RESPONSE OF FOLIAGE OF YOUNG LOBLOLLY PINE TO WOODY AND HERBACEOUS PLANT CONTROL

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Introduction

Woody and herbaceous weeds have been shown to have a significant negative impact on survival and/or growth of planted loblolly pine (*Pinus taeda* L.) in the southeastern United States (Nelson *et al.* 1981, Zutter *et al.* 1986, Bacon and Zedaker 1987, Miller *et al.* 1987, 1991). Most research studies have focused on the effects of controlling only herbaceous, only woody, or both herbaceous and woody components. As a result, our understanding of how woody and herbaceous plants may interact to influence the response of loblolly pine is limited. In the early 1980's the Competition Omission Monitoring Project (COMP) was developed, in part, to compare the relative effects of woody and herbaceous plants and their interaction on the response of loblolly pine across a wide range of sites in the southeastern United States.

Although there is an abundance of information relating loblolly pine response to the amount of competing herbaceous and/or woody plants, the study of the underlying causes for such responses are less well understood. A number of studies have shown soil water to increase and water stress of loblolly pine seedlings to be lessened in the absence of woody and/or herbaceous vegetation (Nelson *et al.* 1981, Miller *et al.* 1987, Perry *et al.* 1994). However, little is understood with regard to the effects of woody and/or herbaceous plants on soil nutrient availability and nutritional status of loblolly pine seedlings. The objective of this study was to determine foliar nutrient responses of young loblolly pine two and six years after planting under conditions of no, herbaceous only, woody only, and herbaceous and woody control following site preparation on a dozen COMP study sites across the southeastern United States.

Materials and Methods

Study locations of COMP are distributed across several physiographic provinces from Louisiana to Georgia to Virginia. In general, most sites were previously occupied by loblolly pine or mixed loblolly pine/shortleaf pine (*Pinus echinata* L.)-hardwood stands. Following a commercial timber harvest the sites were typically chopped and burned and then planted with 1-0 bareroot loblolly pine seedlings. Details of each site can be found in Miller *et al.* (1991).

In general, a randomized complete block design was used to establish four plots in each of four blocks at each study location. Treatment plots were approximately 0.1 ha with interior pine

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measurement plots of approximately 0.04 ha. Trees were planted at a spacing of 2.74m x 2.74m (1329 trees ha^{-1}) on most study sites. Mean density 1-yr after planting averaged 1285 trees ha^{-1}.

Vegetation control treatments included: 1) no additional vegetation control following site preparation, 2) woody control only, 3) herbaceous control only, and 4) woody and herbaceous control. Herbicides were applied one or more times each year during the first three or four years on plots receiving herbaceous control and during the first three to five years on plots receiving woody plant control. Treatments provided excellent control of herbaceous and woody vegetation.

Composite samples of foliage were collected from pines on each measurement plot in January following the second and sixth growing seasons. Foliage was collected from the first growth flush of the most recent growing season in the upper one-third of the crown. Sample sizes per plot were 90 fascicles at age two, with five fascicles from each of 18 trees, and 100 fascicles at age six, with 20 fascicles from each of five trees. Twelve sites were sampled at age two and all 13 sites were sampled at age six. Foliage samples were stored at 4°C until they were oven-dried at 65°C , weighed, and then ground. Foliar N and P concentrations were determined using automated colorimetry on digested 200-mg subsamples. Atomic absorption spectrophotometry was used to determine concentrations of K, Ca, and Mg in the digests.

Individual fascicle mass, nutrient concentration, and nutrient content from each location and sample date were analyzed using a univariate ANOVA which included tests of the main effects of woody treatment (WT), herbaceous treatment (HT), and their interaction. Vector analysis was also used to interpret shifts of nutrients with vegetation control relative to no treatment.

Results and Discussion

Individual fascicle mass at age two increased with herbaceous treatment (HT) on 11 of 12 sites. Natural herbaceous cover was low and herbaceous control poor on the non-responsive site. At seven of 12 sites fascicle mass increased with woody treatment (WT). Other sites were non-responsive and tended to have lower levels of cover and/or densities of woody vegetation. Correlations of plot means of individual fascicle mass and groundline diameter were significant and positive at all sites, ranging from 0.43 to 0.97 with a median of 0.86.

Effects of WT on N, P, and K concentration at age two were neutral at two-thirds or more of the sites and positive at all but one of the remaining sites. Effects of HT varied by element. Effects of HT on N concentration were positive at one-half of the sites and neutral at most of the other sites. P concentrations declined (5 sites) or were neutral in response (7 sites) to HT, likely as a result of dilution due to increases in individual fascicle mass, as well as whole crown biomass (Zutter *et al.* 1986), in response to increased availability of N. Response in concentration of K was more similar to that for N, increasing on four sites and neutral at all but one of the other sites. Effects of HT and WT on N, P, and K content mirrored that for individual fascicle mass.

Effects of HT were generally negative on Ca (10 sites) and Mg (all sites) concentrations at age two. Woody treatment effects were generally neutral on Ca concentration (10 sites) and neutral (5 sites) or negative (6 sites) on Mg concentration. Five of the six sites with negative responses in Mg concentration following WT were sites with higher levels of woody vegetation. Foliar content of Ca in response to either HT or WT and Mg to WT was positive at about one-fourth of the sites and neutral in all (Mg) or all but one (Ca) of the other sites. In contrast, Mg content was negative in response to HT at the other one-half of the sites.

By age six, effects of HT and WT on individual fascicle mass, and nutrient concentration and content became neutral or more neutral across the sites. A notable exception, typically occurring on sites with high levels of woody vegetation, was the positive response in K concentration or content and negative response in Ca and Mg concentrations with WT.

Mean individual fascicle mass across the sites increased on no control and woody control only treatments from age two to age six to become similar to that on the herbaceous control only and total control treatments. Mean N concentration across the sites over the same period significantly decreased on all four treatments. Age two mean N concentration for all treatments was over 1.1% (often regarded as a critical value for N) at all but one site, averaging 1.27% across the sites. However, by age six N concentration differed little by treatment (range = 1.10% to 1.14%) and averaged 1.12% across the sites. Mean P concentration across the sites significantly increased on plots receiving herbaceous treatments, herbaceous control only and total control treatments, and was unchanged on the other treatments from age two to six. No significant change was noted in mean K concentration over the four-year period regardless of the treatment. Ca concentration, like N concentration, significantly decreased on average across the sites from age two (mean = 0.27%) to age six (mean = 0.20%) on all four treatments. Mean Mg concentration across the sites became more uniform among the treatments by age six (mean= 0.09%), having decreased on no control and woody control only treatments and significantly increased on herbaceous control only and total control treatments

These results show that individual fascicle mass and foliar nutrition of seedling loblolly pine following planting can be enhanced by substantial reductions of competing vegetation. This was particularly true for total amounts of N, P and K per fascicle with control of herbaceous vegetation. Substantial increases in tree biomass (Britt *et al.* 1990) and associated greater nutritional demands would seem to explain the diminished positive responses to vegetation control by age six. Lower concentrations at pine age six of Ca and Mg with control of woody vegetation on sites with higher levels of hardwood may reflect the importance of the role that hardwoods may play in cycling of the two elements.

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