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ABOVE- AND BELOW-GROUND GROWTH OF LONGLEAF PINE IN RESPONSE TO THREE PRESCRIBED BURNING REGIMES

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ABSTRACT: *Maintenance of longleaf pine ecosystems requires repeated fire.* Past research has indicated that in some situations, regular burning decreases longleaf pine productivity. Growth reductions may be attributed to fire-induced loss of leaf area. It is possible that the loss of leaf area is a function of both fire intensity and the stage of flush development at the time of burning. The objective of this study is to evaluate the effect of prescribed burning at different stages of branch development on the periodic growth, leaf area dynamics, root elongation and root carbohydrate relations of 45-year-old longleaf pine. We hypothesize that the potential for fire damage to new fascicles will be reflected in leaf area responses to seasonal burning, and that periodic growth, root elongation and root carbohydrate relations will be related to leaf area dynamics.

The study is being conducted on the Palustris Experimental Forest, Rapides Parish, LA, in an existing long-term experiment where seasonal burning treatments have been applied biennially since establishment. Since the long-term study is unevenly stocked, the present study is being conducted in two replications of tree clusters that are of equivalent stocking. Prescribed burning treatments were applied in March, May and July 1998. Tree growth, leaf area index, root elongation and root carbohydrate concentrations were measured periodically during March 1998 through June 2000. Seasonal patterns of leaf area, tree growth, root elongation and root carbohydrate concentrations will be presented. Relationships between season of burn, leaf area dynamics and growth processes in tree clusters will be discussed.

INTRODUCTION

Controversy exists concerning the sustainability of southern pine forests that experience repeated prescribed fire. Although some research indicates that routine prescribed fire does not negatively affect southern pine productivity, other studies show that regular burning reduces tree growth (Boyer 1987, Brockway and Lewis 1997). As a result, long-term use of repeated prescribed fire requires understanding of its interaction with forest productivity.

Carbon fixation and allocation in the crown of trees treated with prescribed fire are affected by fire intensity. For example, crown scorch and premature foliage senescence have been associated with reductions in both diameter growth and root carbohydrate concentrations for two years after prescribed fire (Johansen and Wade 1987, Sword and Haywood 1999).

Growth reductions have also been observed with negligible foliage loss in response to repeated burning (Johansen and Wade 1987, Boyer 1987). The impact of minor foliar damage on tree growth may be a function of two crown variables. First, the stage of fascicle development at the time of prescribed fire and the sensitivity of new foliage to heat may influence fire damage to current-year foliage. Second, the stage of seasonal leaf area dynamics at the time of prescribed burning may influence the risk of fire-induced damage to stand leaf area. Since carbon allocation to sinks such as stem and root diameter growth, new root initiation and starch storage occurs seasonally, damage to the foliar source of carbon for these sinks may limit tree growth.

We hypothesize that prescribed fire damages foliage and subsequently, reduces leaf area which decreases carbon fixation in the crown and carbon allocation to stem and root growth. Furthermore, this effect depends on fascicle development and leaf area at the time of prescribed burning, and the seasonal dynamics of carbon allocation to stem and root growth. Our objective is to present the seasonal dynamics of leaf area and root carbohydrate concentrations in response to three prescribed burning regimes, and evaluate interaction between leaf area and root carbohydrate concentrations in a 45-year-old longleaf pine stand. As the study continues, similar relationships between leaf area and other important carbon sinks will be evaluated.

MATERIALS AND METHODS

The study is being conducted in a long-term experiment on the Palustris Experimental Forest, Rapides Parish, Louisiana. The study site was regenerated with longleaf pine by the seed tree silvicultural system between

1950 and 1956. Prescribed fire was applied biennially between 1966 and the present. The soil is a complex of three well-drained, very fine or fine sandy loam soil series. The original study consisted of four treatments assigned to sixteen 36.6 x 36.6 m^2 plots in a randomized complete block design with four blocks. Blocking was based on topography. Treatments were biennial prescribed burning in winter (March), spring (May) or summer (July).

In the absence of prescribed fire for 35 years, longleaf pine did not persist on the non-burned plots. Also, the burned plots are unevenly stocked with longleaf pine. Thus, the experimental design of the present study was modified from that of the original study. Specifically, measurements were conducted in 3- to 4- and 6- to 7-tree clusters in two replications of three prescribed burning treatments using a completely random design. For comparison to non-burned trees, measurements were conducted in similar tree clusters in one non-treated plot of an adjacent long-term study. Tree age, stocking and site conditions on the non-burned plot were similar to those in the present study.

Leaf area index (LAI) was monitored monthly with two LiCor LAI-2000 Plant Canopy Analyzers (LiCor Inc., Lincoln, Nebraska). At each measurement interval, 10 readings, equidistant and permanently marked along a transect, were taken in each 6- to 7-tree cluster. Above-canopy readings were taken in an adjacent field. Above- and below-canopy readings were used to determine cluster LAI. Root carbohydrate relations were measured monthly in 3- to 4-tree clusters throughout the two-year burning cycle. Five soil cores were extracted from random locations in the periphery of 3- to 4-tree clusters. Cores were pooled and roots (>2≥5 mm in diameter) were removed, washed, lyophilized and ground with a Wiley mill (1 mm^2 mesh). Concentrations of root starch, sucrose and glucose were determined enzymatically by the method of Jones et al. (1977) with modifications for loblolly pine.

RESULTS AND DISCUSSION

Distinct patterns of leaf area were observed annually (**Figure 1**). However, leaf areas did not differ by season of prescribed burn. Maximum LAI occurred in September 1998 and 1999, and minimum LAI occurred in February 1998 and January 1999. Differences between maximum and minimum unadjusted LAI in each large tree cluster were calculated for 1998 and 1999. Values for 1998 and 1999 represent leaf area growth in 1997 and 1998, respectively. The leaf area of foliage produced in 1997 was greater than that produced in 1998.

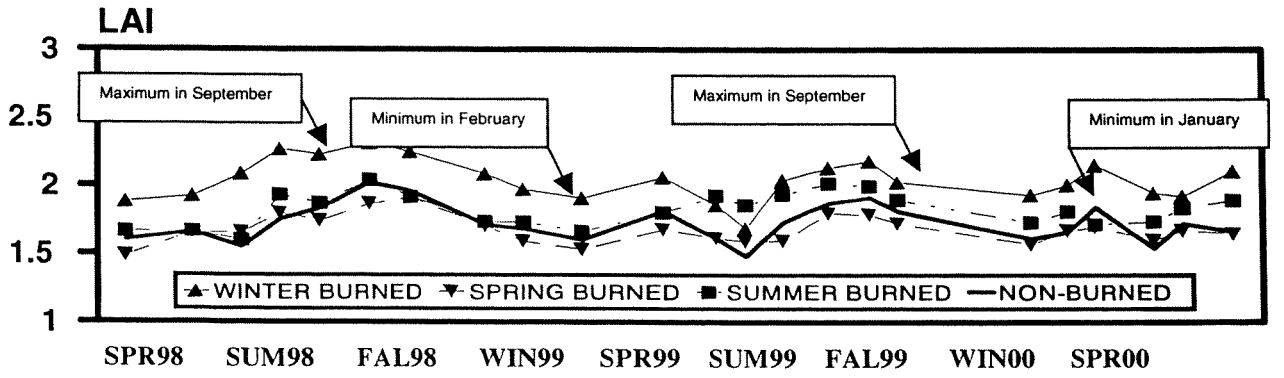

Figure 1. Leaf area index (unadjusted) of 45-year-old longleaf pine in three prescribed burning regimes.

Root carbohydrate concentrations were not affected by season of prescribed burn but did vary seasonally (**Figure 2**). In early spring when environmental limitations were low, significant relationships between leaf area growth and root carbohydrate concentrations were found. Specifically, correlation coefficients (r) between annual leaf area growth and root starch, glucose and sucrose concentrations in April were 0.5036 (P=0.0664), -0.5242 (P=0.0543) and 0.7811 (P=0.0010), respectively. Thus, the potential exists for silvicultural treatments that negatively affect leaf area to reduce root carbohydrate concentrations, and subsequently root metabolism. As the growing season progressed, however, leaf area growth and root carbohydrate concentrations were not correlated. Both 1998 and 1999 were characterized by water deficits and high temperature during the growing season. Limiting environmental conditions

may have directly affected relationships between leaf area growth and root sink activity during the height of the growing season, or indirectly affected these relationships by reducing leaf area production and therefore, whole-crown carbon fixation in 1998.

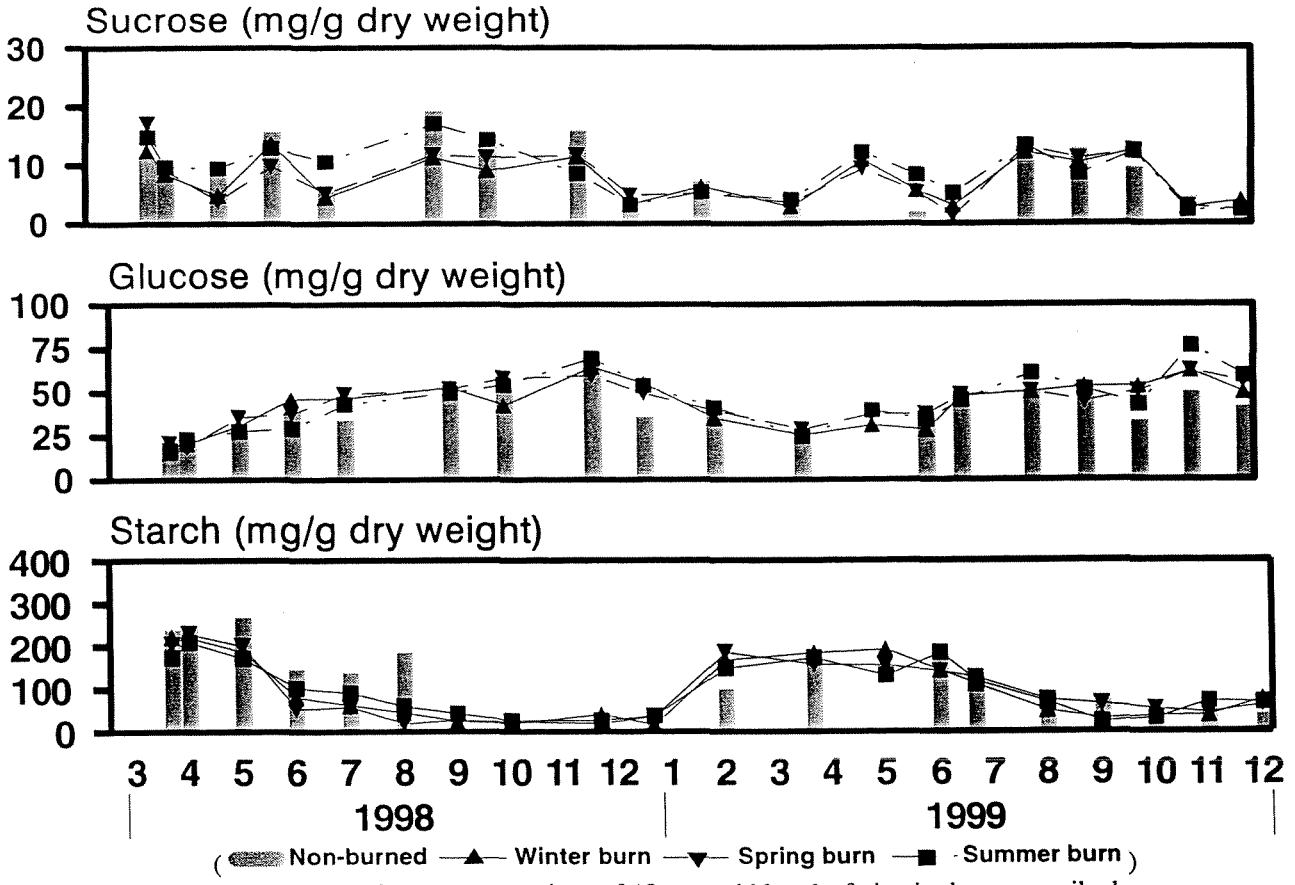

Figure 2. Seasonal root carbohydrate concentrations of 45-year-old longleaf pine in three prescribed burning regimes.

As data analyses continue, we will determine critical times of the year when damage to new foliage or canopy leaf area may be detrimental to stem and root growth. With this information, further research will be designed to evaluate the effect of season of prescribed fire on carbon fixation and allocation in younger and more evenly stocked stands.

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