fertilization and simulated drought (throughfall reduction) treatments (Figure 1A and 1B).
- ❖ Total, litter, and mineral soil respiration will be measured at three subsample locations within each of the 16 treatment plots (Figure 2). Respiration measurements will be taken with the litter layer in place and removed (Figure 1C).
- ❖ Litter samples will be analyzed for nutrient content, lignin, phenolics, condensed tannins, and soluble and insoluble C fractions; these parameters are used to evaluate litter or substrate quality.
- ❖ Litter (O<sub>i</sub>), duff (O<sub>e</sub> + O<sub>a</sub>), and mineral soil samples (upper 10 cm) will be collected from each subsample location. Litter and soil samples will be assayed for enzyme activity (Table 1) using fluorometric and colorimetric microplate analysis (Figure 2).

## Broader Impacts

- ❖ Results from this study could be used to infer shifts in decomposition dynamics and microbial nutrient demand in response to forest management and environmental change.
- ❖ Increased decomposition could reduce C sequestration potential of loblolly pine plantations, but could enhance nutrient availability and improve soil productivity.

## Acknowledgements

The Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP) is a Coordinated Agricultural Project funded by the USDA National Institute of Food and Agriculture, Award #2011-68002-30185.

