HARDWOOD VIGOR AND SURVIVAL FOLLOWING APPLICATIONS OF IMAZAPYR IN MID-ROTATION PINE PLANTATIONS

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Abstract—Tree vigor, live crown ratios, dieback, and survival of hardwood competition were monitored for 2 years following a fall application (16 ounces per acre) of imazapyr on 4 stands of loblolly pine (*Pinus taeda* L.) in the Gulf Coastal Plain of Louisiana and Arkansas. Assessments during the first growing season following application indicated that 87 to 98 percent of the hardwood stems were completely defoliated or had 80 percent or more crown dieback. The lowest levels of defoliation and dieback occurred in the densest stands. Typically, the crowns of the recovered hardwoods had some level of dieback, but live crown ratios of these trees were similar to those found in control areas. Differences in mortality and recovery were evident among species.

INTRODUCTION

Herbicides are extensively used to operationally control brush and hardwood competition in loblolly pine stands (Schultz 1997). Brush and hardwoods compete aggressively for available site resources and thus may reduce crop tree growth and survival. Weed management is most critical during stand initiation to ensure high survival rates and successful establishment of loblolly pine seedlings (Will and others 2002, Zutter and others 1999). As the stand reaches canopy closure, the degree to which further control of competition within or below the stand canopy benefits pine crop tree growth and productivity is poorly documented. As part of a study investigating the effect of competition control and fertilization on mid-rotation pine stands, we are monitoring the response of hardwood and brush to herbicide application following initial thinning. The objectives of this part of the study are to (1) evaluate the impact of herbicide application on hardwood vigor and crown characteristics, (2) determine the extent of hardwood mortality and the timing of mortality from herbicide application, and (3) examine the variation in responses of the various hardwood species found in these stands.

METHODS

The study was established in four stands within the Gulf Coastal Plain of Arkansas and Louisiana at least 1 year after an initial thinning operation. Sites were established in the years 2001 and 2002. Two sites, Marion and Crossroads, were located in Union Parish, LA, while the other two sites, South Crossett and West Crossett, were located in Ashley County, AR.

Soils in all four sites were either classified as Alfisols or Ultisols and were somewhat poorly- to poorly-drained. Loblolly pine was the most dominant overstory species in these stands accounting for approximately 89 percent of the total basal area measured in the sites. Sweetgum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), blackgum (*Nyssa sylvatica* Marsh.), and water oak (*Quercus nigra* L.) represented 67 percent of the basal area of the hardwood and brush species greater than 1 inch d.b.h. These four hardwood species also accounted for 64 percent of the hardwoods and shrubs. The two Louisiana sites had the lowest pine and highest hardwood basal area. The total basal area ranged from a low of 66.3 square feet per acre at the Marion site to 124.4 square feet per acre at the West Crossett site. The proportion of hardwood and shrub to pine basal area ranged from approximately 6.5 percent to 20.1 percent. Thus the four sites comprised a wide range of stand densities as well as diversity in stand composition.

A total of 12 plots were established in each stand. Plots were 0.08 to 0.24 acre in size. Imazapyr was operationally applied to 6 plots within each stand by aircraft at a rate of 16 ounces with 3.2 ounces of surfactant per acre in September or October. All trees > 1 inch d.b.h. were annually measured during the dormant season. Herbicide application occurred just prior to the first tree measurements and leaf fall. Crown vigor, percent live crown, percent dieback, and percent normal foliage were determined in early summer during the next two growing seasons following herbicide application for each non-conifer species. These measurements were based on the U.S. Department of Agriculture forest health measurement guidelines (USDA Forest Service 1999). Crown vigor was quantified using four classes. The crown vigor was assigned class 1 if the live crown ratio was ≥ 40 percent, ≥ 80 percent of the foliage was normal, and there was ≤ 10 percent tree dieback. Foliage was considered normal if 50 percent of leaf was not damaged or missing. Similarly, the trees that did not meet the criteria for class 1 or 3 but had ≥ 30 percent normal foliage and ≤ 70 percent dieback was categorized as class 2. Species with any live crown ratio, 0 to 20 percent normal foliage, and any amount of dieback was classified as class 3. Trees with no visible live foliage or buds were classified as class 4.

RESULTS AND DISCUSSION

Crown Vigor and Defoliation

A drastic reduction of crown vigor was apparent as a result of herbicide application. In addition, the majority of the hardwood trees in the herbicide plot were defoliated following herbicide application (fig. 1). A total of 77 percent of the hardwood trees

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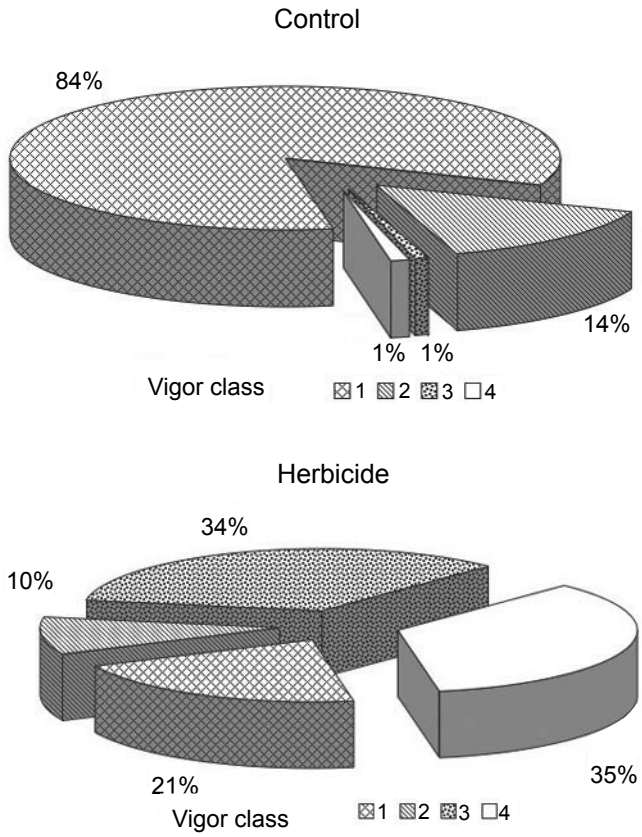

Figure 1—Hardwood crown vigor during the growing season following herbicide application.

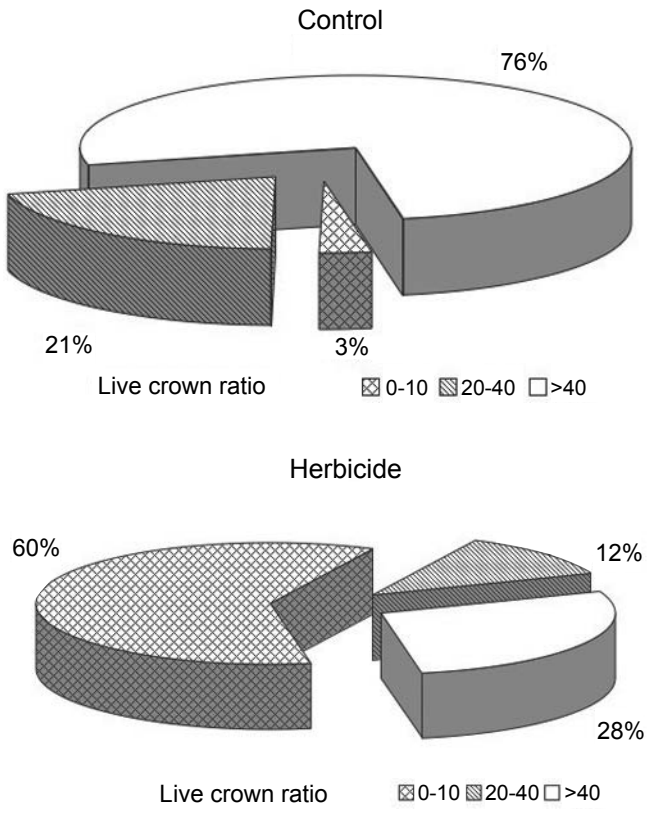

Figure 2—Hardwood live crown ratio during the growing season following herbicide application.

in the herbicide plots (crown vigor class 3 and 4) were entirely defoliated or contained only sporadic deformed leaves early in the growing season following herbicide application. In the control treatment, the majority of the hardwood stems had live crown ratios > 40 percent (fig. 2). In the herbicide treatment, 60 percent of the trees had live crown ratios of ≤ 10 percent.

Mortality

Hardwood mortality differed among sites (table 1). Mortality at the end of the first growing season following herbicide application was greater in the two Louisiana sites (40 to 50 percent) than in the two Arkansas sites (26 to 27 percent). Prior to imazapyr application, hardwood and shrubs comprised a greater proportion of the basal area at the Louisiana sites (15 to 17 percent) than the Arkansas sites (4 to 6 percent).

Table 1—Hardwood mortality as a proportion of standing basal area and density at the end of the first growing season following herbicide application

	Control		Herbicide	
Site	Trees	BA	Trees	BA
	- - - - - - - - - % per acre - - - - - - - - -			
Crossroads	0.2	0.1	41.5	49.9
Marion	0.0	0.0	50.0	56.7
S Crossett	0.0	0.0	26.9	23.8
W Crossett	0.4	0.1	26.1	32.7

Since imazapyr is a foliar active herbicide, it is probable that less imazapyr was intercepted by the pine and more by the hardwood and shrub foliage in Louisiana than in Arkansas. This resulted in a higher rate of mortality at the Louisiana sites. Although many of the trees initially defoliated by the herbicide application did not die, the majority of these trees had low vigor and small live crown ratios during the second growing season following herbicide application. Only 8.6 percent of the trees that were classified with a vigor rating of 4 during the growing season following herbicide application recovered and received a 1 or 2 vigor rating the next year. It seems unlikely that the majority of the stems that were initially severely defoliated will fully recover.

Responses of Different Hardwood/Brush Species

The composition of the dominant hardwood and shrub competitors within the sites was typical of the Upper Coastal Plain in Arkansas and Louisiana. First-year mortality was relatively low for ash (*Fraxinus* spp), red maple, and most oak species (table 2). Although these species were often defoliated by the herbicide, they reflushed the following year. Vigor of these trees was low during the second growing season following herbicide application. Winged elm (*Ulmus alata* Michx.), and some other minor species such as holly (*Ilex opaca* Sol.), showed little if any defoliation by the imazapyr and also had low mortality rates. Sweetgum, persimmon (*Diospyros virginiana* L.), black cherry (*Prunus serotina* Ehrh.), and blackgum suffered high levels of mortality. Further mortality can be expected to occur in remaining living stems as pine grow and more aggressively compete for site resources.

Table 2—Importance values (IV)[a] prior to herbicide application and the percent stem[b] mortality and basal area mortality of the 10 most dominant hardwood species at the end of the first growing season following herbicide application

Species	Pre-herbicide IV	Post-herbicide mortality (control)		Post-herbicide mortality (herbicide treatment)	
		Stems	BA/acre	Stems	BA/acre
		- - - - - - - - - - - - - - - % - - - - - - - - - - - - - - -			
P. taeda	143.8	—	—	—	—
L. styraciflua	26.7	0.3	0.1	51.7	53.5
N. sylvatica	15.1	0.0	0.0	58.5	64.0
A. rubrum	14.0	0.0	0.0	7.7	6.5
Q. nigra	12.5	0.0	0.0	14.7	18.0
U. alata	6.4	0.0	0.0	3.9	5.2
Q. alba	6.4	0.0	0.0	28.8	29.3
P. serotina	6.1	0.0	0.0	59.1	59.1
Miscellaneous[c]	5.9	0.0	0.0	19.5	26.3
D. virginiana	5.3	2.6	1.4	64.7	64.5
Fraxinus spp	5.3	0.0	0.0	15.0	6.2
Q. pagoda	5.0	0.0	0.0	5.3	1.0

[a] Importance value (IV) = relative density + relative dominance + relative frequency. Calculated by taking into account all species present in the 4 sites.
[b] Percent of the pre-herbicide stems and basal area per acre.
[c] Species such as *Aralia spinosa, Ligustrum* spp., *Zanthoxylum clava-herculis*.

CONCLUSIONS

Imazapyr was effective in reducing the crown vigor and live crown ratio of the majority of hardwood and shrub species commonly found in Arkansas and Louisiana. Mortality rates varied among species as well as among sites. Generally, mortality was greater in stands with lower densities of overstory pine trees. Continued monitoring of these stands will provide further insight on how hardwood and shrubs species respond to mid-rotation applications of herbicide.

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