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Financial Analysis of Pruning Combined with Low Density Management of Southern Yellow Pine in East Texas: An Assessment

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FINANCIAL ANALYSIS OF PRUNING COMBINED WITH LOW DENSITY MANAGEMENT OF SOUTHERN YELLOW PINE IN EAST TEXAS: AN ASSESSMENT[1]

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Abstract-Time study was conducted on pruning of research plots in a 12-year-old loblolly pine (*Pinus taeda*) plantation thinned to 58 square feet basal area (190 trees) per acre. Pruning times with labor and equipment costs were used to determine per acre and per tree pruning costs. Pruning costs were used to find values necessary to break-even on a pruning investment. Soil expectation value (SEV) calculations were used to compare profitability of management utilizing heavy thinning with pruning to traditional management regimes. Calculations were performed using a current hourly wage of $8.00, stumpage price of $400.00, per thousand board feet (MBF) and real interest rates of 0.13, 2.78, 7.00, and 10.00 percent. Per acre combined labor and equipment cost was $116.07. Cost per tree to prune to a height of 25 feet was $0.61. Break-even values were found to range from $118.82 to $645.34 per acre depending on interest rate. Profit increase by utilizing low density management combined with pruning was found to range from $491.43 to $88,093.04 per acre over traditional management for a perpetual series of full rotations.

INTRODUCTION

The practice of pruning in pine plantations is nothing new to Australia, New Zealand and Sweden. The procedure has been studied in the United States, but has not been commonly implemented into widespread practice. Until recently, it was virtually unheard-of in East Texas. Temple-Inland Forest Products Corporation has initiated research to grow pine trees at a low stand density on short rotation. The aim is to produce large trees within that short rotation and, by pruning, yield crops of high-quality logs for high-grade products.

Based on studies conducted in Arkansas, the Temple study will determine the feasibility of the practice in East Texas pine plantations. Young pine plantations have been heavily thinned and boles of the selected residual trees were pruned to a height of 25 feet. After a recovery period of several years, the stands may undergo a second thinning. Residuals from this second entry are the crop trees which will remain until the end of the rotation. The study will evaluate various treatment levels of thinning, fertilization and competition control to determine optimum treatment combinations.

The attractiveness of this approach to management is the high-quality wood volume produced. The quality of such a product is the result of intensive, high-cost management. In theory, the product will more than pay for such extensive management. This study is directed toward assessment of whether or not pruning combined with low density management is a wise investment for landowners.

OBJECTIVES

Objectives of this study were to: 1) determine per tree and per acre pruning costs; 2) determine break even values of a pruning investment; and 3) compare profitability of low density management with pruning to traditional management.

METHODS

Background

Data for this study were collected from a 12-year-old loblolly pine plantation in eastern Anderson County, Texas. Planted in 1982, the stand lies primarily on Fuquay series loamy fine sand (Loamy, silicious, thermic, Arenic Plinthic Paleudults), with some small areas on Kirvin-Sacul association fine sandy loam (Clayey, mixed, thermic, Typic and Aquic Hapludults) (Coffee 1975). The research area consists of 42 two-thirds-acre permanent research plots. These plots were established as part of a long-term study initiated by Temple-Inland Incorporated to determine the optimum management regime for short rotation pine plantations in East Texas. The research is based on previous studies conducted in Arkansas (Burton and Shoulders 1974, Wiley and Zeide 1994).

After an initial inventory, crop trees for the residual stand were selected and the stand was thinned, then pruned to a height of 25 feet. Time measurements were collected as workers pruned the stand. Findings presented here focus on portions of the stand thinned to 58 square feet basal area per acre (BA). Mean dbh was 7.5 inches, with 190 trees per acre.

Time Study

Pruning time per tree was measured to the nearest second. Three different measurements were utilized in determination of pruning time per tree: 1) time elapsed while pruning a tree (start to finish); 2) time elapsed moving between trees (finish to start); and 3) time elapsed in pruning and moving between trees (start to start).

For the purposes of this study, pruning was considered to start when the sawblade made contact with the first limb of a tree being pruned. Pruning was considered finished at the moment a worker's behavior began to suggest progression

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towards pruning another tree. This involved observation of very subtle visual signals. There was a perceptible breaking point when a worker would give a tree a final visual inspection, and through facial expression or body motion indicate the completion of pruning on a tree.

Pruning was conducted using pole saws. Pruning to 25 feet required pruners to work in pairs, with one worker (top worker) pruning the top portion of each tree and the other (bottom worker) pruning the lower portion. A pair of workers was selected for observation, and one of the three time measurements was conducted on one worker in the pair. The process was performed for five repetitions then conducted on the other worker in the pair. Timing alternated in this fashion until each worker had been observed on five repetitions of the three time measurement categories. Another pair of workers was then selected for observation and the procedure continued.

Pruning Times

A mean of 51 individual time measurements was taken per worker per measurement category. Including both workers, start to finish times ranged from 25 seconds to 5 minutes and 51 seconds. Between tree times ranged from 1 second to 3 minutes and 8 seconds. Start to start times ranged from 25 seconds to 6 minutes and 1 second. Mean pruning times are presented in Table 1.

Table I--Mean times observed in minutes and seconds for workers pruning one tree to 25 feet In a 12-year-old loblolly pine plantation at 58 BA

Time measurement	Bottom worker	Top worker
Start to finish[a]	1:42	1:14
Finish to start[b]	0:14	0:10
Start to start[c]	2:10	1:09

[a] Start to finish was the time consumed strictly by the pruning activity alone on one tree.
[b] FInish to start was the time between completion of pruning one tree and the commencement of pruning the next tree.
[c] Start to start times were separate, individual measurements of the time between commencement of pruning one tree and the commencement of pruning the next tree.

Because workers functioned as pairs, the slower worker set the pace of the pair. To avoid under representing net time per tree, mean trees pruned per day was calculated using times of the slower worker. In this study, it was the bottom worker mean start to start time of 2 minutes and 10 seconds. Times for both workers were not added together because faster workers yielded the same net productivity as slower workers. Faster workers simply took more breaks during a workday. These per tree times were used to calculate a mean value of 194 trees pruned per day per worker pair. Mean trees pruned per day (179.5) was also calculated from workers' daily tallies in other stands of various densities as a check for comparison to values resulting from time data collected on individual tree prunings.

Trees pruned per day by one pair of workers was calculated by dividing 7 hours by the minutes and seconds value used to represent pruning one tree and moving to the next. For example, a worker can prune at a rate of 2 minutes and 10 seconds per tree. Over a 7 hour (420 minute) period, the worker will complete his portion (one half) of the pruning on 194 trees. A figure of 7 hours was used to calculate trees pruned per day because an 8 hour workday does not contain 8 actual hours physically pruning. The extra hour allowed time for walk-in, walk-out, and equipment assembly, disassembly, and maintenance.

Net trees pruned per hour was found by dividing trees pruned per day by 8 hours. For example, a pair of workers pruned 194 trees in one day. Dividing 194 trees over an 8 hour day showed a 24.25 trees per nour production rate for the worker pair. Since it took a pair of workers to complete a tree, the figure was divided by 2, yielding a net trees pruned per worker per hour of 12.125. A net value of 97 trees per worker per day was found by dividing the pairs 194 trees per day production by the two workers in the pair. In other words, a worker pair's trees per day total must be divided by 16 man-hours to find net hourly worker productivity.

Labor Costs

Wage paid to pruners was assigned at $6.00 per hour. Social Security and benefits paid were assigned at a rate of 19.95 percent (Nathan 1987). Hourly and per acre labor costs were found by combining trees per hour and trees per acre information.

Equipment Costs

Pruning was conducted using pole saws. A saw in this context was considered to be a pole saw head attachment and three 6-foot aluminum pole sections. In practice the bottom worker would use two poles and the top worker would use four poles, for a three poles per worker average. Retail prices were used in determining equipment costs as presented in (table 2). Cant Saw files, needed for sharpening blades, retail for $7.53 (Simonds Industries Inc. Inter-vale Road, Fitchburg, MA, 01420).

Per Acre Pruning Costs

Cost of pruning to 25 feet per acre was found by multiplying man-hours by wages and adding per tree equipment cost for the appropriate number of trees per acre (table 3). Pruning cost per tree per man was found by dividing hourly cost by trees pruned per hour (table 4).

Per Tree Pruning Costs

Per tree equipment costs were calculated based on an average of 97 trees per worker per day and an assumed 250

Table P-Pruning tool costs in dollars from Forestry Suppliers, Incorporated (1998 Catalog 49)

Item	Price	Shipping	Total
		Dollars	
Saw head	48.00	4.20	52.20
6' aluminum pole	26.50	4.20	30.70
Replacement blade	23.95	4.20	28.15

Table 3-Per acre labor and equipment cost, by hourly wage and stand density index, to prune a 12-year-old loblolly pine plantation to 25 feet

Hourly wage	Soc. Sec. & bene.[a]	Man-hours	Equip-ment cost	Total cost
----- Dollars ----			------ Dollars -----	
6.00	1.20	15.67	3.25	116.07

[a] Social Security and benefits paid.

Table 4-Cost per tree to keep one worker pruning loblolly pine plantations to 25 feet

Hourly wage	Soc Sec & bene.[a]	Equipment cost/hour	Trees/ hour	Total cost per tree
----------- Dollars ---------				Dollars
6.00	$1.20	0.21	12.12	0.61

[a] Social Security and benefits paid.

day work-year. Saws were expected to last 3 years, blades were expected to be replaced every 20 days, and files were expected to be replaced after 4 months. Total dollar value of equipment was divided equally by the calculated number of trees it would prune over its useful life. Equipment cost per tree ($0.017105292) was multiplied by trees per acre to establish equipment cost per acre, and trees per hour rates to determine equipment cost per hour.

Break Even Values

To determine break-even values, labor plus equipment costs was expressed on a per acre basis and compounded to rotation age using a range of interest rates. Real rates of interest used were 0.13, 2.78, 7.00, and 10.00 percent. Use of real rates means that the interest rates used in these analyses take inflation into account, as opposed to current rates which do not. The 0.13 percent rate is the 1939-l 997 average real rate of return on investing in 3 month Treasury bills and is analogous to a current rate of 4.34 percent (Economic Report of the President 1998). The average real rate of return from investing in Baa corporate bonds during the same time period was 2.78 percent, and is analogous to a current rate of 7.09 percent (Economic Report of the President 1998). Baa corporate bonds are those rated by Moody's Investors Service as being of medium quality considering risk (Moody's Investors Service 1996). A real rate of 7.00 percent was chosen as an intermediate between returns on Baa corporate bonds and the 10.00 percent real rate selected to represent the real return available from investments like well-chosen mutual funds (Kronrad 1996a). The 7.00 and 10.00 percent real rates are analogous to current rates of 11.59 and 14.72 percent respectively.

SEV Calculations

Soil expectation value (SEV) calculations were used to compare the low density management with pruning (referred to hereafter simply as low density management) to traditional management over the range of interest rates. Soil expectation value is a measure of the net present worth (NPW) of a perpetual series of forest rotations and is defined in this study by the following formula.

$$SEV = NPW\left[\frac{1}{(1+i)^n - 1} + 1\right] \quad (1)$$

where
NPW = net present worth of a single rotation
i = interest rate
n = length in years of a single rotation

Net present worth is a measure of value in today's dollars of an investment minus expenses for a single, finite time frame (Gittinger 1982). This SEV formula is a derivation of Faustmann's original formula from 1849. More detailed discussions on the formula's development are presented by Gaffney (1960), Davis (1966), Samuelson (1976), Hyde, (1980) and Gregory (1987). Analyses were conducted using SEV rather than NPW due to the 5 year difference in rotation length between traditional and low density management. Because an investment in traditional management takes place over a 35 year time frame and investment in low density management takes place over a 30 year time frame, it was necessary to look at both investments on an infinite basis for a meaningful comparison of value.

Future stumpage values were projected by compounding current stumpage price for the appropriate number of years at a real 40 year mean annual price increase of 2.0 percent (Kronrad 1996a). Current stumpage price used was $400.00 per thousand board feet. This was well within the range of prices observed in Texas Timber Price Trends for the year 1997. Wood volume projections were based on growth data from stands in Arkansas under similar management (Kronrad 1994). To present a range of possible outcomes, SEV's were calculated at real interest rates of 0.13, 2.78, 7.00, and 10.00 percent. Values used in analyses are presented in Tables 5 - 7.

Table 5—Stumpage price per thousand board feet (MBF) of pine sawtimber compounded at a real price increase of 2.0 percent

Project year	Price per MBF Doyle $400
	Dollars
0	400.00
8	468.66
12	507.30
15	538.35
17	560.10
18	571.30
20	594.38
23	630.76
27	682.75
30	724.54
35	799.96

Table 6—Projected per acre future volumes of loblolly pine plantations thinned at age 12 to 58 BA

	Cords age 12		MBF Doyle		
Age 12 density	Cut	Keep	Age 20 cut	Age 20 keep	Age 30 total
58 BA	16.04	18.12	3.520	2.560	12.880

Table 7-Range of wood prices and labor costs used in financial analyses presented in year zero dollars

Item	Value
	Dollars
Hourly wage	6.00
Timber harvest marking and administration cost[a]	10.00
Pulpwood price[b]	25.00
Sawtimber price[c]	400.00

[a] Percent commission from harvest revenue.
[b] Dollars per standard cord.
[c] Dollars per MBF Doyle.

SEV Comparisons

Comparison was made using with and without analysis. With and without analysis is comparison of investment value exercising a specific option to the same investment not exercising the option (Gittinger 1982). In this case, comparison was between management of East Texas southern yellow pine plantations with a low density treatment regime and traditional management of East Texas southern yellow pine plantations without the low density treatment regime.

Primary analyses to determine break even values considered the project as it was actually observed walking into the stands at year 12. In the case that landowners are considering implementation of low density management on a tract of bare land, SEV's were calculated at a range of interest rates and used in with and without analyses of full rotations using an assumed planting cost of $125 per acre (Kronrad 1996b). The planting cost was assumed to be $125 per acre in analyses of both traditional and low density management in order to compare more uniform scenarios and avoid confounding evaluation of low density management by using a lower planting cost in comparison to traditional management.

RESULTS

Per Acre Labor and Equipment Costs

Per acre labor and equipment cost was calculated by multiplying hourly wage and the Social Security and benefit percentage by number of man-hours per acre, then adding the product of equipment cost per tree multiplied by trees per acre. Man-hours per acre were calculated by dividing number of trees per acre by number of trees pruned per worker per hour. For example, at 58 BA, a single worker pruned at a net rate of 12.125 trees per hour. With a mean of 190 trees per acre, pruning the acre would take 15.67 hours. At the $6.00 minimum hourly wage, 15.67 hours of labor costs $94.02 Social Security and benefits paid at the U.S. Department of Labor calculated rate of 19.95 percent on wages brings the total up to $112.82. Equipment use on 190 trees at a cost of $0.0171 per tree raises the total cost by $3.25 to $116.07 per acre (table 3).

Cost Per Tree

Cost per worker to prune a tree to 25 feet can be found by dividing total per acre pruning cost by trees per acre. To show separate components of total cost, the value was calculated by dividing the sum of hourly wage, Social Security and benefits, and hourly equipment cost by trees pruned per hour. Because hourly equipment cost was found by multiplying per tree equipment cost of $0.0171 by trees pruned per hour, the result was the same as dividing the sum of hourly wage and Social Security and benefits by trees pruned per hour and adding the per tree equipment cost. Hourly equipment cost is presented here as a point of interest. For example, at 58 BA, a single worker incurs a total cost of $7.41 including labor, benefits, and equipment use. Dividing the cost by the 12.125 trees the worker prunes in that hour shows a net cost of $0.61 per tree (table 4).

Break Even Values

Tables 3 and 4 present pruning costs in today's dollars. To find the future value of the costs carried to the end of the rotation, these values were compounded using a range of interest rates (table 8). Values in Table 8 represent the per acre dollar value increase at time of final harvest needed to break-even on a pruning investment. This means that the per acre dollar value of the final harvest must be increased by amounts shown in the table ($118.82 to $645.34) over that of like stands as a direct result of pruning. This dollar value increase may rise from production of additional merchantable board footage (from decreased "topwood") or from a premium paid for pruned stumpage.

Financial Analyses

In the case that landowners may consider implementation of low density management on a tract of bare ground today, soil expectation values for full rotations under both treatment options were calculated using a range of interest rates

Table O-Total cost per acre of pruning a 12-year-old loblolly pine plantation to 25 feet compounded 18 years using various Interest rates

	Interest rate (percent)			
Hourly wage	0.13	2.78	7.00	10.00
	------------------Dollars------------------			
6.00	118.82	190.14	392.31	645.34

Table 9—Per acre soil expectation values using medium stumpage prices and medium labor costs for full rotation length by management regime and interest rate

Stand treatment	Interest rate (percent)			
	0.13	2.78	7.00	10.00
	Dollars			
58 BA	**259,893.68**	**8,652.23**	**1,839.32**	775.96
Traditional management	**171,800.64**	**5,242.07**	897.50	284.53

(tables 8 and 9). Over the full rotation length low density management was more profitable than traditional management in all cases.

With and Without Analyses

With and without analyses yield a dollar value showing how profitable it is to implement a particular management option versus not implementing the option. Outcome of evaluating East Texas pine plantation management with low density treatments, versus a traditional management treatment (without low density management) is shown in Table 10.

Depending on interest rate, the profitability increase from low density management over traditional management ranged from $491.43 to **$88,093.04** per acre on a perpetual series of full rotations. For example, landowners who could invest elsewhere at a real interest rate of 7.00 percent, but choose today to begin low density management on a tract of bare land, can expect to earn an additional $941.82 per acre over investment in traditional management for a series of perpetual rotations. As a moderate scenario, this figure is relative to current prices of $400.00 per MBF for sawtimber, $25.00 per cord for pulpwood, $6.00 per hour for labor, and 10.00 percent commission paid for marking and administration of a thinning or harvest operation.

DISCUSSION AND CONCLUSIONS

This study presents information at a range of interest rates in attempt to provide broadly applicable outcomes for a range of financial scenarios. The assumption should not be made that results of this study would be applicable to any species, pruned at any age, on any site in any region. To assess the potential profitability of low density management under those varied conditions, further research is necessary. Presently, no premium is offered to landowners selling pruned logs. Because of this, and in the interest of providing conservative figures, this study assumed no premium price allowance for pruned stumpage. It is reasonable to think that if low density management were to come into widespread common practice, industry would be willing to compensate landowners for the higher value of their wood. Although **a** reasonable expectation, landowners should be quite reluctant to engage in low density management without some guarantee of compensation. This study has considered values necessary to break even, but has not considered methods by which landowners may assure compensation for a pruning investment. Future research may investigate some type of certification system whereby landowners and industry were both guaranteed that logs from specified stands were pruned at a recorded size and age.

Ultimately, the profitability of low density management comes from the additional wood volume produced as a result of the reduced stems per acre. It must be noted, however, that fewer stems per acre alone cannot be used to produce merchantable wood volume since open grown pines are excessively knotty, making pruning a necessity. Therefore, these two management techniques must be practiced together to be effective. By these analyses, low density management was more profitable than traditional management in all cases.

Table 10—With and without analysis showing added profitability per acre of east Texas pine plantation management with low density management treatments and without low density management treatments under traditional management on perpetual rotation

Stand treatment	Interest rate (percent)			
	0.13	2.78	7.00	10.00
	Dollars			
58 BA	**88,093.04**	**3,410.22**	941.82	491.43
Traditional management	0.00	0.00	0.00	0.00

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