# EFFECTS OF CROP TREE THINNING AND PRUNING ON LOG AND LUMBER QUALITY OF SCARLET AND BLACK OAK STANDS[1/]

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Abstract.--Scarlet and black oak crop trees were sampled from stands which had been subjected to five different crop tree thinning and pruning levels. The stands were established over 31-years ago to determine which treatments were most effective in producing high value timber. Sample trees were felled, logs graded, scaled, and sawn to produce the highest grade lumber. Results showed that scarlet oak responded better to thinning than black oak in producing a tree of higher value. The moderate-100 crop tree thinning treatment which consisted of removing all trees whose crowns interlocked and touched the crop tree, as well as the heavy-100 crop tree thinning treatment where all trees one-half inch dbh and larger were removed, produced stands which yielded significantly higher value than the control, light-100 crop tree, and the heavy-50 crop tree thinning treatments. The light-100 crop tree treatment consisted of removing trees whose crowns interlocked with the 100 crop trees. The heavy-50 crop tree treatment removed all trees whose crowns were within 8 feet or less of the 50 crop trees. Pruning did not increase tree value. Thinning and pruning did not interact to produce higher stand values.

Keywords: Crop tree thinning, pruning, grade lumber

## INTRODUCTION

Currently, the oak forest type encompasses three-fourths (9.7 million acres) of the commercial forest land base in Missouri. Eighty-four percent of these forest lands are in small non-industrial ownerships, yet these lands are producing only one-third their potential due to lack of good timber management practices (Spencer and Essex 1972).

The black oak (Quercus velutina Lam.) and scarlet oak (Q. coccinea Muechh.) type combined comprises over one-third (4.4 million acres) of the oak forest type in Missouri (Kurtz et al. 1981) These two species are found in association primarily in the Ozark region where commercial forest land is in excess of 50 percent of the land area (Spencer and Essex 1972).

Typically this scarlet-black oak association is found on sites ranging from low to average productivity with two-thirds (2.9 million acres) of these stands in seedling, sapling, or poletimber-sized classes (Spencer and Essex 1972). Due to past mismanagement or no management, these stands have developed into an overstocked and stagnant component with little economic value (Durham 1982).

In practice, the major opportunity in the forest management of scarlet-black oak stands is the improvement in individual tree quality. The recognition of growing stock quality classes as a criterion for evaluating stands is an important first step in the management of north central oaks (Sander 1977).

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Forty-seven percent of the hardwood sawtimber volume in Missouri is in the lowest log grade (Spencer and Essex 1972). The increasing national demand for high quality hardwood sawlogs plus significant price differentials in value among log and lumber grades makes the production of quality sawlogs an important consideration in stand management (Phelps 1982).

This study examines the effects of different crop tree thinning and pruning levels on the log and lumber quality of scarlet and black oak stands after a 31-year period.

## METHODS

Data on log and lumber quality were collected on sample scarlet and black oak crop trees from a crop tree release thinning at the University of Missouri Experimental Forest, located in Butler County, Missouri. The experimental design consisted of fifteen 1-acre plots with a 1-chain wide buffer strip surrounding each plot. At the time the study was initiated in 1953, these fully stocked and even-aged natural scarlet-black oak stands were 32 years old. The site index ranged from 65 to 70 feet (base age of 50 years).

The initial inventory showed scarlet and black oak were the principal species in the red oak group accounting for 68% of the trees greater than 3.5 inches dbh. White (*Quercus alba* L.) and post oak (*Quercus stellata* Wang.) were the principal species in the white oak group with over 49% of the total trees less than 3.5 inches dbh.

Five thinning treatments in three 1-acre replications were applied to the stand. The objective was to apply different treatments to immature oak stands in order to determine which treatments would be most effective in producing the greatest volume and value of high quality timber with the highest net income.

To accomplish this goal crop trees were selected based on the criteria of species, vigor, form, crown class, and spacing. The five thinning treatments were:

| Method | Description |
|---|---|
| I | Control - Approximately 100 crop trees were selected but no thinning was done. |
| II | Light 100 crown thin - Approximately 100 crop trees were chosen and all trees in the upper canopy whose crowns interlocked with the crowns of the crop trees were removed. The term "interlocking" also refers to trees whose crown did not interlock because of crown friction. |
| III | Moderate 100 crown thin - Approximately 100 crop trees were again selected and all trees in the upper canopy whose crown interlocked (as defined by light thin specifications) and whose crown touched the crop tree crown. |
| IV | Heavy thin 100 - Approximately 100 crop trees were selected and all other trees one-half inch d.b.h. and larger were removed. |
| V | Heavy thin 50 - Approximately 50 crop trees were chosen and all other trees whose crowns were within 8 feet or less of crop tree crowns were removed. |

In addition to the thinning treatment, a pruning treatment was applied on each plot. One-half of each plot was randomly selected and crop trees were pruned to a height of 17-feet using a pole saw.

Table 1 summarizes the stand conditions prior to and after the 1954 thin. As the data indicate, the basal area was remarkably uniform for all treatments prior to the thin.

Table 1. Number of trees 2.0 inches d.b.h. and larger and average basal area before and after treatment.

| Thinning Treatment | Trees Per Acre (Number) | | Basal Acrea (sq.ft. per acre) | |
|---|---|---|---|---|
| | Before Thin | After Thin | Before Thin | After Thin |
| I Control | 516 | 516 | 62 | 62 |
| II Light-100 | 592 | 513 | 63 | 51 |
| III Moderate-100 | 538 | 431 | 62 | 45 |
| IV Heavy-100 | 518 | 97 | 60 | 22 |
| V Heavy-50 | 506 | 397 | 60 | 40 |

In July 1985, a random sample of six (3 pruned and 3 non-pruned) scarlet oak trees (90 total for all plots) were randomly selected from all main plots in order to assess the impact of the thin and prune treatments on the value of the lumber produced from these treated stands. The same scheme was used for the black oak with the exception that not all replicates had the required number of samples present. All plots had at least 1 tree which could be used. There were 72 black oak trees sampled from all treatment replicates.

Data on dbh, crown class, and tree grade was collected on all crop trees and sample trees prior to felling. The tree grade for each sample tree was determined by considering the length of the grading zone to be the butt 16 feet. Trees were harvested to a merchantable height of 8.0 inches dib. After felling the test trees, sectional measurements were taken on the bole of each test tree. Aluminum tags were placed on the butt and top end of each tree so that the identity of each piece could be maintained at all stages of the conversion process.

The felled trees were skidded to a landing area where the tree-length log was graded by a private consultant using U.S. Forest Service standard specifications for hardwood factory lumber logs (Anon. 1975). The trees were cut into logs in order to yield the highest log grade and then scaled. Logs had to be a minimum of 8.0 inches diameter inside the bark at the small end.

The scarlet oak sample trees averaged 3.6 logs per tree and the black oak trees averaged 3.2 logs.

Following grading, the logs were transported to the mill located on the University Experimental Forest where each log was assigned a sequential number prior to sawing. As each log was sawn, all the boards produced from that log were given the same number. All the logs were sawn with a circular saw and edged on a Schuerman edger. All lumber was sawn to a four-quarter (4/4) thickness. The last board (backing board) produced from each of the logs was a full two inches thick. After the sawing operation, all lumber was stickered, stacked, and air dried.

In March 1986 the lumber was graded by a consulting lumber inspector using National Hard-Wood Lumber Association grade specifications.

## RESULTS AND DISCUSSION

In order to evaluate the effectiveness of the release thinning and pruning treatments the lumber value for each sample tree was calculated. The lumber volume for each tree was determined by summing the board foot volume by lumber grade for each board sawn from all the logs contained in each tree. Lumber values for each tree were then determined by using lumber price quotations, averaged over the past two years, from the weekly Hardwood Market Report published by Abe Lemsky.

### Log Grade Production

#### Species Differences

The production of grade 1 and 2 scarlet oak logs was significantly greater ($P<.001$) than the number of black oak grade 1 and 2 logs. This was somewhat expected because the scarlet oak group had become more dominate in the overstory and the trees were larger in diameter. The average dbh for all sample scarlet oak trees was 14.5 inches while the black oak was 13.0 inches. In addition to tree diameter differences, log scaling data show that scarlet oak logs averaged 11.0 inches scaling diameter and the average log length was 11.0 feet, whereas, the black oak logs averaged 9.6 inches scaling diameter and the average log length was 8.0 feet.

In an effort to determine if there was a log value response due to thinning and pruning, logs were valued by grade using local mill delivered log price data.

Treatment V, the heavy thin 50-crop tree treatment, had an average log value of $10.28 which was significantly higher than treatments I, II, and III (at the .05 level of significance).

Treatment IV, the heavy thin 100-crop tree treatment, had an average log value of $8.15.

Thinning and Pruning Differences

Within the scarlet and black oak group, each considered separately, the actual number of grade 1 and 2 logs did not provide sufficient evidence (P>.10) to indicate whether there was a significant relationship between thinning and pruning and the number of grade 1 and 2 logs produced.

Due to the rapid diameter growth of the level IV (heavy 100) and V (heavy 50) thinning treatments, the crop trees showed no external signs of ever having been pruned. Since both scarlet and black oak are known to develop epicormic branches or water sprouts following pruning (Burns and Nichols 1952, Valiunas, 1967), data taken on the number of epicormic branches was analyzed to determine if the treatments might have reduced epicormic branching which might help explain a higher quality of log produced. In table 2 the average number of epicormic branches per tree is shown for both scarlet and black oak combined.

Table 2. Average number of epicormic branches per tree by thinning treatment.

| Treatment | Pruned | Not Pruned |
|---|---|---|
| I | 2.8 | 2.9 |
| II | 4.3 | 2.7 |
| III | 3.8 | 2.5 |
| IV | .8 | 1.9 |
| V | 1.2 | 2.2 |

There were no significant differences (at the .05 level of significance) in epicormic branching found between the two species groups, or between the pruned and unpruned subplots, or among the thinning treatments. However it is interesting to note that as the level of thinning intensified the number of sprouts decreased. Between species groups the average number of epicormic branches per tree was 1.9 for scarlet oak and 3.4 for black oak. While this is not statistically significant (at the .05 level of significance), it may have practical significance and as such may help explain why scarlet oak logs were of higher grade than black.

Lumber Production

Lumber values were determined by summing the board foot volumes by lumber grade for each board within a given log and extending them by an appropriate lumber price for each grade of board. The lumber values were then summed for each log contained in the sample trees to determine a value per tree. An average value by species, main plot treatment (thin), and subplot treatment (prune) was determined and analyzed using analysis of variance techniques. Since the number of observations was not equal for the black oak species within each treatment replicate, a general linear models procedure was used for an analysis of variance of unbalanced data.

The average value per tree for all classification levels (species, mainplot, subplot) were expanded by the actual number of all crop trees within each classification level to estimate an average value per acre.

The average lumber value per acre for scarlet oak was $880.86 while the black oak averaged $133.87 per acre. These figures represent the effects of all treatments combined and these differences were highly significant (at the .05 level of significance).

Value responses due to the different main thinning treatments are shown in table 3. Comparing the effects of thinning treatment on the value of scarlet oak, treatments III and IV show to produce significantly higher values per acre than treatments I,II, and V. Likewise in comparing value responses between species, within each thinning level, scarlet oak crop tree values per acre were significantly higher than black oak for each thinning treatment with the exception of the control.

Table 3. Average crop-tree value per acre by thinning level and species.

| Thinning Treatment | Scarlet Oak Value ($) | Black Oak Per Acre | | %Difference |
|---|---|---|---|---|
| I | 359.45 a[1/] | 166.72 | ac | + 116 |
| II | 721.42 a | 124.91 | bc | + 478 |
| III | 1311.99 b | 192.34 | ac | + 582 |
| IV | 1282.39 b | 83.22 | ac | + 1440 |
| V | 729.06 a | 102.16 | bc | + 614 |

[1/] Sample means within a row or column followed by the same letter are not significantly different at the .05 level of significance.

With the exception of the control, all other treatments showed a significant difference in value per acre between the scarlet and black oak crop trees due to the thinning treatment.

Within the scarlet oak species there was a significant increase in value per acre as the level of crop tree thin intensified.

The pruning treatment did not affect the value of the stand. Stand value of the unpruned trees averaged $514.21 per acre and the pruned trees averaged $500.52 per acre. There was no apparent interactive effect on stand value due to thinning and pruning (Table 4). The data in table 4 show that within thinning treatments comparisons made between pruned and non-pruned trees showed no significant differences in value per acre. However comparisons made between whole plot thinning treatments for either pruned or non-pruned trees show that value per acre increases as the thinning level intensifies. The only exception is the heavy-50 treatment which is lower because there were fewer crop trees. This is because the heavy 50-crop tree treatment only had an average of 33 crop trees per acre still alive at the time of measurement. The control, light, moderate, and heavy 100-crop tree treatments averaged 43, 54, 64, and 61 trees per acre. For this reason the heavy 50-crop tree treatment did not approach the moderate and heavy 100-crop tree treatments in per acre value production. The data show that the value response was produced as a result of the level of thinning rather than from the pruning treatment, not from a thinning and pruning interaction.

The highest stand value per acre was achieved at the moderate thinning level (Table 4). The moderate 100-crop tree thinning treatment (III) originally was about 72 percent stocked prior to treatment. Thinning reduced stocking by 15 percent to just below the B-level on the stocking control charts (Rogers 1980). Both the heavy-100 (IV) and heavy-50 (V) were approximately 69 percent stocked prior to the thin. Following thinning both were left with stocking below the C-level.

Table 4. Average Stand Value By Treatment.

| Thinning Treatment | Pruned Value ($) | Not Pruned Per Acre | % Difference |
|---|---|---|---|
| I | 365.77 ab[1/] | 160.40 b | + 128 |
| II | 412.07 ac | 434.26 ab | - 5 |
| III | 726.70 c | 777.63 cd | - 7 |
| IV | 691.90 c | 673.71 ac | + 3 |
| V | 306.15 a | 525.07 ac | - 42 |

[1/] Sample means within a row or column followed by the same letter are not significantly different at the .05 level of significance.

## Economic Analysis

The purpose of the economic analysis was to compare the financial returns on a pre-tax basis from the various levels of thinning and pruning. The analysis was calculated using a current-value approach which included the effects of inflation on thinning and pruning costs which were incurred in 1954.

Costs and revenues correspond to the year in which they occurred. Therefore, an annual inflation rate of 8 percent (Durham 1982) is assumed for the 31 years following the thinning and pruning treatments. Net present worth (NPW) per acre was determined by subtracting the production costs from the gross value per acre (column 4, table 5).

Net present worth can be used to compare the actual management activities. The NPW figure may also be thought of as a conversion return to the stumpage or (RTS). Stumpage values were not calculated because it is a residual value which presupposes knowledge of the purchaser's margin for profit and risk as well as other supply and demand factors. However stumpage value (SV) may be estimated using the relationship SV = RTS - %M(RTS) if an estimate for the margin (%M) is made.

Table 5. Summary of costs and revenues for scarlet/black oak on a per acre basis for various thin and prune treatments.

| Treatment | | Yield[1/] | Value | --------Production Costs Per Acre ($)---------- | | | | |
|---|---|---|---|---|---|---|---|---|
| Thin | Prune | b.f./Ac. | $/Ac. | Thin | Prune | Harvest | Mfg. | Shipping |
| I | No | 5318.00 | 320.80 | - | - | 224.95 | 289.25 | 61.10 |
| | Yes | 5297.00 | 731.54 | - | 57.38 | 224.06 | 288.10 | 61.88 |
| II | No | 4839.00 | 868.53 | 65.31 | - | 204.69 | 263.19 | 55.33 |
| | Yes | 5565.00 | 824.14 | 65.31 | 62.82 | 235.40 | 302.68 | 61.09 |
| III | No | 9001.00 | 1555.27 | 69.34 | - | 380.74 | 489.56 | 108.89 |
| | Yes | 7978.00 | 1453.40 | 69.34 | 54.99 | 337.47 | 433.92 | 87.81 |
| IV | No | 7602.00 | 1347.41 | 147.69 | - | 321.56 | 413.47 | 96.92 |
| | Yes | 8467.00 | 1383.81 | 147.69 | 60.97 | 358.15 | 460.52 | 93.10 |
| V | No | 6405.00 | 1050.14 | 95.09 | - | 270.93 | 348.37 | 81.59 |
| | Yes | 3846.00 | 612.30 | 95.09 | 31.52 | 162.69 | 209.18 | 48.99 |

[1/] International 1/4-Inch Rule

Lumber Grade Yields

Figure 1 shows the average lumber volume by lumber grade for scarlet and black oak at each thinning level. The scarlet oak shows a significantly higher volume of lumber in lumber grades #2C and #1C & better than the black oak.

Also it is apparent that the volume of lumber in the #2C and #1C and better is higher for the scarlet oak as the level of thin intensifies. Furthermore the total volume per tree for all grades of lumber within the scarlet oak is higher as the thinning level intensifies.

Costs

Thinning and pruning costs come from actual production and cost data gathered at the time the study was established. All other production costs were converted to a log value basis in order to account for a mill underrun. The mill underrun was 3.3 percent.

The harvesting cost was $42.30 per MBF Greg Hoss, personal interview). This figure represents an average for similar sites in southern Missouri.

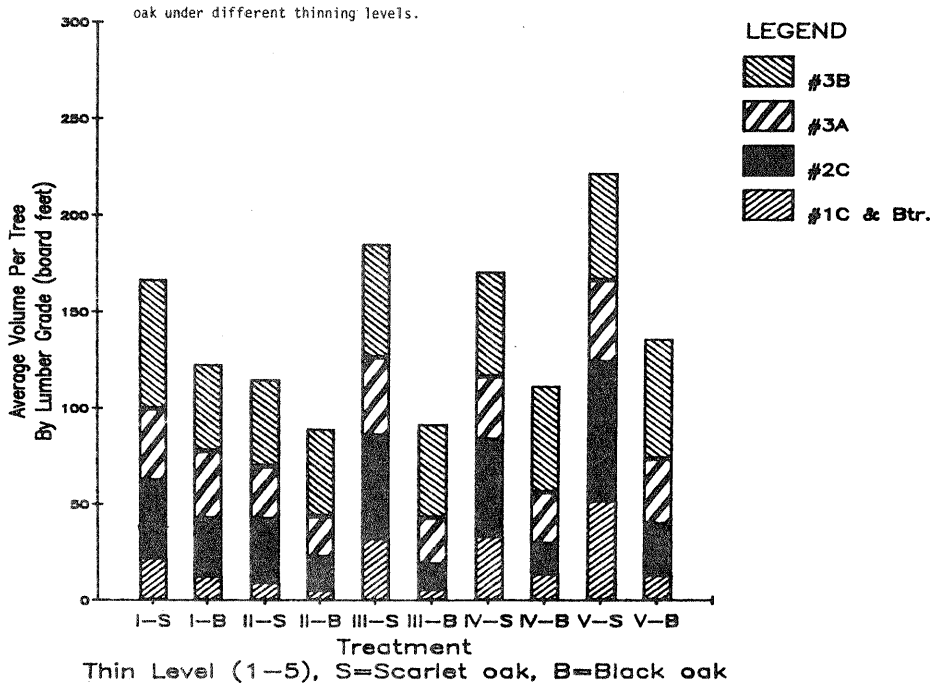
Manufacturing costs assume an average production of 14 MBF per day with a 20 percent downtime and total operating costs of $1.40 per minute (Timothy French, personal interview). Total operating costs include all variable costs (labor, supplies, and equipment) as well as periodic charges for depreciation, insurance, and supervisory overhead. Raw materials costs are not included. Production is based on 181 days and 7.5 operating hours per day.

Transportation costs for the finished product were calculated using a cost of $1.55 per loaded mile (Shelby Jones, personal interview). All 3A and 3B lumber was assumed to be shipped an average of 40 miles to the nearest pallet mill, while all 2 common and better lumber was assumed to travel about 100 miles to either a secondary manufacturer or broker for reworking or distribution. Table 5 shows the costs and lumber revenues for scarlet/black oak at various treatment levels.

This table shows the expected volume yield to an 8.0 inch top dib along with the sampled value per tree expanded to a per-acre basis. Residual volumes alove the 8.0 inch limit along with milling residues were not calculated because there are no markets in the immediate area for fuelwood, charcoal wood, or pulpwood.

The value differential (table 5) between prune versus no prune in treatment I is $410.74 per acre. This differential is explained by the

Figure 1. Average lumber grade yield per crop tree for scarlet and black oak under different thinning levels.




fact that the average value per tree for pruned scarlet oak was $24.16 compared to $9.66 for the unpruned trees. The increase in value per acre from the prune does pay for the prune treatment.

For treatment II the value per acre was higher for the thin compared to the thin and prune. In this case the value added from the prune would not have paid for the cost of the prune. Likewise for treatment III the adoption of the prune treatment did not result in an increase in value sufficient enough to cover the cost of the practice. Also for treatment IV the difference in value per acre of the thin and prune treatment compared to thin only was $36.40. Once again this value increase would not pay for the prune treatment. The large value per acre differential of $437.84 between the no prune versus prune treatment within treatment V is reflective of two things: The value per tree for the non-pruned black oak was significantly higher at $26.21 compared to $16.10 per tree for the pruned trees. Second, the number of scarlet oak trees per acre on each replicate was, on the average, higher for the non-pruned as compared to the pruned treatment. However the additional cost of the prune treatment does not pay for itself.

It is also interesting to note that although the heavy-50 treatment produced trees with significantly higher value, $34.01 compared to $18.26, $17.36, $24.75, and $26.43 for control, light, moderate, and heavy 100-crop tree treatments, the final value per acre for the 50 crop tree treatment was comparable to the light thin 100 crop tree treatment. There has to be a balance between the level of crop trees needed to produce high quality trees and the level of stocking to achieve volume production.

In order to evaluate the effect of sawing method on lumber recovery, a comparison was made between the logs sawn from this project and a yield study reported by Hanks et. al. in 1980. Two points are worth noting in regards to this comparison:

1. Logs sawn in the USFS yield study did not come from randomly selected trees in treated stands.
2. Lumber produced from this study was sawn to a 4/4 thickness. Some volume was foregone because the lumber generated from this project was to be sold to cover expenses of the project, and it was felt that a 4/4 lumber could be marketed better in the local area.

Recovery percentage[1] by log grade

| | ---Scarlet oak--- | | | ---Black oak--- | | |
|---|---|---|---|---|---|---|
| | Log Grades | | | | | |
| | 1 | 2 | 3 | 1 | 2 | 3 |
| UMC | +4.70 | -5.20 | -6.50 | +1.70 | -8.50 | +2.40 |
| USFS | +4.40 | +2.30 | +6.20 | +0.90 | -0.01 | +0.10 |

[1] + = mill overrun, - = mill underrun;

## CONCLUSIONS

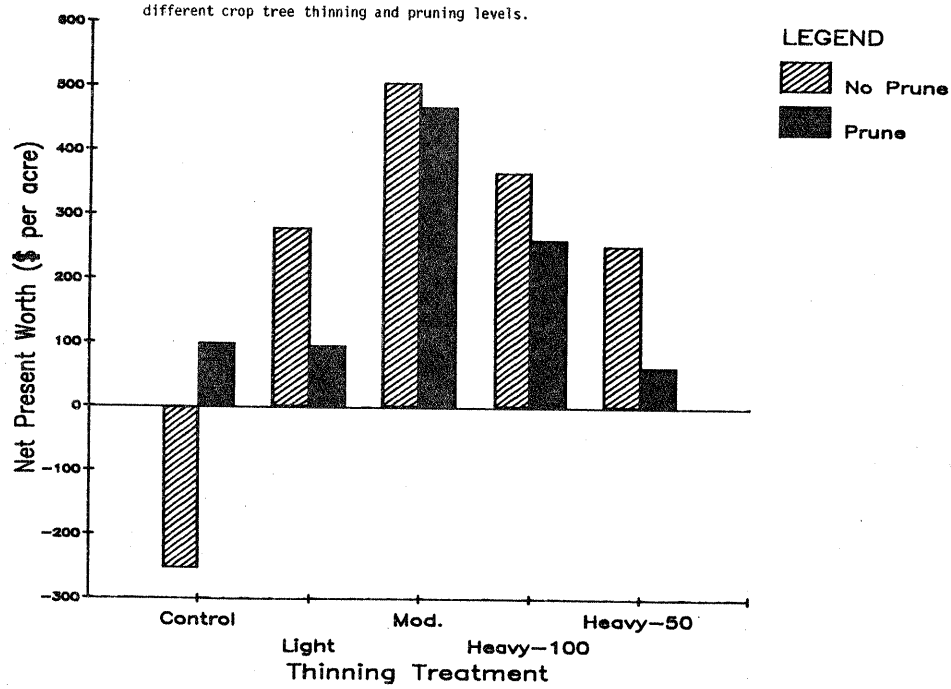
The scarlet oak species outperformed the black oak in terms of the lumber volume and quality recovered from these trees. This volume and value

differential was the result of the thinning treatment used to release crop trees and not due to the pruning treatment. Moreover, there is no additional value added in terms of net present worth as the result of pruning because there were no significant differences in the value of the pruned trees as compared to the unpruned trees.

The moderate 100 crop tree thinning treatment had the highest current net present worth per acre (figure 2). While the heavy-50 treatment had a significantly higher volume and value per tree than the moderate-100 treatment and heavy-100 treatments, this treatment did not have sufficient growing stock (crop trees) to fully optimize per acre volume and value production.

A crop tree thinning which released at least 100 crop trees and which reduced stocking to a level below 55% yielded current net present worth per acre in the $300 to $550 range for scarlet/black oak stands on average sites in the Missouri Ozarks.

Figure 2. Net present worth per acre for scarlet and black oak under different crop tree thinning and pruning levels.



## LITERATURE CITED


Anonymous.
1975. Timber Sale Preparation Handbook. USDA For. Serv. Handbook 2409.24 R-9 May 1970.

Burns, Paul Y. and J. Milford Nichols
1952. Oak pruning in the Missouri Ozarks. University of Missouri College of Agriculture Exp. Stn. Bull. 581, 8p.

Durham, J.F.
1982. The economic and silvicultural feasibility of thinning mixed stands of oak in Southern Missouri. MS Thesis. University of Missouri-Columbia. 77p.

French, Timothy A.
1986. Personal interview with Wood Processing Specialist, Forestry Division, Missouri Department of Conservation, P.O. Box 180 Jefferson City, Missouri 65102

Hanks, Leland F., G.L. Gammon, F.L. Brisbin and E.D. Rast
1980. Hardwood log grades and lumber grade yields for factory lumber logs. Northeast. For. Exp. Stn., Broomall, PA. For. Serv. Res. Pap. NE-468 92p.

Hoss, Gregory A.
1986. Personal interview with Resource Forester, Bootheel Forest District, Box 631 Poplar Bluff, Missouri 63901

Jones, Shelby G.
1986. Personal interview with Forest Products Specialist, Forestry Division, Missouri Depart- of Conservation, P.O. Box 180 Jefferson City, Missouri 65102

Kurtz, W.B., H.E. Garrett, and R.A. Williams
1981. Young stands of scarlet oak in Missouri can be thinned profitably. Southern Journal of Applied Forestry 5(1):12-16.

Lemsky, A.
Hardwood Market Report. Volume 62, Number 6, February 11, 1984 thru Volume 64, Number 12, March 22, 1986.

Phelps, R.B.
1982. An analysis of the timber situation in the United States 1952-2030. USDA For. Serv. Rpt. No. 23, 499p. U.S. Government Printing office, Washington, D.C.

Rogers, Robert
1980. Evaluating stocking in upland hardwood forests using metric measurements. U.S. Department of Agriculture Forest Service, Research Paper NC-187, 5p. North Cent. For. Exp. Stn., St. Paul, Minnesota.

Sander, Ivan L.
1977. Manager's handbook for oaks in the north central states. USDA For. Serv. Gen. Tech. Rep. NC-37, 35p. North Cent. For. Exp. Stn. St. Paul, Minnesota.

Spencer, J.S., Jr. and B.L. Essex
1972. Timber in Missouri. USDA For. Serv. Res. Bull. NC-30, 108p. North Cent. For. Exp. Stn., Upper Darby, PA.

Valiunas, Algird J.
1967. Crop tree release thinning of immature oak in Missouri. MS Thesis. University of Missouri-Columbia. 125p.