THINNING A COPPICE REGENERATED OAK-HICKORY STAND: THIRTY YEARS OF GROWTH AND DEVELOPMENT[1]

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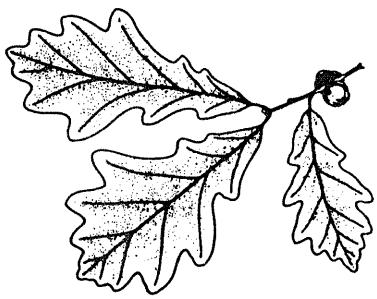

ABSTRACT.--Thinning five-year-old stump sprouts to a single sprout resulted in increased diameter and basal area growth of selected sprouts. Sprout growth differed significantly between species. Generally, species within the red oak group (Quercus coccinea Muenchh., Q. velutina Lam. and Q. falcata Michx.) were significantly taller and greater in diameter than species in the white oak group (Q. alba L. and Q. stellata Wangenh.); in turn, the latter group grew better than hickory (Carya spp.) sprouts. Height of the dominant sprout at five years was significantly correlated with tree height and diameter at thirty years; this relationship may permit the selection of superior performing stump sprouts early in stand development. Selection of such individuals should reduce the costs of precommercial thinnings necessary for producing optimum growth and adequate tree quality.

INTRODUCTION

Regeneration of hardwood stands from stump sprouts is perhaps the oldest and historically the most widespread of all regeneration methods (Kharitonovich 1937). In the central hardwood region, the influence of silvicultural treatments, such as thinning, on sprout growth has been little studied. Recent reports have suggested that intra-stump thinning is important if the growth potential of northern red oak (Quercus rubra L.) in the Lake States is to be maximized (Johnson and Godman 1983, Johnson and Rodgers 1984). Lamson (1983) also found that precommercial thinnings of hardwood sprouts in West Virginia increased diameter and volume growth.

The objectives of this study were: 1) to document the long term (30 years) growth and development of a coppice-regenerated oak-hickory stand; 2) to evaluate the effects of intra-stump sprouts; and 3) to evaluate characteristics, such as number of sprouts, diameter of stump, and height of the sprout at five years as predictors of growth at thirty years.

MATERIALS AND METHODS

The study is located in Butler County, Missouri at the edge of the Ozark Plateau and adjacent to the Mississippi lowlands. The soil, a typic fragiudalf, contains a fragipan overlain by a loessal cap. Valiunas (1967) estimated the site index to be 18.3 m for black oak (Quercus velutina Lam.).

Little is known about the history of the area before clearcutting, however, there was no evidence that the stand had been burned. The stand was approximately thirty years old and the overstory was predominately scarlet oak (Quercus coccinea Muenchh.). Black oak , southern red oak (Quercus falcata Michx.), white oak (Quercus alba L.), post oak (Quercus stellata Wangenh.) and hickory (Carya spp.) were also present.

Three 0.4 ha clearcuts were established by late winter of 1953. Each clearcut was divided into four plots (0.06 ha) with one plot randomly selected for the thinning treatment, and one designated the control (the remaining two plots were not used). Five years after clearcutting, a sprout on each stump in both the control and thinned plots was selected for its potential for high quality. In the thinned plots each stump was thinned to a single sprout, while in the control plots no thinning occurred. Species, diameter of the stump, number of sprouts, and height of the dominant sprout were recorded for each selected sprout at this time. Twelve, sixteen, twenty-one and thirty years after cutting, dbh, height and mortality of the selected sprouts were inventoried. Significant differences in the parameters measured, between thinning treatements and between species were de-

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[1]A paper presented at the Fifth Central Hardwood Conference held at Urbana, Illinois on April 15-17, 1985.

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termined using analysis of variance. Multiple comparisons were made using the least significant difference (L.S.D.) test.

RESULTS

Thinning stumps to a single sprout significantly increased the average sprout diameter for every period examined (Figure 1). The average diameter of the sprout seven years after thinning (year 12) was 37 percent greater than that of the selected sprouts in the control treatment. Sixteen, twenty-one and thirty years after clearcutting, thinning increased the average diameter of the dominant sprout by 28, 30 and 25 percent, respectively.

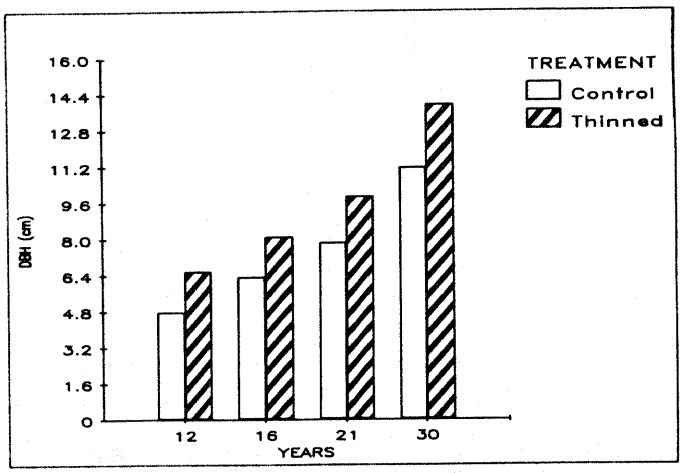

FIGURE 1.--The average sprout dbh in thinned and control treatments twelve, sixteen, twenty-one, and thirty years after clearcutting.

Height growth was not significantly affected by the thinning treatment, although increased height growth was consistently observed for the sprouts in the thinned treatement (Figure 2).

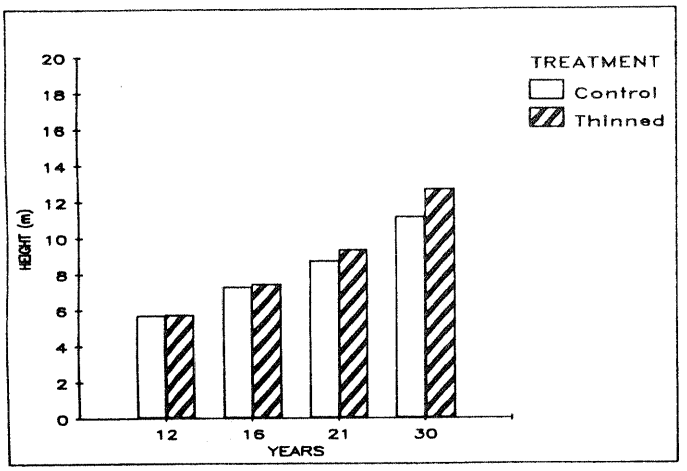

FIGURE 2.--The average sprout height in thinned and control treatments twelve, sixteen, twenty-one, and thirty years after clearcutting.

Mortality at years 16 and 21 was significantly reduced by thinning (Figure 3). No significant differences in mortality were observed between the thinning treatments, however, for years 12 and 30.

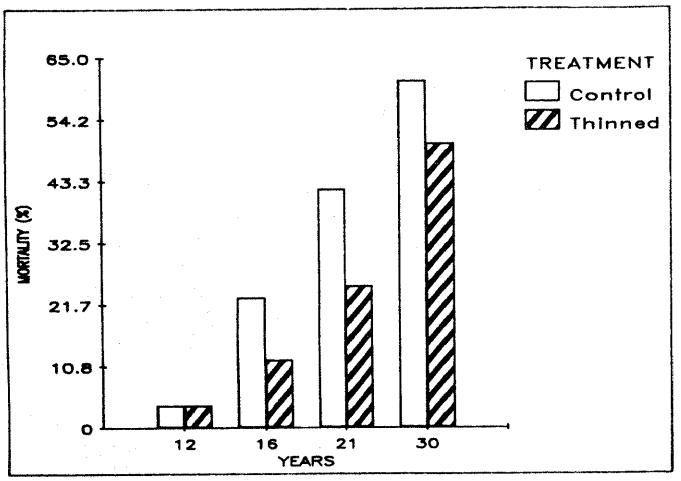

FIGURE 3.--Mortality of sprouts in thinned and control treatments twelve, sixteen, twenty-one and thirty years after clearcutting.

Significant differences were observed between species for diameter, height growth, and mortality (Figures 4, 5 and 6). Generally, the red oak species (scarlet, southern red, and black oak) were significantly larger in both height and diameter than the white oak species (post and white oak). Hickory was significantly inferior, in height and diameter, to species in either the red oak or white oak groups. Mortality decreased in the following order: post oak, black oak, hickory, scarlet oak, white oak and southern red oak.

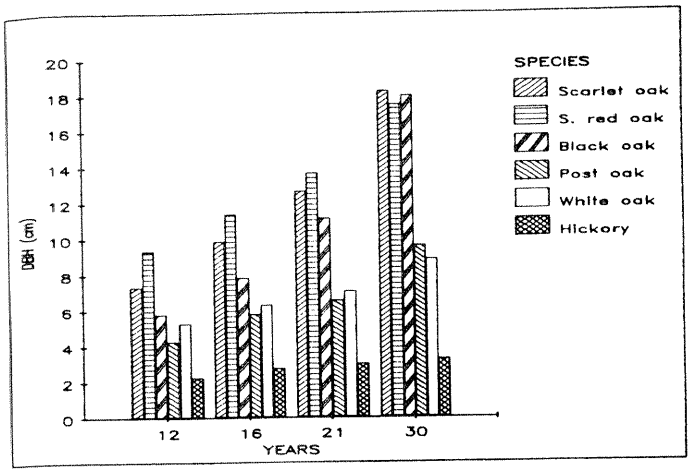

FIGURE 4.--The average sprout dbh of scarlet oak, southern red oak, black oak, post oak, white oak, and hickory twelve, sixteen, twenty-one, and thirty years after clearcutting.

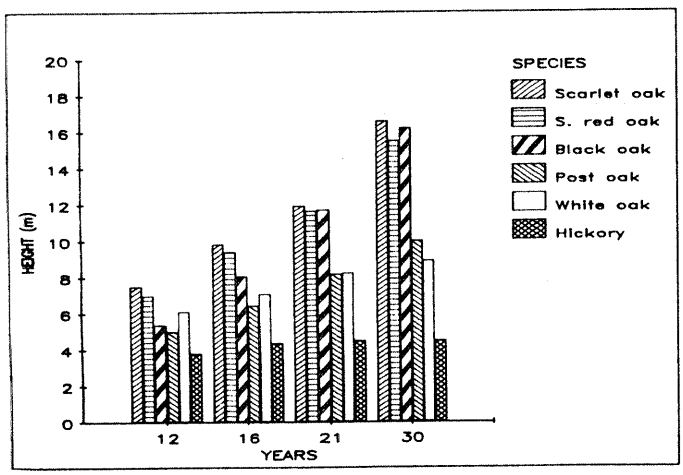

FIGURE 5.--The average sprout height of scarlet oak, southern red oak, black oak, post oak, white oak, and hickory twelve, sixteen, twenty-one and thirty years after clearcutting.

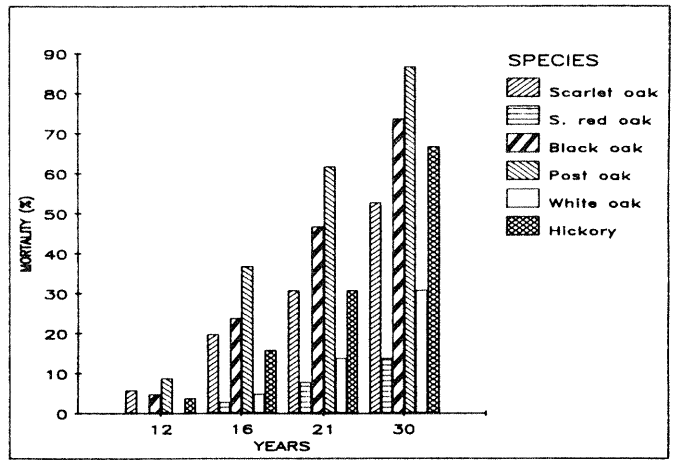

FIGURE 6.--Mortality of scarlet oak, southern red oak, black oak, post oak, white oak, and hickory twelve, sixteen, twenty-one and thirty years after clearcutting.

Basal area (per hectare) of the selected sprouts was significantly increased (α = 0.10) by thinning (Table 1). Differences in basal area between species were also significant (Table 2).

TABLE 1.--Basal area of thinned and nonthinned stump sprouts.

TREATMENT	YEAR 12	16	21	30
	Basal Area (m^2ha^{-1})			
Control	6.54a[1]	8.83a	10.65a	12.77a
Thinned	9.89b	14.01b	17.55b	20.93b

[1]Means within a column followed by the same letter are not significantly different at α = 0.10 using Fisher's L.S.D. procedure.

TABLE 2.--Basal area by species of a coppice regenerated oak-hickory stand.

Species	YEAR 12	16	21	30
	Basal Area (m^2ha^{-1})			
Scarlet oak	3.42a[1]	5.02a	6.61a	8.45a
Southern red oak	0.92b	1.33b	1.79b	2.60b
Black oak	1.61b	2.20b	2.71b	2.81b
Post oak	0.74b	0.85b	0.68b	0.42b
White oak	1.38b	1.87b	2.16b	2.52b
Hickory	0.14c	0.16c	0.15c	0.09c

[1]Means within a column followed by the same letter are not significantly different at α = 0.05 using Fisher's L.S.D. procedure.

Scarlet oak consistently had the greatest basal area followed by black oak, southern red oak, and white oak. Post oak and hickory had the lowest basal area.

The importance of the increase in basal area growth of the thinned dominant sprouts is further emphasized when the largest (dbh) 370 trees per hectare (150 trees per acre) at year 30 are considered (Table 3). Thinning at age five increased the average diameter of the largest (dbh) 370 trees per hectare 23 percent at 30 years while basal area was increased 52 percent. The largest 370 trees per hectare included scarlet oak (208), black oak (67), southern red oak (72), and white oak (23). When the total population of living selected sprouts at year 30 is compared with the number of trees in the top 370 trees per hectare, 69, 68 and 63 percent of the southern red oak, black oak and scarlet oak were included; however, only 7 percent of the white oak were in the largest 370 trees per acre (Table 4).

TABLE 3.--Average diameter and basal area of the largest (dbh) 370 trees per hectare after 30 years.

	Control	Thinned
dbh(cm)	17.5 + 1.8[1]	21.6 + 1.3
Basal Area (m^2ha^{-1})	9.3 + 2.1	14.3 + 1.5

[1]mean + standard deviation

TABLE 4.--The number of trees (A) in the largest (dbh) 370 trees per hectare and the percentage of the live selected sprouts (B) within a given species included in the top 370 stems per hectare after 30 years.

	Control		Thinned	
	A	B	A	B
	number of trees	percent	number of trees	percent
Scarlet oak	247	63	170	63
S. red oak	46	67	98	71
Black oak	51	80	82	57
Post oak	0	0	0	0
White oak	26	11	20	4
Hickory	0	0	0	0

For both control and thinned treatments the number of sprouts per stump, diameter of the stump and the height of the selected sprout (five years after cutting) were all significantly correlated (α = 0.0001) with both sprout height and diameter at 30 years (Table 5). The correlation coefficients (r) between the diameter of the stump and height of the dominant sprout (at year five) with dbh at year 30 was increased when only the thinned treatment was included. Further analysis of this apparent relationship showed that two-thirds of the tallest ten percent of the young sprouts maintained their superiority and were included in the upper ten percent in both height and diameter growth at year 30 (Table 6).

TABLE 5.--Correlations between diameter of the stump, number of sprouts, and height of the dominant sprout (at year five) with dbh and height at age 30 in control and thinned plots.

	Control		Thinned	
	DBH	Height	DBH	Height
Number of sprouts	.46[1] .0001[2]	.45 .0001	.54 .0001	.48 .0001
Diameter of the stump	.39 .0001	.39 .0001	.81 .0001	.74 .0001
Height of the dominant sprout	.76 .0001	.74 .0001	.84 .0001	.79 .0001

1. correlation coefficient (r value).
2. probability that rho(r) is equal to zero.

TABLE 6.--The percentage of individuals in the top 10 percent of height growth at 5 years also represented in the top 10 percent dbh and height at year 30.

Control		Thinned	
Diameter	Height	Diameter	Height
53 + 7.5[1]	50 + 10.0	63 + 11.3	67 + 8.1

[1]Mean + standard deviation.

DISCUSSION

Coppice regeneration is one of the oldest methods of regenerating oak stands (Kharitonovich 1937); however, few data are published that can be used to determine expected gains from cultural practices applied to coppice regenerated upland central hardwood stands. In this study, height and diameter growth of stump sprouts was rapid; thinning to a single sprout at five years resulted in increased diameter and basal area growth of the selected sprouts. Moreover, thinning increased the average diameter 25 percent and basal area 64 percent over the control after 30 years.

Thinning northern red oak stump sprouts has previously been shown to increase diameter growth

(Johnson and Rodgers 1984, Johnson and Godman 1983, Lampson 1983). Haney (1962) also reported the stimulation of white oak by intra-stump thinning. Johnson and Godman (1983) reported that thinning to a single dominant sprout at year five resulted in a 16 to 125 percent increase in diameter growth by year twenty-five for northern red oak in the Lake States. Furthermore, Johnson and Rodgers (1984) estimated that on a good site, when stumps have been thinned to a single dominant sprout, the potential exists for northern red oak in the Lake States to obtain a dbh of 30 cm in twenty-five years. Our results indicate the potential to achieve an average dbh of 21 cm in thirty years (370 trees per hectare) on an intermediate site by thinning at year five. Further stimulation of dbh growth, in all probability, could have been obtained by applying an intermediate thinning at year sixteen. Annual basal area growth of the dominant sprouts in the thinned plots reached a maximum between the twelfth and sixteenth year of stand development (0.88 $m^2ha^{-1}yr^{-1}$) with significant reductions observed during the remainder of the study period. A crop tree thinning favoring the stump sprouts that exhibited the greatest promise in growth and quality at this time could have further increased diameter growth.

Early thinning of stump sprouts not only increased diameter growth, but also improved the quality of the stems produced. The two primary entry points of decay-causing-organisms in stump sprouts are through heartwood connections with the parent stump or through dead companion sprouts (Roth and Hepting 1943). Buttrot of stump sprouts can be minimized by cutting practices that promote sprout initiation at or below the groundline, and by thinning stumps to one dominant sprout early in the rotation (Stroempl 1983). In our study, stump sprouts in the control plots contained numerous defects caused by decay organisms which spread from dead suppressed sprouts. The dominant or codominant individuals in the thinned treatment, however, appeared to have little defect due to decay.

A number of studies reported in the early 1900's refer to sprout growth of various oak species; however, the lack of statistical treatment of the data make comparisons difficult. Leffelman and Hawley (1925) reported that only small differences in height growth were observed between four-year-old black oak, white oak, and scarlet oak stump sprouts. Spaeth (1928) reported that northern red oak and black oak stump sprouts exhibited greater height and diameter growth than did white oak sprouts. Wendell (1975) found that northern red oak sprouts averaged approximately eight meters in height while white oaks were only six meters tall after ten years. Johnson (1979), however, reported no difference in shoot elongation of black and white oak sprouts during a four-year study. Our study showed stump sprouts in the red oak group to have superior height and diameter growth to individuals in the white oak group. Growth rate differences between species may vary depending on the quality of the site. Thus, on better sites white oak sprouts may show better growth than observed in this study. No significant interactions between thinning and species were detected; consequently, thinning should improve the growth of all the oak species investigated.

Precommercial thinnings represent a cost that has to be carried throughout the rotation. This cost, however, could be reduced in coppice regeneration programs by selecting superior sprouts early in the rotation, and applying cultural practices only to those individuals that have a high probability for superior growth. These data indicate that the height of the dominant sprout (at year five) is a reliable predictor of the growth potential of the sprout throughout the rotation. Work is presently ongoing at the University of Missouri which should result in specific recommendations as to the number and types of sprouts to be favored in a precommercial thinning. This study suggests that on a site of intermediate quality, approximately twice the number of individuals desired at the end of the rotation should be released, and species in the red oak group should be favored over species in the white oak group. Further work is required to determine the economic efficiency of coppice regeneration management in upland oaks, however, this study indicates the need for precommercial thinnings if the optimal growth and quality of oak sprouts is to be realized.

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