THE SILVICULTURAL AND ECONOMIC FEASIBILITY OF THINNING MIXED STANDS OF OAK ON A SITE INDEX OF 70 IN SOUTH MISSOURI

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Abstract.--A silvicultural and economic analysis on land of a site index 70 was conducted following a thinning of 40-year old mixed stands of black (*Quercus velutina* Lam.) and scarlet oak (*Quercus coccinea* Muenchh.). Thinnings were conducted in 1960 leaving residual basal area stocking levels of 50, 60 and 70 square feet per acre.

In 1980, diameter growth of released trees was found to be significantly greater ($P < 0.05$) than for nonreleased trees. However, no significant differences in diameter growth were observed between stands of different residual stockings.

Thinning black and scarlet oak was found to generate minimal acceptable internal rates of return of at least 10 percent only when stands were carried to an 80-year rotation.

Keywords: Black and scarlet oak, thinning, stand management, economics, Ozarks, stocking level.

INTRODUCTION

Commercial forestland in Missouri encompasses 12.3 million acres of which 36 percent (4.4 million acres) supports growth of a black (*Quercus velutina* Lam.)-scarlet oak (*Quercus coccinea* Muenchh.) mix. As a rule, 28 percent of these trees are classified as rough and rotten (Spencer and Essex 1972). Silvicultural treatment such as thinning is needed in order to improve the overall quality of stands by regulating the density of stocking and removing the cull and rotten trees.

Because of the low commercial value of oak stumpage grown on Missouri sites, landowners are reluctant to invest in precommercial thinnings. While the economic desirability of precommercial thinning in scarlet oak stands has been demonstrated (Kurtz et al. 1981) the question of thinning mixed oak stands on intermediate quality sites still remains. The purpose of this study was

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to evaluate the biological and economic feasibility of a precommercial thinning of 40-year old mixed oak stands on a medium quality site in southern Missouri.

METHODS

Study Site

The study site is located on Peck Ranch Wildlife Area in Carter County, Missouri. Stands are comprised of 60-year old black and scarlet oak interspersed with white oak (*Quercus alba* L.) and shortleaf pine (*Pinus echinata* Mill.). The site index for black oak is 70. The Clarksville soil series was identified throughout the study area. Mean annual temperature of the area is 56°F while the mean annual precipitation is 42 inches.

Stands were thinned in three acre parcels in 1960 from an original stocking level of 110 square feet of basal area per acre to residual stocking levels of 50, 60 and 70 square feet basal area per acre. Trees were deadened using conventional injectors and left to deteriorate on the site.

Sampling Procedure and Growth Measurements

The effects of thinning on growth and yield of black and scarlet oak were evaluated by establishing 12 tenth acre plots throughout the study site. Three plots were located in each of the three residual stocking classes (50, 60 and 70 square feet per acre) for a total of nine plots. An additional three plots were positioned in the unthinned control area.

Within each plot, diameter at breast height (DBH) and height measurements were obtained from each black and scarlet oak tree greater than 6 inches DBH. An increment core was extracted from each tree to determine growth since the thinning. Measurements were made of five- and ten-year diameter growth after the thinning. A least significant difference (LSD) test was used to compare diameter growth means between residual stocking levels.

Economic Analysis

Four alternative management regimes were evaluated which include thin once at age 40 and harvest at age 60, thin once at age 40 and harvest at age 80, no thinning and harvest at age 60, and no thinning and harvest at age 80. Regimes involving thinnings were examined on the basis of the three residual stocking levels.

This analysis was conducted using a current-value (nominal) approach which includes the effects of inflation. Prices used correspond to the actual year in which the costs and returns occur. With this method, rates of return can be directly compared to alternative investments such as saving accounts or money market funds. Thinning costs of $13.14 per acre (1960) were used for the analysis. Due to the manner in which cost records were kept, a precise calculation of specific thinning costs was not possible. For the purpose of this analysis, thinning costs were held constant irrespective of residual basal area. Land and annual costs were exluded from the analysis enabling an incremental comparison of thinning alternatives.

The current volume of merchantable timber per acre in the stand was used in the estimation of benefits for the regimes carried to a 60-year rotation. For the regimes carried to an 80-year rotation, growth projections were made utilizing data tables by Gingrich (1971) and Dale (1972).

Returns were computed by multiplying the merchantable volume per acre by stumpage price. Current (1981) stumpage prices of $50.00 per MBF and $4.00 per cord were used for the regimes carried to a 60-year rotation. This price approximates an 8 percent annual increase from the 1959 mid-range stumpage price of $10.00 per MBF (Farrell 1964). Stumpage prices were inflated at an assumed 8 percent annual rate over the next 20 years for the 80-year rotation. This means that in 2000, estimated stumpage prices would be $233.05 per MBF and $18.64 per cord.

Cost and revenue transactions for each of the alternative management regimes were constructed to calculate investment profitability. Present net worth (PNW) and internal rate of return (IRR) were utilized to gauge each of the alternatives. Present net worth is the net value of a stream of costs and revenues discounted back to the present (1960) at a predetermined interest rate. It is a measure of the increase in absolute size of an investment. Internal rate of return is the average interest rate earned on all costs up until the time of investment maturity. It is a measure of the rate at which an investment grows into a final value.

Present net worth was calculated using discount rates of 10 percent and 12.5 percent. Using two discount rates allows for some judgement as to the sensitivity of the PNW's of the respective management regimes to different real rates of return--the difference between discount rate and inflation rate.

The internal rate of return to thinning was calculated for the respective management regimes which include the thinning operation. This procedure involved estimating the net product yield (the difference between the benefits from the treated stand and the untreated stand) occurring as a result of the thinning (Mills and Fischer 1980).

RESULTS AND DISCUSSION

Diameter Growth Responses

Thinning resulted in significant increases in diameter growth for up to ten years. However, there were no significant differences attributable to residual stocking differences among the thinning treatments during the five-year period following the thinning (Table 1). Plots containing a residual density of 50 square feet basal area per acre did show the greatest diameter growth of 2.54 cm. during a 5-year period. Trees in all three residual stocking levels grew significantly faster in diameter than trees in the control plots which averaged only 1.55 cm.

Table 1.--Five-year diameter growth responses of thinned and unthinned stands by residual stocking levels.

Residual stocking	5-year diameter growth[1/]
B.A. per acre	cm
50	2.54a
60	2.44a
70	2.50a
110 (control)	1.55b

[1/] Numbers with the same letter are not significantly different based on a LSD test ($P < 0.05$).

Results similar to those observed for the five-year analysis were also observed at the end of ten years (Table 2). Thinning to 50 square feet basal area per acre stimulated the greatest diameter growth (4.76 cm). Correspondingly, trees within all three residual stocking levels created by thinning showed significantly greater diameter growth than trees in the control plots which averaged only 3.00 cm of growth in ten years. Thinned plots were still exhibiting a somewhat greater annual diameter growth increment than the control (non-thinned) plots 20 years after treatment.

Table 2.--Ten-year diameter growth responses of thinned and unthinned stands by residual stocking levels.

Residual stocking	10-year diameter growth[1/]
B.A. per acre	cm
50	4.76a
60	4.54a
70	4.68a
110 (control)	3.00b

[1/] Numbers with the same letter are not significantly different based on a LSD test ($P < 0.05$).

Thinning black and scarlet oak at age 40 appears to substantially stimulate the diameter growth of residual trees over that of non-released trees. However, within the range of stocking used in this study, no significant differences were observed between the diameter growth of trees in stands thinned to 50, 60 or 70 square feet basal area per acre.

Volume Estimates

Merchantable timber volume per acre for each of the stands representing a particular residual stocking level were estimated by a Missouri Department of Conservation forester. Trees were scaled for 16-foot sawlogs up to an 8-inch top; cordwood volume was estimated for the tops. Current volumes were used in the analysis for the 60-year rotations (Table 3). Product yields for the 80-year rotations were estimated through growth projections from the existing stands (Table 3). For the unthinned stands, projections were made utilizing yield tables developed for unthinned stands of upland oaks (Gingrich 1971). For the thinned stands, volumes were projected from yield tables constructed by Dale (1972).

Table 3.--Estimated volume at harvest for 60-year and 80-year rotations, respectively, by residual stocking levels.

Residual stocking	Volume[1/]	
B.A. per acre	board feet	cords
	60-year rotation	
50	8890	2.4
60	10093	3.4
70	10186	2.7
110 (control)	8444	5.5
	80-year rotation	
50	14155	3.8
60	15603	5.3
70	15723	4.2
110 (control)	11375	7.4

[1/] Scribner rule.

Economic Analysis

The financial returns from the alternative thinning options are presented in Table 4.

Thinning once to a residual basal area of 70 square feet per acre over an 80-year rotation yielded the highest PNW (10%) and greatest IRR to the thinning investment. Furthermore, the IRR's for the stands carried over the 80-year rotation were somewhat higher than the IRR's computed for the 60-year rotation. In contrast, however, over a 60-year rotation, the no-thin option yielded the highest PNW's at both discount rates as well as the highest PNW at the 12.5 percent discount rate over the 80-year rotation. The least

Table 4.--Present net worth (10% and 12.5%), internal rate of return to thinning investment and sensitivity of internal rate of return to thinning costs for alternative thinning options, by rotation length.

Thinning option	$PNW_{10\%}$	$PNW_{12.5\%}$	IRR	Sensitivity[1/]
	$/acre	$/acre	%	%
	60-year rotation			
No thin	66.02	42.11	---	---
Thin--70 B.A.	64.17	36.18	9.2	16.8
Thin--60 B.A.	63.82	35.96	9.0	16.7
Thin--50 B.A.	54.36	29.92	-1.4	---
	80-year rotation			
Thin--70 B.A.	69.55	20.51	11.3	29.9
Thin--60 B.A.	69.39	20.45	11.2	30.1
No thin	61.61	25.07	---	---
Thin--50 B.A.	61.31	17.16	9.9	30.4

[1/] Percent decrease in thinning costs required to raise IRR by an absolute one percent.

desirable alternative is thinning to a residual basal area of 50 square feet per acre which apparently has too little growing stock to efficiently utilize the site.

While the IRR's suggest that the thinning investment yields returns similar to alternative investment opportunities, the real return (net of inflation) is approximately 3 percent. A real return of this magnitude is felt to be acceptable by many. On the other hand, others might require a greater return from the investment considered here. There is an inherent risk in conducting thinnings on intermediate quality sites at such an advanced age (40 years). In this case, the decision might be to not thin since it can be seen that the greatest PNW's at the higher discount rate (4.5% real rate) accrue to the no-thin option.

A sensitivity analysis was utilized to evaluate the changes in thinning costs that would be required to raise the internal rate of return by one percent. It measures the extent to which data uncertainty will affect the economic outcome. Internal rate of return was found to be more sensitive to changes in thinning costs in regimes carried for 60 years than those carried for 80 years. This reflects the inability of the costs to be absorbed over the shorter investment period of 60 years. Although slight differences in sensitivity of IRR to thinning costs were observed between regimes of different residual stocking levels, they were not believed to be of any real significance.

CONCLUSIONS

Thinning black and scarlet oak at age 40 can result in a significant increase in diameter growth. A somewhat larger annual growth increment is found in the thinned stands in comparison to the non-thinned stands. However, significant differences in diameter growth do not occur between residual stockings of 50, 60 and 70 square feet of basal area per acre.

Within the framework of this study, the recommendation is made to thin within the basal area range of 60 to 70 square feet per acre and carry the stand to an 80-year rotation. This recommendation holds within the context of an 8 percent annual inflation rate and 10 percent discount rate. At the higher discount rate of 12.5 percent, the recommendation would be to not thin and carry the stand to only a 60-year rotation.

The decision to conduct thinnings in hardwood stands is difficult due to the many uncertainties. However, with continually rising energy costs and the correspondingly increased interest in wood as an alternative heating source, a little-utilized opportunity exists for no-cost or low-cost thinnings. With innovative thinking and planning this market could provide an economic justification for thinnings in the central hardwoods, much as the pulp market has for thinnings in the southern pines.

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