TREE SHELTERS INCREASE HEIGHTS OF PLANTED NORTHERN RED OAKS

Douglas O. Lantagne[1]

Abstract: A clearcut in southern Michigan was planted to 2-0 northern red oak (*Quercus rubra* L.) seedlings in the spring of 1987. Four treatments included: control (clearcut harvest only), woody brush control, plastic tree seedling shelters 122 cm tall, and woody brush control plus tree seedling shelters. After three growing seasons, the seedlings planted in tree shelters were 53 cm taller than unsheltered seedlings. Sheltered seedlings grew 18 cm/year more than unsheltered seedlings over that same period. Over 65 per cent of sheltered seedlings were 122 cm tall or taller after three growing seasons compared to only 8.5 percent of unsheltered seedlings. The height growth of sheltered seedlings was related to the increased extension of the initial growth flush. The number of growth flushes was similar for sheltered and unsheltered seedlings. Tree shelters thus accelerated the growth of planted red oak into dominant and codominant positions on this clearcut site after three growing seasons. The increased elongation may result from seedlings modifying their growth habit, rather than an a result of increased stem dry weight.

INTRODUCTION

Planting oak as an alternative to natural regeneration has often resulted in failure caused by the slow growth of planted seedlings relative to the rapid growth of competing vegetation (Johnson et al. 1986). However, release of planted oak seedlings from competing vegetation alone does not guarantee success (Hilt 1977). Johnson et al. (1986) recommended that tree planters control undesirable woody vegetation before harvest, establish a medium density shelterwood, use large-diameter oak seedlings, and remove the overstory after three years. Tuley (1983), working in Great Britain, used individual tree shelters similar to those shown in Figure 1 to establish planted oak seedlings. Tree shelters protect planted hardwood seedlings from animal damage and improve seedling survival and height growth. One measure of their effectiveness is reflected in the estimated number of tree shelters used in Great Britain, which increased from 80 in 1979 to over 6 million in 1986 (Potter 1987).

This study investigated oak planting with tree shelters as a method of establishing oak in a clearcut. Lantagne et al. (1990) reported increased growth of northern red oak in tree shelters in a southern Michigan clearcut after two years. This paper presents 3-year results of that study.

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[1]Associate Professor of Forestry, Michigan State University, Department of Forestry, 126 Natural Resources Building, East Lansing, MI 48824.

METHODS

The study was established in an oak-hickory forest at the W.K. Kellogg Experimental Forest in southern Michigan. Soils were predominantly sandy loam (Alfisols) developed from stony glacial drift on a rolling, well drained site. Average red oak site index (base age 50) for the study area was 66. The study area underwent a shelterwood seed cut in 1954 and a removal cut in 1964 as part of a previous oak regeneration study (Rudolph and Lemmien 1976). Before the study was established, all stems > 5 cm dbh were removed in a whole-tree clearcut harvest in the fall of 1986. All remaining stems > 2.54 cm dbh were removed by hand.

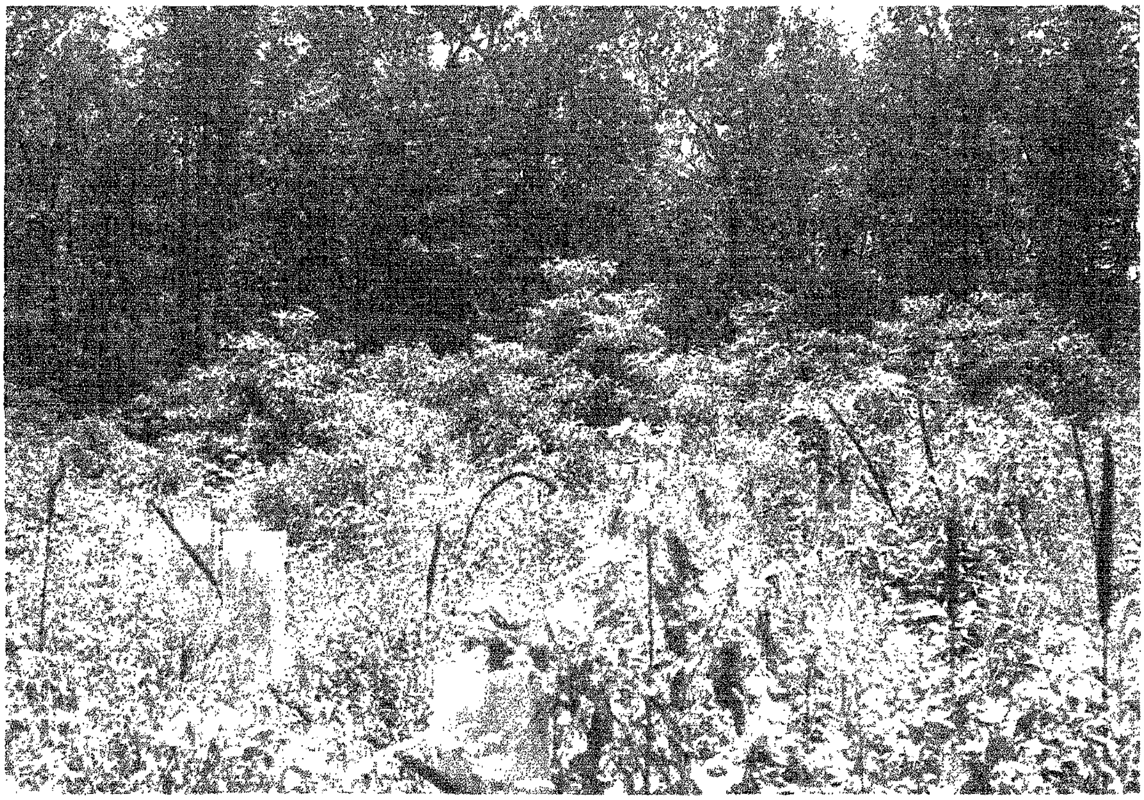

Figure 1. Tops of 1.2-m-tall tree shelters in a woody brush control plot after two growing seasons.

A 2 X 2 factorial combination of treatments was replicated on four 0.5 hectare blocks in a split-plot design. A 0.1-hectare buffer zone was established around each block. Each 0.4-hectare block was split in half to accommodate brush control treatments (main plots). Each main plot was then split in half to accommodate tree shelter treatments (split plots). The four treatments were: control (no woody brush control, no shelters); woody brush control only;

shelters only, and woody brush control and shelters. All treatments were randomly applied within replications.

Woody brush control occurred in five steps, two before harvest and three after harvest. The first steps were a prescribed burn in the spring of 1986 and a basal application of triclopyr and oil to non-oak species in the summer of 1986. The final three steps were post-harvest basal applications of triclopyr and oil to non-oak species during the summers of 1987, 1988 and 1989.

Plastic shelters were constructed from 51 X 122 X 0.63 cm sheets of corrugated polyethylene plastic. Each sheet cost about $1.50. Individual sheets were bent and stapled to 2.5- X 2.5-cm stakes driven into the ground next to planted oak seedlings. Shelters were placed as close as possible to the soil surface but were not sealed at the soil surface or along the stake used for support. Stakes were also driven into the ground next to all unsheltered seedlings.

Northern red oak acorns collected from the study site in the fall of 1984 were immersed in water. "Sinkers" were collected and 86 per square meter were sown in a prepared nursery bed. Following the first growth flush in June 1986, seedlings were undercut at 20 cm to encourage development of a fibrous root system. The 2-0 northern red oak seedlings were lifted in mid-April 1987, sorted to a minimum 1-cm root collar diameter, root pruned to 20 cm, wrapped and stored at 1° C until planting. Seedlings were planted over a two day period in late April 1987 with dibble bars at a 3.4- X 3.4-meter spacing for a total of 90 oak seedlings per treatment. After planting, seedlings were clipped 18 cm above the ground-line. Tree shelters were then installed. All work was completed by May 1, 1987.

Six 4 m^2 permanent regeneration survey plots were randomly placed in the areas without brush control. Seedlings and sprouts of all naturally occurring woody species in the survey plots were counted at the end of the 1988 growing season. Heights of all planted northern red oak seedlings were measured in the fall of 1989. Number and length of flushes were measured on 40 trees in three of the four brush control plots in the spring of 1990. Twenty trees above 125 cm were randomly selected from the shelter plots and the 20 tallest trees from brush-control-only plots.

Analysis of variance and Duncan's new multiple range test were used to test for significant differences among treatment means. Survival percentages were transformed with the arcsine procedure and growth flush data with the square root procedure (Little and Hills 1978). Chi-square analysis was used to test for differences in height class distribution between the sheltered and unsheltered seedlings.

RESULTS

Total vegetative cover averaged 85 to 90 percent across all treatment plots during the first three growing seasons. The predominant species included *Rubus* spp., goldenrod (*Solidago nemoralis* Ait.), wild grape (*Vitis* spp.), aster (*Aster pilosus* Willd.), pokeweed (*Phytolacca* *americana* L.), daisy fleabane (*Erigeron strigosus* Muhl.) and bull thistle (*Cirsium vulgare* (Savi) Tenore). Two years after clearcut harvest, there was an average of 1,611 natural oak seedlings per hectare. Non-oak reproduction averaged over 12,429 stems per hectare.

Brush control had no significant affect on total height of planted red oak ($P = 0.25$), but heights of sheltered and unsheltered trees differed significantly ($P < 0.0001$)(Table 1). Seedling survival and height for sheltered seedlings were significantly greater than unsheltered seedlings (Table 2). The height increase of sheltered trees was 1.7 times greater than that of unsheltered trees.

Table 1.--Analysis of variance for total tree height for planted trees.

Factors	DF	Mean Square	F Ratio
Main Plots			
Replication (Rep)	3	242.74	
Brush Control (BC)	1	23.01	0.67
Rep X BC (Error a)	3	102.98	
Split Plots			
Shelters (S)	1	11313.96	199.15***
BC X S	1	37.11	0.45
Error	6	56.81	

*** Significant ($p < 0.0001$)

Table 2.--Effect of shelters and brush control on survival and height of planted northern red oak seedlings after the third growing season.[1]

Treatments	Survival	Total Height	Height Increase[2]
	--(%)--	---(cm)---	---(cm)---
Main Plots			
Brush Control	94a	105(1.9)a	29(1.1)a
No Brush Control	95a	102(1.8)a	25(1.2)a
Split Plots			
Shelter	98a	130(1.7)a	34(1.2)a
No Shelter	90b	77(1.4)b	20(1.0)b

[1]Means (standard errors) within the columns followed by the same letter are not significantly different ($p < 0.05$) using Duncan's New Multiple Range Test.
[2]Height increase was determined by subtracting 1988 total height from 1989 total height for each individual seedling measured.

Figure 2 illustrates the effect of shelters on seedling height class distribution. More sheltered than unsheltered seedlings were in the larger height size classes. A Chi-square analysis indicated that the distributions were significantly different ($P < 0.0001$). After three growing seasons, over 65 percent of the sheltered seedlings were above shelter height (122 cm), compared to only 8.5 percent of unsheltered seedlings.

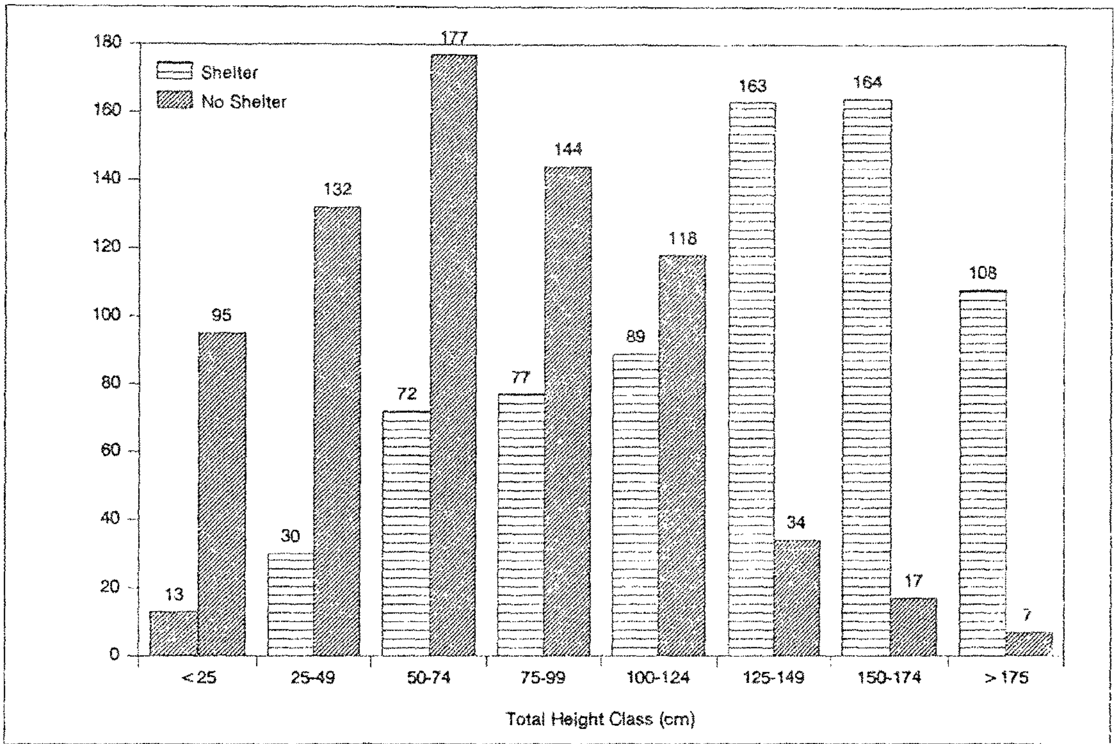

Figure 2. Height distributions of sheltered and unsheltered northern red oak seedlings after the third growing season. (Distributions of the two classes of seedlings differ significantly based on Chi-square ($X^2 = 487$, $p < 0.0001$).

Analysis of variance indicated that shelters increased the number of growth flushes in 1987 ($P = 0.064$) and 1988 ($P = 0.088$), but not in 1989 ($P = 0.423$). The average length of the initial growth flush was also affected by shelters in 1988 ($P = 0.002$) and 1989 ($P = 0.016$). These initial flushes averaged 13 cmgreater in 1988 and 12 cm greater in 1989 than unsheltered trees (Table 3). The average length of secondary growth flushes did not differ significantly between sheltered and unsheltered trees.

DISCUSSION

Tree shelters can improve both survival and height growth of oak seedlings (Tuley 1983, Lantagne et al. 1990). This was reaffirmed by the third year data,which showed a greater increase in total height and growth for sheltered seedlings than for unsheltered controls

Table 3.--Effect of shelters and brush control on the number and length of growth flushes of planted northern red oak seedlings for the first three growing seasons.

Treatments	Number of Flushes[1]			Length of First Flush[2]		
	1987	1988	1989	1987	1988	1989
			------------(cm)------------			
Shelters/Brush control	33a	32a	37a	23a	40a	39a
Brush control only	27b	28b	36a	19a	27b	27b

[1]Means were derived by counting the total number of flushes for twenty trees for each treatment in each of three replications. Means within the columns followed by the same letter are not significantly different ($p < 0.1$) using Duncan's New Multiple Range Test.
[2]Means within the columns followed by the same letter are not significantly different ($p < 0.05$) using Duncan's New Multiple Range Test.

(Figure 3). Sheltered red oak seedlings averaged 53 cm taller than unsheltered seedlings after three growing seasons. Average height increases over the past three growing seasons show that sheltered seedlings grew 18 cm/year more than unsheltered seedlings (Figure 3). This additional growth has placed over 65 percent of the sheltered seedlings in a dominant crown position in areas with woody brush suppression and the same percentage in an intermediate or codominant crown position in areas with unsuppressed woody vegetation. Only 8.5 percent of unsheltered seedlings reached an equivalent height of at least 122 cm after three growing seasons and most were in a subordinate canopy position.

The increased growth of sheltered seedlings over unsheltered seedlings has been attributed to several possible factors: (1) a microenvironment that promotes multiple flushes, (2) a reallocation of growth from roots, stem caliper and branches to the terminal leader and (3) physical protection from breakage and animal browse (Lantagne et al. 1990). The data showed that the increased growth of the initial terminal flush was more important to total height growthof the seedling than an increased number of flushes. During the second and third growing seasons, sheltered trees averaged 12.5 cm/year more elongation of their first growth flush than unsheltered trees.

Sheltered trees exhibit three physical stem characteristics which unsheltered trees do not exhibit: longer stems, few, if any branches and limited caliper growth. These characteristics indicate that increased height growth of sheltered seedlings may not be synonymous with increased stem dry weight. Rather, sheltered seedlings may simply be modifying their height growth at the expense of structural stability and branch formation. As a consequence of less stem caliper, trees must be supported for two years after exiting the shelters. The affect of shelters on root growth has not been studied. However, Johnson (1979) working with northern red oaks in a root regeneration study found no reduction in the rate of root growth during periods of shoot elongation. Therefore, increased shoot elongation of sheltered seedlings may not be negatively impacting root system establishment.

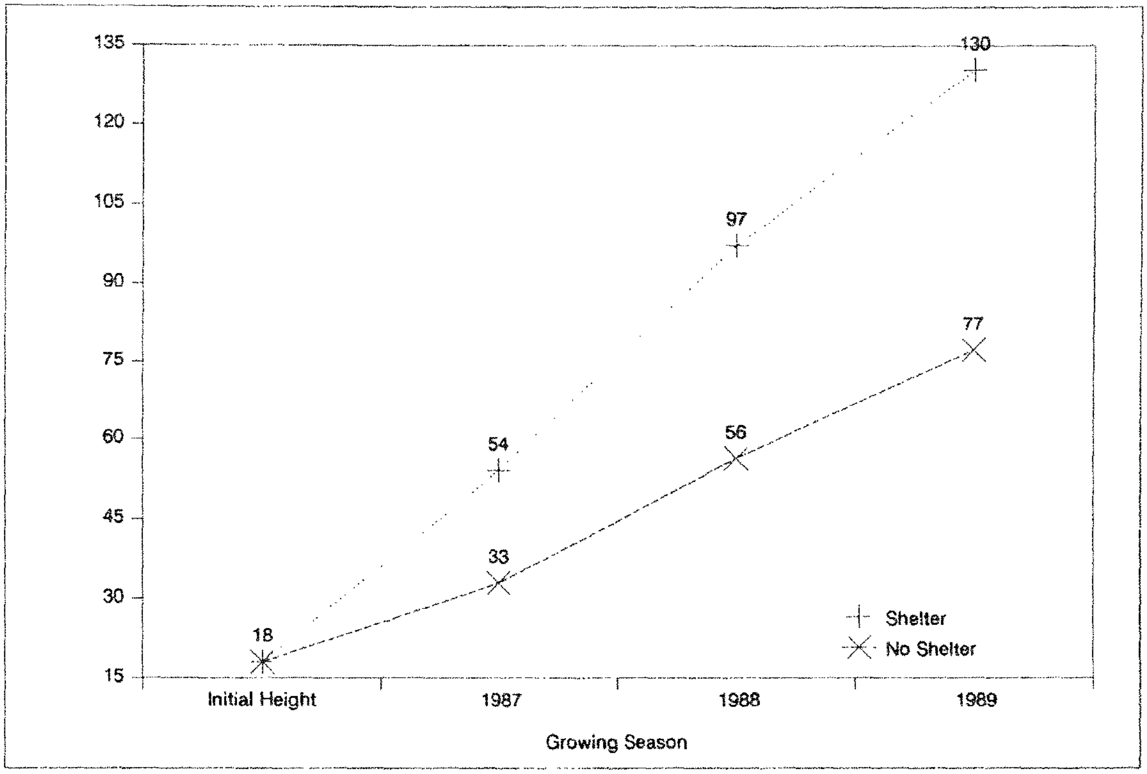

Figure 3. Means Heights of surviving planted northern red oak seedlings. (All seedlings were top pruned at 18 cm above the groundline immediately following planting. Sheltered seedlings were significantly taller at the end of each growing season.)

SUMMARY

Many sheltered trees grew into dominant and codominant crown positions, where÷áas few other planted seedlings or natural oak reproduction did. The mechanism for increased growth is not a result of increased number of growth flushes, but an increase in the amount of elongation of the initial growth flush. This increased elongation may result from seedlings modifying their growth habit, rather than an a result of increased stem dry weight. The cost and environmental issues associated with the use of plastic tree shelters for oak regeneration have to be evaluated and discussed as additional growth data is collected.

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