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FINANCIAL CONSEQUENCES OF COMMERCIAL THINNING REGIMES IN YOUNG-GROWTH DOUGLAS-FIR

by

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ABSTRACT

Commercial thinning in fully-stocked normal Douglas-fir stands of merchantable size is evaluated and compared to the alternatives of leaving stands to grow unthinned or of liquidating them. Comparisons are made in terms of volume production and financial returns.

KEYWORDS: Thinning (commercial), economic evaluation, young-growth stands, Douglas-fir.

The tables contained in this note show the financial returns that can be expected from given regimes of commercial thinning in young-growth Douglas-fir stands of merchantable size. The stands evaluated are fully stocked and have not been precommercially thinned. The audiences for this note are forest owners and managers who are faced with the decision of what to do with existing merchantable stands of Douglas-fir. Should the stands be thinned, allowed to grow further without thinning, or immediately harvested?

The decision criteria used are strictly financial. Each stand is evaluated independently on a per acre basis. This means that the possible effects of stand treatment on allowable cut quotas for entire forests are ignored.

Data and Thinning Assumptions

In order to determine the financial consequences of thinning Douglas-fir, data had to be obtained on the yield response of stands to thinning and the performance of unthinned stands. Both types of data have been developed from the results of studies across the Douglas-fir region of the growth patterns of thinned and unthinned Douglas-fir stands. The means for generating these data are available from the DFIT (Douglas-fir Interim Table) program.[1/] The DFIT program is a stand simulator containing growth equations and many assumptions about management practices and their effect on stand development. The assumptions are based on data representing currently available information on the thinning of Douglas-fir and on the growth and yield of unmanaged stands. A publication in which the assumptions are discussed is also being prepared.[2/]

For this paper the prediction of yields from thinning is based on several important assumptions concerning the condition of stands and the way thinning is done. These assumptions follow:

1. At time of initial thinning, stands are "normal" by DFIT standards--in terms of number of trees, average d.b.h., and volume per acre. This approximates Bulletin 201.[3/]

2. Yield data are based on fully stocked acres. No deductions are made for insect and disease losses nor for nonproductive features such as roads, landings, or skidroads.

3. Commercial thinning is first feasible when average d.b.h. of cut trees is about 9 inches (22.9 cm).

4. Commercial thinning is regarded as a regime, i.e., a series of thinning entries, applied to a stand. The regime consists of an initial thinning followed by subsequent thinnings, the last being no closer to final harvest than 10 years. Intervals between thinnings are generally 10 years except for lower site classes where the interval is longer to allow the stand to build thinning volume in excess of 1,000 cubic feet per acre (70 cubic meters per hectare) (4-inch (10.2 cm) top), the assumed minimum volume needed to conduct a commercial thinning operation.

5. Thinnings reduce the merchantable basal area to the greater of two-thirds of prethinning basal area or to a level which varies by average diameter of merchantable trees, ranging from 51 percent for 10-inch (25.4-cm) d.b.h. to 63 percent for 30-inch (76.2-cm) d.b.h.

6. Average d.b.h. of cut trees (d) relative to average d.b.h. of merchantable trees before thinning (D) varies with age. Maximum d/D is 1.0 at the first possible commercial thinning. Minimum d/D is 0.8.

These assumptions were used in developing commercial thinning yields. The cubic-foot (4-inch (10.2-cm) top) and Scribner (6-inch (15.2-cm) top)[4/] volume gains resulting from thinning are shown in table 1.

[1/] Bruce, David, Donald J. Demars, and Donald L. Reukema. "Douglas-fir managed yield simulator: DFIT user's guide." Unpublished.

[2/] Reukema, Donald L., and David Bruce. Effects of thinning on yield of Douglas-fir; concepts and some estimates obtained by simulation. Unpublished.

[3/] McArdle, Richard E., Walter H. Meyer, and Donald Bruce. 1961. The yield of Douglas-fir in the Pacific Northwest. U.S. Dep. Agric. Tech. Bull. 201 (revised). 74 p., illus.

[4/] Based on scaling 16-foot (4.88-m) logs to nearest 0.1 inch (.25-cm) and using formula rule.

Table 1--*Change in volume yield expected from commercially thinned stands of Douglas-fir compared to yields from natural stands. Change is expressed in cubic feet*[1/] *(4-inch top) and Scribner board feet (6-inch top) and as a percentage of natural stand yields. Comparisons vary by age at initial thinning entry, rotation age, and site class*

SITE I (SITE INDEX 200)

Log rule	Rotation age	Volume yield of natural stand	Volume change of stand by age at initial thinning entry									
			30		40		50		60		70	
	Years	M ft/acre	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent
Cubic	80	18.3	2.7	15	2.6	14	2.1	11	1.4	8	0.6	3
	70	16.6	1.8	11	1.8	11	1.4	8	.7	4	--	--
	60	14.7	.9	6	.9	6	.6	4	--	--	--	--
	50	12.3	.1	1	.2	2	--	--	--	--	--	--
	40	9.1	-.3	-3	--	--	--	--	--	--	--	--
Scribner	80	118.4	9.2	8	8.4	7	7.6	6	5.5	5	2.7	2
	70	104.1	4.8	5	4.5	4	4.2	4	2.5	2	--	--
	60	87.2	.9	1	1.2	1	1.4	2	--	--	--	--
	50	67.0	-1.6	-2	-.8	-1	--	--	--	--	--	--
	40	42.8	-1.6	-4	--	--	--	--	--	--	--	--

[1/] Metric conversion: cubic feet per acre x .0700 = cubic meters per hectare.

SITE II (SITE INDEX 170)

Log rule	Rotation age	Volume yield of natural stand	Volume change of stand by age at initial thinning entry									
			35		45		55		65		75	
	Years	M ft/acre	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent
Cubic	85	15.2	1.7	11	1.7	11	1.4	9	1.0	7	0.4	3
	75	13.9	1.1	8	1.1	8	.9	6	.5	4	--	--
	65	12.4	.4	3	.5	4	.3	2	--	--	--	--
	55	10.5	-.1	-1	0	0	--	--	--	--	--	--
	45	7.9	-.2	-3	--	--	--	--	--	--	--	--
Scribner	85	93.2	4.6	5	4.1	4	4.0	4	3.0	3	1.7	2
	75	82.0	1.8	2	1.7	2	2.0	2	1.3	2	--	--
	65	69.0	-.5	-1	-.1	--	.4	1	--	--	--	--
	55	53.7	-1.8	-3	-1.0	-2	--	--	--	--	--	--
	45	35.6	-1.3	-4	--	--	--	--	--	--	--	--

SITE III (SITE INDEX 140)

Log rule	Rotation age	Volume yield of natural stand	Volume change of stand by age at initial thinning entry									
			45		55		65		75		85	
	Years	M ft/acre	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent
Cubic	95	12.5	1.0	8	1.0	8	0.9	7	0.5	4	0.2	2
	85	11.5	.6	5	.6	5	.5	4	.3	3	--	--
	75	10.4	.2	2	.3	3	.2	2	--	--	--	--
	65	9.2	-.2	-2	0	0	--	--	--	--	--	--
	55	7.4	-.2	-3	--	--	--	--	--	--	--	--
Scribner	95	70.8	1.4	2	1.5	2	1.5	2	1.2	2	.7	1
	85	63.0	0	0	.3	0	.6	1	.5	1	--	--
	75	54.2	-1.1	-2	-.5	-1	0	0	--	--	--	--
	65	43.9	-1.6	-4	-.7	-2	--	--	--	--	--	--
	55	32.0	-1.1	-3	--	--	--	--	--	--	--	--

SITE IV (SITE INDEX 110)

Log rule	Rotation age	Volume yield of natural stand	Volume change of stand by age at initial thinning entry									
			60		70		80		90		100	
	Years	M ft/acre	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent	M ft/acre	Percent
Cubic	110	9.6	0.3	3	0.4	4	0.3	3	0.2	2	0.1	1
	100	9.0	.1	1	.2	2	.2	2	.1	1	--	--
	90	8.3	-.1	-1	0	0	0	0	--	--	--	--
	80	7.5	-.2	-3	-.1	-1	--	--	--	--	--	--
	70	6.4	-.2	-3	--	--	--	--	--	--	--	--
Scribner	110	48.8	-.8	-2	-.5	-1	-.2	0	0	0	.1	0
	100	44.1	-1.2	-3	-.7	-2	-.4	-1	0	0	--	--
	90	38.7	-1.4	-4	-.9	-2	-.2	-1	--	--	--	--
	80	32.7	-1.4	-4	-.6	-2	--	--	--	--	--	--
	70	25.8	-.8	-3	--	--	--	--	--	--	--	--

SITE V (SITE INDEX 80)

Log rule	Rotation age	Volume yield of natural stand	Volume change of stand by age at initial thinning entry			
			90		100	
	Years	M ft/acre	M ft/acre	Percent	M ft/acre	Percent
Cubic	110	5.7	-0.2	-4	-0.1	-2
	100	5.1	-.1	-2	--	--
Scribner	110	21.7	-1.0	-5	-.4	-2
	100	18.5	-.5	-3	--	--

Yield Results

Table 1 shows the changes in volume yield expected from commercially thinned stands compared to yields from natural stands. Differences in yields are shown as percentages and in cubic-foot (4-inch (10.2-cm) top) and Scribner (6-inch (15.2-cm) top) volumes. Alternative ages at which stands can be thinned for the first time are shown across the top of the table. Alternative rotation ages are shown down the left-hand side of the table. Five site class conditions are evaluated. Volume yields of natural stands grown to comparable rotation ages are given for purposes of comparison. The reader should keep in mind that where 20 or more years separate the initial entry from final harvest, more than one thinning entry is made. Table 2 contains a column showing total number of thinning entries that correspond to each combination of site class, rotation age, and age at initial entry.

The yield results were obtained from the DFIT program under the assumptions stated in the previous section. The yield results summarize volumes cut at each thinning and at final harvest. In addition, an allowance was made for salvaging merchantable mortality.

To use table 1, one needs to specify site class, age of stand to the nearest 10 years, and the proposed rotation age. For example, if the stand is on site II and is closest to age 45 with a proposed final harvest at age 65, the table shows that in terms of cubic feet, commercial thinning would produce 500 feet per acre (35 cubic meters per hectare) of additional volume or 4 percent more than a natural stand. In terms of Scribner log scale there would be a slight loss. The thinning regime imposed in this case would consist of the initial thinning at age 45 and an intermediate thinning 10 years later at age 55.

A number of observations drawn from the data shown in table 1 follow:

1. In terms of Scribner board-foot production, commercial thinning contributes little (5 percent or less) or reduces total output on sites II to V. This is also true for site I with the exception of rotations of 80 years.

2. In terms of cubic-foot production, commercial thinning contributes from 5 to 15 percent on sites I to III when thinning begins early and rotations are relatively long. In other cases, gains, if any, are less than 5 percent.

3. Stands entered early and held for relatively long rotations, especially on sites I to III, produce the largest volume gains from commercial thinning. Stands managed for shorter rotations and lower site stands produce the least volume and often result in losses. To reduce such losses, managers might thin later in the stand's life or reduce the number of thinnings or reduce the amount thinned, especially at the first thinning.

4. In terms of generating additional volume, commercial thinning on higher sites is clearly more productive than thinning on lower sites.

Financial Criteria and Assumptions

Table 1 presented the yield results of commercial thinning in Douglas-fir. In table 2 the same regimes and site conditions are evaluated using present value criteria at 4-percent and 7-percent discount rates.

Each present value entry in table 2 represents a sum of two calculations. The first is a discounting of all costs and returns occurring during the first rotation. The second is a discounting of all costs and returns from subsequent rotations. The second calculation is done to get around the problem of comparing dissimilar analytical time periods resulting from different rotation ages and ages at initial entry. For the second set of calculations, it was necessary to make assumptions about

Table 2--*The present value of selected management options, discounted to current stand age for five site classes. Present value is based on discounted (at 4 and 7 percent) values of the first rotation plus a perpetual series of rotations thereafter*

SITE I

Current stand age	Management alternative number	Proposed final harvest age	Total number of thinnings	Present value/acre at 7 percent		Present value/acre at 4 percent	
				Thinning regime	Stand unthinned	Thinning regime	Stand unthinned
Years		Years		Dollars			
30	1	30	0	NA[1/]	2,878	NA	4,181
	2	40	1	3,308	3,164	5,077	5,084
	3	50	2	2,998	2,428	5,214	4,883
	4	60	3	2,549	1,591	4,938	4,135
	5	70	4	2,173	962	4,498	3,273
	6	80	5	1,916	556	4,043	2,486
40	1	40	0	NA	6,223	NA	7,526
	2	50	1	5,215	4,777	7,372	7,228
	3	60	2	4,288	3,129	6,890	6,121
	4	70	3	3,572	1,893	6,246	4,844
	5	80	4	3,076	1,093	5,585	3,681
50	1	50	0	NA	9,396	NA	10,699
	2	60	1	6,850	6,155	9,321	9,060
	3	70	2	5,358	3,723	8,266	7,171
	4	80	3	4,379	2,151	7,272	5,448
60	1	60	0	NA	12,108	NA	13,411
	2	70	1	8,218	7,325	10,940	10,614
	3	80	2	6,232	4,229	9,390	8,065
70	1	70	0	NA	14,408	NA	15,711
	2	80	1	9,380	8,321	12,298	11,937

[1/] NA = not applicable.

SITE II

Current stand age	Management alternative number	Proposed final harvest age	Total number of thinnings	Present value/acre at 7 percent		Present value/acre at 4 percent	
				Thinning regime	Stand unthinned	Thinning regime	Stand unthinned
Years		Years		Dollars			
35	1	35	0	NA	2,567	NA	3,477
	2	45	1	2,723	2,591	4,041	4,058
	3	55	2	2,405	1,930	4,069	3,824
	4	65	3	2,032	1,251	3,820	3,215
	5	75	4	1,737	754	3,473	2,541
	6	85	5	1,536	435	3,124	1,933
45	1	45	0	NA	5,097	NA	6,007
	2	55	1	4,143	3,797	5,749	5,661
	3	65	2	3,389	2,459	5,330	4,759
	4	75	3	2,829	1,483	4,829	3,761
	5	85	4	2,449	857	4,328	2,862
55	1	55	0	NA	7,469	NA	8,379
	2	65	1	5,377	4,839	7,222	7,045
	3	75	2	4,205	2,917	6,387	5,568
	4	85	3	3,454	1,686	5,633	4,236
65	1	65	0	NA	9,518	NA	10,428
	2	75	1	6,427	5,740	8,471	8,242
	3	85	2	4,885	3,315	7,267	6,271
75	1	75	0	NA	11,290	NA	12,200
	2	85	1	7,334	6,523	9,544	9,283

Continued on p. 6

Table 2--*The present value of selected management options, discounted to current stand age for five site classes. Present value is based on discounted (at 4 and 7 percent) values of the first rotation plus a perpetual series of rotations thereafter*--Continued

SITE III

Current stand age	Management alternative number	Proposed final harvest age	Total number of thinnings	Present value/acre at 7 percent		Present value/acre at 4 percent	
				Thinning regime	Stand unthinned	Thinning regime	Stand unthinned
Years		Years		Dollars			
45	1	45	0	NA	2,726	NA	3,325
	2	55	1	2,430	2,272	3,422	3,425
	3	65	2	2,044	1,563	3,276	3,034
	4	75	2	1,650	974	2,963	2,473
	5	85	3	1,451	576	2,690	1,922
	6	95	4	1,297	330	2,407	1,449
55	1	55	0	NA	4,470	NA	5,069
	2	65	1	3,377	3,074	4,558	4,490
	3	75	2	2,697	1,918	4,113	3,661
	4	85	2	2,161	1,134	3,619	2,846
	5	95	3	1,925	648	3,260	2,145
65	1	65	0	NA	6,047	NA	6,646
	2	75	1	4,201	3,773	5,541	5,420
	3	85	2	3,240	2,231	4,820	4,213
	4	95	2	2,584	1,274	4,164	3,175
75	1	75	0	NA	7,423	NA	8,022
	2	85	1	4,914	4,388	6,391	6,236
	3	95	2	3,708	2,507	5,427	4,701
85	1	85	0	NA	8,631	NA	9,230
	2	95	1	5,541	4,931	7,138	6,958

SITE IV

Current stand age	Management alternative number	Proposed final harvest age	Total number of thinnings	Present value/acre at 7 percent		Present value/acre at 4 percent	
				Thinning regime	Stand unthinned	Thinning regime	Stand unthinned
Years		Years		Dollars			
60	1	60	0	NA	2,500	NA	2,841
	2	70	1	1,953	1,797	2,625	2,619
	3	80	1	1,521	1,153	2,371	2,191
	4	90	2	1,233	693	2,086	1,732
	5	100	2	1,053	401	1,852	1,321
	6	110	3	945	226	1,645	984
70	1	70	0	NA	3,536	NA	3,877
	2	80	1	2,507	2,267	3,287	3,243
	3	90	1	1,890	1,364	2,853	2,563
	4	100	2	1,526	788	2,462	1,956
	5	110	2	1,316	445	2,174	1,458
80	1	80	0	NA	4,460	NA	4,801
	2	90	1	2,993	2,682	3,870	3,794
	3	100	1	2,213	1,552	3,274	2,896
	4	110	2	1,775	874	2,787	2,157
90	1	90	0	NA	5,276	NA	5,617
	2	100	1	3,422	3,052	4,382	4,286
	3	110	1	2,498	1,721	3,644	3,194
100	1	100	0	NA	6,004	NA	6,345
	2	110	1	3,804	3,384	4,839	4,727

SITE V

Current stand age	Management alternative number	Proposed final harvest age	Total number of thinnings	Present value/acre at 7 percent		Present value/acre at 4 percent	
				Thinning regime	Stand unthinned	Thinning regime	Stand unthinned
Years		Years		Dollars			
90	1	90	0	NA	2,021	NA	2,172
	2	100	1	1,400	1,265	1,793	1,783
	3	110	1	1,057	752	1,541	1,397
100	1	100	0	NA	2,489	NA	2,640
	2	110	1	1,651	1,479	2,094	2,068

management practices that will follow the first rotation. It was assumed that timber would continue to be the main crop and that managers would seek a financially optimal rotation. Subsequent rotations were based on stand establishment, precommercial thinning costs, and returns from commercial thinning and final harvests.

Each present value entry is discounted to current stand age (shown in the first column of table 2). For example, for site I all present values in the first six lines (management alternatives 1 to 6) are discounted to age 30.

The financial assumptions behind the data shown in table 2 follow:

1. Timber volumes harvested were valued by using a net stumpage value of $138 per thousand board feet Scribner for final harvest timber (based on the average stumpage price for Douglas-fir sawtimber sold on National Forests in the Douglas-fir region in 1973) and $103.50 per thousand board feet for thinning stumpage (assumed to be 75 percent of final harvest stumpage). There was no adjustment of stumpage price based on diameter.

2. Rotations subsequent to the first rotation were financially optimized and based on the prices shown above plus costs of $75/acre for regeneration and $70/acre for precommercial thinning.

3. Net stumpage values were assumed constant over time. There was no attempt to estimate future rates of inflation nor future rates of increase in the value of wood products relative to other products. Since current interest rates reflect inflationary trends, an analysis that uses constant prices also needs adjustment of the discount rate for inflation. Just what the appropriate rate should be depends on the time, the circumstance, and the investor. The rates of 4 percent and 7 percent are offered here both to contrast the effects of different rates and as reasonably close approximations of what noninflationary, before-tax rates may be.

4. The financial returns shown in table 2 do not include administrative costs nor do they account for taxes.

Financial Guidelines

Table 2 can be used in at least two ways that might aid decisionmaking. On the one hand, when financial returns are paramount, it can be used to determine rotation length and to decide whether to thin or not. On the other hand, if rotation length is already established (probably for reasons other than financial), the table can be used to find out what would be gained from commercial thinning as opposed to not thinning.

To use table 2 in the financial case, one must specify current stand age, site class, and interest rate. With this information, one is given a set of numbered management alternatives representing "proposed final harvest ages." The financial solution is the highest number under the columns "thinning regime" and "stand unthinned." For example, if current stand age is 30, on site class I at 4 percent, the solution is the value $5,214, indicating that the stand would be thinned twice and grown to age 50 when it would be harvested. If current stand age is 40, on site class I at 4 percent, the financial solution is $7,526, indicating that the stand should be harvested immediately.

To further illustrate finding the financial solution, assume that a 35-year-old site II Douglas-fir stand has a 4 percent real rate of interest adjusted for inflation. To find the optimal decision, look for the highest number under the 4-percent heading in the block of numbers representing site II at current stand age 35. That number is $4,069, indicating that the

stand can be held to age 55 and thinned twice, now and at age 45.

To illustrate a situation where rotation age is set, assume that the 35-year-old site II stand discussed above has a specified rotation of 75 years. At 4 percent, the thinning regime is worth $3,473 while the non-thinning regime is worth $2,541, a net difference of $932 per acre in favor of thinning. Note, however, that the highest financial solution is worth $4,069.

The thinning regimes assumed for table 2 begin immediately if the decision is made to thin and thinning is done frequently. What are the results if thinning is delayed or done less frequently? In the case of the 35-year-old site II stand, the financial consequences of delaying the first thinning to age 45 and still harvesting at age 55 at 4 percent can be found in table 2. With a current stand age of 45 and a final harvest age 55, the value of an initial entry at age 45 (discounted to age 45) is $5,749. The next step is to discount this figure 10 years to age 35 and then compare alternatives. The present value of delayed thinning is $3,884. This represents a loss compared to the regime with two thinnings.

Only a few runs were made to test what happens with less frequent thinnings. On the basis of limited data, it appears that present net values are reduced somewhat if there is any reduction in thinning frequency.

In general, the financial solutions shown in table 2 will hold for reasonable changes in the assumptions concerning stumpage price levels and price-diameter relationships. Stumpage price levels reflecting the range of price levels over the last 10 years were tested with no appreciable change in the optimal rotations or relationship of thinning to no thinning. Likewise, there was no appreciable change in the results when stumpage price as a function of diameter was changed so that prices ranged from a low of $113 for 9-inch (22.9-cm) trees to $138 for 21-inch (53.3-cm) trees; thinning values were assumed to be 75 percent of these.

The most dramatic changes occurred with discount rates outside the 4-to 10-percent range. For rates above 10 percent, liquidation as soon as the stand reached merchantable size was indicated. Below 4 percent, financially optimal rotations tended to increase about 10 years for every drop of 1 percent. For higher sites (I to III), this increased thinning opportunities by increasing the age at which thinning was financially feasible. On lower sites, however, leaving the stand unthinned was generally the financially optimal solution.

Conclusions

The value of commercial thinning in previously unthinned merchantable stands of Douglas-fir depends primarily on the goals of management. If optimization of financial returns is the primary goal, managers interested in commercial thinning should direct their attention to higher sites and young stands that have recently reached merchantable size. Older stands and stands on lower sites would be harvested and a new crop started. If financial goals are subordinated to other goals, then rotations will probably be longer than those set by financial criteria. In such cases, thinning will, in general, be financially preferable to leaving the stand unthinned. In addition, longer rotations also provide increased opportunities to increase volume production.

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