# RELEASE OF NITROGEN AND PHOSPHORUS FROM LOBLOLLY PINE FOREST FLOOR IN A POST-HARVEST MICROCLIMATE

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Loblolly pine (*Pinus taeda* L.) plantations grown on nutrient deficient soils in the southeastern U.S. require nitrogen (N) and phosphorus (P) fertilization to increase growth (Albaugh et al., 2007; Fox et al., 2007). Fertilization increases growth by increasing foliar nutrients and leaf area (Albaugh et al., 1998) which also results in higher litterfall mass. Nutrients sequestered in foliage eventually accumulate in the forest floor. As a loblolly pine stand ages forest floor mass increases (Switzer and Nelson, 1972). Nitrogen and P content also increase (Switzer and Nelson, 1972) due to an accumulation of N and P as the litter decomposes (Piatek and Allen, 2001; Sanchez, 2001) suggesting a forest floor sink. In fertilized systems, the forest floor sink is magnified due to higher inputs from litterfall and increased foliar N and P concentrations (Will et al., 2006). When a stand is harvested, forest floor decomposition increases due to changes in environmental conditions. Since next rotation seedling nutrient demand is not great enough to capture nutrient released through forest floor decomposition (Fox et al., 2007), a significant amount of site nutrient capital could be lost. Our objectives were to: (1) determine whether fertilization results in a forest floor N and P sink and (2) quantify N and P release from decomposing forest floor material in a post-harvest microclimate.

This study was conducted at the Southeast Tree Research and Education Site (SETRES). The site is a 25-year old loblolly pine plantation growing on an infertile, excessively-drained, sandy soil (Wakulla series, Psammentic Hapludult). The experimental design is a $2^2$ factorial with 4 blocks. Treatments include fertilization (no addition and optimal nutrition) and irrigation (no addition and optimal soil water content). Treatment levels include a control, irrigation, fertilization, and fertilization x irrigation. Fertilization is conducted by applying a balance of macro- and micro-nutrients to provide optimal nutrition. Irrigation is conducted by maintaining a soil water content >40% field capacity during the growing season. Total N and P additions from 1992 to 2008 were 1378 and 168 kg/ha, respectively. The forest floor and mineral soil were sampled in March 2008 and analyzed for N and P. Treatment effects were determined with a general linear model. In May 2009, forest floor Oi and Oe horizons were collected in each plot, approximately 100 g were placed in a litterbag (20x40 cm; 2 mm opening). Initial masses were determined and litterbags were placed on the mineral soil surface in an open-sky area adjacent to the experimental plots replicating the layout of the plots. Four replicate litterbags were prepared for each of the 16 plots resulting in 64 total litterbags. One litterbag representing each of the 16 plots was destructively sampled every 3 months for 1 year. At each sampling interval, remaining mass and N and P concentration was determined. The proportion of N and P released was determined for each sampling interval (Schlesinger and Hasey, 1981) and the decay rate constant (k; per month) and mean residence time (MRT) of 99% mass loss were calculated (Olson, 1963). Treatment effects were determined with repeated measures ANOVA.

Fertilization did not increase mineral soil N but increased mineral soil P by 57 kg/ha. Fertilization increased forest floor Oi and Oe horizon N by 200 kg/ha and P by 10 kg/ha. These results indicated a forest floor sink for added N and a forest floor and mineral soil sink for added P. In the post-harvest replicated decomposition experiment, fertilization and irrigation did not affect the decay rate constant (k) or proportion of N and P released. The overall decay rate constant for all the data ($k = 0.411$; $R^2=0.95$) indicated a MRT of 12.2 months. Nitrogen and P content released was increased by fertilization ($p<0.0001$) (Figure 1). Approximately 255 kg/ha and 13 kg/ha of N and P, respectively, were released from fertilized forest floor within 1 year.

The forest floor Oi and Oe horizons retained 15% of N added through fertilization. This represents a significant amount of site N capital on an infertile site. The amount of N released from the decomposing forest floor exceeds the capacity of newly planted pine seedlings to take-up N which could result in a loss of N from the site.

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## LITERATURE CITED


**Albaugh, T.J.**, H.L. Allen, P.M. Dougherty, L.W. Kress and J.S. King. 1998. Leaf-area and above- and belowground growth responses of loblolly pine to nutrient and water additions. Forest Science 44: 317-328.

**Albaugh, T.J.**, H.L. Allen, and T.R. Fox. 2007. Historical patterns of forest fertilization in the southeastern United States from 1969 to 2004. Southern Journal of Applied Forestry 31(3):129-137.

**Fox, T.R.**, H.L. Allen, T.J. Albaugh, R.A. Rubilar, and C. Carlson. 2007. Tree nutrition and forest fertilization of pine plantations in the southern United States. Southern Journal of Applied Forestry 31(1):5–11.

**Olson, J.S.** 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology 44:322-331.

**Piatek, K.B.** and H.L. Allen. 2001. Are forest floors in mid-rotation loblolly pine stands a sink for nitrogen and phosphorus. Canadian Journal of Forest Research 31:1164-1174.

**Sanchez, F.** 2001. Loblolly pine needle decomposition and nutrient dynamics as affected by irrigation, fertilization, and substrate quality. Forest Ecology and Management 152:85-96.

**Schlesinger, W.H.** and M.M. Hasey. 1981. Decomposition of chaparral shrub foliage: losses of organic and inorganic constituents from deciduous and evergreen leaves. Ecology 62:762-774.

**Switzer, G.L.** and L.E. Nelson. 1972. Nutrient accumulation and cycling in loblolly pine (*Pinus taeda* L.) plantation ecosystems: the first twenty years. Soil Science Society of America Journal 36:143-147.

**Will, R.E.**, D. Markewitz, R.L. Hendrick, D.F. Meason, T.R. Crocker, and B.E. Borders. 2006. Nitrogen and phosphorus dynamics for 13-year old loblolly pine stands receiving complete competition control and annual N fertilizer. Forest Ecology and Management 227:155-168.


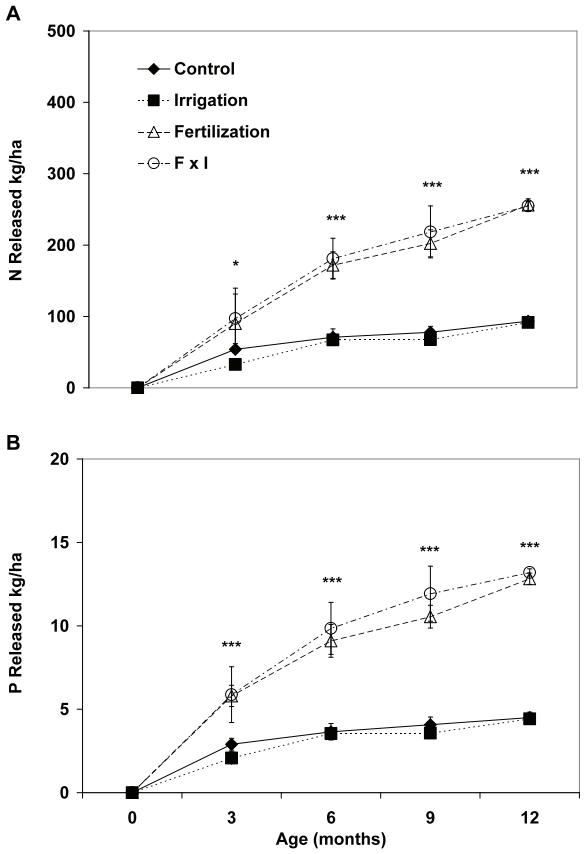


Figure 1—Mean nitrogen (A) and phosphorus (B) content released from forest floor Oi and Oe horizons. Significant fertilization x month interaction effect denoted by * ($p<0.05$), *** ($p<0.0001$). Error bars represent 1 standard deviation.