

CHANGES IN NON-PINE WOODY SPECIES DENSITY, COMPOSITION, AND DIVERSITY FOLLOWING HERBICIDE AND FERTILIZATION APPLICATION TO MID-ROTATION LOBLOLLY PINE STANDS

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ABSTRACT

We monitored woody vegetation (dbh>1.0 in) response for up to six years following a herbicide (16 ounces imazapyr /acre), a fertilizer (365 pounds urea and 175 pounds diammonium phosphate/acre) and a combined fertilizer and herbicide application in four mid-rotation loblolly pine stands located within the Upper Gulf Coastal Plain in Arkansas. Approximately 60-80% of the original non-pine woody vegetation died within three years following herbicide application. Non-pine mortality was greater on plots that received both an herbicide and a fertilizer application than only the herbicide application. Significant recruitment of additional woody vegetation occurred following all treatment applications, but herbicide reduced this recruitment for up to six years. Woody vegetation species richness and diversity was reduced by the herbicide application but was not altered by fertilization.

INTRODUCTION

Fertilization and herbicide application are common practices used to increase productivity of loblolly pine (*Pinus taeda* L.) mid-rotation stands growing in the Gulf Coastal Plain. Growth responses of crop trees to fertilizer and herbicide applied individually or in a combined cultural treatment have frequently been reported for mid-rotation stands in this region (Bataineh and others 2006, Haywood and Tiarks 1990, Sword Sayer and others 2003, Williams and Farrish 2000). However, impacts of these treatments on non-crop trees or other woody species are rarely documented in the Gulf Coastal Plain. Studies in other regions have indicated that successful control of hardwood root stocks at younger ages (three to five years following loblolly pine establishment) reduces hardwood basal area and tree species richness into latter stand ages (Miller and others 2003). However, single release applications of herbicide may have only short-term impacts on woody vegetation and only minimal long-term impacts on woody species richness and diversity (Boyd and others 1995, Zutter and Zedaker 1989).

A better understanding of the impacts of herbicide and fertilization applications on non-pine woody vegetation in the Gulf Coastal Plain will not only help to explain pine

crop tree response to these treatments but also the effect of these treatments on woody vegetation biodiversity. Maintenance of biodiversity can be an important forest management concern (Burton and others 1992) and can be an important consideration or component of forest management activities by landowners. We established a study in the Upper Gulf Coastal Plain of Arkansas and Louisiana to compare the effects of herbicide, fertilizer, and a combined herbicide+fertilizer application on non-pine woody (hardwood) vegetation in mid-rotation loblolly pine stands. We monitored density, composition, and diversity of these stands for up to six years following application of these treatments.

METHODS

DESIGN

Twelve plots (between 0.09 and 0.26 acres) were established at each of four mid-rotation loblolly pine stands (W. Crossett, S. Crossett, Crossroads, and S. Monticello) during 2001, 2002, and 2003. The sites were located in Union Parish, LA and the counties of Ashely and Drew in AR. The W. Crossett, S. Crossett, and S. Monticello stands were established by planting 681 or 726 seedlings/acre during the early winter of 1986, while the S. Crossett stand was established using a seed tree regeneration harvest in 1981. All stands had been thinned the year prior to the study initiation. At each site herbicide (16 ounces imazapyr and 0.23 ounces surfactant/acre in 15 gallons/acre of water) was aerially applied to six of the twelve plots, as well as a 50 foot buffer around each plot, during the fall following plot establishment. During January or February following the first growing season after the herbicide application, 365 pounds/acre of urea and 175 pounds/acre of diammonium phosphate was applied by hand to three plots and associated buffers that received the herbicide treatment and three that did not receive the herbicide treatment. These herbicide and fertilizer applications provided four individual treatments

(control, herbicide, fertilizer, and herbicide+fertilizer) with each treatment replicated three times in each stand.

MEASUREMENTS AND STATISTICAL ANALYSIS

Dbh (dbh $\geq$ 1.0 inches) and species were recorded prior to or just after herbicide application for all trees in each measurement plot. Dbh of each tree (dbh $\geq$ 1.0 inches) was measured annually through the end of the sixth growing season after plot establishment. The W. Crossett stand was inadvertently fertilized prior to the sixth growing season, so measurements following the fifth growing season for the W. Crossett and the sixth growing season for the remaining three sites were used for this study. Mortality of the trees was assessed annually and the number and species of ingrowth trees (dbh $\geq$ 1.0 inches) were recorded. The experimental design of the study was a split plot with the herbicide treatment being the whole plot treatment. Analysis of variance was used to determine differences between herbicide and fertilizer treatments. If there was a significant interaction, Tukey's mean separation test was used to determine differences between herbicide and treatment combinations. To evaluate differences in the proportion of hardwood mortality between herbicide and herbicide+fertilizer treatment combinations, a Kolmogorov-Smirnov nonparametric test was used. All statistical tests were performed using $\alpha=0.05$.

RESULTS

Non-pine woody vegetation (here after referred to as hardwood) basal area at the end of the fifth or sixth growing season was lower with herbicide applications than without (Table 1). Fertilization did not have any impact on hardwood basal area. At the end of the study the hardwood basal area represented 10.1-10.6 percent of the total tree basal area in the plots that did not receive herbicide but only 3.0-3.2 percent in plots that received an herbicide application. Although herbicide application significantly increased net pine basal area growth, differences in total pine basal area among treatments at the end of the study were not significant (Table 1).

Within the control and fertilizer treatments between 8.2 and 8.5 percent of the hardwood basal area initially measured within the plots died during the 5 to 6 year study period. In plots that received an herbicide application 60.0-73.6 percent of the initial hardwood basal area died. The majority of the mortality within the herbicide and herbicide+fertilizer treatments occurred within the first three years following herbicide application. Mortality with the herbicide application was consistently greater when fertilizer was applied in addition to the herbicide (73.6 percent) compared to that of the herbicide only treatment (60.0 percent). Fertilization without herbicide application did not appear to alter hardwood mortality.

At the end of the study the amount of hardwood ingrowth was much lower in treatments that involved herbicide application than in treatments without herbicide application (Figure 1). However, ingrowth represented a similar proportion of the total hardwood basal area (24-36%) within each of the four treatments. Growth of the hardwood trees that survived the herbicide applications grew much slower than trees that were in treatments that did not receive the herbicide application. Annual basal area growth of the surviving hardwoods in the herbicide and herbicide+fertilizer treatments was approximately 3 percent, but annual growth in the other two treatments was 9-11 percent. Many of the hardwood trees that survived the herbicide application had reduced crown areas and low vigor. In addition the composition of the surviving hardwood trees in the plots which received the herbicide application was much different than in the control and fertilizer treatments. Fast growing hardwood trees such as sweetgum (*Liquidambar styraciflua* L.) and blackgum (*Nyssa sylvatica* Marsh.) were a major component of the hardwood mid-story within the control and fertilizer treatments but only a minor component in the other treatments due to their sensitivity to the imazapyr herbicide.

Species richness was the highest (36) in the control and the lowest (32) in the combined herbicide+fertilizer treatment (Table 2) at the end of the fifth or sixth growing season following study initiation. Although the combined herbicide+fertilizer treatment had the lowest species diversity (highest Simpson's diversity index and the lowest Shannon's diversity index), diversity was only significantly impacted by the herbicide application (Table 2). Diversity was significantly lower with herbicide application than without. Diversity was not significantly impacted by the fertilizer application.

DISCUSSION

The reduction in hardwood density with the herbicide application indicates that the imazapyr successfully reduced competition to the pine. Herbicide application had a much greater impact on the hardwood component of these stands than did the application of fertilizer. Herbicide significantly reduced hardwood and other non-pine woody vegetation for up to 6 years following application. The hardwoods in these stands did not recover to pre-treatment levels by the end of the six-year study period. Mid-rotation application of the herbicide also decreased diversity and species richness. Results from this study appear to be similar to those reported by Miller and others (2003) involving control of hardwoods at earlier stand ages. Miller and others (2003) indicated that long-term changes in hardwood species richness and basal area can occur with successful hardwood control or pine release activities. Reductions in growth of the surviving hardwoods and the amounts of ingrowth associated with

herbicide application in our study suggests that these changes may persist to later stand ages beyond our six year period of observation. Although fertilization combined with the herbicide application increased hardwood mortality, differences in the amount of living hardwood basal area within the herbicide and the herbicide+fertilizer area at the end of the study were not significant. Increased mortality of the hardwood with the combined treatment may have been related to an increase in pine growth in response to fertilization.

CONCLUSIONS

An application of imazapyr herbicide can have a significant long-term impact on the non-pine woody vegetation within mid-rotation stands. Application of herbicide reduces the amount of this vegetation in these stands and thus reduces the species richness and diversity of mid-rotation loblolly pine stands. Application of fertilizer had little impact on the non-pine woody vegetation regardless of whether an herbicide application occurred or not.

LITERATURE CITED

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Table 1 — Mean (standard deviation) hardwood and pine basal area prior to and at the end of the fifth or sixth growing season following the initial herbicide application for each treatment combination

	Control	Herbicide	Fertilizer	Herbicide +Fertilizer
-----BA Prior to Treatment (ft ² /ac)-----				
Hardwood	7.8(5.4) a ¹	6.8(5.1) a	7.1(5.0) a	6.9(5.1) a
Pine	89.0(24.2) a	85.6(19.3) a	88.9(20.2) a	87.0(20.5) a
-----BA 5 th or 6 th Growing Season (ft ² /ac)-----				
Hardwood	13.8(5.8) a	4.0(2.3) b	13.0(4.7) a	2.9(1.1) b
Pine	129.5(24.4) a	126.7(18.9) a	128.6(20.3) a	131.3(21.9) a

¹Means with the same letter in a row are not significantly different at p=0.05.

Table 2—Species richness, mean Simpson’s diversity index, and Shannon’s (basal area) diversity index at the end of the fifth or sixth growing season following the initial herbicide application for each treatment combination

	Control	Herbicide	Fertilizer	Herbicide +Fertilizer
Species Richness	36	34	33	32
Simpson’s Diversity	0.25 a ¹	0.35 b	0.27 a	0.36 b
Shannon (Basal Area)	0.43 b	0.40 a	0.47 b	0.32 a

¹Means with the same letter in a row are not significantly different at p=0.05.

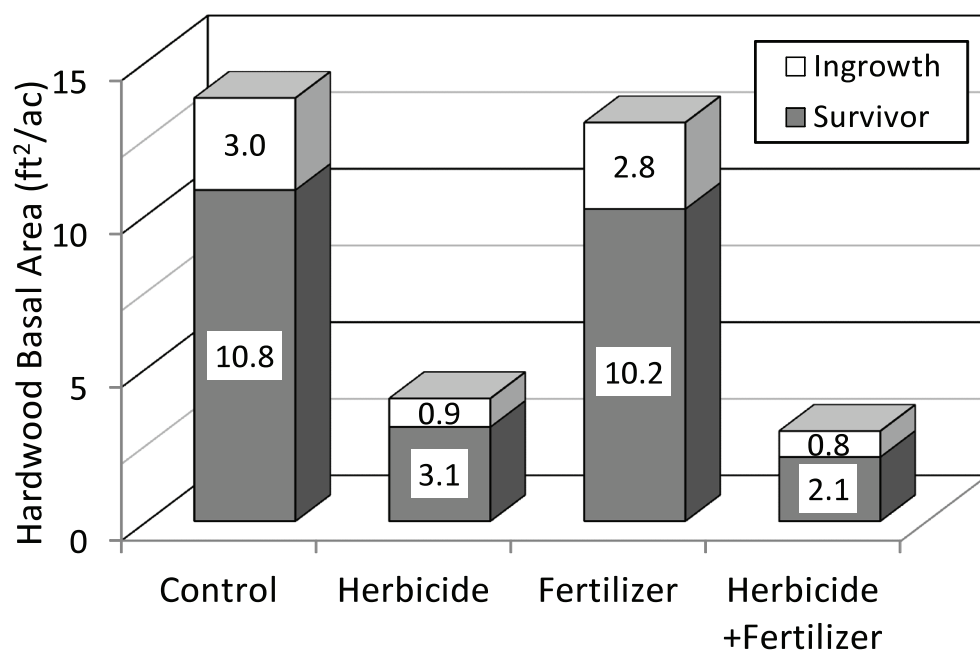


Figure 1—Living ingrowth and survivor hardwood basal area for each treatment at the end of the fifth or sixth growing following study initiation.