FINANCIAL ASPECTS OF LONG-LENGTH LOGGING IN THE SECOND-GROWTH FINE-HARDWOOD FORESTS WEST OF THE MISSISSIPPI RIVER.

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by
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A Thesis Submitted in Partial Fulfilment of the Requirements for a Degree of Master of Forestry

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T. D. M.

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GENERAL:

The data for this study was collected on young, second-growth shortleaf pine loblolly pine forests, typical of the forests west of the Mississippi, and represents present logging practices in that region. Most of the present stands have been logged of their merchantable volume at least once during the past forty years, and in most cases these logging operations have had little consideration for the future economic possibilities of the stand. Clear cutting, destructive logging, and in general, lack of future planning has left 90 per cent of the present stands understocked. Exploitation of forest resources has been remedied to a great extent with proper management planning, but utilization methods have not kept in stride with the economical and physical betterment of the forest.

The advancement of mechanized equipment in recent years has brought forth new and more economical methods of logging. Crawler tractors have replaced teams resulting in greater hourly production at lower man-hour costs. Mobile loaders have also increased production by quicker and more efficient loading. Modern trucks and trailers offer wider bunks and larger tires which make larger loads possible. In most cases a great reduction in man-hours has resulted. The mere use of this mechanized equipment has reduced man-hour costs, but little has been done to improve utilization methods resulting in a waste of manpower. Production of short length logs, 12 to 22 feet, has not fully utilized the efficiency of the present equipment. Production of short length logs requires more handling in woods to mill operation resulting in a waste of man-power.

Unnecessary handling coupled with increased man-hour costs makes this especially evident. In general, utilization methods are far behind the times and have not kept pace with advances in equipment design and use.

It follows, then, that there is much room and need for improvement in utilization methods. In order to more fully utilize equipment, thus increasing and cheapening production, and to secure better utilization of forest products the production of long-length logs is offered as a possible improvement over the old practices.

COOPERATION:

This study was conducted by the Southern Forest Experiment Station in cooperation with the Crossett Lumber Company. The Company was responsible for the furnishing the timber, the contractor, the equipment with which to do the logging, the marking of the timber for cutting, and assumed the responsibility from the financial standpoint for the employment of two men. The Company was also responsible for the bucking of the long-length logs and long-length pulpwood into proper lengths for use by the mills. The Southern Forest Experiment Station in turn furnished the remaining men needed to collect the data, supervise the study, compute the data, and prepare the final report.

MARKING FOR CUTTING:

As stated above, in order to secure data that would be directly applicable to the Crossett and to other lumber companies and contractor operations, the Crossett Lumber Company had their crews mark the timber for cutting on the study area. This marking conformed to the usual practices with the exception that the Company marked a considerable number of the smaller size trees for removal. It was desired to determine the felling, bucking, skidding, and loading on some material smaller than the usual size produced at Crossett in order that the data may be applied to operations with smaller log averages and for smaller mills. Enough trees in the smaller sizes were marked, down to ten inches in diameter, to get a fair average. "Usual practices" referred to marking for cutting under sustained yield management.

SCOPE OF STUDY:

The data presented in this paper represent only a part of the Forest Service study. The entire scope of the study included pulpwood and hardwood production in long vs. short-lengths as well as pine production. However, time and study limited the scope of this paper to pine logs only. Pulpwood computations represent a study in itself. In all similar loblolly-shortleaf pine stand in the south a certain amount of hardwoods will be removed with each cut, however, in such stands it is the policy to gradually eliminate the hardwoods through successive cuts to make room for the faster growing and the financially better pines. In such stands the hardwoods, oaks, maples, and gums, are considered weed trees. Data collected on the small percentage of hardwoods cut in the study was not sufficient for the construction of strong cost tables, so instead of combining the pine and hardwood logging costs the hardwood data was not used.

OBJECTIVES:

The main objectives covered in the paper are listed below in order of their importance.

1. To determine the time and costs of cutting, skidding, loading, and hauling of long-length material to be used for sawlogs as com-

pared to the handling of the usual short-length logs.

2. To determine whether the cutting of long-length logs results in better utilization of the log portion of the tree and more efficient grade recoveries.

3. To determine the effect of long-length logging upon selectively cut stands.

STUDY AREA:

Eighty acres of well stocked pine-hardwood second-growth stands were selected 9.8 miles east of Crossett, Arkansas. The terrain was flat to gently rolling. The area contained approximately 7,000 board feet per acre in trees 13 inches d.b.h. and larger. Approximately forty per cent of this volume was cut. The stand is representative of the better grade second-growth stands in the locality. This eighty acre tract was divided into four plots of twenty acres each. The plots were numbered one to four and handled for sawlog production as follows:

Plots 1 and 3. Logs were handled in the usual manner; that is, short logs ranging from 12 to 22 feet in length were cut at the point of felling.

Plot 2. Each tree was cut into one or more long-lengths with the maximum length of 48 feet. These long-lengths were then skidded to a designated loading point and loaded and hauled by truck to a designated banking ground in Crossett where they were later bucked up into the lengths needed by the mill.

Plot 4. The entire tree, including top, was skidded to the landing point after felling and limbing. At the landing point the top was removed and the log portion bucked into one or more long-lengths and loaded and hauled.

Logs were cut to a minimum top diameter of eight inches.

As customary in the locality woods roads connected the cutting area with the main road. These woods roads, tractor built, have been found satisfactory on the level terrain characteristic of the region, except in wet weather. Two main woods roads were constructed from the cutting area to the main road, one for each forty acres.

COST COMPARISONS:

Since plots 1 and 3 were handled in the same manner, short lengths cut in place, it was possible to average operating costs on the two plots for comparison with the long-length log plots 2 and 4. Due to the difference method of felling and skidding on plots 2 and 4 it was impossible to average their total operating costs. Loading and hauling may be averaged for plots 2 and 4. This may be seen more clearly in table 8.

I. ECONOMIC FEASIBILITY OF LOGGING LONG VS. SHORT-LENGTH LOGS, BY TEST BLOCK

FELLING AND BUCKING:

With saw log production in mind, plots 1 and 3 were cut in accordance with the usual practice of the Crossett Lumber Co., the trees cut were converted at the point where they were felled into the log lengths demanded by the mill or the market. Logs were cut from 12 to 22 feet in length, the length in each case depending upon the quality of individual portions of the tree and the total merchantable length, the object being to secure the greatest grade recovery from each tree, i.e. it is better to get a 12 foot grade #1 log, a 12 foot grade #2 log, and a 12 foot grade #3 log from a tree than an 18 foot grade #2 log and an 18 foot grade #3 log. In most cases, the logs averaged 16 feet in length.

On plot 2 logs were bucked to lengths at the point of felling. Lengths ranging from 20 to 48 feet were cut keeping in mind the grade recovery object per tree. Normally, trees with 48 feet or less of merchantable length would be taken as one log, unless they were too large and heavy to handle. The butt log averaged from 38 to 44 feet in length while the second log in the tree averaged from 26 to 28 feet in length. On plot 4 the entire tree was left intact for skidding, just felled and limbed by the felling crew, and bucked at the landing before loading into long length logs as on plot 2.

No special attempt was made to fell the timber in any one direction on plots 1 and 3. Here the objective was to follow the present logging practice since skidding would not be made cheaper or less damaging to the reserve stand by directional felling. On plots 2 and 4 the loading points were predetermined. Once these were established all timber tributary to each was, in so far as possible, felled directly away from the particular bunching point. This permitted the skidding of the long-length logs directly to the loading point with a minimum of damage to standing timber caused by turning of the load in reaching the loading point.

Two man crews did the felling and bucking, swamping, and limbing. Four saw crews were employed on the study area. Tree and log numbers were placed on each log, so that it could be identified in later parts of the study and no further measurements would be necessary. Two men with stop watch, calipers, scale stick, and necessary forms were assigned to each saw crew and obtained the following information for each tree felled: (1) species and diameter, (2) length of each log by position in tree, (3) top diameter of each log inside and outside bark, (4) grade of each log, (5) Doyle-Scribner scale of each log, (6) total time to fell and buck, swamp, and limb each tree, (7) delays or rest periods. Scaling of logs on plots 1 and 3 was simply to scale each log according to actual length cut, but on plots 2 and 4, in order to get an accurate scale, the log portion of the bole was measured outside and inside bark at the following points;

1. If the log is over 16' but less than 24' scale as one log.
2. If 24' scale as two 12' logs.
3. If 26' scale as 14' and 12'

4. If 28' scale as 16' and 12'

5. If 30' scale as 16' and 14'

6. If 32' scale as 16' and 16'

7. If 34' scale as 18' and 16'

8. If 36' scale as 12', 12', and 12'

9. If 38' scale as 14', 12', and 12'

10. If 40' scale as 16', 12', and 12'

11. If 42' scale as 16', 14', and 12'

12. If 44' scale as 16', 16', and 12'

13. If 46' scale as 16', 16', and 14'

14. If 48' scale as 16', 16', and 16'

The outside measurements were taken with calipers, and the inside measurements were taken with a bark punch.

All logs were graded according to the following grade rules in order to determine if higher grade recoveries can be obtained by cutting long rather than the usual short length;

Grade #1 -- Surface clear logs 10 inches d.i.b. or over, and logs over 16 inches d.i.b. with not more than three 2 to 4 inch knots; length 10 feet or over.

Grade #2 -- Logs 8 inches d.i.b. or over containing numerous small knots; or logs more than 14 inches d.i.b. containing four to six 2 to 4 inch knots; length 10 feet or over.

Grade #3 -- Knotty or crooked merchantable logs 8 inches

d.i.b. or over that do not fall in either
#1 or #2 grade; length 10 feet or over.

Wages paid saw crews in the south are normally on a piece work or contract basis. The contract basis was the mtthod implոyed for paying the saw crews in the study for both long and short log production. However, the wage scale of a saw crew producing long or treee-length logs would not remain as high as when producing short-length logs, because of the less work and time required in bucking. Therefore, to more easily compare the cost advantages of either long or short-length log production an hourly wage rate system was used for conparison in this paper. The hourly wage rate was arbitrarily chosen at $1.00 per hour per man or $2.00 per 2-man saw crew per hour.

From Table 1 is shown an increas of 175 board feet or 24.4 percent in hourly production of long-length logs (plot 2), and an increase of 582 board feet or 51.0 percent for tkee lengths over the usual short lengths (plots 1 and 3 averaged). With the hourly cost constant this increase in production of long-length logs and tree lengths results in a definate reduction in total operating time. The increased hourly production of 175 board feet for plot 2 over the average of plots 1 and 3 results in a saving of 23.4 cents per M board feet.

However, time and cost figures in Table 1 for tree lengths of plot 4 do not contain the time and cost of bucking of the tree lengths at the loading point, and no data was collected for this operation. Actual wages paid the bucking crew (2-man saw crew) in the study were erroneous for use in this paper. Each member of the bucking crew received a fixed daily rate of $6, and the crew only bucked for the skidding of one tractor, which resulted in a high cost per unit of volume. The lack of adequate time and cost data for bucking does not permit comparable cost calculations for tree length production to long or short log production. On operator planning tree length felling and skidding would probably employ some sort of power saw to do the bucking at the landing. In order to make it financially feasible to fell and skid tree lengths an operator must keep his bucking costs below 24 percent of his felling costs if he is producing long-length logs, or 34 percent below felling costs if he is producing short-length logs. These percentages were obtained be calculating the percentage difference in felling and bucking costs (Table 1) per M board feet between plots 2 and 4 ($1.521 - $1.161 = $0.360 or 24 percent), and between plots 1 and 3 averaged and plot 4 ($1.755 - $1.161 = $0.594 or 34 percent).

Increased production not only reduces direct labor costs per unit of volume, but also overhead costs are reduced with the reduction of total felling and bucking time. This increase in production may be of great significance when weather is considered, since during the wet fall and winter months contractors are able to get into the woods only a week or so at a time. Under present practices the saw crews must enter the woods three or four days in advance of tractors and loader to build up a back log of logs. These extra days may be reduced to one or two when producing long-length logs.

Table 1 -- Hourly production[1] for felling and bucking per 2-man saw crew, by test block.

Test Block and total volume cut (board feet)[1]	Effective and Ineffective time Man-hours	Hourly Production (board feet)[1]	Cost per M[2] Dollars.
	SHORT LOGS		
1 (63,431)	57.05	1,110	1.802
3 (50,684)	43.65	1,170	1.709
	100.70	2.280	$3.511
Average	50.35	1,140	$1.755
	LONG LOGS		
2 (68,763)	52.37	1,315	1.521
4 (44,667)	25.97	1,722	1.161[3]

1--Doyle-Scribner rule.
2--Based on $2.00 per hour per 2-man saw crew
3--Minus bucking cost at landing.

SKIDDING:

International TD-9 tractors were used in the skidding. The apparatus involved was a set of tongs connected to the crossbar of the tractor by means of a short length of chain. Each tractor was equipped with three sets of tongs enabling it to skid three logs per turn. No pans or dollies or other means of raising the front end of the log off the ground were used. Reskidding of individual logs was held to a minimum, however, it was necessary in a few cases in order to fill out individual loads. Two tractors were used in the study.

One observer with stop watch, scale stick, and necessary forms was assigned to each tractor and obtained the following information on each round-trip or turn: (1) total time per turn, (2) log and tree number of each log per turn, (3) Doyle-Scribner scale of each turn, (4) delays or rest periods. In addition to driving, the tractor operator also did the hooking and unhooking of the logs. There fore frequent rest periods were necessary for the operator. The efficiency rate for skidding was nine per cent lower for the long log plots than for the short log plots indicating less coordination between skidding and loading. This nine per cent reduction may be attributed to the greater volume per turn in skidding long logs, thus requiring fewer turns and logs to build up a load. Skidding on plots 1 and 3 was similar to present practices, while on plots 2 and 4 with predetermined loading points and directional felling much twisting and turning in skidding was avoided. Woods, roads and landing points were built by the tractors as the operation progressed and as they were needed. However, this time taken for road and landing point construction was not counted as ineffective time or delay when figuring average turn time.

Table 2

Estimated hourly cost involved in operating TO-9 International tractors

Direct labor cost		Cost per hour
Driver		$0.750
Supervision		.150
Social Security -- 4%		.036
	Total	$0.936
Other direct costs		
Fuel (1.96 gallons at .08)		.157
Lub. oil (.078 gal. at .60)		.047
Grease (0.32 pound at .125)		.040
Starting engine gas (.027 gal. at .20)		.005
Service labor		.010
Cable and rigging		.249
Repair parts and labor		.500
Transportation of crew		.063
	Total	$1.071
Ownership Cost		
Depreciation		.500
Interest		.116
Taxes		.030
Insurance and Risk		.046
	Total	$0.692
	Total hourly cost	$2.699
	Cost per minute	$0.0449

Data in Table 3 was calculated from original data on time and volume per turn.

Table 3

Time requirement[1] and cost[2] per turn, per average log, and per M for skidding,[3] by test block

Test Block	Volume (Bd.Ft.)[4]		Skidding					
	per Turn	per Log	per Turn		per Log		per M	
			Man Min.	Dollars	Man Min.	Dollars	Man Min.	Dollars
Short Logs								
1	236	96	5.44	0.244	2.21	0.099	23.00	1.034
3	200	88	5.75	0.258	2.52	0.113	28.65	1.284
Average	218	92	5.59	0.251	2.36	0.106	25.82	1.159
Long Logs								
2	253	174	7.00	0.314	4.81	0.216	27.66	1.240
4	275	258	10.40	0.466	9.75	0.438	37.80	1.697

1 -- Including delays
2 -- Rate per man-minute = $0.0449
3 -- Including hook, unhook, and travel time
4 -- Dayle-Scribner rule

From Table 3, the cost per M-board feet of skidding long-length logs in plot 2 was 8.1 cents or seven per cent greater than average costs of plots 1 and 3 logged by present practices. This increase in cost per M-board feet was due to the fact that the increase in load per turn in plot 2, 83 board feet, did not justify the increase in total time per turn, 1.41 man-minutes. The increase in total time per turn was caused by the slower speed of the tractor necessary in snaking the long-length logs from the point of felling to the loading point. Also, an average of 2.5 short logs were skidded per turn and 1.45 logs per turn on plot 2. Many times only one long log was brought on per turn due to the difficulty of manuvering into position for a second log. The increased cost of skidding per M-board feet on plot 4 compared to plots 1 and 3 was 53.8 cents or 46.5 per cent. Here too, the increase in load per turn did not compensate for the increased time per turn. The greatly increased time per turn is due, mainly, to the fact that tree lengths were skidded to the loading point, bucked, and then reskidded into loading position; the extra time taken in hooking and unhooking in the reskid. Normally only one tree-length was skidded per turn, some reaching 90 feet in length. These tree-lengths required very carefuly skidding to prevent binding between standing timber, and also prevent undue destruction to the remaining stand from debarking and reproduction damage.

LOADING:

Loading equipment used in the study was similar to that commonly used in logging operations in Southern Arkansas. The loader consisted of an "A" frame and winch mounted on a 1940 Ford $1\frac{1}{2}$ ton truck. This type of loader is highly mobile and equally as efficient. All short logs were loaded in the usual manner, by means of hooks, one on either end of the log. The use of end hooks in loading is only adapted to lengths up to 22 feet due to the size of equipment, therefore, for loading long-length logs a single pair of tongs was used. This means that the tongs must be hooked in the center of the log so that the log will be balanced when lifted from the ground to the truck. The latter method of loading requires more time per log unless an experienced "hook tender" is employed. A few of the short logs and several of the long logs were too heavy for the loader to lift and had to be loaded by the cross-haul method.

Both methods of loading require three men; the loader operator, and two men on the hooks or tongs. As customary in the South the truck driver aids in loading. In this study he acted as one of the hook tenders. He had charge in the loading of his truck, but the building of the load was left to the more experienced hook tender. It was necessary for one of the tractor drivers to do a great deal of the loader operating when loading long logs, because he was the only one who had the experience, required in loading long length logs, in operating the loader. The time and cost of the truck driver and the tractor driver on loading was charged to the loading operation and not to their regular duties, that is, the time spent by the truck driver while loading was not charged to the truck, but to the loader. Idle time on the truck while loading was also included in loading costs. The following information was obtained by an observer on the loading operation: (1) log and tree number of each log loaded, (2) loading time per log, (3) truck and load number, (4) delays.

The observer carried a stop watch and the necessary forms.

Table 4

Estimated hourly cost for "A" Frame loader

Cost of truck (used)		$800
Cost of "A" Frame, Construction cost plus cost of tulsa #sl winch		600
	Total	$1400
	Less trade-in value	200
	Amount to be depreciated	$1200
Life of loader 4 years -- cost of loader per year		$ 300

Running Expenses per year of 200 days

Depreciation		$ 300.00
Interest on investment @ 4%		38.00
Taxes		2.80
Insurance		30.00
Gas, oil, and grease		415.80
Repair labor		60.00
Repairs, supplies, cable and slings		138.00
		$ 984.60
	Cost per day	4.92
	Cost per hour (8 hr. day)	$ .615

Direct Labor Costs

		Cost per hour
Loader operator (tractor or truck driver)		.750
Helper		.650
Truck driver (helps load)		.750
Social Security at 4%		.086
		2.236
	Total cost per hr.	$ 2.851
	Cost per minute	$ 0.0475

In comparing costs of loading, the average of both short length plots may be compared with the average of both the long length plots. From table, loading of the long lengths figures 17 cents higher than loading of short lengths. This increase in cost is due mainly to the increased loading time per log.

Table 5

Time requirements[1] (man-minute) and cost[2] per average log and per M for loading,[3] by test block

Test Block	Volume (Bd.ft.)[4]		Loading				Stand-by Cost[5]	Total Cost of Load
	Total	per log	per log		per M		per M	per M
			Man-minutes	Dollars	Man-minutes	Dollars	Dollars	Dollars
			Short Logs					
1	63,431	96	.91	.043	9.47	0.450	.167	.617
3	50,684	88	.98	.047	11.14	0.529	.226	.755
Average		92	.945	.045	10.305	0.490	.196	.686
			Long Logs					
2	68,763	174	2.42	.1153	13.90	.660	.266	.926
4	44,667	157	2.18	.1035	13.90	.660	.268	.928
		165.5	2.30	.1094	13.90	0.660	.267	.927

1 -- Including delays and reload
2 -- Rate per man-minute = $.0475
3 -- Including hook, unhook, and travel time
4 -- Dayle-Scribner rule
5 -- Based on Truck Stand-by time - Plot 1 - 13.87 minutes = $0.265
Plot 2 - 25.87 minutes = 0.494
Plot 3 - 18.00 minutes = 0.344
Plot 4 - 24.31 minutes = 0.464

The increase in loading time per long log is a combination of the following factors: (1) greater care necessary in loading with balance tongs, (2) more cross-hauled logs, (3) inexperience in this method of loading. The first factor was caused by the difficulty in hooking the tongs in the center of the log so that the log would balance when lifted. Two or three attempts were made before the tongs were properly placed on the log. Also, time was spent in keeping the log from turning or spinning and getting it in its proper position in the load. The second factor was caused by the fact that the loader itself was not large enough, and its wheelbase too short to handle the larger logs. The third factor is self-explanatory, experience coming only with practice.

In general, it may be said that with proper equipment and experience in long-length log loading unit costs may be reduced.

HAULING:

The development of bigger and more efficient trucks and trailers within the past ten years has almost crowded railroad logging out of the picture. The increased practice of sustained yield management, which calls for lighter periodic cuts, is also responsible for the change from railroad logging to truck logging, because of less overhead required and greater mobility of trucks and trailers. Four trucks were used on the study. They were late model $1\frac{1}{2}$ ton trucks with 7.50 x 20 tires on the front and 8.25 x 20 both the rear and on the trailer. This type of truck is standard equipment with operators in Southern Arkansas. They have a short wheel-base with dual-wheels at the rear and on the trailer. The trailer attaches to the truck by means of of a coupling pole, which can be lengthened or shortened according to log lengths. In order to avoid losing time in changing the length of the coupling pole two trucks were used exclusively in hauling short length logs and two for long length logs. Since one short and one long length log plot were logged simultaneously it was possible to keep all four trucks operating at the same time. The distance from the study area to the mill was 10.2 miles, including .4 miles of woods road and 9.8 miles of graded dirt and better quality roads. Hauling costs are figured for each type of road in the foot notes of Table 7. Each truck averaged 3.2 loads per day.

Time records on the hauling were recorded by the same observer who records loading times. He was equipped with stop watch and the necessary forms. The following information was recorded by the observer: (1) time the truck leaves the woods, (2) the time the truck returned to the woods and is in position for loading of the second load, (3) truck number, (4) load number. The fact that each log had been numbered and measured made it possible to record the volume of each load. In case of any delays while enroute to or from the mill the truck drivers were asked to record such times and report them to the observer.

The hourly cost of operating a $1\frac{1}{2}$ ton truck and trailer was taken from a U.S. Forest Service Occasional Paper #107, Dec., 1945, by R. R. Reynolds, and given in Table 6.

Table 6

Estimated costs per truck used for log hauling
($1\frac{1}{2}$ ton, 85 horsepower truck with trailer)

Investment:	
Truck, complete with cab and dual wheels	$1740.12
Trailer, complete with dual wheels	603.43
Gross Investment	2343.55
Minus tires[1]	955.48
Net Investment	1388.07
Less trade-in-value of truck and trailer	450.00
Total amount to be depreciated	938.07
Fixed Expenses:	
Interest on investment[2] at 6% per year	68.54
License and taxes	51.31
Operating overhead and risk	50.00
Total per year	169.85
Fixed expenses above, per day (225 -day year)	.755
Depreciation of truck[3] and trailer[4] per day	2.208
Total per day	2.963
Fixed expenses per hour (8 hour day), truck, trailer	.370
Driver, cost per hour	.750
Social security -- 4% labor cost	.030
Total fixed expenses per hour	$ 1.150
Running expenses per mile:	
Woods or low-quality roads	
Tires (life -- 4,000 miles)	.239
Gasoline -- (4 miles per gallon)	.050
Oil and grease	.003
Repair Labor	.100
Repair supplies	.010
Total	.312
Graded dirt or better-quality road:	
Tires (life -- 7,500 miles)	.127
Gasoline -- (8 miles per gallon)	.025
Oil and grease	.003
Repair labor	.010
Repair supplies	.010
Total	.175

1 -- Cost of tires: Front tires and tubes, 7.50 x 20, $89.74 each.
Head and trailer, 8.25 x 20, $97.00 each.

2 -- Average investment -- $\frac{\text{Initial investment and trade-in-value and}}{\text{annual depreciation}}$

Truck = $\frac{1,172.64-400}{2} - \frac{434.61}{2}$ = $1,003.62

Trailer = $\frac{165.43 - 50.00}{2} - \frac{62.10}{2}$ = $138.76

$1,142.38

3 -- Life = 400 days

4 -- Life = 600 days

Table 7

Time requirements[1] and cost[2] per load and per M for truck hauling, by test block

Test block	Volume (Bd, ft.)[3]	Total no. loads	Volume per load	Hauling time round trip (hour)	Hauling Costs[4] per load	Hauling Costs[4] per M
			Short logs			
1	63,431	40	1591	1.584	$5.502	$3.456
3	50,684	33	1521	1.584	5.502	3.610
Average			1556	1.584	$5.502	$3.533
			Long logs			
2	68,763	37	1851	1.584	$5.502	$2.970
4	44,667	26	1729	1.584	5.502	3.180
Average			1790	1.584	$5.502	$3.075

1 -- Including unload time and delays

2 -- Based on .4 mile woods road and 9.8 miles gravel road.
Total = 10.2 miles or 20.4 roundtrip miles.
Fixed expenses per hour ----------------------------$1.150
Running expenses on woods road (.8x$.312) -- $0.250
Running expenses on gravel road (19.6x.175) - 3.430
$3.680

3.-- Doyle-Scribner rule

4 -- ~~Truck stand-by charge included~~ ~~Plot 1 - 13.87 minutes $0.265~~
~~Plot 2 - 25.87 minutes $0.494~~
~~Plot 3 - 18.00 minutes $0.344~~
~~Plot 4 - 24.31 minutes $0.464~~

It was found that total time per round-trip haul was not affected by log length, so for use in Table 7 an average total time was used for all plots. Total time per round-trip haul included both effective and ineffective time. Effective time consists of travel time and unload time. Round-trip haul time being the same for all plots, the only factors influencing unit costs are stand-by time for the truck while loading, and volume per load. The increased stand-by time, equivalent to loading time, on the long-length log plots increased unit costs, while the greater volume per load decreased unit costs. It is evident, from the last column on Table 7, that the increased volume per load had a greater influence in reducing unit costs than did stand-by charges. This may be realized by the fact that running expenses for truck and trailer are three times the fixed charges. From Table 7 is shown a 38.6 cent saving in hauling long-length logs.

In conclusion it may be said that a 10.3 per cent reduction in cost was realized in hauling long-length logs.

SUMMARY OF LOGGING COSTS:

Large areas of timberland in the South are owned separately from sawmills. Private timberland owners with 500 acres or more can engage in selling logs independently of manufacture. It is common practice, also, for manufacturing concerns owning timber to contract the logging. Resulting costs of this study are, therefore, of great concern to many. Initial interest in the production of long-length logs must necessarily come from the sawmill operators and other manufacturing concerns, since they must be equipped to handle the long lengths as they arrive at the mill. Table 8 presents an overall picture of costs of logging long vs. short-length logs. The felling and bucking costs for plot 4 are arbitrary, and the figures used are conservatively high. Contractors cutting tree-length logs would very likely reduce bucking costs at the landing by using a portable buck saw or some similar means. It is evident, however, that cost of skidding tree-length logs is considerably higher than either the normal short log or the long logs on plot 2. The difference in felling and bucking, and skidding methods on plots 2 and 4 does not permit the averaging of total operating costs as done with plots 1 and 3.

MILL COSTS IN LONG-LENGTH LOG PRODUCTION:

Typical of the larger mills in the South is the Crossett Lumber Co. Such a mill usually has two or more head saws, each cutting 60 to 90 M-board feet per 8-hour shift. If such a mill were to start handling long-length logs it would have to have some means of cutting the long lengths into shorter lengths so that a maximum of grade and price could be realized. Costs of operating a swing saw at the foot of the jackladder are estimated as follows:

Cost of operating swing saw per 8-hour shift ----	$10.00
Cost of experienced operator per 8-hour shift ---	10.00
Total cost ---	$20.00

Production -- 2 head saws cutting 60 to 90 M-board feet per 8-hour shift -- (120 to 180 M)
Average -- 150 M

Estimated cost per M-board feet -- $\frac{\$20}{150\ M}$ -- $0.133

Cost per M-board feet will vary with production. Also, the size of the mill will determine the type and expense of saw used.

Table 8

Time requirements (man-minutes) and cost per M for all logging operations, by test block

Dayle-Scribner Rule

Test Block	Fell & Buck dollars	Skidding[1] man-min.	Skidding[1] dollars	Loading[2] man-min.	Loading[2] dollars	Hauling[3] man-min.	Hauling[3] dollars	Total[4] man-min.	Total[4] dollars
				Short Logs					
1	1.802	23.00	1.034	9.47	0.450	95.04	3.625	127.51	6.911
3	1.709	28.65	1.284	11.14	0.529	95.04	3.840	134.83	7.362
Average	1.755	25.82	1.159	10.305	0.490	95.04	3.732	131.17	7.136
				Long Logs					
2	1.521	27.66	1.240	13.90	0.660	95.04	3.237	136.60	6.655
4	1.161	37.80	1.697	13.90	0.660	95.04	3.455	146.74	6.973
Average				13.90	0.660	95.04	3.346		

1 -- Rate per man-minute = $0.0449
2 -- Rate per man-minute = $0.0475
3 -- Running expenses for 20.4 miles = $3.680
Fixed expenses per hour = 1.150
4 -- Felling and bucking time not included
5 -- $2.771 plus 4% social security

II. INDIVIDUAL LOG VALUES -- HOW EFFECTED IN LONG-LENGTH LOGGING.

With competition as it is today and the increased practice of sustained yield management, operators must realize the economical diameter limit in their operations in order to stay in business. It is not always possible for loggers to produce logs of the smaller size but still acceptable by the mill; that is, a mill may accept logs down to an eight inch minimum top diameter, but the logger may only be able to profitably produce logs to a ten inch top, thus resulting in a loss for the logger if he produces eight inch logs or a loss to the mill if he does not.

Thus, tables 9 to 17 show the relationship of size to time and cost in production of long vs. short-length logs.

FELLING AND BUCKING: (on next page)

~~With cost per M board feet constant, regardless of log size, it is not necessary to construct cost tables. The cost of cutting per M board feet, $2.771 plus 4 per cent social security, on plot 4 is used in table 19, as explained in Part I.~~

SKIDDING:

In order that skid time per log size might be determined, it was necessary to calculate the average log diameter for each turn and record the volume in board feet, Doyle-Scribner scale. For short logs average log diameters were calculated to the nearest one half inch. An average volume was then found for each average log diameter and these averages plotted and curved to give column two in tables 9, 10, 11 and 12. This may be more clearly shown by an example. A tractor skids two

FELLING AND BUCKING:

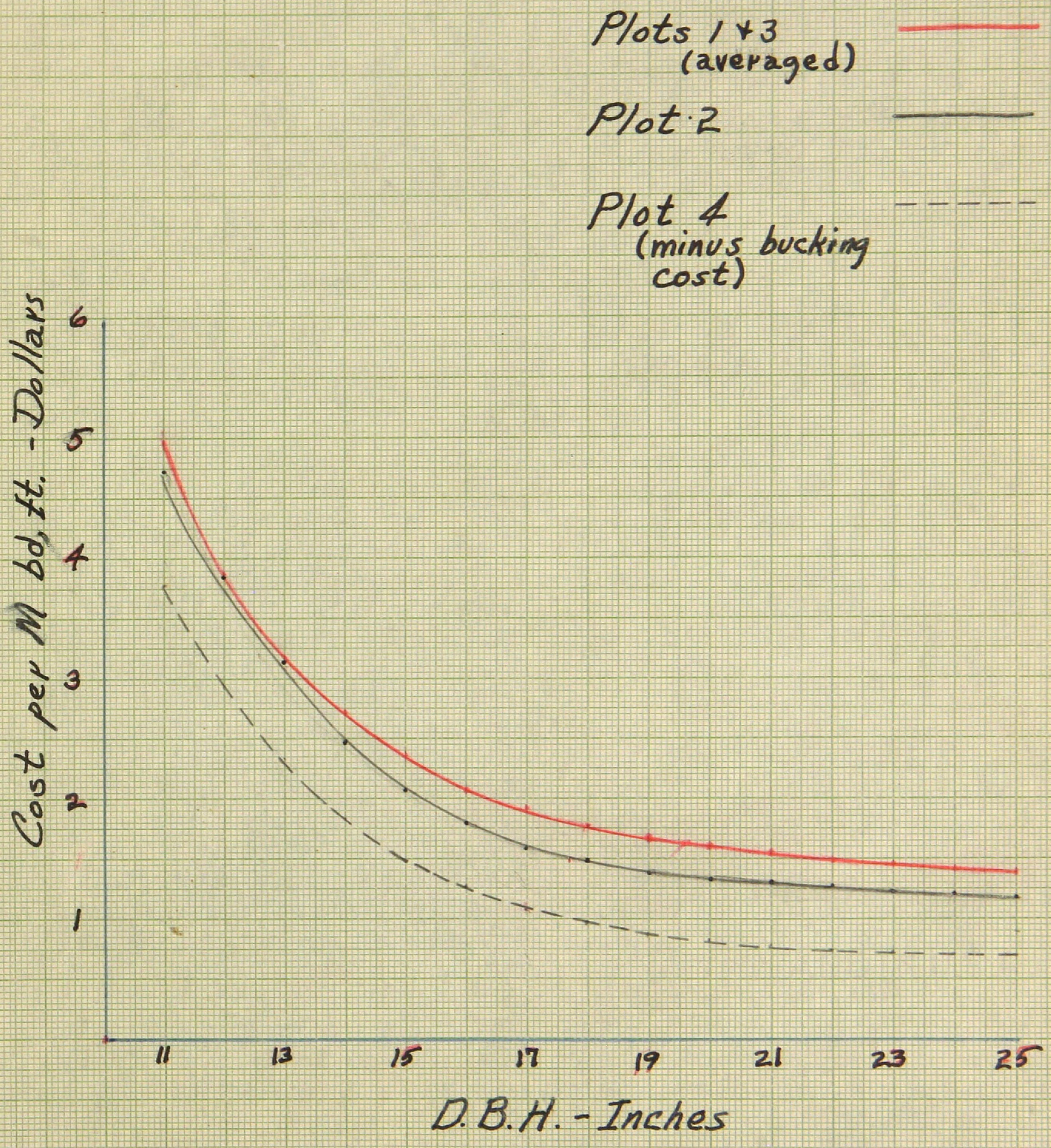
Figure XX presents the cost of felling and bucking per M board feet for tree diameters 11 to 25 inches. As explained in Part I, the lack of data on bucking of tree lengths at the landing prevents a true comparison 66 felling and bucking to the bucking of long and short lengths in place in the woods. Curves in Figure XX were constructed from data in Tables A,B, and C in Appendix.

Felling and bucking costs per tree and per M board feet were obtained as follows: Basic data was merchantable volume per tree and the time in man-hours for felling and bucking per tree. Cost per tree was calculated by multiplying time per tree by the hourly rate, $2.00. Cost per M per diameter class was found by dividing the volume per tree into 1000, and mul'ipling the quotent by the cost per tree.

Cost curves on Figure XX for short and long-length logs tend to level off after 17 inches and the cost difference is constant. The cost of felling and bucking increases sharply for diameters below 17 inches. The felling cost curve for plot 4, tree length, follows the same cost trend as the felling and bucking cost curv s for long and shott-length logs. This means that the percentage of bucking cost to felling costs may be greater in the larger diameters, 17 inches and up, and that this method of felling and bucking is better adapted to the larger diameters.

Figure XX

Felling & Bucking Costs



logs, one 13 inches in diameter and the other 15 inches in diameter. The average log diameter for the turn is, therefore, 14 inches. The volume for the two logs is determined and recorded in the 14 inch average log diameter column at 221 board feet. All the volumes in the 14 inch class are then averaged, plotted and curved with the resulting volume of 250 board feet for the 14 inch class as in column 2, table 9. Calculation of average diameter per turn for the long-length logs was similar to above explanation except that the diameters measured along the long log in order to scale it accurately were averaged to get an average diameter for each long-length log. The third column in tables 9 to 12 simply show the average volume of a single log, long or short, for each diameter. For short logs on plots 1 and 3 the average length produced was sixteen feet. The average length for the long logs on plots 2 and 4 was calculated for each diameter class, because log lengths varied considerably. It was found that log size did not have any effect on skidding time per turn, so an average turn time was calculated for each plot. Delay time was included in the average turn time by determining the efficiency rate of the tractor, for the short log plots 77.5 per cent, and 67.7 per cent for the long log plots. With time and volume per turn and per diameter class skidding costs per log and per M board feet were easily found by using proportions. Time and cost of skidding per log and per M board feet for 14 inch logs in table 9 was calculated as follows: Dividing the average volume per log into the average volume per turn gives the number of logs per turn, 250/100 -- 2.5 logs. This quotient may then be divided into the average time per turn to give skidding time per log, 5.44/2.5 -- 2.17 man minutes. Time per M board feet is found by dividing the average volume per log into 1000 to give the number of logs required to make M board feet, 1000/100--10 logs. This quotient is multiplied by skid time per log to give the skid time per M board feet, 10 x 2.17--21.70 man-minutes. Costs are found simply by multiplying the time per log and per M board feet by the machine rate of the tractor (table 2); 2.17 x $0.097 per log, 21.7 x $0.0449--$0.975 per M.

Figure I graphically presents costs per M board feet for skidding. Similar cost trends may be seen for both long and short-length logs. The cost curve for short logs crosses the long log curve of plot 2 between the eleven and twelve inch diameter class, but the difference between the two curves is very small in all classes. Only tree length skidding shows any marked difference in cost, and this difference is only in the lower diameter classes, from eight to fifteen inches, where it merges with the long log cost curve.

<u>LOADING</u>:

An average loading time per log was used in tables 13 to 16, since it was found that log size did not materially effect loading time. In calculating the average diameter for the long logs the figures found in "SKIDDING", as explained above, were used.

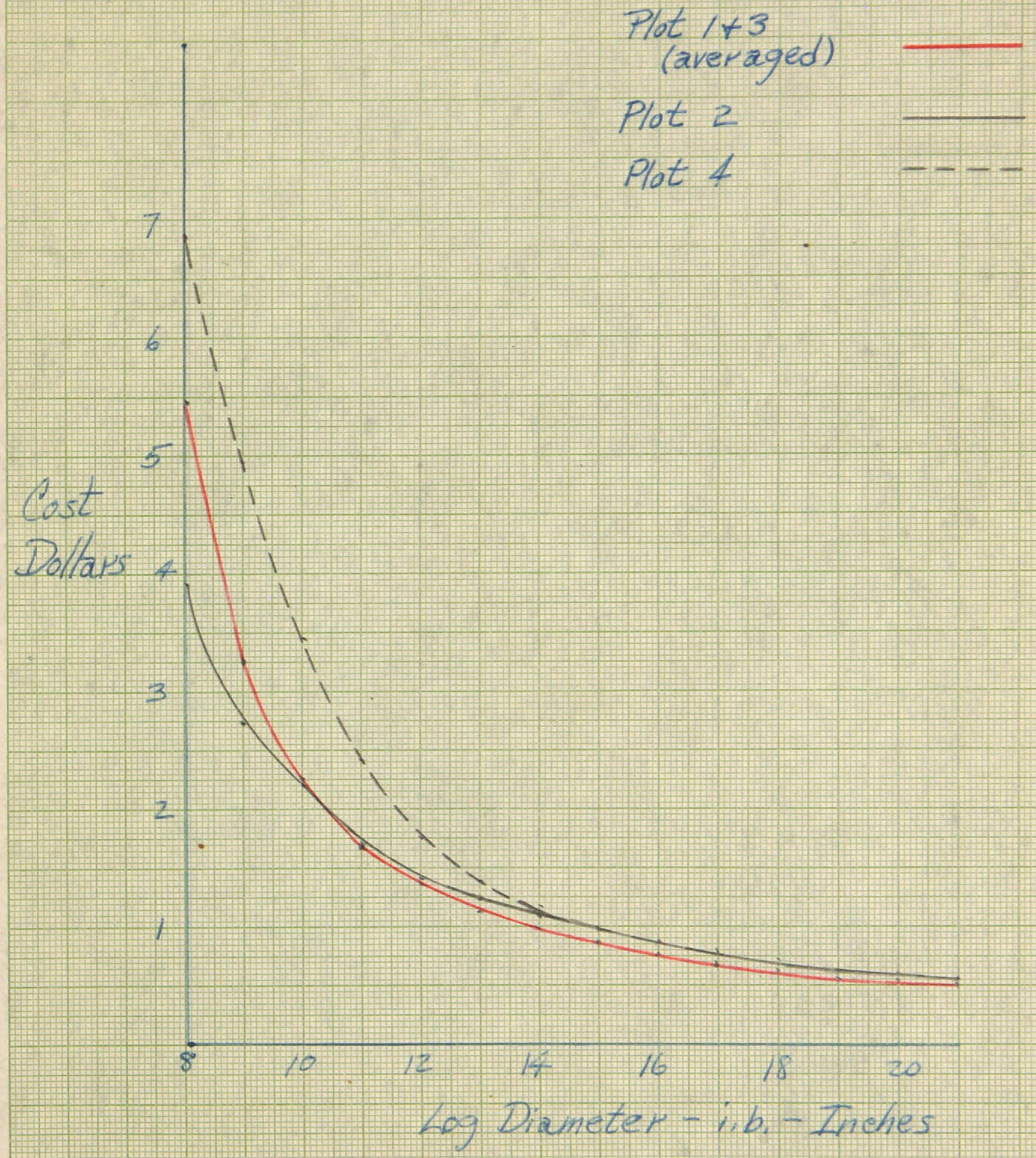
From Figure II it is definitely shown that cost per M board feet is higher when loading long-length logs than when loading short-length logs, but the difference in cost diminishes from 45 cents for ten inch logs to 5 cents for eighteen inch logs. Extension of the cost curves to thirty inches would probably show lower costs for loading long-length logs.

<u>HAULING</u>:

The time required for the 10.2 mile truck haul was 95 minutes,

Figure I

Skidding Cost Per M Board Feet



10 Millimeters to the Centimeter
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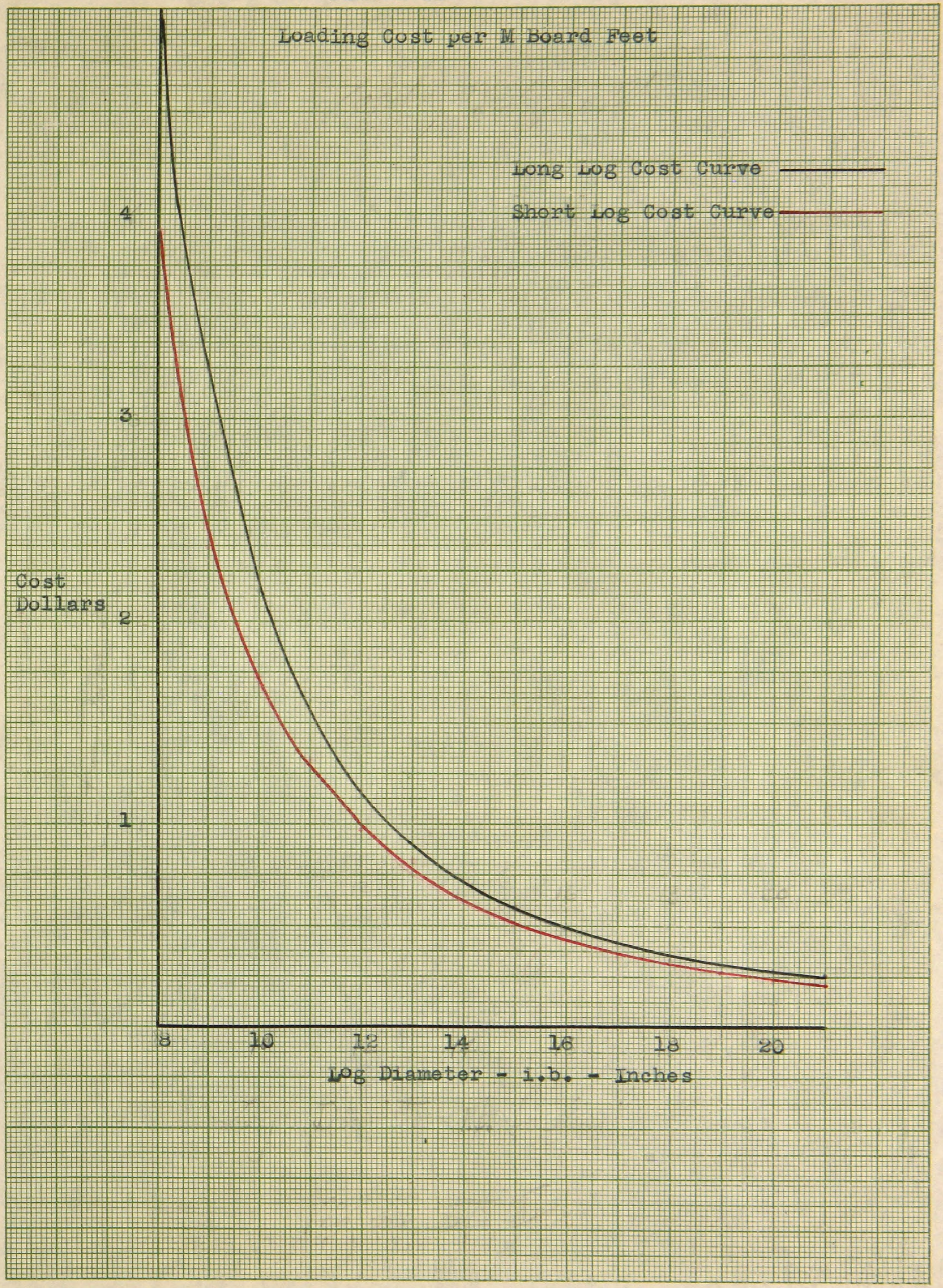
FIGURE II



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an average of all plots. No properly conducted selective-logging operation produces logs of one size only from any cutting area, and logs are never hauled in loads of uniform log diameter. Therefore, in order to prorate time and cost to log sizes it was necessary to calculate the number of logs, for each diameter class, required to make a load. This is shown in column 2, table 17. To find time and cost per log and per M board feet simple proportions were used as those used to calculate skidding time and cost.

The largest difference in cost of logging long vs. short-length logs occurs in the hauling operation. Figure III shows a definite saving when hauling long-length logs. These savings are attributed solely to the larger volume per load when hauling long-length logs. Coupled with the fact that loads are never built of uniform log diameter and the volume capacity of the $1\frac{1}{2}$ ton truck generally used in the locality is approximately 2.5 M board feet, Doyle-Scribner scale, costs for hauling long-length logs on table 17 can not actually be realized, but will approach those costs of short-length logs.

SUMMARY OF LOGGING COSTS:

It is generally accepted, through intensive study and research, that there is a marked effect of log size on logging costs. Costs per unit of volume decrease with an increase in log diameter. This was found true with all single operations, skidding, loading, and hauling, within the study. Cost curves on Figure IV, though not applicable to a logging operation, do show definite cost reductions in favor of long-length logs. Total costs increase rapidly as the logs become smaller.

FIGURE III

Hauling Cost per M Board Feet

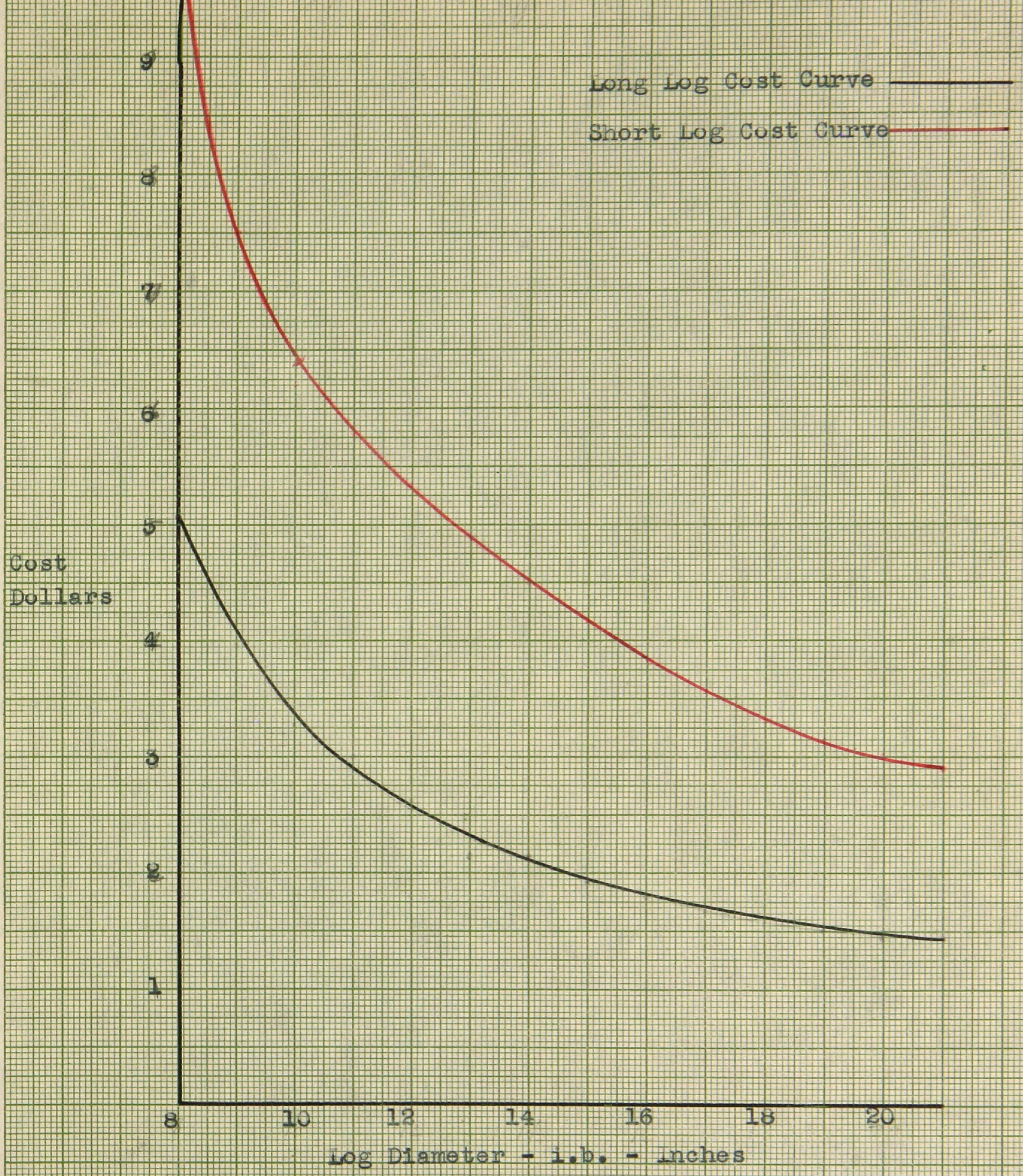

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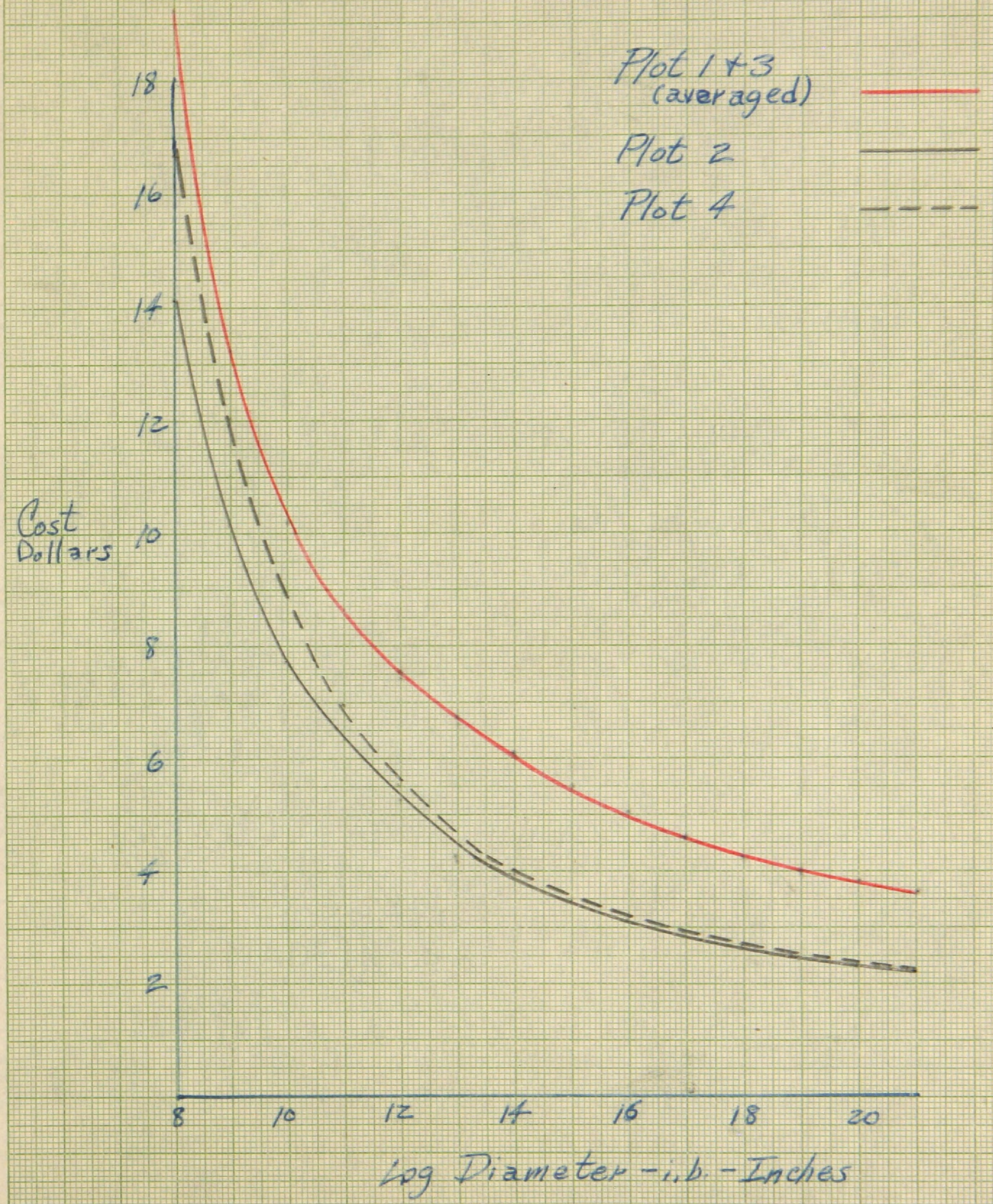
Figure IV

Logging Cost Per M Board Feet
(minus Felling & Bucking Costs)



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The rapidity of growth of southern pines, particularly in the small and medium diameter classes, is well enough known to make it very obvious that holding vigorous individual trees for ten or twenty years not only will permit each tree to double in volume but also will bring greatly reduced logging costs per unit of volume. These savings in utilization costs far exceed the cost of holding these trees sizes for a few more years.

Cost curves in Figures I to IV were constructed from data in tables 9 to 20 located in APPENDIX.

III. LOG GRADE RECOVERIES -- LONG vs. SHORT-LENGTH LOGS

The use of experienced men in any position is generally considered most desirable for the best quality and quantity output of work. The head sawyer in a sawmill is a key man in producing the greatest returns in grade recovery from sawlogs. It is only through long years of working on and around the log carriage that a man can get the experience required for a sawyer. The edger and the trimmer must also be experienced men in order to obtain the best grade recoveries from the lumber produced. However, present practices allow the use of inexperienced men to determine the grade of log that goes through the mill. Though the saw crews in the woods may be very efficient in log production, they do not know the effect of log defects on the lumber produced. This is not to say that logs are cut with no thought of grade, because an attempt is made to cut out crook and sweep. However, without actually seeing just what grades of lumber can be cut from logs with different defects and just how these defects effect grade recovery it is impossible to obtain a maximum of the higher logs grades when logs are cut in the woods. The production of long-length logs in the woods would permit the use of a man, experienced in grade recovery, to control the bucking of these logs into shorter lengths at the mill.

In order to determine if the cutting of long-length logs into shorter lengths at the mill will result in better utilization practices it would have been desirable to run a mill scale study on these logs. Since this was not done it was desirable to record the lengths and log grade of each log cut at the mill from the tree-length or long-length material as produced in the woods. This gives a comparison of the log scale and log grade of the material as it would have been cut had short logs been cut from it in the woods.

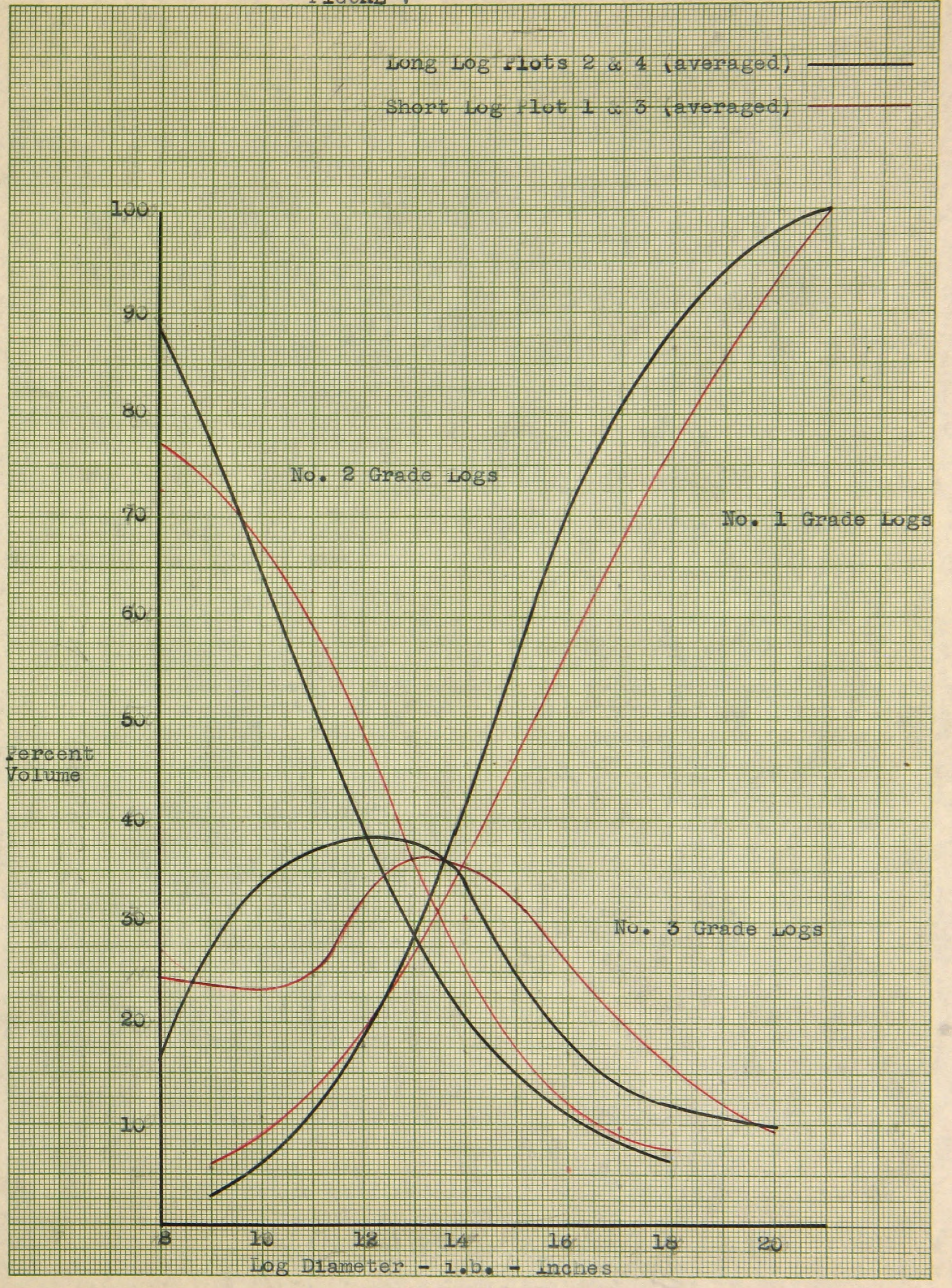
Figure V presents percentage curves for grades #1, #2, and #3 logs by volume for long and short-length logs. The long log curve is an average of plots 2 and 4, and the short log curve an average of plots 1 and 3. Data for figure VI was taken from table 21 (Appendix). Long log production produced 7.7 per cent more grade #1 logs by volume in logs twelve inches and larger, or an average increase of 4.2 per cent for all diameters. The production of grade #2 logs may be seen to vary greatly with the size, but there were on the average 2.2 per cent by volume more short logs produced than long logs. Grade #3 logs varied very little with only a 0.75 per cent increase for short logs.

In order to more fully appreciate the significance of the percentages above the following data is presented to show the difference in grades of lumber produced from the three log grades. This data was taken from the United States Forest Service Bulletin No. 861, June, 1944.

Log grade	Per cent of grade produced				Dimensions and timbers
	B&B	#1C	#2C	#3C	
1	30	27	25	2	16
2	15	34	33	6	12
3	5	30	51	9	5

It may be seen that No. 1 grade logs yield 15 per cent more B and Better lumber than No. 2 grade logs and 25 per cent more than No. 3 grade logs. In general, it may be seen that a higher percentage of high grade lumber can be produced from No. 1 grade logs, and a lower percentage of the lower grade lumber.

FIGURE V



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In conclusion, it may be stated that the cutting of long-length logs at the mill under experienced supervision yields a higher percentage of better grade logs than when cut to short lengths by the saw crews in the woods.

IV. LOGGING DAMAGE.

In order to study thoroughly the results of long-length logging it was necessary to record the results of damage to the remaining timber and reproduction after logging. These results are of prime importance to the timberland owner, since the first thought in the production of long-length logs from the silvicultural standpoint would be the increased difficulty in skidding, resulting in a probably increase of skinning and binding of the logs on the standing timber, and reproduction destruction. Except in a liquidation operation, which is rapidly disappearing as a part of management policy, the remaining stand holds the key to the future health and productivity of the stand and future financial returns to its owner. In selectively cut stands this is especially important.

Records of the damage were classified according to tree size, namely, reproduction and logs, poles, and saplings. The stocked quadrat method was used for inventorying reproduction. Forty quadrats were observed on each plot. Each quadrat was divided up into four milacres with each milacre being classified into one of the following categories: (1) reproduction present; (2) no reproduction present, but not as a result of logging damage; (3) evidence of logging damage. It was also recorded, if logging damage was evident according to the type of damage, that is, by skidding, by road construction, or by the construction of banking grounds. From this data it was possible to figure the approximate percentage of the area disturbed by the logging operation. The percentage of stocking is then found by dividing the number of milacres, both with and without reproduction. These two quotients are then multiplied together to give the approximate per cent of reproduction previously present which had been damaged by logging. The following table represents a summary of the reproduction inventory data.

Table 22

Plot No.	Percent of area touched by logging.	percent of stocking.	Reproduction damage Percent
1	16.25	62.09	10.10
2	20.64	37.80	7.81
3	25.00	68.30	17.08
4	14.40	67.20	9.68

With the exception of plot #2 it may be seen from the preceding table that all plots are equally stocked with reproduction. However, considering equivalent stocking on plot #2, approximately 65 per cent, the resulting per cent of reproduction damage would be approximately 13 per cent. A comparison of the average per cent of reproduction damage for plots #1 and #3 (13.59 per cent) as compared to that average for plots #2 and #4 (approximately 11.34 per cent) indicate that the logging of long-length logs does not result in greater damage to reproduction.

Column 2, in table 22, may be broken down into the type of damage incurred.

Damage from;	Plot #1	Plot #2	Plot #3	Plot #4
Skidding	57.7	63.6	55.0	82.6
Banking	38.5	18.2	22.5	00.0
Roads	3.8	18.2	22.5	17.4
Total	100	100	100	100

Skidding has been shown to be greatest factor in reproduction damage. A higher percentage of damage is caused by skidding in the long log plots #2 and #4, and lower percentages for banking and roads. This is due to the fact that plots #2 and #4 required fewer banking points, thus fewer roads and longer skids.

The damage to logs, poles, and saplings was recorded by a 10 per cent line-plot inventory. Table 23 shows nature of records kept and the results.

Table 23

Type of damage	No. of trees damaged, by plot			
	1	2	3	4
I. Butt damage				
a. light skinning	15	12	9	12
b. heavy skinning	1	0	0	0
c. Uproot	0	0	0	1[1]
II. Upper bole				
a. light skinning	4	0	5	2
b. heavy skinning	0	0	0	0
c. top broken	0	0	0	0
III. Bent over	0	0	0	0
IV. Broken off	2[2]	0	0	0

1. 5 inch tree.
2. 4 and 5 inch tree.

Butt damage may be attributed to skidding, whereas, the other types of damage result from felling. Damage to the upper bole was very light, because the saw crews were instructed to cut any merchantable tree heavily skinned or with a borken top due to felling. From table 23, light butt damage appears equal for both long and short log plots, indicating that the skidding of long-length logs and tree lengths does not result in greater damage to standing timber. This may be attributed to directional felling exercised on plots #2 and #4, and fewer number of turns required by the tractor.

CONCLUSION

Log-production costs in the western part of the pine-hardwood region in the Lower South have increased 129 per cent during the war years from 1940 to 1945. Wage rates have risen contrary to a decrease in labor efficience. Transportation and maintenance costs have risen, due mainly to shortage and increased price of new equipment and supplies. Supervision costs have also risen with the change from contract to direct-employment operations. Equipment and supplies are now returning to the market, but prices are still high, and wages show no indication of coming down.

Present logging in the south is conducted almost entirely in second-growth stands just now reaching merchantable sawlog size. These second-growth stands are not yet producing the size and quality trees found in the original virgin stands, thus average log diameters per operation have decreased resulting in higher logging costs. Forestry is being practiced more intensively than before and competition is greater. Considering the prevailing logging conditions the logging operator today who seeks and realizes new and cheaper methods of logging is the one who will survive and stay in business.

Results and conclusions from the studies are summarized as follows:

(1) Felling and bucking time per tree and per unit of volume is reduced when producing long-length logs.

(2) No appreciable difference in skidding costs was indicated between long and short-length logs. However, a 53.8 cent increase per M board feet resulted in tree-length skidding compared to usual short-

length skidding. This increase is due to the increased time per turn.

(3) The loading costs for long-length logs was 17 cents higher than short logs. The increase loading time per log may be attributed to inadequate equipment and inexperience in loading long-length logs, since a larger number of long logs had to be cross-hauled.

(4) The largest saving in long-length logging may be realized in the hauling operation. A saving of 10.3 per cent was realized as an average for plots #2 and #4 over averages for plots #1 and #3.

(5) Long-length logs cut at point of felling, plot #2, showed a 3.2 per cent decrease in total logging costs over the averaged costs for plots #1 and #3.

(6) Time and costs increase with a decrease in log size, from figures I to IV in part II, and from tables 9 to 20 in Appendix.

(7) Experienced supervision in the bucking of long-length logs at the mill yields a higher percentage of better grade logs than when cut to short lengths by the saw crews in the woods.

(8) The effect of long-length logging on selectively cut stands was approximately the same as the usual short-length logging. Indications show that slightly greater damage to reproduction results when skidding tree-length and long-length logs, but a decrease in damage due to roads and banking. Skinning of standing timber by skidding appeared equal on both the long and short log plots.

(9) The mobile loader used in the study was not large enough to efficiently handle many of the larger long-length logs. Larger loaders are necessary for efficient loading.

(10) The disorganization for skidding and bucking of tree-lengths on plot #4 resulted in a great deal of delay time, especially for the reskidding of the long logs after bucking. Therefore, time and cost figures for plot #4 are unreasonably high and do not show a true picture of normal operation and efficiency.

Time of production for each part of the logging operation is given in man-hours or man-minutes to permit easy application in operations in which unit costs differ from those of the experimental operation, and also to facilitate revision of cost figures as changes take place in conditions affecting costs.

In general, the results of this study show that long-length log production, as produced on plot #2, offers lower logging costs along with better utilization in the form of increased volume of better grade logs. Results also show that the effect of long-length logging from the silvicultural standpoint is not more injurious to the remaining stand. It is also offered as a means of improving and speeding up the development of better utilization methods so badly needed in the South.

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APPENDIX

SUPPLEMENTARY TABLES FOR PART II AND III

<u>Plot 1</u>

Table A

Cost per tree and per unit of volume for felling and bucking shortleaf-loblolly pines.

Doyle-Scribner Rule

D.B.H. Inches	Average Vol. per Tree	Man-hours per Tree	Hourly Cost Dollars	Cost - Dollars per Tree	Cost - Dollars per M
11	50	.133	2.00	.266	5.320
12	68	.140	2.00	.280	4.110
13	89	.150	2.00	.300	3.370
14	112	.164	2.00	.328	2.930
15	138	.180	2.00	.360	2.610
16	174	.198	2.00	.396	2.275
17	213	.220	2.00	.440	2.067
18	259	.245	2.00	.490	1.895
19	310	.274	2.00	.548	1.767
20	366	.304	2.00	.608	1.660
21	423	.336	2.00	.672	1.590
22	485	.370	2.00	.740	1.525
23	547	.405	2.00	.810	1.480
24	610	.441	2.00	.882	1.447
25	675	.476	2.00	.952	1.414

<u>Plot 3</u>

Table C

Cost per tree and per unit of volume for felling and bucking shortleaf-loblolly pines.

Doyle-Scribner Rule

D.B.H. Inches	Average Vol. per Tree	Man-hours per Tree	Hourly Cost Dollars	Cost - Dollars per Tree	Cost - Dollars per M
11	45	.104	2.00	.208	4.620
12	63	.116	2.00	.232	3.683
13	89	.134	2.00	.268	3.008
14	122	.153	2.00	.306	2.510
15	161	.174	2.00	.348	2.160
16	205	.192	2.00	.384	1.874
17	250	.222	2.00	.444	1.777
18	300	.250	2.00	.500	1.666
19	350	.278	2.00	.556	1.587
20	400	.309	2.00	.618	1.545
21	450	.340	2.00	.680	1.511
22	505	.373	2.00	.746	1.478
23	560	.403	2.00	.806	1.440
24	620	.431	2.00	.862	1.392
25	675	.470	2.00	.940	1.592

Plot 2

Table B

Cost per tree and per unit of volume for felling and bucking shortleaf-loblolly pines.

Doyle-Scribner Rule

D.B.H. Inches	Average Vol. per Tree	Man-hours per Tree	Hourly Cost Dollars	Cost per Tree	Dollars Per M
11	50	.118	2.00	.236	4.725
12	64	.124	2.00	.248	3.870
13	85	.134	2.00	.268	3.153
14	118	.146	2.00	.292	2.475
15	154	.160	2.00	.320	2.078
16	195	.175	2.00	.350	1.798
17	240	.192	2.00	.384	1.600
18	287	.213	2.00	.426	1.488
19	338	.236	2.00	.472	1.396
20	390	.262	2.00	.524	1.343
21	447	.293	2.00	.586	1.311
22	510	.325	2.00	.650	1.272
23	579	.358	2.00	.716	1.230
24	649	.393	2.00	.786	1.212
25	720	.429	2.00	.858	1.191

Plot 4

Table D

Cost per tree and per unit of volume for felling shortleaf-loblolly pines. (Does not include bucking costs.)

Doyle-Scribner Rule

D.B.H. Inches	Average Vol. per Tree	Man-hours per Tree	Hourly Cost Dollars	Cost per Tree	Dollars per M
11	45	.085	2.00	.170	3.790
12	64	.094	2.00	.188	2.940
13	88	.103	2.00	.206	2.342
14	124	.114	2.00	.228	1.840
15	166	.123	2.00	.246	1.484
16	212	.134	2.00	.268	1.267
17	265	.145	2.00	.290	1.096
18	317	.156	2.00	.312	0.986
19	372	.163	2.00	.326	0.873
20	430	.181	2.00	.362	0.844
21	489	.194	2.00	.388	0.794
22	550	.208	2.00	.416	0.755
23	612	.224	2.00	.448	0.733
24	677	.240	2.00	.480	0.710
25	742	.260	2.00	.520	0.701

Table 9

Plot I (Short Logs)

Time requirements[1] (man-minutes) and cost[2] per log and per unit of volume for skidding[3] shortleaf-toblolly pine logs of various sizes

Dayle-Scribner Rule

Av. Dia. per Turn i.b.(Inch) & Basis Turns	Av. Volume per Turn (Board Feet)	Av. Volume per log (Board Feet)	Time man-minutes per log[4]	Time man-minutes per M	Cost - dollars per log	Cost - dollars per M
8 (0)	44	16	1.98	123.75	0.089	5.550
9 (3)	80	25	1.70	68.00	0.076	3.050
10 (4)	115	36	1.70	47.36	0.076	2.120
11 (14)	148	49	1.80	36.72	0.081	1.645
12 (22)	180	64	1.93	30.17	0.087	1.351
13 (22)	215	81	2.04	25.19	0.091	1.129
14 (15)	250	100	2.17	21.70	0.097	0.975
15 (22)	286	121	2.30	18.97	0.103	0.851
16 (14)	322	144	2.43	16.86	0.109	0.755
17 (11)	366	169	2.51	14.86	0.113	0.666
18 (3)	401	196	2.65	13.51	0.119	0.606
19 (2)	446	225	2.74	12.18	0.123	0.545
20 (0)	488	256	2.85	11.14	0.128	0.500
21 (0)	538	289	2.92	10.10	0.131	0.454

1 — Including delays
2 — Rate per man-minute = $0.0449
3 — Including hooking, skidding, and unhooking
4 — Based on average turn time 5.44 man-minutes

Table 10

Plot II (Long Logs)

Time requirements[1] (man-minute) and cost[2] per log and per unit of volume for skidding[3] shortleaf-loblolly pine logs of various sizes

Dayle-Scribner Rule

Ave. Dia. per Turn i.b.(Inches) & Basis Turns	Av. Volume per Turn (Board Feet)	Av. Volume per log	Time man-minutes per log[4]	Time man-minutes per M	Cost - dollars per log	Cost - dollars per M
8 (4)	80	31	2.71	87.50	0.122	3.920
9 (11)	114	47	2.88	61.25	0.129	2.746
10 (18)	147	68	3.24	47.60	0.145	2.130
11 (19)	186	95	3.57	37.58	0.160	1.685
12 (22)	225	130	4.05	31.20	0.182	1.400
13 (17)	261	188	5.05	26.90	0.226	1.202
14 (14)	296	210	4.96	23.65	0.223	1.070
15 (10)	332	258	5.44	21.07	0.244	0.945
16 (11)	368	308	5.86	19.05	0.263	0.855
17 (4)	408	361	6.19	17.15	0.278	0.770
18 (2)	450	413	6.41	15.52	0.288	0.698
19 (1)	495	469	6.62	14.11	0.297	0.634
20 (0)	546	525	6.72	12.80	0.302	0.575
21 (0)	603	584	6.77	11.60	0.304	0.521

1 -- Including delays
2 -- Rate per man-minute - $0.0449.
3 -- Including hook, skid, and unhook time
4 -- Based on average turn time, 7.00 man-minutes

Table 11

Plot III (Short Logs)

Time requirement[1] (man-minutes) and cost[2] per log and per unit of volume for skidding[3] shortleaf-loblolly pine logs of various sizes

Dayle-Scribner Rule

Av. Dia. per Turn i.b.(Inch) & Basis Turns	Av. Volume per Turn (Board Feet)	Av. Volume per log	Time man-minutes per log[4]	Time man-minutes per M	Cost - dollars per log	Cost - dollars per M
8 (3)	48	16	1.92	120.00	0.086	5.390
9 (7)	75	25	1.92	76.75	0.086	3.440
10 (16)	108	36	1.92	53.38	0.086	2.384
11 (19)	147	49	1.92	39.17	0.086	1.758
12 (24)	186	64	1.98	30.89	0.089	1.385
13 (15)	225	81	2.07	25.56	0.093	1.146
14 (13)	259	100	2.22	22.20	0.100	.996
15 (11)	293	121	2.38	21.68	0.107	.974
16 (9)	327	144	2.53	17.58	0.114	.789
17 (5)	359	169	2.71	16.04	0.121	.720
18 (3)	389	196	2.90	14.79	0.130	.663
19 (0)	417	225	3.10	13.79	0.139	.617
20 (1)	445	256	3.31	12.94	0.148	.580
21 (0)	468	289	3.55	12.28	0.159	.550

1 -- Including delays
2 -- Rate per man-minute = $0.0449
3 -- Including hook, skid, and unhook time
4 -- Based on average turn time, 5.75 man-minutes

Table 12 Plot IV (Long Logs)

Time requirements[1] (man-minutes) and cost[2] per log and per unit of volume for skidding[3] loblolly-shortleaf pine logs of various sizes

Dayle-Scribner Rule

Av. Dia. per Turn i.b.(Inches) & Basis turns	Av. Volume per Turn (Board Feet)	Time man-minutes		Cost - dollars	
		per tree length	per M	per tree length	per M
8 (0)	68	10.40	153.00	.467	6.867
9 (7)	94	10.40	110.60	.467	4.960
10 (8)	135	10.40	77.00	.467	3.460
11 (13)	194	10.40	53.50	.467	2.400
12 (17)	265	10.40	39.20	.467	1.761
13 (15)	335	10.40	31.05	.467	1.393
14 (9)	406	10.40	25.57	.467	1.149
15 (2)	476	10.40	21.84	.467	0.976
16 (0)	548	10.40	19.00	.467	0.850
17 (0)	617	10.40	16.82	.467	0.756
18 (0)	688	10.40	15.10	.467	0.677
19 (0)	758	10.40	13.71	.467	0.615
20 (0)	827	10.40	12.57	.467	0.564
21 (0)	896	10.40	11.60	.467	0.520

1 -- Including delays
2 -- Rate per man-minute - $0.0449
3 -- Including hook, skid, and unhook time

Table 13 Plot I (Short Logs)

Man-minute requirements[1] and cost[2] per log and per unit volume for loading shortleaf-loblolly pine logs of various sizes

Dayle-Scribner Rule

Dia. Log i.b. (Inches)	Av. Volume per log (Board Feet)[3]	Load Time man-minutes		Stand-by cost for truck (dollars)		Cost Dollars		Basis logs
		per log	per M	per log	per M	per log	per M	
8	16	.91	57.90	.018	1.110	0.0612	3.810	20
9	25	.91	36.40	.018	0.698	.0612	2.428	30
10	36	.91	25.27	.018	0.485	.0612	1.685	50
11	49	.91	18.58	.018	0.356	.0612	1.238	55
12	64	.91	14.21	.018	0.273	.0612	0.948	52
13	81	.91	11.24	.018	0.273	.0612	0.750	100
14	100	.91	9.10	.018	0.216	.0612	0.607	78
15	121	.91	7.52	.018	0.175	.0612	0.501	64
16	144	.91	6.32	.018	0.144	.0612	0.421	60
17	169	.91	5.38	.018	0.121	.0612	0.359	38
18	196	.91	4.64	.018	0.103	.0612	0.309	32
19	225	.91	4.05	.018	0.089	.0612	0.278	16
20	256	.91	3.56	.018	0.078	.0612	0.237	19
21	289	.91	3.15	.018	0.078	.0612	0.210	5

1 -- Including delays
2 -- Rate per man-minute = $0.0475

Table 14

Plot II (Long Logs)

Man-minute requirements[1] and cost[2] per log and per unit volume for loading shortleaf-loblolly pine logs of various sizes
Dayle-Scribner Rule

Dia. Log i.b. (Inches)	Ave. Volume per log (Board Feet)	Load Time man-minutes		Stand-by cost for truck (dollars)		Cost Dollars		Basis logs
		per log	per M	per log	per M	per log	per M	
8	31	2.42	78.10	.044	1.423	0.159	5.133	74
9	47	2.42	51.50	.044	0.938	0.159	3.384	45
10	68	2.42	35.60	.044	0.650	0.159	2.340	54
11	95	2.42	25.00	.044	0.465	0.159	1.676	42
12	130	2.42	18.61	.044	0.339	0.159	1.224	36
13	188	2.42	12.87	.044	0.234	0.159	0.844	46
14	210	2.42	11.51	.044	0.210	0.159	0.757	36
15	258	2.42	9.39	.044	0.171	0.159	0.616	24
16	308	2.42	7.85	.044	0.143	0.159	0.516	10
17	361	2.42	6.71	.044	0.124	0.159	0.443	14
18	413	2.42	5.86	.044	0.107	0.159	0.385	5
19	469	2.42	5.15	.044	0.094	0.159	0.339	4
20	525	2.42	4.60	.044	0.084	0.159	0.302	-
21	584	2.42	4.15	.044	0.076	0.159	0.273	1

1 — Including delays
2 — Rate per man-minute = $0.0475

Table 15

Plot III (Short Logs)

Man-minute requirements[1] and cost[2] per log and per unit volume for loading shortleaf-loblolly pine logs of various sizes

Dia. Log i.b. (Inches)	Av. Volume per log (Board Feet)	Load Time man-minutes		Stand-by cost for truck (dollars)		Cost Dollars		Basis logs
		per log	per M	per log	per M	per log	per M	
8	16	.98	61.20	.018	1.110	0.064	4.020	42
9	25	.98	39.20	.018	0.698	0.064	2.558	64
10	36	.98	27.20	.018	0.485	0.064	1.778	85
11	49	.98	20.00	.018	0.356	0.064	1.306	68
12	64	.98	15.31	.018	0.273	0.064	1.000	77
13	81	.98	12.10	.018	0.216	0.064	0.891	80
14	100	.98	9.80	.018	0.175	0.064	0.640	66
15	121	.98	8.10	.018	0.144	0.064	0.529	54
16	144	.98	6.80	.018	0.121	0.064	0.444	34
17	169	.98	5.80	.018	0.103	0.064	0.379	32
18	196	.98	5.00	.018	0.089	0.064	0.327	18
19	225	.98	4.35	.018	0.078	0.064	0.285	5
20	256	.98	3.83	.018	0.068	0.064	0.250	3
21	289	.98	3.28	.018	0.060	0.064	0.216	2

1 — Including delays
2 -- Rate per man-minute = $0.0475

Table 16

Plot IV (Long Logs)

Man-minute requirements[1] and cost[2] per log and per unit volume for loading shortleaf-loblolly pine logs of various sizes

Dia. Log i.b. (Inches)	Av. Volume per log (Board Feet)	Load Time man-minutes		Stand-by cost for truck (dollars)		Cost Dollars		Basis logs
		per log	per M	per log	per M	per log	per M	
8	31	2.18	70.30	.044	1.423	0.179	4.763	52
9	47	2.18	46.40	.044	0.938	0.179	3.139	38
10	68	2.18	32.10	.044	0.650	0.179	2.175	32
11	95	2.18	22.90	.044	0.465	0.179	1.553	22
12	130	2.18	16.80	.044	0.339	0.179	1.137	29
13	188	2.18	11.60	.044	0.234	0.179	0.785	29
14	210	2.18	10.40	.044	0.210	0.179	0.705	32
15	258	2.18	8.45	.044	0.171	0.179	0.572	19
16	308	2.18	7.08	.044	0.143	0.179	0.479	14
17	361	2.18	6.21	.044	0.124	0.179	0.419	6
18	413	2.18	5.28	.044	0.107	0.179	0.358	2
19	469	2.18	4.65	.044	0.094	0.179	0.315	-
20	525	2.18	4.15	.044	0.084	0.179	0.281	[illegible]
21	584	2.18	3.74	.044	0.076	0.179	0.253	-

1 -- Including delays
2 -- Rate per man-minute = $0.0475

Table 17

Man-minute requirements and cost[1] per log and per unit of volume for hauling[2] pines, by log size.

Plots 1 and 3 (Short Logs)

Dia. Log i.b. Inches	Logs per load	Volume[3] per log board feet	Haul time[4]		Cost - dollars	
			per log	per M	per log	per M
8	37.0	16	2.57	160.6	.157	9.850
9	31.0	25	3.06	122.5	.188	7.508
10	26.0	36	3.65	101.4	.224	6.215
11	20.4	49	4.65	94.9	.285	5.805
12	17.0	64	5.58	87.2	.342	5.346
13	14.7	81	6.46	79.8	.396	4.890
14	12.9	100	7.36	73.6	.451	4.510
15	11.5	121	8.25	68.2	.505	4.180
16	10.5	144	9.05	62.9	.555	3.850
17	9.6	169	9.90	58.5	.606	3.583
18	8.9	196	10.67	54.5	.654	3.340
19	8.2	225	11.58	51.5	.710	3.158
20	7.5	256	12.67	49.5	.776	3.030
21	6.9	289	13.78	47.5	.844	2.910

Table 17 (continued)

Plots 2 and 4 (Long Logs)

Dia. Log i.b. Inches	Logs per load	Volume per log board feet	Haul time		Cost - dollars	
			per log	per M	per log	per M
8	37.0	31	2.57	82.90	.157	5.075
9	31.0	47	3.06	65.00	.188	3.980
10	26.0	68	3.65	53.70	.224	3.290
11	20.4	95	4.65	49.00	.285	3.000
12	17.4	130	5.58	42.95	.342	2.630
13	14.7	188	6.46	34.40	.396	2.110
14	12.9	210	7.36	35.00	.451	2.143
15	11.5	258	8.25	32.00	.505	1.910
16	10.5	308	9.05	29.40	.555	1.800
17	9.6	361	9.90	27.40	.606	1.680
18	8.9	413	10.67	25.80	.654	1.580
19	8.2	469	11.58	24.70	.710	1.515
20	7.5	525	12.67	24.10	.776	1.478
21	6.9	584	13.78	23.60	.844	1.449

1 -- Rate per man-minute - $0.0613
2 -- Distance 10.2 miles
3 -- Dayle-Scribner Rule
4 -- Based on average haul time of 95 minutes.

Table 18

Cost[1] (dollars) per Log and per M for logging standard length pine logs, by log size

Plot 1

Dia. Log i.b. (Inches)	~~Felling and Bucking per M~~	Skidding		Loading		Hauling[2]		Total[3]	
		per log	per M	per log	per M	per log	per M	per log[3]	per M
8	~~2.080~~	0.089	5.550	0.061	3.810	0.157	9.850	0.313	19.210
9	~~2.080~~	0.076	3.050	0.061	2.428	0.188	7.508	0.324	12.966
10	~~2.080~~	0.076	2.120	0.061	1.685	0.224	6.215	0.361	10.020
11	~~2.080~~	0.081	1.645	0.061	1.238	0.285	5.805	0.421	8.688
12	~~2.080~~	0.087	1.351	0.061	0.948	0.342	5.346	0.490	7.645
13	~~2.080~~	0.091	1.129	0.061	0.750	0.396	4.890	0.548	6.669
14	~~2.080~~	0.097	0.975	0.061	0.607	0.451	4.510	0.609	6.092
15	~~2.080~~	0.103	0.851	0.061	0.501	0.505	4.180	0.669	5.432
16	~~2.080~~	0.109	0.755	0.061	0.421	0.555	3.850	0.725	5.046
17	~~2.080~~	0.113	0.666	0.061	0.359	0.606	3.583	0.781	4.608
18	~~2.080~~	0.119	0.606	0.061	0.309	0.654	3.340	0.835	4.255
19	~~2.080~~	0.123	0.545	0.061	0.278	0.710	3.158	0.894	3.981
20	~~2.080~~	0.128	0.500	0.061	0.237	0.776	3.030	0.965	3.777
21	~~2.080~~	0.131	0.454	0.061	0.210	0.844	2.910	1.037	3.574

Table 18 (continued)

Plot 3

Dia. Log i.b. (Inches)	~~Felling and Bucking per M~~	Skidding per log	Skidding per M	Loading per log	Loading per M	Hauling [2] per log	Hauling [2] per M	Total [3] per log	Total [3] per M
8	~~2.080~~	0.086	5.390	0.064	4.020	0.157	9.850	0.312	19.260
9	~~2.080~~	0.086	3.440	0.064	2.558	0.188	7.508	0.337	13.506
10	~~2.080~~	0.086	2.384	0.064	1.778	0.224	6.215	0.374	10.377
11	~~2.080~~	0.086	1.758	0.064	1.306	0.285	5.805	0.435	8.869
12	~~2.080~~	0.089	1. 385	0.064	1.000	0.342	5.346	0.495	7.732
13	~~2.080~~	0.093	1.146	0.064	0.891	0.396	4.890	0.553	6.927
14	~~2.080~~	0.100	0.996	0.064	0.640	0.451	4.510	0.615	6.146
15	~~2.080~~	0.107	0.974	0.064	0.529	0.505	4.180	0.676	5.683
16	~~2.080~~	0.114	0.789	0.064	0.444	0.555	3.850	0.733	5.083
17	~~2.080~~	0.121	0.720	0.064	0.379	0.606	3.583	0.792	4.682
18	~~2.080~~	0.130	0.663	0.064	0.327	0.654	3.340	0.849	4.332
19	~~2.080~~	0.139	0.617	0.064	0.285	0.710	3.158	0.913	4.060
20	~~2.080~~	0.148	0.580	0.064	0.250	0.776	3.030	0.988	3.860
21	~~2.080~~	0.159	0.550	0.064	0.216	0.844	2.910	1.068	3.677

1 -- Man-minute rates: Skidding, $0.0449; loading, $0.0475; hauling, $0.0613

2 -- Distance, 10.2 miles

3 -- Minus felling and bucking.

Table 19

Cost[1] (dollars) per log and per M for logging long length pine logs, by log size

Plot 2

Dia. Log i.b. (Inches)	Felling and bucking per M	Skidding		Loading		Hauling[2]		Total[3]	
		per log	per M	per log	per M	per log	per M	per log[3]	per M
8	2.080	.122	3.920	.159	5.133	.157	5.075	.438	14.128
9	2.080	.129	2.746	.159	3.384	.188	3.980	.476	10.186
10	2.080	.145	2.130	.159	2.340	.224	3.290	.528	7.760
11	2.080	.160	1.685	.159	1.676	.285	3.000	.604	6.361
12	2.080	.182	1.400	.159	1.224	.342	2.630	.683	5.254
13	2.080	.226	1.202	.159	0.844	.396	2.110	.781	4.156
14	2.080	.223	1.070	.159	0.757	.451	2.143	.833	3.970
15	2.080	.244	.945	.159	0.616	.505	1.910	.908	3.471
16	2.080	.263	.855	.159	0.516	.555	1.800	.977	3.171
17	2.080	.278	.770	.159	0.443	.606	1.680	1.043	2.893
18	2.080	.288	.698	.159	0.385	.654	1.580	1.101	2.663
19	2.080	.297	.634	.159	0.339	.710	1.515	1.166	2.488
20	2.080	.302	.575	.159	0.302	.776	1.478	1.237	2.355
21	2.080	.304	.521	.159	0.273	.844	1.449	1.308	2.243

1--Man-minute rates: skidding, $0.0449; loading, $0.0475, hauling, $0.0613.

2--Distance, 10.2 miles.

3--Minus felling bucking costs.

Table 19 (continued)

Plot 4

Dia. Log i.b. (Inches)	~~Felling and bucking per M~~	Skidding		Loading		Hauling[2]		Total[3]	
		per log	per M	per log	per M	per log	per M	per log	per M
8	~~2.882~~	.467	6.867	.179	4.763	.157	5.075	.638	16.705
9	~~2.882~~	.467	4.960	.179	3.139	.188	3.980	.622	12.079
10	~~2.882~~	.467	3.460	.179	2.175	.224	3.290	.657	8.924
11	~~2.882~~	.467	2.400	.179	1.553	.285	3.000	.692	6.953
12	~~2.882~~	.467	1.761	.179	1.137	.342	2.630	.750	5.528
13	~~2.882~~	.467	1.393	.179	0.785	.396	2.110	.837	4.288
14	~~2.882~~	.467	1.149	.179	0.705	.451	2.143	.871	3.997
15	~~2.882~~	.467	0.976	.179	0.572	.505	1.910	.936	3.458
16	~~2.882~~	.467	0.850	.179	0.479	.555	1.800	.996	3.129
17	~~2.882~~	.467	0.756	.179	0.419	.606	1.680	1.058	2.955
18	~~2.882~~	.467	0.677	.179	0.358	.654	1.580	1.113	2.615
19	~~2.882~~	.467	0.615	.179	0.315	.710	1.515	1.177	2.445
20	~~2.882~~	.467	0.564	.179	0.281	.776	1.478	1.251	2.323
21	~~2.882~~	.467	0.520	.179	0.253	.844	1.449	1.327	2.222

1--Man-minutes rates: skidding, $0.0449; loading, $0.0475. hauling, $0.0613.

2--Distance, 10.2 miles.

3--Minus felling bucking costs.

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Table 21

Grade recovery from pine logs, by log size

Dia. Log i.b. & Grade	Short Logs				Av. %	Long Logs				Av. %
	Plot I		Plot III			Plot II		Plot IV		
	Vol.	%Vol.	Vol.	%Vol.		Vol.	%Vol.	Vol.	%Vol.	
8 #1	-	-	-	-	-	15	.9	-	-	.45
2	96	35.3	112	19.0	27.15	163	12.7	89	7.4	10.05
3	176	64.7	480	81.0	72.85	1110	86.4	1110	92.6	89.50
9 #1	-	-	125	5.6	2.80	-	-	-	-	-
2	175	18.0	625	27.8	22.90	575	25.8	396	27.7	26.75
3	800	82.0	1500	66.6	74.30	1655	74.2	1034	72.3	73.35
10 #1	72	4.1	576	17.4	10.75	264	6.7	96	5.4	6.05
2	396	22.4	755	22.8	22.60	1450	36.7	576	32.7	34.70
3	1295	73.5	1980	59.8	66.65	2243	56.6	1089	61.9	59.25
11 #1	196	6.4	580	18.3	12.35	490	10.0	368	11.3	10.65
2	588	19.0	980	30.8	24.90	1570	32.0	920	28.1	30.05
3	2303	74.6	1615	50.9	62.75	2840	58.0	1979	60.6	59.30
12 #1	320	7.7	1470	28.7	18.20	1102	15.5	825	19.5	17.50
2	1471	36.0	2176	42.6	39.30	2495	35.0	1430	33.8	34.40
3	2301	56.3	1470	28.7	42.50	3540	49.5	1980	46.7	48.10

Table 21 (continued)

Dia. Log i.b. & Grade	Short Logs				Av. %	Long Logs				Av. %
	Plot I		Plot III			Plot II		Plot IV		
	Vol.	%Vol.	Vol.	%Vol.		Vol.	%Vol.	Vol.	%Vol.	
13 #1	973	13.5	2186	37.5	25.50	2101	25.0	2000	32.4	28.70
2	2590	35.9	2186	37.5	36.70	3160	38.0	2960	48.0	43.00
3	3650	50.6	1460	25.0	37.80	3080	37.0	1200	19.6	28.30
14 #1	2200	30.0	2500	41.6	35.80	3840	38.2	3550	52.9	45.55
2	2600	35.7	1900	31.7	33.70	4125	40.8	2267	33.8	37.30
3	2500	34.3	1600	26.7	30.50	2110	21.0	897	13.3	17.15
15 #1	3510	42.7	3750	62.0	52.35	3990	44.6	4220	65.4	55.00
2	3020	36.8	1695	28.0	32.40	2540	28.4	1490	23.1	25.75
3	1693	20.5	605	10.0	15.25	2420	27.0	745	11.5	19.25
16 #1	4600	57.0	4170	82.9	69.95	5050	62.2	3750	83.4	72.80
2	2740	34.1	720	14.3	24.20	1685	20.8	600	13.3	17.05
3	720	8.9	144	2.8	5.85	1375	17.0	150	3.3	10.15
17 #1	4560	64.4	3045	62.0	63.20	3750	83.0	2910	82.6	82.80
2	1860	26.1	1353	27.6	26.85	600	13.3	459	13.0	13.15
3	675	9.5	506	10.4	9.95	169	3.7	153	4.4	4.05
18 #1	4900	80.6	3530	94.7	87.65	2680	72.3	2341	100	86.15
2	613	10.1	196	5.3	7.70	618	16.6	-	-	18.30
3	563	9.3	-	-	9.30	411	11.1	-	-	11.10

Table 21 (continued)

Dia. Log i.b. & Grade	Short Logs				Av. %	Long Logs				Av. %
	Plot I		Plot III			Plot II		Plot IV		
	Vol.	%Vol.	Vol.	%Vol.		Vol.	%Vol.	Vol.	%Vol.	
19 #1	2700	93.2	984	77.8	85.50	2390	87.6	309	100	93.80
2	197	6.8	281	22.2	14.50	338	12.4	-	-	6.20
3	-	-	-	-	-	-	-	-	-	-
20 #1	2300	81.8	512	100	90.90	384	100	256	100	100
2	256	9.1	-	-	9.10	-	-	-	-	-
3	256	9.1	-	-	9.10	-	-	-	-	-
21 #1	578	100	578	100	100	903	100	-	-	100
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-

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