

# INTENSIVE STRAW HARVESTING, FERTILIZATION, AND FERTILIZER SOURCE AFFECT NITROGEN MINERALIZATION AND SOIL LABILE CARBON OF A LOBLOLLY PINE PLANTATION

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**Abstract**—Straw harvesting can supplement traditional revenues generated by loblolly pine (*Pinus taeda* L.) plantation management. However, repeated raking may alter soil properties and nutrition. In northcentral Louisiana, a study was conducted to evaluate the long-term effects of intensive straw raking and fertilizer source (inorganic or organic) on nitrogen (N) cycling and soil carbon (C) quality. Monthly *in situ* soil N mineralization, total N and C concentrations, and end-of-season soil labile C concentrations were measured in response to: (1) annual straw raking for 4 years, (2) annual straw raking and fertilization with inorganic fertilizer for 4 years, and (3) annual straw raking and fertilization with broiler poultry litter application for 4 years. Straw raking led to significant increases in N mineralization. Significant increases in N mineralization larger than those from straw raking alone occurred in response to both fertilization treatments, whereas N was immobilized in response to unfertilized treatments. Applying poultry litter annually to raked soil increased soil C, N, and labile C concentrations and thus reduced the soil C to N ratio. However, application of poultry litter did not raise N mineralization above that found in response to fertilization with inorganic fertilizer. Total soil N concentrations were highest in response to poultry litter application, suggesting that N applied with this fertilizer source was better retained within soil than with inorganic fertilizer. Application of inorganic fertilizer reduced the potential C turnover rate to levels below those of all other treatments. Poultry litter may be superior to inorganic fertilizer in maintaining nutrition of frequently raked loblolly pine plantations because it more readily increased soil N availability and labile C critical in soil nutrient turnover. Inorganic fertilizer, by contrast, increased the potential turnover of C in the soil.

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# Intensive Straw Harvesting, Fertilization, and Fertilizer Source Affect Nitrogen Mineralization and Soil Labile Carbon of a Loblolly Pine Plantation



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## Abstract

Straw harvesting can supplement traditional revenues generated by loblolly pine (*Pinus taeda*) plantation management. However, repeated raking may alter soil properties and nutrition. A previous study documented altered bulk densities and microbial populations related to straw harvesting and different fertilizer applications. Another study at this same site was initiated to evaluate the long-term effects of intensive straw raking and fertilizer source (inorganic or organic) on nitrogen cycling and soil carbon quality. Monthly in situ soil nitrogen mineralization and end-of-season soil labile C concentrations were measured in response to: (1) annual straw raking for four years, (2) annual straw raking and fertilization with inorganic fertilizer for four years, and (3) annual straw raking and fertilization with broiler poultry litter application for four years. Results of these analyses will be presented and related to the potential sustainability of these differing treatments.

## Introduction

Pine straw (pine needles) harvested for mulch from pine plantations is a valuable commodity in the southeastern U.S. It is marketed to the landscaping industry and represents a multimillion dollar industry in this region. There is concern that excessive removal of pine needles and repeated trafficking with heavy equipment may have adverse effects on the sustainability of soils and the long term productivity of these stands. The nutrient content in pine needles is substantial and repetitive harvesting of pine straw removes significant amounts of organic nitrogen and carbon as well as other nutrients from the soil. This may also reduce nitrogen availability which would ultimately reduce tree productivity. Nutrient amendments are commonly utilized in southern pine plantations to replenish macro and micronutrients that are essential for tree growth and are limiting. Both inorganic and organic fertilizers (such as poultry litter) have been used to increase nutrient availability in and increase productivity of pine plantations harvested for pine straw. Poultry litter is an important by-product of broiler poultry production and consists of chicken manure, bedding materials (rice or peanut hulls and pine shavings) and feed waste. Poultry litter differs from inorganic fertilizer in that it adds organic matter along with nitrogen and phosphorus. This additional carbon source may be important for sustaining soil quality in stands where organic matter is removed by raking. The fertilizer source applied to pine plantations in order to achieve desired soil conditions will be crucial in maintaining the long term productivity and sustainability of pine plantations managed for pine straw raking.

## Objectives

The purpose of this study is to examine the effects of pine straw raking and organic and inorganic fertilizer amendments on:

1. Nitrogen mineralization
2. Soil carbon and nitrogen



Figure 1. Study location in Ouachita Parish, Calhoun, LA

## Treatment Regimes

- CONTROL - No pine straw raking and no fertilizer
  - RAKE - Pine straw raking\* with no fertilizer
  - RAKE-IN - Pine straw raking\* with 308 kg ha<sup>-1</sup> urea<sup>‡</sup>, 280 kg ha<sup>-1</sup> DAP<sup>‡</sup>
  - RAKE-PL - Pine straw raking\* with poultry litter<sup>‡</sup>, 7.7 Mg ha<sup>-1</sup>
- \*Pine straw raking occurred three times annually in Feb., Aug., and Nov.  
<sup>‡</sup>Annual fertilizer treatments were respectively applied at total N and P input rates of 193 kg ha<sup>-1</sup> and 129 kg ha<sup>-1</sup> beginning April 2003.

## Methods

- Eight 0.08 ha plots located in each of two stands
- Four replications of each treatment regime
- Potential nitrogen mineralization determined by in situ soil incubations using the buried bag method during March 2007
- Labile carbon samples collected during seasonal peak of pine and understorey growth, September 2007
- Labile carbon quantified using the sequential fumigation-incubation procedure
- Total carbon and total nitrogen quantified using the dry combustion method

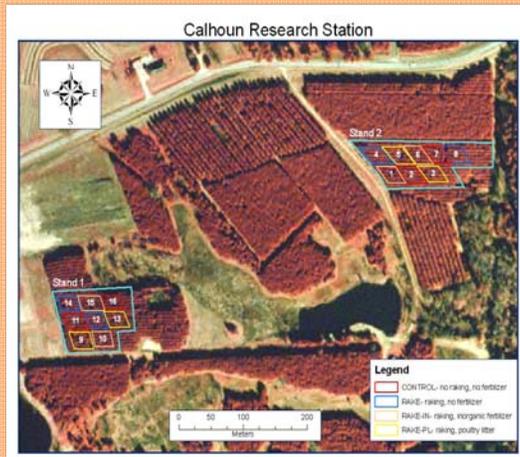
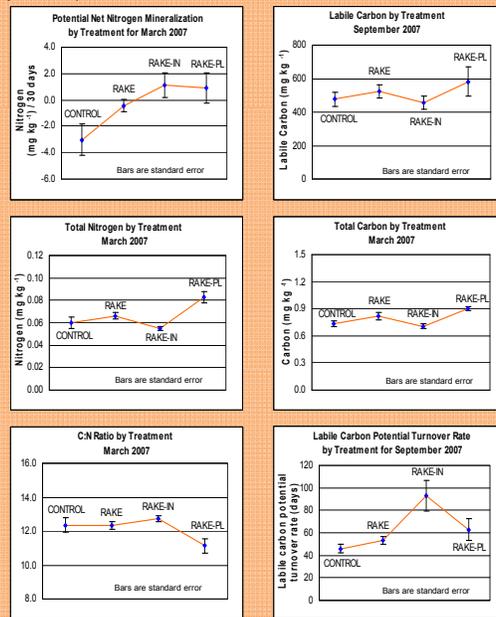


Figure 2. Plot layout and treatments at Calhoun Research Station, Calhoun, LA



## Preliminary Results

- Nitrogen mineralization occurred in fertilized treatments; mineral nitrogen became immobilized in unfertilized treatments.
- RAKE-IN treatments had concentrations of N, C, and labile carbon similar to those of the rake only and control treatments. The higher N mineralization in the RAKE-IN treatment appears to be related to N, C, and labile carbon.
- Poultry litter adds C, labile C, N and thus lowers C:N but does not appear to improve N mineralization over the RAKE-IN treatment.
- Reduced labile carbon in RAKE-IN increased the carbon turnover rate.
- Added N appears to be retained better with poultry litter
- Pine straw raking increases N mineralization



## Conclusions

Fertilizer amendment is recommended in stands that are intensively raked for pine straw. Availability of mineral nitrogen that is important for productive tree growth can be improved with the addition of either organic or inorganic fertilizer. Nitrogen additions may be best retained with poultry litter resulting in greater nitrogen availability. Increased N mineralization following pine straw raking is perhaps due to increased soil temperature and may only be temporary. Soil labile carbon concentrations can be maintained in raked stands with organic or inorganic fertilizer sources but poultry litter increases soil labile carbon levels which may improve stand productivity. Soil productivity may be best sustained with poultry litter amendment due to the shorter labile carbon turnover rate. This short turnover rate may improve nitrogen mineralization rates, availability of nitrogen, and thus stand productivity. Poultry litter may be a preferred fertilizer source over inorganic fertilizer for replenishing nutrient resources and sustaining labile carbon levels in loblolly pine plantations intensively raked for pine straw production. This is important for the long-term sustainability and productivity of soil resources. The nutrient management applied to pine plantations in order to achieve desired soil conditions will be crucial in maintaining the long term productivity and sustainability of pine plantations managed for pine straw raking.



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