Decomposition Rate Comparisons between Frequently Burned and Unburned Areas of Uneven-aged Loblolly Pine Stands in Southeastern Arkansas

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Abstract

Although fire has been used extensively over long periods of time in loblolly pine (*Pinus taeda* L.) ecosystems, little is known concerning the effects of frequent fire use on nutrient cycling and decomposition. To better understand the long-term effects of fire on these processes, foliar litter decomposition rates were quantified in a study investigating prescribed fire and uneven-aged loblolly pine management in the Upper Coastal Plain in Arkansas. Part of the study area had been burned on a 2- to 3-year cycle since 1981, whereas another portion had not received any prescribed fires. Decomposition rates were determined by placing foliar litter from each area in litterbags, installing these bags in the field within each area, and monitoring the litter mass loss over a 10-month period. During this period, no differences were found in decomposition rates between the burned and unburned areas. However, an initial increase in decomposition was found in litterfall collected from the burned areas when compared with litterfall collected from unburned areas.

Introduction

The dependence of the pine forest upon recurring fires in the southern pine belt of the southeastern United States is well known (Barnes et al., 1998). Although fire was once considered a destructive agent with few benefits, it is now apparent that fires are important in maintaining and establishing forests. The use of prescribed fire has now become a well accepted silvicultural practice (Barnes et al., 1998). Prescribed fire is often used to reduce fuels; prepare sites for regeneration; dispose of logging debris; improve wildlife habitat; manage for competing vegetation and disease; improve aesthetics, access, and grazing; perpetuate fire dependent species; and to manage for endangered and other species (Wade and Lunsford, 1989). Fuel burned by prescribed fires includes dead trees, logs, slash, needles, leaves, and other litter (McCullough et al., 1998).

The effects of fire on forest ecosystems are complex and can be beneficial or detrimental depending on fire intensity, stand structure, and community composition (Barnes et al., 1998). Positive benefits of fire can include increased nutrient uptake, accelerated tree growth, enhanced nutrient cycling (Clinton et al., 1996), and improved nutrient availability (Shoch and Binkley, 1986). Negative effects of prescribed fire may include forest floor and organic matter destruction, nutrient and soil loss, erosion, decreased soil aeration and penetrability, and vegetation mortality (Wade and Lunsford, 1989).

While some of the more direct impacts of fire have been documented, less is known of the indirect affects of fire on forest ecosystem processes, such as decomposition. With this in mind, we superimposed a litter decomposition study within an ongoing study of the silvicultural effects of fire in uneven-aged loblolly pine (*Pinus taeda* L.) stands in southeastern Arkansas. The objectives of the study were to determine if 1) pine foliar litterfall on burned areas decomposes at a different rate than litterfall on unburned areas and 2) pine foliar litterfall collected from burned areas decomposes at a different rate than litterfall collected from unburned areas. These objectives were quantified by examining pine litterfall decomposition as well as foliar litter nutrient concentrations.

Methods

Study Area.--The study was located on compartments 11, 24, and 55 of the Crossett Experimental Forest in Ashley County, Arkansas at 32°02'N mean latitude and 91°56'W mean longitude. The study area is 53 m above mean sea level and has nearly level topography. Annual precipitation averages 140 cm. Soils are predominantly Bude and Providence silt loams (fine-silty, mixed, thermic, Glossaquic and Typic Fragiudalfs, respectively) that have an impervious layer at a depth of 50-100 cm which impedes internal drainage and root growth (Gill et al., 1979). Soil reactivity varies from medium acid to very strongly acid (Gill et al., 1979). Site index for loblolly pine is 27 m at age 50 (Cain, 1993).

Treatments.--The study sites were managed using uneven-aged silviculture with single-tree selection and the complete exclusion of fire starting in the late 1930's until the late 1960's (Cain, 1993). After the late 1960's, no harvesting or vegetativion control was performed until 1980. The initial burn treatments began in January of 1981. The burn

treatments consisted of 1) an unburned control, 2) an irregular winter burn [every 2-3 years], 3) a winter burn every five years, and 4) a winter burn every 10 years (Cain et al., 1998). Each of the 16-ha compartments was divided into sixteen 1-ha plots. Each 1-ha plot had an interior measurement plot of 0.65 ha that was surrounded by a 10-m wide isolation strip. Four contiguous 1-ha plots comprised a 4-ha burn treatment in each compartment. For the purposes of this study, only the unburned control and irregular burn treatments were used. Within these treatments, there was one 1-ha measurement plot that was maintained at a residual basal area of 14 m^2/ha. Timber harvests have been applied on a 6-year cutting cycle. To reduce hardwood competition, the unburned (check) plots were treated in 1992 with a broadcast application of Arsenal AC herbicide (1.7 kg a.i) in 113 L of water/ha using articulated rubber-tired skidders in swaths 9 m wide. Because the herbicide had been applied 8 years earlier, we were not concerned with the herbicide directly affecting the results of the decomposition study.

A total of six 1-ha plots were used in the study, one unburned control and one irregularly burned plot in each of the three compartments. Within each 1-ha plot, three 4- x 4-m subplots were installed for installation of litter bags.

Litterbag Sampling.--The litterbag method is well recognized and has been used for many decomposition studies (Mellilo et al., 1982; Lockaby et al., 1995). Each bag is 30 cm x 30 cm with a mesh size of 5 mm on the top and 2 mm on the bottom. In the fall of 1999, pine foliar litterfall was collected from all plots within each treatment. The litter was dried, mixed by treatment, and stored for later use inside of the litterbags.

Vegetation was trimmed to ground level in three strips (approximately 40 cm wide) within each of the 4- x 4-m subplots on each treatment plot. Litterbags containing 20 g of air-dried litter collected from the burned areas and litterbags containing 20 g of air-dried litter collected from the unburned areas were placed in rows on each subplot. Litter collected from the two treatments was kept separate by treatment so comparisons in decomposition rates could be made between 1) litterfall placed on the burned and unburned treatments and 2) litterfall collected from each treatment. One litterbag of each litter source (burned or unburned areas) was collected from each subplot after 0.5, 1, 2, 5, 7, and 10 months. The litterbags were transported in plastic bags to the laboratory where all foreign material was removed. The litter was dried at 70° C, and mass loss was determined. Loss on ignition was used to calculate ash free masses. Ash free masses, which are free from contamination by mineral soil, were used in the analysis. In addition, a correction factor was applied to adjust the initial air-dried mass of the litter to an oven-dried basis.

Litter Quality.--Initial litter quality of loblolly pine litterfall was assessed for each treatment. Several studies have used litter quality as a variable to assess decomposition rates (Fogel and Cromak, 1977; Taylor et al., 1989). The litter collected for litterbags was dried, ground, and analyzed for macro-nutrient concentrations by the University of Arkansas Soil Test Laboratory, Fayetteville, Arkansas. Nutrient data were used to determine C/N ratios and to compare initial litter quality for the decomposition study.

Statistical Design.--The ash free mass loss data were analyzed using ANOVA with a split-plot through space and time design. The litter quality data were analyzed using a paired *t*-test. All tests were performed at an α level of 0.05.

Results and Discussion

After 10 months, there was no evidence that 20 years of prescribed fires had altered decomposition rates at these sites. The ash free pine litterfall masses did not significantly differ between the burned and unburned treatments for any of the collection dates. As can be seen in Figure 1, pine litterfall masses were similar for the two treatments throughout the 10 months.

In contrast, mass loss was significantly different at all dates between the litterfall collected from the burned and unburned treatments (Fig. 2). It is apparent that long-term prescribed fire can affect mass loss indirectly. The litterfall collected from the burned areas either decomposed faster or experienced rapid leaching after only two weeks. At the two week collection period, litterfall collected from burned areas had lost 56% more mass than litterfall collected from

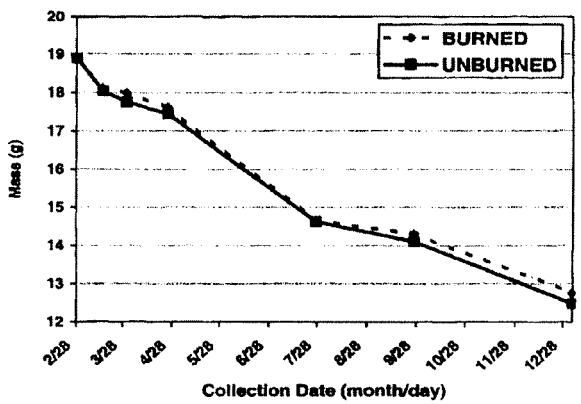

Fig. 1. The loss of mass from decomposing foliar litter located in burned and unburned areas of uneven-aged loblolly pine stands.

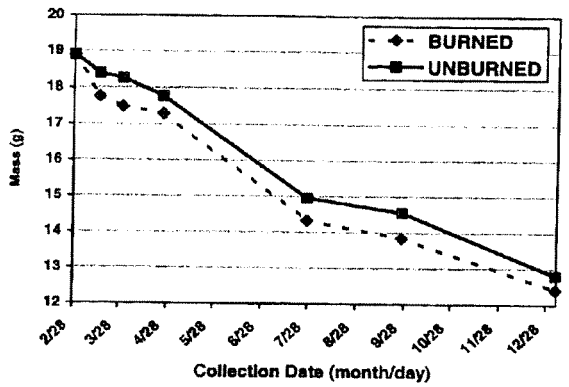

Fig. 2. The loss of mass from decomposing foliar litter collected from burned and unburned areas of uneven-aged loblolly pine stands.

unburned areas. After the first 2 weeks, decomposition rates were similar for the subsequent 9.5 months. Masses of the two litterfall sources remained significantly different throughout the 10 months.

Nutrient analysis showed significant differences in K, Ca, Mg, and C concentrations between the burned and unburned areas. There were no significant differences for N, P, or S (Table 1) or C/N ratios. Litterfall collected from the burned treatment contained higher concentrations of K, Ca and Mg but lower concentrations of C than foliar litterfall from the unburned treatments. These differences in nutrient concentrations could be partially responsible for the initial increase in mass loss in litterfall from the burned areas. However, these differences in nutrient concentrations were not enough to fully explain the differences in mass loss. It is possible that these differences would be better explained by examining nutrient content in combination with cellulose, lignin concentrations, or soluble sugar concentrations.

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Table 1. Initial nutrient concentration of foliar litter collected from burned and unburned areas in uneven-aged loblolly pine stands.

Nutrient	Litterfall Source	Mean Concentration (%)	Standard Error
N	Burned	0.43 a[1]	0.006
	Unburned	0.43 a	0.012
C	Burned	47.84 a	0.083
	Unburned	48.21 b	0.104
P	Burned	0.02 a	0.001
	Unburned	0.02 a	0.002
K	Burned	0.13 a	0.004
	Unburned	0.11 b	0.007
Ca	Burned	0.37 a	0.006
	Unburned	0.33 b	0.011
Mg	Burned	0.09 a	0.002
	Unburned	0.08 b	0.003
S	Burned	0.04 a	0.001
	Unburned	0.04 a	0.001

[1]Means for a nutrient concentration followed by different letters were significantly different at $\alpha = 0.05$.

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