NORTHERN RED OAK AND WHITE OAK PLANTING IN A COMMERCIAL CLEARCUT WITH CHEMICAL WEED CONTROL[1]

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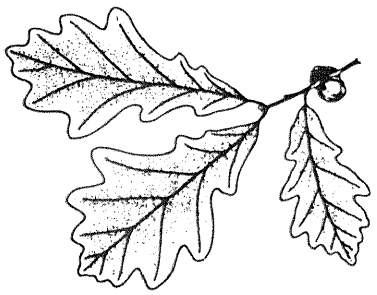

ABSTRACT.--This study was designed to monitor the growth and development of planted 1-0 red and white oak nursery seedlings in a commercial clearcut with the vegetation management levels of (1) residual tree removal with tree injection and (2) preharvest mist blowing of a herbicide and residual tree removal with tree injection. Ground cover and advanced woody vegetation were significantly altered with both injection-only and mist blowing-injection treatments. Higher percentages of pioneer tree species were found following mist blowing. Planted oak seedling survival was significantly better with mist blowing, while seedling height was not significantly different.

INTRODUCTION

The high value and continued demand for oak sawtimber has spurred interest in finding solutions to the complex oak regeneration problem. Landowners, foresters, and researchers have each considered this to be a high priority research problem in recent years (McClintock, 1979). However, a general management solution continues to be lacking.

It is generally accepted that if oak regeneration is to become successfully established, an oak seedling must be 4.5 feet tall at the time of release (Sander et al., 1976). If oak is not well established at the time of release, it is unlikely that oak will be a significant component of the future stand (Sander, 1979; Loftis, 1979). In most situations, advanced oak regeneration is the exception and not the norm, making up only 2-10 percent of new stands (Watt, 1979; Sander, 1979; Fischer and Holt, 1981; Loftis, 1983). Johnson (1976), noted the failure of northern red oak to regenerate in upland forests on good sites in southern Wisconsin and similar areas in adjacent states. In Indiana many stands that presently contain a high percentage of oak sawtimber trees are being converted to less valuable, non-oak species such as yellow poplar and sugar maple by both evenaged and unevenaged silvicultural systems (Standiford and Fischer, 1980; Callahan and Fischer, 1982).

New approaches to regenerating oak are presently being investigated. These include partial cutting to reduce overstory density (Johnson and Jacobs, 1981; Sander, 1979; Loftis, 1979), clearcutting (Sander, 1977) and underplanting (Hilt, 1977; Johnson, 1984; Wendel, 1980; Wright et al., 1984). Emphasis on planting prior to and after harvesting is currently being investigated throughout the hardwood region.

Abbott and Fitch (1977) estimated that about two million oak seedlings are produced annually in forest tree nurseries in the United States. With this annual production, oak plantings should be easily identifiable. But a successful oak planting is rare. What is happening to all of these seedlings? McGee (1979) noted that in most cases fertilization, weeding, clipping and pruning does not result in significant long term increases in total height but merely increases survival. Poor shoot growth in oak as compared to natural regeneration of other woody species ultimately results in overtopping in underplanting programs and eventual death due to herbaceous competition in plantations.

In a nursery environment, soil moisture, nutrients, light and heat are favorable for multiple growth flushes per season or exceptional single shoot growth. However, in most forest environments, one or more of the environmental factors is less than the minimum for good growth (Johnson, 1980). Manipulating the outplanting

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environment by specifically timing weed control has been suggested as a means of improving growth conditions for planted oak (Johnson, 1984).

The objective of this study was to evaluate the effect preharvest understory weed control has on the survival and initial growth of planted oak seedlings in a commercial clearcut.

MATERIALS AND METHODS

The Study Area

The study was conducted at the Southeast Purdue Agricultural Center located in Jennings County in southeastern Indiana. The predominant soil type in the study area is a Grayford/Corydon silt loam with a slope of 18-25% and a northern aspect. The soil is deep, well drained with a depth to bedrock of sixty inches. Water permeability is moderate and the available water holding capacity is high. The Grayford-Corydon silt loam soil type is formed from loess, loamy glacial till and residuum weathered from underlying limestone bedrock. Organic matter content of the soil is moderate. The soil-site index (50 year base) for upland oak is 85-95 feet and 95-105 feet for yellow poplar.

The study area was commercially clearcut in October, 1982 with all cut trees being removed by a rubber tired skidder. Any tree greater than 10 inches dbh and sound was removed by the operator. Residual standing trees were either cull or below local merchantability standards.

Prior to commercial clearcutting sugar maple (Acer saccharum Marsh.) was the dominant species comprising 25% of the stems in this sawtimber-sized stand. Sassafras (Sassafras albidum (Nutt.)), yellow-poplar (Liriodendron tulipifera L.) and white ash (Fraxinus americana L.), followed sugar maple with each species comprising less than 7% of the stems in the total stand. Total basal area per acre for all stems was 96 square feet per acre and 86 square feet per acre for stems greater than ten inches dbh. Understory species composition was sugar maple, eastern hophornbeam (Ostrya virginiana (Mill.) K. Koch), American hornbeam (Carpinus caroliniana Walt.), pawpaw (Asimina parviflora) and American beech (Fagus grandifolia Ehrh.).

Experimental Design

The experimental design for the study was a completely randomized design. There were a total of 12 plots established with 4 left untreated except for clearcutting. Plots were 45.7 meters by 22.8 meters or approximately 0.1 hectare in size. The untreated plots were used to evaluate the response of natural regeneration to clearcutting. Eight plots, 4 per treatment, were established. The treatments were: (1) residual tree removal down to two centimeters with tree injection and planting; and (2) preharvest mist blowing with a herbicide, residual tree removal down to two inches with tree injection and planting. The total study area including buffer strips was 1.9 hectares.

Herbicide Application

On September 20, 1982 an eleven liter Solo (model 423) backpack mist blower was used to apply a broadcast application of glyphosate (Roundup) at 2.34 kg/ha in 190 liters of water per hectare as a total vegetation control treatment. All understory vegetation (4 plots) less than three meters in height was treated with a fine droplet spray.

To assess seedling and sapling levels, and determine the degree of woody vegetation control a two meter by 45 meter permanent transect was established in each plot (7.5% sample). Transects were established systematically across the slope 10.5 meters from the west edge of each plot. Transects in mist blown plots were measured prior to herbicide application and were remeasured in June 1983 to assess weed control. All regeneration transects were measured in December, 1984 to assess seedling and sapling regeneration. Following commercial clearcutting, residual trees were injected with picloram (Tordon RTU) using a hack and squirt method to make a complete frill.

Planting Stock

Two species of 1-0 planting stock, red oak and white oak, were underplanted (April, 1983) in alternating rows on a three meter by three meter spacing in all plots except the controls. A total of 64 seedlings per species per plot were planted. A total of 1536 seedlings were planted. Seedlings were grown at the Indiana State Nursery at Vallonia.

RESULTS

Weed Control

Ninety-seven percent of the understory woody vegetation was controlled by mist blowing. Herbaceous vegetation was completely controlled by the non-selective nature of glyphosate. Woody species controlled 100% were: sassafras, eastern hophornbeam, American hornbeam, American beech, pawpaw, white ash, and yellow poplar. Sugar maple was the only species that was not completely controlled. Ninety-five percent of all the sugar maple stems were controlled. The remaining 5% had severe leaf distortion. At the time of herbicide application, the understory canopy was very dense and those sugar maple trees that were not killed may have not received an adequate coverage of the herbicide.

All woody species and herbaceous ground cover except pawpaw showed leaf yellowing and decline fourteen days after application. Pawpaw showed no yellowing or signs of decline typical of glyphosate injury at that time. In the spring of 1983, the pawpaw component in the mist blown plots did not break bud. No signs of basal sprouting was noted for pawpaw.

TABLE 1.—Woody species regeneration by number per acre, percent of total and treatment in December, 1984. Planted oak seedlings are excluded.

Species	Untreated		Injection only		Injection - mist blowing	
SLE [1/]	562	(8) [2/]	1136	(12)	424	(4)
BLC	1823	(27)	3111	(36)	1274	(11)
SYC	25		298	(3)	2349	(20)
YEP	299	(4)	136	(2)	1984	(19)
EHB	136	(2)	373	(4)	736	(6)
WHA	1609	(24)	474	(5)	410	(3)
SUM	1111	(16)	1537	(15)	646	(5)
SAS	537	(8)	399	(4)	3086	(27)
BAS	12		37		74	
AMB	0		12		0	
REO	37		0		12	
WHO	0		0		0	
BLG	12		0		0	
PAW	86	(1)	2424	(24)	12	
REM	50	(1)	0		0	
BLL	186	(3)	0		0	
DWS	162	(2)	0		0	
MIS [3/]	185	(3)	123	(1)	543	(5)
Total	6832		10,072		11,530	

1/ SLE = Slippery elm (Ulmus rubra Muhl.); BLC = Black cherry (Prunus serotina Ehrh.); SYC = Sycamore (Platanus occidentalis L); YEP = Yellow poplar (Liriodendron tulipifera L.); EHB = Eastern hophornbeam (Ostrya virginiana (Mill) K. Koch); WHA = white ash (Fraxinus americana L.); SUM = Sugar maple (Acer saccharum Marsh.); SAS = Sassafras (Sassafras albidum (Nutt)); BAS = American basswood (Tilia americana L.); AMB = American Beech (Fagus grandifolia Ehrh.); REO = Northern Red oak (Quercus rubra L.); WHO = White Oak (Quercus alba L.); BLG = Black Gum (Nyssa sylvatica Marsh.); PAW = Pawpaw (Asimina triloba (1) Dunal); REM = Red Maple (Acer Rubrum L.); BLL = Black Locust (Robina pseudoacacia L.); DWS = Devils-walkingstick (Ralia spinosa L.); MIS = Miscellaneous species.

2/ Percent of column total.

3/ Miscellaneous species include: Black Walnut (Juglans nigra L.); American hornbeam (Carpinus caroliniana Walt.); Mulberry spp. (Morus); Flowering Dogwood (Cornus florida L.); Eastern Red Cedar (Juniperus virginiana L.); Sumac spp. (Rhus); Ailanthus (Ailanthus altissima (Mill.) Swingle); Hickories spp. (Carya); American Bladdernut (Staphylea trifolia L.).

Natural Regeneration After Two Years

Species regeneration by treatment and for the nontreated plots is recorded in Table 1. The total number of stems per acre increased with the intensity of management resulting in a 41% increase in stems per acre for the mist blowing treatment over the nontreated plots. Also, there was a decrease in the number of tolerant and moderately tolerant species and an increase in the number of intolerant species with increased management.

Table 2 summarizes the woody regeneration grouped by height class for each treatment and the untreated plots. The percent of seedlings greater than 60 cm has been reduced from 80% in the untreated and injection plots to 50% in the mist blown plots.

TABLE 2.—Natural regeneration grouped by size and plot treatment. Planted oak seedlings are excluded.

Total height (cm)	Untreated No.	%	Injection only No.	%	Injection - mist blowing No.	%
0-15	37	(1) [1/]	0		423	(4)
10-30	335	(5)	348	(3)	1756	(15)
31-60	910	(13)	1697	(17)	3354	(29)
61-90	1234	(18)	2359	(23)	2335	(20)
91-120	873	(13)	2048	(21)	1160	(10)
120+	3443	(50)	3584	(36)	2522	(22)
Total/ac	6,832		10,072		11,550	

1/ Percent of the column total.

Planted Oak Seedling Survival and Growth

After two growing seasons, planted oak seedling survival (Table 3) was significantly greater for year one and two (.01 level) for both red and white oak seedlings in the mist blown plots when compared to the injection-only plots (residual tree injection and planting). After two growing seasons, there is a 15% difference between injection-only and mist blowing for white oak and a 9% difference for the same comparison for red oak. Mortality the second growing season was about 3% across all treatments. Total height (Table 3) after two growing seasons was not significantly affected by treatment except the second year total height for white oak planted in the injection-only treatment. This was not expected, especially considering the similar mean total tree heights for red oak. The apparent difference in total height for white oak seedlings between treatments the first growing season, became statistically significant (.05 level) the second season. Increment height growth was not significantly different (.05 level) between understory treatments for both growing seasons and tree species. A small annual increase in increment growth has occurred the second year over the first for both species. Increments were about the same for red and white oak by treatment and year.

TABLE 3.--Height growth and survival for planted oak seedlings after two growing seasons by species and treatment.

Species	Treatment[1/]	Survival (%)		Height (cm)		Increment (cm)	
		Growing Season[2/]					
		1	2	1	2	1	2
R. Oak	Inj.	80	78	30.3	43.3	8.9	12.4
	Mist	91[b]	86[b]	30.0	42.4	9.4	12.4
W. Oak	Inj.	73	73	28.5	41.5[a]	8.6	13.4
	Mist	89[b]	86[b]	23.7	32.2	8.0	10.4

1/ Injection = Residual tree injection and oak planting treatment.
Mist = Preharvest mist blowing of glyphosate, residual tree injection, and oak planting.

2/ For a specific year and species, values followed by an **a** were significantly different (.05 level) and values followed by a **b** were significantly different (.01 level) by Student's t test.

DISCUSSION AND CONCLUSIONS

Although the study is only two years old, some interesting observations and trends can be noted. Mist blowing significantly increased planted seedling survival for both species. When comparing treatments a valid question to consider is whether the mist blowing treatments has merely prolonged the life of the less vigorous planted seedlings for a few more years than in the injection-only treatments.

The mist blowing of glyphosate greatly altered the species mix and size of naturally regenerating hardwoods. Most woody and herbaceous vegetation less than three meters was controlled including the sometimes difficult to control sugar maple and beech. Tierson (1969) demonstrated the successful use of 2,4,5-T as a understory treatment for controlling less desirable woody species. He also noted that the herbicide application did not hinder the development of seed origin desirable species. Levavesseur and Hendler (1982) have documented the lack of soil activity of glyphosate on germinating seeds. Horsley (1981, 1982) and Horsley and Bjorkbom (1983) have demonstrated the advantage of mist blowing glyphosate to remove undesirable striped maple and other woody vegetation and herbaceous competition without destruction of desirable seed. The removal of advanced regeneration prior to harvesting, reduced the number of desirable ash and greatly increased the pioneer tree species such as yellow-poplar, sassafras and sycamore. The high number of sassafras in the mist blowing treatment can be attributed to root suckering from merchantable sassafras trees that were harvested.

In this study, planted white and red oak shoot growth is 10-13 cm per year and survival is about 85% following two growing seasons. Shoot growth averages in other studies are between five and fifteen cm per year for one to three years (Wright, 1984; Johnson 1984; Hilt, 1977; Olson et al, 1972). An idea worth exploring would be to increase the number of trees per acre to take advantage of natural genetic variability in shoot elongation. Johnson (1979) states that in many of his plantings about ten percent of all trees planted had 50-60 cm shoot growth per year. For the second year increment growth in this planting, 15% of the seedlings were growing 30 cm or more. This type of shoot growth could be very competitive with natural regeneration growth.

Mist blowing as a silvicultural tool for controlling unwanted advanced regeneration has potential in a number of situations. Johnson and Jacobs (1981) and Loftis (1978) and others have reported that preherbiciding clearcuts resulted in increased numbers of desirable species, increased numbers of desirable stems in the dominant tree position and reduced numbers of undesirable species. Future work on this study will include weed control (1/2 of each planted plot) around each planted seedling to determine if an additional weed control treatment will result in a higher percentage of the planted seedlings reaching dominant or co-dominant position in the developing stand.

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