LOBLOLLY PINE HETEROTROPHIC AND AUTOTROPHIC SOIL RESPIRATION AS INFLUENCED BY FERTILIZATION AND REDUCED THROUGHFALL

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Carbon (C) in terrestrial ecosystems is one of the main reservoirs in the global C cycle (Schimel 1995). Within these terrestrial ecosystems, soil C in the form of organic matter and plant biomass are the two largest pools of C. Further, the processes of photosynthesis and respiration that occur in these systems are the two largest fluxes of C globally (Schlesinger 1997). Given their size, even small changes in these pools and fluxes can significantly impact atmospheric CO_2 concentrations. Forest ecosystem management can actively influence global C dynamics by manipulating these pools and fluxes. Afforestation in general, and forest management (silviculture) specifically, can increase terrestrial ecosystem C in soils and biomass (Watson and others 2000). In the southern U.S., intensive management of loblolly pine forests has shown appreciable increases in productivity since widespread establishment of plantations in the 1950s (Fox and others 2007). Understanding the interacting effects of management (e.g., fertilization) and climate variability (e.g., drought) will be critical in guiding the adaptation of these forest ecosystems for the mitigation of negative climate impacts.

In order to quantify the effects of management and climate change, a measure of C storage is necessary. One such measure that forest scientists utilize is known as net ecosystem productivity (NEP). NEP is a measure of the net C accumulated by an ecosystem. For a loblolly pine ecosystem, it represents the C captured by photosynthesis minus the losses due to plant and soil respiration. Direct measurements of NEP are difficult over large geographic areas. Ecosystem C models have the capacity to predict NEP with one modification of their present configuration. There is a need to understand the relative contributions of soil heterotrophic, microbial respiration (R_H) and autotrophic, root respiration (R_A) to the overall belowground, or soil, respiration (R_S). Present estimates suggest R_A and R_H are roughly evenly split (Subke and others 2006), but deviations from this perception could have significant impacts on the estimates C storage in managed forest ecosystems.

In order to attain estimates of R_S components R_H and R_A, R_S needs to be measured in a root-free environment. Such conditions hardly exist in nature. On small scales, however, these conditions can be artificially created by use root-severing collars to cut the supply of plant carbohydrates. Over time, stored carbohydrates in roots (Hogberg and others 2001) used for continued maintenance are depleted, and R_A falls to zero. At this point, a measure of R_S is equal to R_H.

During the 2012 field season, we tested this at the Virginia Tier III PINEMAP installation. This 9-year-old loblolly pine stand is located in the Appomattox-Buckingham State Forest in the Piedmont of Virginia. This location represents the northernmost range of climatic conditions where loblolly pine is intensively managed in the southeastern U.S. The study utilizes large (0.10 ha) plots in a fully replicated (n = 4) 2 x 2 factorial design that includes fertilization (optimal nutrition, no addition) and throughfall exclusion (0, 30 percent). In each treatment three subsample locations were measured, and means were used to estimate R_H.

Respiration measurements were taken approximately every 2 weeks both adjacent to and on top of each root-severing collar to measure the decline in R_A over 90 days. Soil temperature (at 12 cm) and moisture

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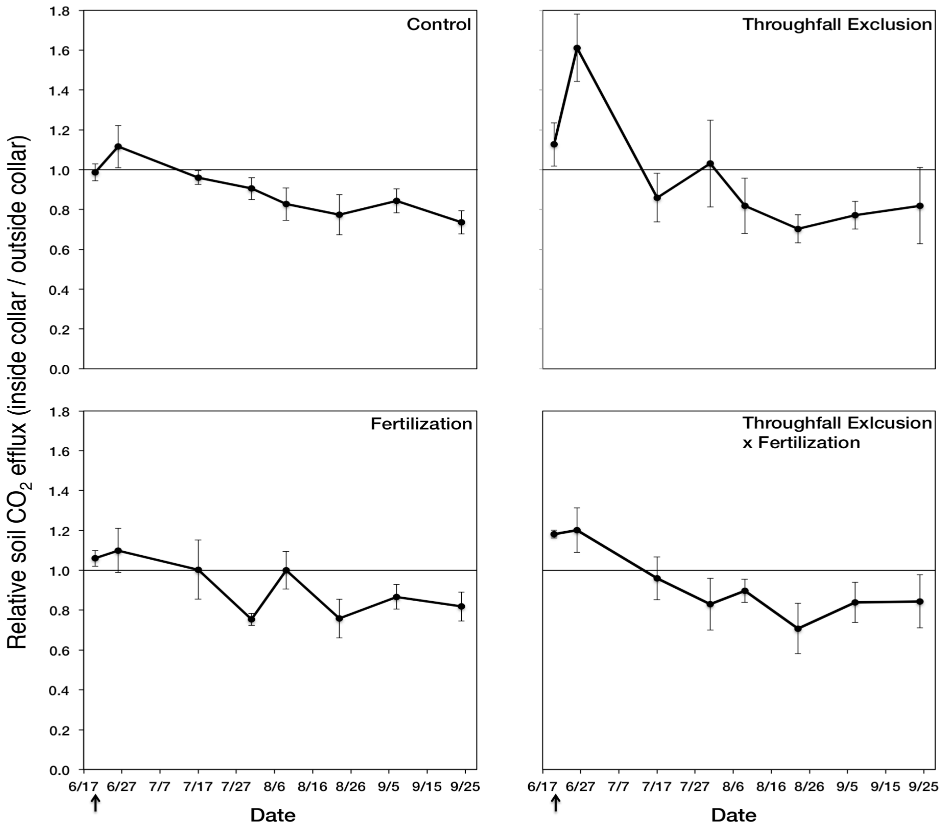

Figure 1--Relative soil CO_2 efflux (inside collar / outside collar) in a 9-year-old loblolly pine stand located on the Virginia Piedmont as influenced by the four treatment combinations. Arrow indicates date of collar installation.

measurements (0 to 12 cm) were also taken adjacent to the collar during each measurement.

Respiration initially increased inside the collars due to the disturbance of collar installation. After a period of equilibration, however, the respiration inside the collar began to decrease relative to outside the collar before stabilizing after approximately 65 days (fig. 1). After stabilization, means for each plot in each treatment were used to estimate R_H. R_H is estimated to account for 76.1, 81.4, 74.0, and 81.4 percent of R_S (table 1). Since there are no significant differences among treatments, a grand partitioning coefficient of 78.2 percent was calculated among all treatments.

Based on these initial results, PINEMAP researchers will be deploying this method at the other Tier III installations as well as in a broader regional context at some Tier II sites to estimate loblolly pine NEP across the range of the species.

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