Nolan N. Weller

Management and logging plan

for

The Kaul Lumber Company Tracts

1939

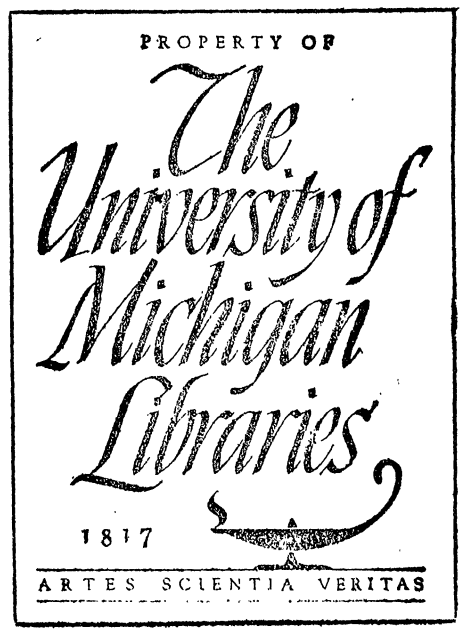
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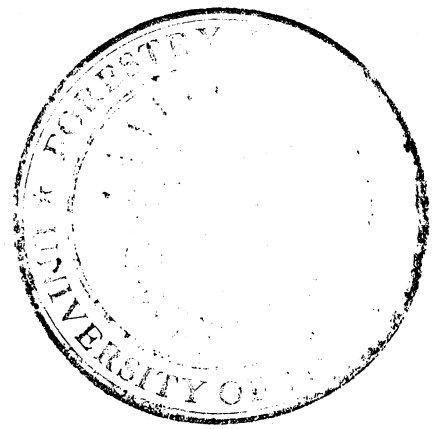
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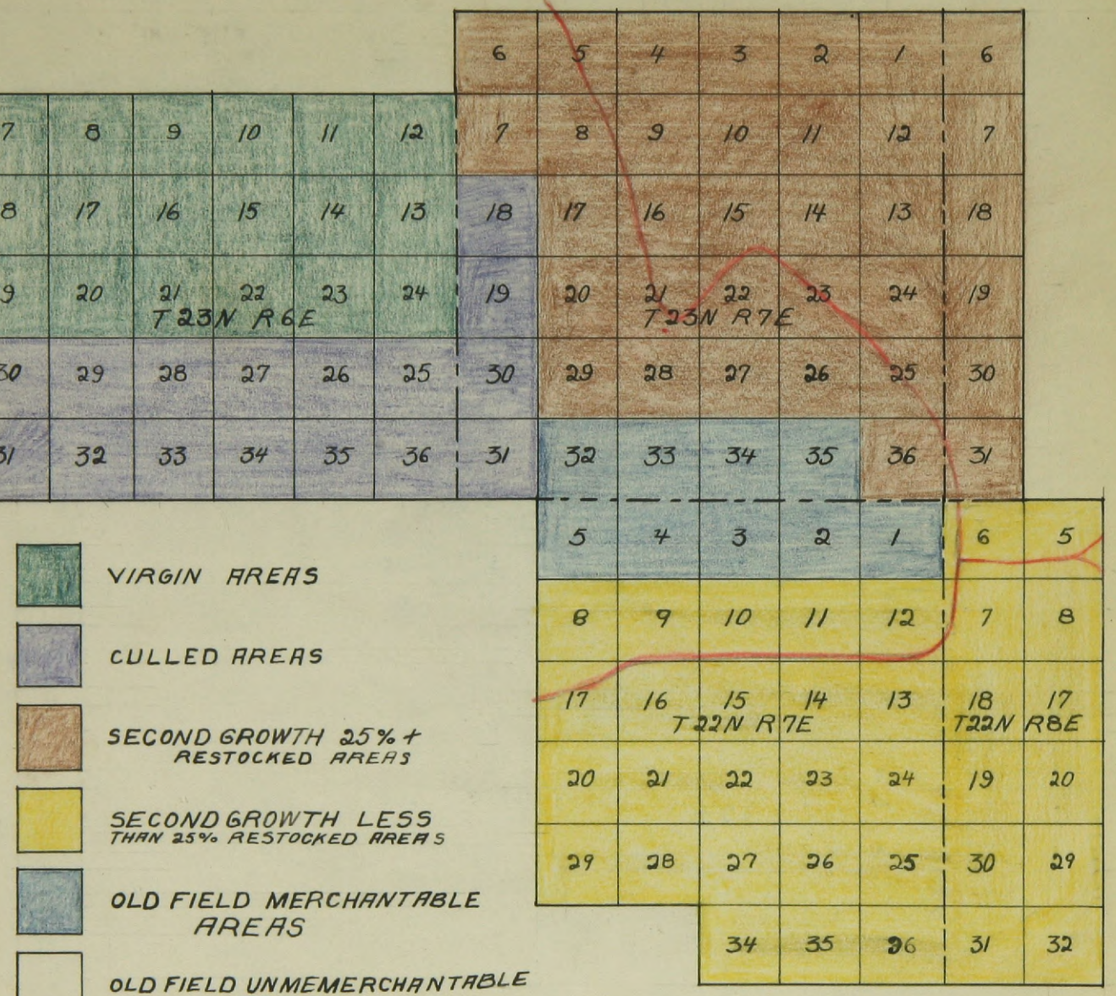
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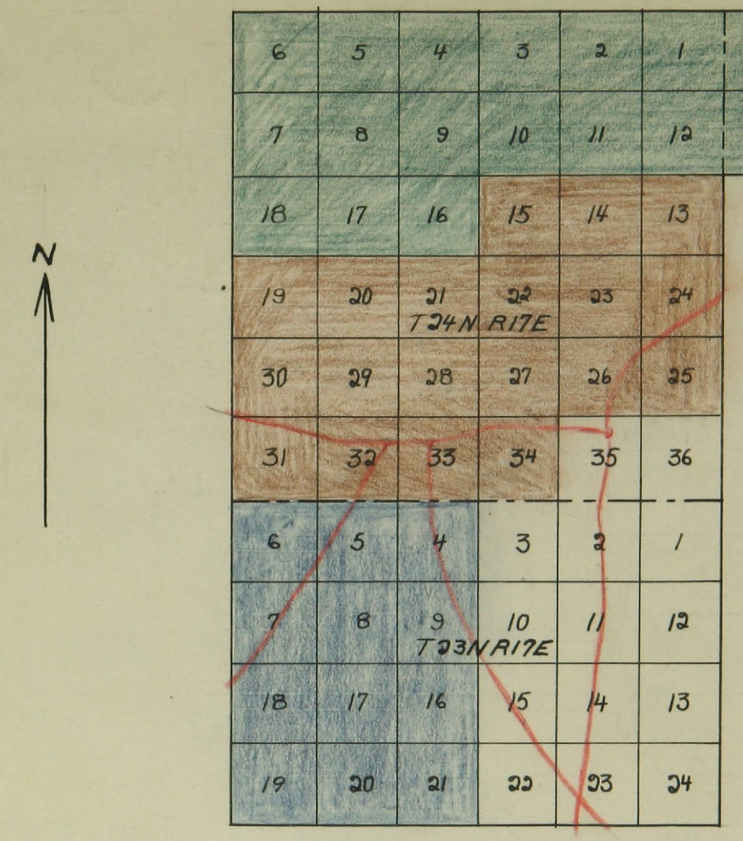
BF 1938
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WESTERN HOLDINGS



EASTERN HOLDINGS

KAUL LUMBER CO. TRACT

SCALE 1/2 INCH = 1 MILE

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MANAGEMENT AND LOGGING
PLAN FOR
THE KAUL LUMBER COMPANY TRACTS IN ALABAMA

WITH A DIAGONAL ROAD

SUPPLEMENT

Introduction:

For the most part the problem to follow is hypothetical. A stand table for each of six different stands, previously designated as the East Texas Land Company, was given. These stand tables are applied to a smaller area in central Alabama, known as the Kaul Lumber Company Tract[1], a report of which is given in Forest Service Bulletin No. 68. The approximate percentage of area, which each stand occupied in the case of the East Texas Land Co. has been maintained in this problem, all areas being taken to the nearest full section. The total area to which these stand tables apply has been reduced from 202 sections or approximately five and one-half townships to 176 sections or a little less than five townships. This in no way interferes with the value of this problem for the development of a management and logging plan.

It is the purpose of this problem to develop a complete management plan for the area, thereby determining the cut per acre during the first three cutting cycles, on five of the areas, neglecting the sixth primarily because no profitable cut is possible there until atleast the fourth cycle.

A further objective is the development of a logging plan using tractors and trucks, the area being tapped by a highway, rather than a railroad as was the case in the original East Texas Land Co. problem.

The holdings of the Kaul Lumber Co. referred to above, consists of two areas approximately sixty miles apart. In this problem the further assumption is made that both areas

are logged to the same mill, which is located in a town with a population of slightly over 1,000, geographically lying between the two holdings.

Fire and slash disposal: 2

In the shortleaf-loblolly pine type slash is a fire hazard for only three or four years, but the hardwoods accompanying them, are slower to decompose. Lopping the slash is said to shorten the period of decomposition by one year. For the most part no special precautions will be taken along the lines of slash disposal. Such action would be considered unnecessary expense in an area so intensely cut up by truck roads.

Insects:

The southern pine beetle (Dendroctonus frontalis) and the Nantucket tip moth (Rhyacionia frustrana) attack both species of pine. In general the southern pine beetle attacks are not of serious consequence. The Nantucket tip moth attacks both species when the trees are under six to eight feet high. The attacks are the most serious when the trees grow under full light, and would therefore tend to be discouraged when the trees were grown in an all aged stand. The usual damage is not death of the sapling, but a loss in height growth as a result of the death of the leader.

Disease:

Red heart and butt rot are the main fungus enemies of the living trees, and are most active in the virgin stands, the amount of rot in the second growth stands being negligible.

The hardwoods growing in mixture are oftimes highly defective, southern red oak being the poorest in the matter of merchantable volume. It therefore appears that logging out the hardwoods will not produce much valuable lumber.

Silviculture:

Loblolly pine trees produce some seed every year, and a full crop at intervals of two to four years. Although an exposed mineral soil is most favorable as a seed bed, the seed will germinate well under a variety of conditions, adequate moisture being the limiting factor, particularly where herbaceous plants are competing.

Shortleaf pine trees normally have full crops of seed every three years, although some is produced annually. Moisture is not as serious a limiting factor in shortleaf germination as is the case with loblolly. Shortleaf pine also reproduces by coppice, but such reproduction is limited to small saplings and will therefore be of minor importance under a selection system of silviculture.

3

The two species of pine present on these areas are capable of surviving quite intensive suppression and still recover to produce valuable trees after release, providing they have sufficient crown length. A selection system of silviculture is recommended for this type, because of the ability to recover after suppression, adequately seed the area, protect the site, and to keep a lower relative fire hazard.

In the stand tables hardwoods are mentioned, but the

species are not designated. According to Westvelt the associated hardwood species of the shortleaf-loblolly type are hawthorn, persimmon, black gum, post oak, red oak, and red gum. Cutting the hardwoods will be part of the management plan, as they will otherwise form the climax type.

Growth:

The average diameter growth for ten year periods is shown in Table I, along with the diameter at ten year intervals.

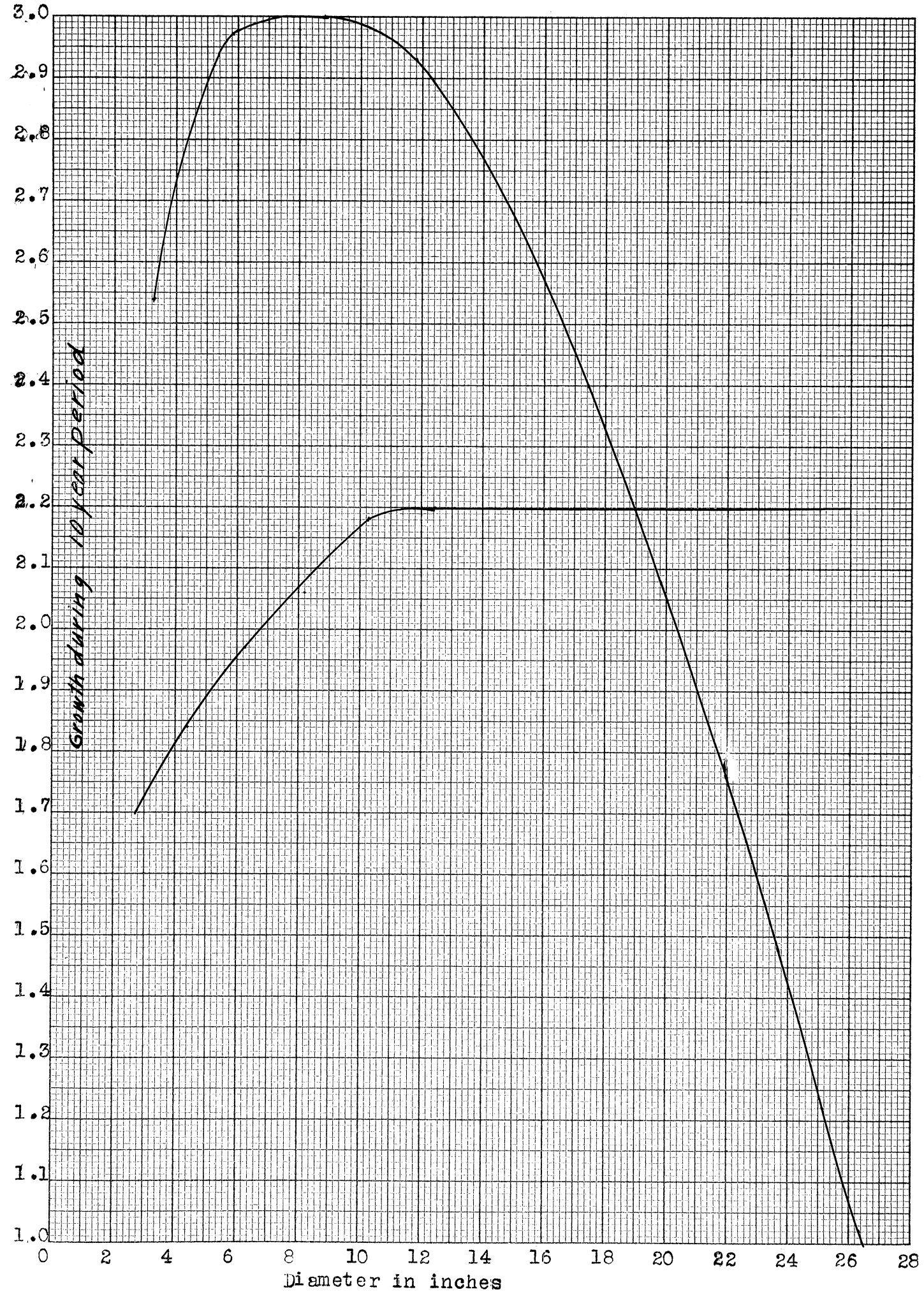
It is necessary to convert this into a form which will show the growth during the next ten years for the trees of various diameters. This is done by the use of Graph No. I, the curves of which are plotted with D.B.H. on the abscissae, and growth during the ten year perior on the ordinate. From this graph it is possible to read off directly the growth by ten year periods for the even diameter classes. This has been done and will be found in tabular form in Table II.

These growth figures are used throught this paper for predicting growth during subsequent cycles. It is plainly evident that loblolly pine grows considerably faster than shortleaf, particularly in the small amd middle diameter classes, from eight to eighteen inches, where growth is the most important. From Table I we see that at 60 or 70 years of age the loblolly is five inches larger in diameter than the shortleaf pine of the same age.

For that reason it is plainly evident that loblolly pine should be favored when thinnings are made, that is, inasmuch as the growth of loblolly is faster it will be a

Table I

Age	Average diameter growth in ten year period (inches)		Diameter 10-year age intervals (inches)	
	Loblolly	Shortleaf	Loblolly	Shortleaf
10	2.54	1.70	3.3	2.7
20	2.97	1.84	5.84	4.4
30	3.00	1.97	8.81	6.24
40	2.93	2.06	11.81	8.21
50	2.70	2.18	14.74	10.27
60	2.40	2.20	17.44	12.45
70	2.08	2.20	19.84	14.65
80	1.76	2.20	21.92	16.85
90	1.48	2.20	23.68	19.05
100	1.22	2.20	25.16	21.25
110	1.02	2.20	26.38	23.45
120	-	-	27.40	25.65



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Table
II

Growth in ten-year period
by diameter classes.

From Graph

Diam.	Loblolly Growth in 10 years	Shortleaf Growth in 10 years
2	-	-
4	2.72	1.81
6	2.97	1.96
8	3.00	2.07
10	2.99	2.17
12	2.92	2.20
14	2.77	2.20
16	2.51	2.20
18	2.33	2.20
20	2.05	2.20
22	1.75	2.20
24	1.42	2.20
26	1.08	
28	.75	

much more desirable tree to have in the stand. For the same reason, when a calculation indicates that a portion of any one diameter class should be removed, the shortleaf should all be cut from that class if at all possible, because the growth during the ensuing ten years is enough greater on the loblolly to make subsequent cuts enough larger to pay.

By following the plan outlined above the stand will be converted into a pure loblolly stand eventually. This won't happen the first cycle, but the fact that you have more seed trees of loblolly pine will eventually bring it about.

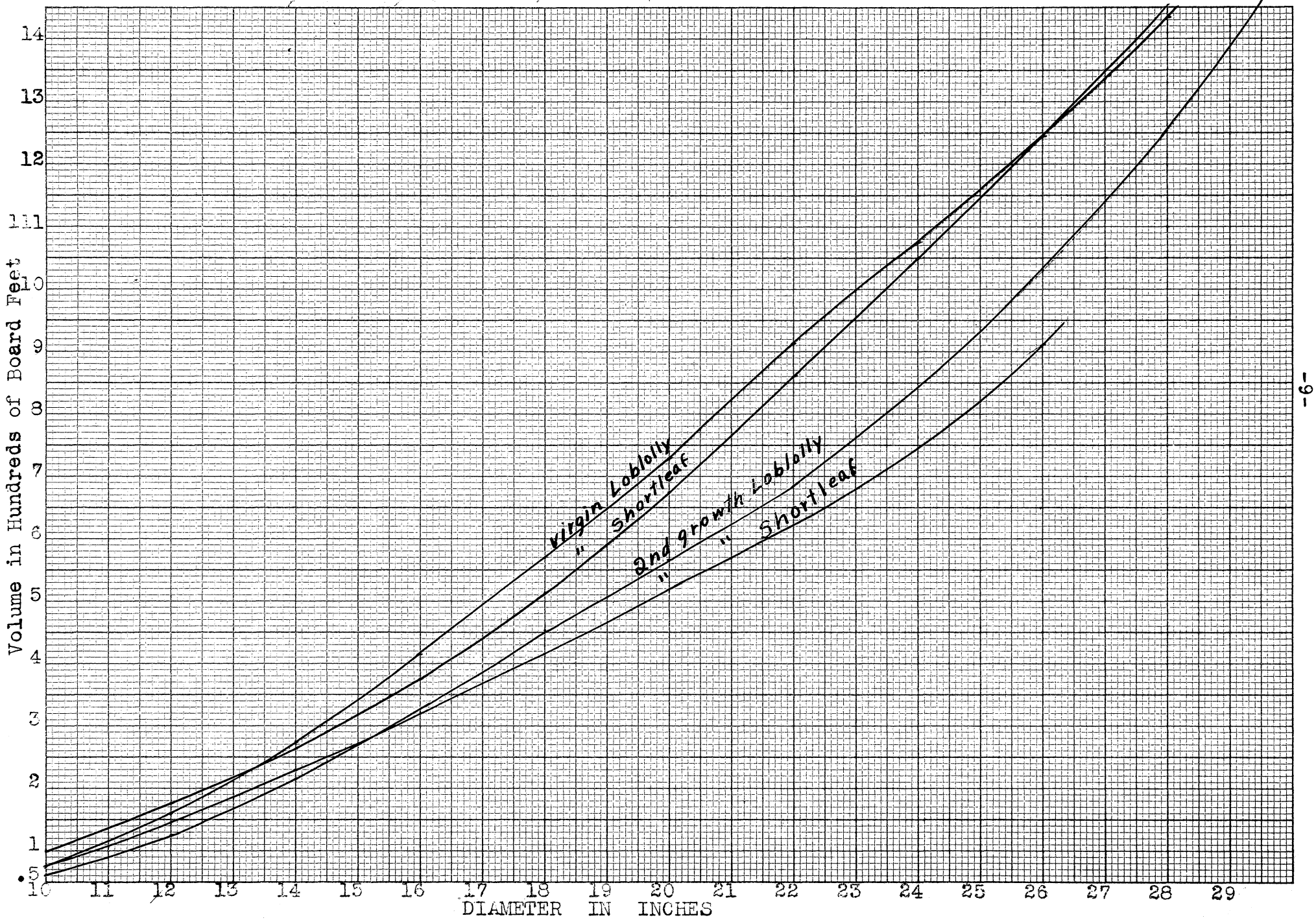
Volume Tables:

In as much as volume tables were not given it was necessary to construct some. This is done by dividing the number of board feet in a diameter class by the number of trees in the class. This gives you the aveerage board foot contents per tree. There are two types of stands present, that is virgin and second growth, so there will be two volumes for both loblolly and shortleaf, depending on the type of stand they are taken from.

Several diameter classes were missing, thus necessitating the making of a graph so as to take the trend into account and to project the curves to higher diameters than are given , in the case of the second growth stands. The curves are shown in Graph No. II on the following page, and the volume table, showing volumes for all diameters from ten to twenty-eight inches are shown in Table III.

The question naturally arises as to when virgin stands

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Table III

VOLUME TABLES
Board Feet Per Tree

	VIRGIN STANDS		2ND GROWTH STANDS	
D.B.H.	Lob.	Sh.leaf	Loblolly	Sh. leaf
10	74	100	62	77
12	160	176	125	148
14	276	266	217	231
16	415	374	327	323
18	570	515	452	415
20	730	675	565	515
22	910	860	685	620
24	1075	1050	840	750
26	1245	1245	1030	910
28	1435	1455	1250	1100
30			1540	

will have the volumes shown for the second growth stands. In other words the second and subsequent cuts on the virgin area will be cuts of second growth or similar timber. This might not happen for two or more cycles, many people would hold. In this regard it is my contention that the volume on the virgin stands will never be lower because they are of the second cut variety. It seems to me that the lower volumes on the second growth stands are due to site deterioration, either by erosion or fire and that eventually the second growth stands will have volumes approaching the virgin, when the sight is sufficiently built up, rather than the reverse happening.

Rotation:

The first question which arises in setting up a management plan is what rotation to use. This has been worked out in Table IV, the present volumes being taken from Table III and the future volumes direct from the graph. The value per tree is more difficult to determine, it being necessary to make adjustments for overrun on each diameter class. The values used were taken from the "East Texas Area" of U.S.D.A. Technical Bulletin No. 375, put out in 1933, entitled " "Selective Logging in the Shortleaf and Loblolly Pine Forests of the Gulf States Region".4

The future value per tree is calculated by finding the value a tree with that volume ten years hence would have. For example the tree that is 14" in diameter at present will have 475 board feet contents in ten years. By interpolation that

Table IV

Present D.B.H.	D.B.H. 10 yrs. hnce.	Present Volume	Present Value Ber Tree	Future Volume	Future Value Per tree	Value Growth Per Tree Per Year	Value Growth Percent
Virgin Lob.							
14	16.77	275	1.29	475	$3.49	.220	17%
16	18.56	415	2.69	610	5.43	.274	10.2%
18	20.33	570	4.75	760	7.91	.316	6.65%
20	22.05	730	7.48	920	11.33	.385	5.15%
22	23.75	910	11.08	1055			
24	25.45	1075	15.15	1200			
26	27.08	1245	19.87	1340			
Virgin Shortleaf							
14	16.20	266	1.24	390	2.65	.141	11.3%
16	18.20	374	2.43	530	4.53	.210	8.6%
18	20.20	515	4.28	690	7.16	.288	6.75%
20	22.20	675	6.91	880	10.53	.362	5.25%
22	24.20	860	10.03	1070			
24	26.20	1050	14.78	1270			
26	28.20	1245	19.85				

Table IV

Present D.B.H.	D.B.H. 10 Yrs.Hnce.	Present Volume	Present Value per Tree	Future Volume	Future Value per Tree	Value Grth per tree per year	Value Growth Percent
2nd Grth Loblolly							
14	16.77	217	$1.01	370	$2.69	$ .168	16.6%
16	18.56	327	2.12	480	4.27	.215	10.1%
18	20.33	452	3.77	585	6.28	.251	6.7%
20	22.05	565	5.78	690	8.43	.265	4.6%
22	23.75	685	8.32	820	11.35	.303	3.64%
24	25.42	840	11.80	975	15.06	.326	2.75%
26	27.08	1030	16.40	1150			
2nd Grth Shortleaf							
14	16.20	231	$1.08	330	$2.20	.112	10.4%
16	18.20	323	2110	425	3.63	.153	7.3%
18	20.20	415	3.45	530	5.60	.215	6.2%
20	22.20	515	5.27	630	7.80	.253	4.8%
22	24.20	620	7.55	760	10.97	.342	4.5%
24	26.20	750	10.55	930			
26	28.20	910	14.50				

is applying the percentage position of the volume to the value we find the tree to be worth $3.49. It would be possible to apply the interpolated percentage of the future diameter to the value to find the future value, but such a method is unreliable because the value varies with volume rather than diameter, and the relationship of volume to diameter is not a straight line relationship.

It will be seen from the tables that the point where you are still relatively certain of making atleast 5% on the investment is about eighteen inches, which corresponds to a 70 year rotation for loblolly pine and a longer period for shortleaf pine. Inasmuch as the intention is to manage primarily for loblolly because of its having more rapid growth the rotation should be set to favor that species. Therefore 70 years has been chosen as the rotation for all of the stands.

Cutting Cycle:

Normally the faster a tree grows the shorter the cutting cycle should be, within limits. In no case should the time between cuts be so long as to result in a slowing down of the growth rate, due to the competition which inevitably results from the stands closing in. In this stand a ten year cycle has been adopted, with the reservation of shortening it if it later seems advisable.

Mortality:

Table V shows the mortality per for for the trees of different diameters. It is based on the supposition that dead pine in the South loose their bark after the second year. So to construct a mortality table you would merely count the number of dead trees on each plot, having bark on. This would be divided by two on the assumption that half died each year, that is to get the mortality on a yearly basis.

Although such a process is better than not figuring mortality at all it has very distinct limitations. The period the bark remains on the tree is not entirely a function of time, but also of the weather during the two years, and whether or not and to what extent insects and fungi attack the dead tree. Errors are bound to creep in, because of the inevitable variations in the amount of time the bark remains on a tree. It seems reasonable that mortality should be allowed for, so the figures given in Table V are used, with a full realization as to their limitations and inaccuracy.

Using a ten year cutting cycle the mortality percent figures are multiplied by ten. This introduces a further error because the mortality rate changes during the cutting cycle as the tree grows. To attempt to correct this error would be as the statisticians say "Making the error more accurate".

Table V

Mortality Table for One Year

Basis 555 Plots

Per Cent of Number of Trees by D.B.H. Classes
Shortleaf-Loblolly Stands

Diam. Class	Mortality PerCent Curved Values	Sound Stand
2	.40	99.60
4	.34	99.66
6	.30	99.70
8	.27	99.73
10	.26	99.74
12	.28	99.72
14	.34	99.66
16	.43	99.57
18	.56	99.44
20	.72	99.28
22	.92	99.08
24	1.12	98.88
26	1.34	98.66
28	1.56	98.44
30	1.80	98.20

Note: Applies to all average stands

VIRGIN AREA

Table VI is the stand table for the present virgin area. The average net volume per acre at the present time is 10,634 board feet. There are at present 65.46 trees in the main stand, and 17.82 trees in the suppressed stand counting the few longleaf, which are present. In this plan the longleaf will be grouped with the loblolly the species it closely resembles.

Growth is said to equal mortality in this stand, consequently cutting should begin immediately. In determining the cut per acre the stands are classified by the basal area control method. The control table used as a basis for this classification may be found on page 160 of "Management of American Forest" by D.M. Matthews. It has been cut down from twelve age classes to seven, by increasing each basal area by 5 sevenths. New percentages are then calculated for the five known age groups, there being no data for the two youngest. Inasmuch as the youngest age class with a known basal area is 20 years old, it was decided to drop out all trees less than six inches in diameter, because they wouldn't be that old.

In this stand, in view of the rotation it was decided to call all trees over 22 inches overmature and then classify the remaining stand to determine the total cut. The reasoning behind this is that trees of that size will never again occupy the area and should not be considered to when classifications are made. As a result of the above the first cycle cut is calculated to be 5,720 board feet per acre of which 3,050 bd.ft. are from the overmature classification. The diameters

cut range from 18 to 28 inches. The classification is shown in Table VII.

Table VIII shows growth predictions for both species. Reynold's method of predicting growth is used throughout the management plan, for the determination of future volumes. The growth rates per diameter class as given in Table II are cut in half, because the stand is given by two inch classes. The stand as found to be ten years hence is reclassified by the basal area control in Table IX, and shows the cut for the second cycle to be 3,500 bd.ft. ranging in diameter from 18 to 22".

It will be noted that only four age classes are present in the second classification. The youngest one has been dropped out because it has grown into the next older class, with no known data to replace it.

The method used for finding the second cut is used on the residual stand to find the third cut. The calculations are found in Tables X and XI. The youngest diameter class has again been omitted for lack of data, thus leaving only three in the third cut classification. The volume cut the third cycle, that is starting in 21 years is calculated to be 4,520 bd.ft. per acre, an increase of 1 M per acre over the second cycle. The third cycle cut of 4.5M is assumed to continue during all succeeding cycles, and is probably a low estimate because the stand is not fully stocked at present. Stocking should increase under good management and proper logging practice.

Table VI

Stand Table
Average acre - Shortleaf - Loblolly Area
Virgin Stands

Diameter Class	Loblolly Pine Main Stand	Loblolly Pine Sup. Stand	Loblolly Pine Total Volume	Shortleaf Pine Main Stand	Shortleaf Pine Sup. Stand	Shortleaf Pine Total Volume	Hardwood Main Stand	Hardwood Sup. Stand	Longleaf Pine Main Stand	Longleaf Pine Sup. Stand
2	1.45	2.00		5.45	4.36		7.45	13.45	.18	.73
4	.18	.55		4.91	3.27		6.73	8.36	.73	1.82
6	.73	.91		6.91	3.09		4.36	5.27		.18
8	.55			6.18	.73		7.09	1.45	.18	
10	1.09		81	7.64		764	3.82			
12	1.45		232	7.09		1248	1.45		.36	
14	2.91		800	2.91		774	1.64			
16	2.36		979	2.55	.18	954	.91	.18		
18	1.27		723	1.64		841	1.09			
20	.55		402	.73		491	1.27			
22	.18		164	.36		310	.18			
24	.73		786	.55		578	.18			
26	.55		686	.18		224	.18			
28	.36		517	.18		262				
Total	14.36	3.46	5370	47.28	11.63	6446	36.35	28.71	1.45	2.73

Total Pine Volume =-11,816 Reduced 10% = 10,634 bd. ft.
No. Trees, Pine = 63.01 (Main Stand only)

Growth = Mortality - Volume (1) year hence = same as at present

Assessed Value = $30 per acre

Table VII

VIRGIN AREA

Determination of Total Basal Area

Diam.	No. Trees	B.A.per tree	Total B.A.
6	11.10	.196	2.88
8	7.63	.349	2.66
10	8.73	.545	4.76
12	8.90	.785	6.98
14	5.82	1.069	6.23
16	4.91	1.396	6.84
18	2.91	1.767	5.14
20	1.28	2.181	2.79
22	.54	2.640	1.43
Total	51.83		39.71

Determination of Cut using Basal Area Control Method

Age Group	B.A. Sq.Ft.	% B.A.	Actual B.A.	Diam. Range	Volume
0 -10	No Data		No Data		
11-20	" "		" "		
21-30	20.1	17.5	6.94	6-10	
31-40	22.3	19.4	7.71	10-12	
41-50	23.7	20.6	8.18	12-14	
51-60	24.2	21.1	8.38	14-18	83% of 18"
61-70	24.5	21.4	8.50	18-22	2667 cut
	114.8	100.0	39.71		

Cut of overmature 3,050 bd.ft.

Total cut 5,720 bd.ft.

Table VIII

VIRGIN AREA

Growth prediction and reclassification for the purpose of finding the second cut.

Loblolly Pine

D.B.H.	No. trees	% Mort.	No. trees	Grth 10yrs.	No.Tr.: 10yrs. hence	Move 1 cl.	Move 2 cl.	Vol. Per Tr.	Total Volume
6	1.82	3.0	1.77	1.48		.92	.85		
8	.73	2.7	.71	1.50	.92	.36	.35		
10	1.09	2.6	1.06	1.49	1.21	.54	.52	74	90
12	1.81	2.8	1.76	1.46	.89	.95	.81	160	140
14	2.91	3.4	2.81	1.38	1.47	1.74	1.07	275	405
16	2.36	4.3	2.26	1.29	2.55	1.61	.65	415	1060
18	.49	5.6	.46	1.16	2.68	.38	.08	570	1530
20					1.03			730	750
22					.08			910	70
Totals			10.83		10.83				4050 b.m.

Shortleaf Pine

						M-0	M-1	M-2		
6	10.00	3.0	9.70	.98	.20	.20	9.50			
8	6.91	2.7	6.72	1.03	9.50		6.52	.20		
10	7.64	2.6	7.44	1.09	6.52		6.77	.67	100	650
12	7.09	2.8	6.89	1.10	6.97		6.20	.69	176	1225
14	2.91	3.4	2.81	1.10	6.87		2.53	.28	266	1825
16	2.55	4.3	2.44	1.10	3.22		2.20	.24	374	1200
18					2.48				515	1280
20					.24				675	160
Totals			36.00		36.00					6340

Table IX
VIRGIN AREA

Basal Area After 10 Years

D.B.H.	No. Trees	B.A. Per Tree	Total B.A.
6	.20	.196	.04
8	10.42	.349	3.64
10	7.73	.545	4.21
12	7.86	.785	6.17
14	8.34	1.069	8.92
16	5.77	1.396	8.05
18	5.16	1.767	9.10
20	1.27	2.181	2.77
22	.08	2.640	.21
Total	46.83		43.11

- Classification Using Basal Area Control -

Age Class	% B.A.	Actual B.A.Per Class	Range D.B.H.	Number TREES	VOLUME Per Class
0 - 10	No data				
11- 20	" "				
21-30	" "				
31-40	23.5	10.13	6 - 12	21.18	1230
41-50	25.0	10.79	12 - 14	11.45	2590
51-60	25.6	11.03	14 - 18	8.21	3065
61-70	25.9	11.16	18 - 22	5.99	3500 2nd CC Cut
Totals	100.0%	43.11		46.83	10,385 b.m.

Table X
VIRGIN AREA

GROWTH PREDICTION FOR THE PURPOSE OF FINDING THE THIRD CUT

Loblolly Pine

D.B.H.	No. trees	% Mort	No. Trees	Grth 10yrs.	No.Tr. 10yrs. Hence	Move 1 Cl.	Move 2 cl.	Total Volume
6		3.0						
8	.92	2.7	.90	1.50		.45	.45	
10	1.21	2.6	1.18	1.49	.45	.60	.58	30
12	.89	2.8	.87	1.46	1.05	.47	.40	170
14	1.47	3.4	1.42	1.38	1.05	.88	.54	290
16	2.55	4.3	2.44	1.29	1.28	1.73	.71	530
18	.52	5.6	.49	1.16	2.27	.41	.08	1290
20					1.12			820
22					.08			70
24								
Totals			7.30		7.30			3200

6	.20	3.0	.19	.98	.19	.19	.13	
8	9.50	2.7	9.24	1.03	8.96	8.96	.28	
10	6.52	2.6	6.35	1.09	6.06	5.78	.57	895
12	6.97	2.8	6.78	1.10	6.67	6.10	.68	1070
14	6.87	3.4	6.64	1.10	6.66	5.98	.66	1770
16	3.22	4.3	3.09	1.10	3.44	2.78	.31	2490
18					.31			1770
20								210
Totals			32.29		32.29			8206

Table XI

VIRGIN AREA

Basal Area After 20 Years

D.B.H.	No. Trees	B.A. Per Tree	Total B.A.
8	.19	.349	.07
10	9.41	.545	5.13
12	7.11	.785	5.58
14	7.72	1.069	8.25
16	7.94	1.396	11.08
18	5.71	1.767	10.08
20	1.43	2.181	3.12
22	.08	2.640	.21
Totals	39.59		43.52

- Classification Using Basal Area Control Method

Age Class	% B.A.	Actual B.A.Per Class	Range D.B.H.	Number Trees	Volume
0-10	No.data				
11-20	" "				
21-30	" "				
31-40	" "				
41-50	32.6	14.18			
51-60	33.5	14.59			
61-70	33.9	14.75	16-22	7.88	4520 b.m. 3rd Cycle Cut

CULLED STAND

The other stand where cutting in the first cycle will be doneis thethe Culled Area, the stand table of which is found in Table XII.

This a type of stand which complicates the determination of cuts, because the stand grows while it is being cut. By this I mean that during the ten year cycle the areas cut after the first year will have put on appreciable growth before being cut. The main thing desired is the average cut during each cycle. To determine this a cut is calculated at the present time and another one ten years hence, the intervening growth being considered, and the two averaged to determine the cut for the cycle. This has been done in Tables XIII, XIV, and XV. The cut begins at 2980 bd.ft. and rises to 4760 bd.ft. in ten years, with an average of 3870 bd.ft.

In this stand the same as in the Virgin all trees over 22" are called overmature and only those under that are classified. The volume so designated is approximately 1 M and is assumed not to increase during the cycle.

The cut for the second cycle is determined in the same manner, the residual stands after the first cut being used to predict the growth on. Tables XVI, XVII, XVIII, and XIX show the growth predictions for the beginning and ending second cut. The cut starts with 3255 bd.ft. and rises to 3920 at the endof the cycle, making an average of 3587.

Tables XX, XXI, XXII, and XXIII show a similar prediction and classification to determine the third cycle cut, which begins at 3940 bd.ft. and rises to 5130, with an average of 4535 or

almost exactly the same as the Virgin stands produced. This cut is assumed to continue in the future as was the case with the virgin stands.

As was the case with the Virgin stand this area produces a lower cut during the second cycle. This is to be expected in view of the fact that part of the first cut came from the overmature stand. Disregarding this the cut from the classified stands increases during the first three cycles.

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Table XII

Stand Table
Average Acre - Shortleaf-Loblolly Area
Culled Stands

Diameter Class	Loblolly Pine			Shortleaf Pine			Hardwood	
	Main Stand	Suppr'd Stand	Volume	Main Stand	Suppr'd Stand	Volume	Main Stand	Suppr'd Stand
2	3.56	.44		8.89	5.78		19.56	12.44
4	1.33	.89		8.00	5.33		24.00	7.11
6	4.89			10.22	3.11		15.11	3.11
8	3.56			5.78	.44		4.44	.44
10	2.67		198	6.22		622	6.22	
12	1.78		285	5.78		1017	4.00	
14	3.56		979	3.56		947	2.22	
16	.89		369	2.67		999	1.33	
18				.89		457	.44	
20				.44		296		
22							.44	
24				.44		462		
26				.44		548		
Total	22.24	1.33	1831	53.33	14.66	5348	77.76	23.10

Total Pine Volume = 7179
No.Trees (Pine) = 65.92 (Main Stand Only)

7179 bd.ft. reduced 10% for defect and utilization = 6461bd.ft.

Assessed Value = $18 per acre

Page Missing in Original Volume

Table XIII

CULLED STAND - Cut at start of ten year cyle if cut now.

D.B.H.	No. Trees	B.A. per Tree	Total B.A.
6	18.22	.196	3.57
8	9.78	.349	3.41
10	8.89	.545	4.85
12	7.56	.785	5.93
14	7.12	1.069	7.62
16	3.56	1.396	4.97
18	.89	1.767	1.57
20	.44	2.181	.96
Totals	4.49		33.88

Basal Area Control Classification

Age Class	Basal area%	Actual B. A.	Diameter Gange	Volume	Number Trees
0 010	No Data				
11-20	"	"			
21-30	17.5	5.75			
31-40	19.4	6.38			
41-50	20.6	6.77			
51-60	21.1	6.94			
61-70	21.4	7.04	16-22	1971	4.49

Table XIV

CULLED STAND -
Growth during 1st ten years or while being cut -
Loblolly Pine

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs.	No.Tr.: 10yrs. hence	Move 1 cl.	Move 2 cl.	Volume
6	4.89	3.0	4.74	1.48		2.47	2.27	
8	3.56	2.7	3.46	1.50	2.47	1.73	1.73	
10	2.67	2.6	2.60	1.49	4.00	1.33	1.27	296
12	1.78	2.8	1.73	1.46	3.06	.93	.80	490
14	3.56	3.4	3.44	1.38	2.20	2.13	1.31	600
16	.89	4.3	.85	1.29	2.93	.60	.25	1220
18					1.91			1090
20					.25			182
Totals			16.82		16.82			3878

Shortleaf Pine

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs.	No.Tr.: 10yrs. hence	Move 0 cl.	Move 1 cl.	Move 2 cl.	Volume
6	13.33	3.0	12.93	.98	.26	.26	12.67		
8	6.22	2.7	6.05	1.03	12.67		5.87	.18	
10	6.22	2.6	6.06	1.09	5.87		5.52	.54	585
12	5.78	2.8	5.62	1.10	5.70		5.06	.56	1000
14	3.56	3.4	3.44	1.10	5.60		3.10	.34	1490
16	2.67	4.3	2.56	1.10	3.66		2.30	.26	1370
18	.89	5.6	.84	1.10	2.64		.76	.08	1360
20	.44	7.2	.41	1.10	1.02		.37	.04	690
22					.45				385
Totals			37.87		37.87				6880

Table XV

CULLED STAND -

D.B.H.	No. TREES	Basal Area Per tree	Total Basal Area
6	.26	.196	.05
8	15.14	.349	5.28
10	9.87	.545	5.38
12	8.76	.785	6.87
14	7.80	1.069	8.33
16	6.59	1.396	9.20
18	4.55	1.767	8.04
20	1.27	2.181	2.77
22	.45	2.640	1.19
24			
	54.69		47.11

Basal Area Control Classification

Age Class	% B.A.	Actual B.A.	Diameter Range	Number of trees	Volume
0-10	No Data				
11-20	"	"			
21-30	"	"			
31-40	23.5	11.08			
41-50	25.0	11.77			
51-60	25.6	12.05			
61-70	25.9	12.20	16-22"	6.41	3762 b.m.

Overmature 1000 b.m.
Cut at end of CC 4762 b.m.
Cut at beginning of CC 2981

Ave. Cut 1st C.C. 3871 bd.ft.

Table
XVI

CULLED STAND -
Growth predictions for the beginning cut of the second cycle -

Loblolly Pine

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs.	No.Tr.: T0yrs : hence :	Move 1 cl.	Move 2 cl.	Volume
6	4.89	3.0	4.74	1.48		2.47	2.27	
8	3.56	2.7	3.46	1.50	2.47	1.73	1.73	
10	2.67	2.6	2.60	1.49	4.00	1.33	1.27	296
12	1.78	2.8	1.73	1.46	3.06	.93	.80	490
14	3.56	3.4	3.44	1.38	2.20	2.13	1.31	600
16	.40	4.3	.38	1.29	2.93	.27	.11	1220
18					1.58			900
20					.11			80
Totals			16.35		16.35			3586 b.m.

Shortleaf Pine

D						M-0	M-1	M-2	
6	13.33	3.0	12.93	.98	.26	.26	12.67		
8	6.22	2.7	6.05	1.03	12.67		5.87	.18	
10	6.22	2.6	6.06	1.09	5.87		5.52	.54	585
12	5.78	2.8	5.62	1.10	5.70		5.06	.56	1000
14	3.56	3.4	3.44	1.10	5.60		3.10	.34	1490
16					3.66				1370
18					.34				175
Totals			38.84		38.84				4620 b.m.

Table XVII

CULLED STAND -

Basal Area at Beginning of 2nd Cycle

D.B.H.	Number Trees	Basal area per tree	Total B. A.
6	.26	.196	.05
8	15.14	.349	5.28
10	9.87	.545	5.38
12	8.76	.785	6.87
14	7.80	1.069	8.33
16	6.59	1.396	9.20
18	1.92	1.767	3.39
20	.11	2.181	.24
Totals	50.45		38.83

Basal Area Control Classification

Age Class	% B. A.	Actual B. A.	Diameter Range	Number Trees	Volume
0-10	No Data				
11-20	" "				
21-30	" "				
31-40	23.5	9.12			
41-50	25.0	9.72			
51-60	25.6	9.95			
61-70	25.9	10.05	16-20	7.37	3255 b.m.

Table XVIII
CULLED STAND -
Growth prediction to determine the cut at the end of the second cycle -

Loblolly Pine -

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs.	No.Tr. in 10 yr.	Move 1	Move 2	Volume
8	2.47	2.7	2.40	1.50		1.20	1.20	
10	4.00	2.6	3.90	1.49	1.20	1.99	1.91	90
12	3.06	2.8	2.97	1.46	3.19	1.60	1.37	510
14	2.20	3.4	2.13	1.38	3.51	1.32	.81	960
16	2.93	4.3	2.80	1.29	2.69	1.99	.81	1120
18					2.80			1600
20					.81			590
Totals			14.20		14.20			4870

Shortleaf Pine

6	.26	3.0	.25	.98		.25		
8	12.67	2.7	12.33	1.03	.25	11.96	.37	
10	5.87	2.6	5.72	1.09	11.96	15.21	.51	1200
12	5.70	2.8	5.54	1.10	5.58	4.99	.55	980
14	5.60	3.4	5.41	1.10	5.50	4.87	.54	1460
16	3.52	4.3	3.37	1.10	5.42	3.03	.34	2030
18					3.57			1840
20					.34			230
Totals			32362		32.62			7740

Table XIX
CULLED STAND -

Basal Area at end of 2nd Cycle

D.B.H.	No. Trees	B. A. Per Tree	Total B.A.
8	.25	.349	.09
10	13.16	.545	7.17
12	8.77	.785	6.88
14	9.01	1.069	9.63
16	8.11	1.396	11.30
18	6.37	1.767	11.24
20	1.15	2.181	2.51
Totals	46.82		48.82 Sq.ft.

Basal area Control Classification

Age Class	% B.A.	Actual B.A.	Diameter Range	Number Trees	Volume Cut
0-10	No.	Data			
11-20	"	"			
21-30	"	"			
31-40	23.5	11.48			
41-50	25.0	12.21			
51-60	25.6	12.50			
61-70	25.9	12.63	18-20	6.88	3920 b.m.
Total		48.82			

Cut at beginning of 2nd CC 3255 b.m.
Cut at end of 2nd CC 3920 b.m.

Ave. Cut 2nd C C 3588 bd.ft.

Table XX
CULLED STAND -
BEGINNING CUT, THIRD CYCLE GROWTH PREDICTION

Loblolly Pine

D.B.H. class	No. TREES	% Mort	No. Trees	Grth 10yrs.	No.Tr. 10yrs. hence	Move 1	Move 2	Volume
8	2.47	2.7	2.40	1.50		1.20	1.20	
10	4.00	2.6	3.90	1.49	1.20	1.99	1.91	90
12	3.06	2.8	2.97	1.46	3.19	1.60	1.37	510
14	2.20	3.4	2.13	1.38	3.51	1.32	.81	960
16	1.25	4.3	1.20	1.29	2.69	.85	.35	1120
18					1.66			950
20					.35			250
Totals			12.60		12.60			3880

Shortleaf Pine

6	.26	3.0	.25	.98		.25		
8	12.67	2.7	12.33	1.03	.25	11.96	.37	
10	5.87	2.6	5.72	1.09	11.96	5.21	.51	1200
12	5.70	2.8	5.54	1.10	5.58	4.99	.55	980
14	5.60	3.4	5.41	1.10	5.50	4.87	.54	1460
16					5.42			2030
18					.54			280
Totals			29.25		29.25			5950

Table XXI

CULLED STAND -

Basal Area at Beginning of 3rd cycle

D.B.H.	Number of trees-	B.A. Per Tree	Total Basal Area
8	.25	.349	.09
10	13.16	.545	7.17
12	8.77	.785	6.88
14	9.01	1.069	9163
16	8.11	1.396	11.30
18	2.20	1.767	3.88
20	.35	2.181	.76
Totals	41.85		39.71 Sq.Ft.

Basal area control classification

Age Class	% B. A.	Actual B.A.	Number Trees	Diameter Range	Volume
0-10	No	Data			
11-20	"	"			
21-30	"	"			
31-40	"	"			
41-50	32.6	12.93			
51-60	33.5	13.31		78% of 16"	
61-70	33.9	13.47	8.86	16-20	3940 bd.ft.

Table XXII

CULLED STAND

Growth prediction for the purpose of finding the cut at the end of the third cycle.

Loblolly Pine

D.B.H. Class	No. Trees	No. Trees	No. Trees	Grth 10yrs.	No. Tr. 10yrs hence	Move 1	Move 2	Volume
10	1.20	2.6	1.17	1.49		.60	.57	
12	3.19	2.8	3.09	1.46	.60	1.67	1.42	100
14	3.51	3.4	3.39	1.38	2.24	2.10	1.29	680
16	2.69	4.3	2.57	1.29	3.52	1.82	.75	1460
18	.64	5.6	.60	1.16	3.11	.50	.10	1770
20					1.25			910
22					.10 .10			90
Totals			10.82		10.82			4950 b.m.

Shortleaf Pine

8	.25	2.7	.24	1.03		.23	.01	[illegible]
10	11.96	2.6	11.65	1.09	.23	10.60	1.05	25
12	5.58	2.8	5.42	1.10	10.61	4.88	.54	1700
14	5.50	3.4	5.31	1.10	5.93	4.78	.53	1580
16	5.42	4.3	5.19	1.10	5.32	4.67	.52	1990
18					5.20			2680
20					.52			350
Totals			27.81		27.81			8325

Table XXIII

CULLED STAND

Determination of the cut at the end of the third cycle -

Basal Area at end of 3rd Cycle

D.B.H.	Number of Trees	Basal area per tree	Total Basal Area
10	.23	.545	.13
12	11.21	.785	8.80
14	8.17	1.069	8.75
16	8.84	1.396	12.33
18	8.31	1.767	14.68
20	1.77	2.181	3.86
22	.10	2.640	.26
Totals	38.63		48.81

Basal Area Control Classification

Age Class	% B. A.	Actual B. A.	Diameter Range	Number of Trees	Volume cut-
0-10	no	Data			
11-20	"	"			
21-30	"	"			
31-40	"	"			
41-50	32.6	15.92			
51-60	33.5	16.35	85% of 18"		
61-70	33.9	16.54	18-22"	8.92	5130 bd.ft.

Cut at beginning of 3rd CC 3940
Cut at end of 3Rd CC 5130

Ave. cut 3rd Cycle 4535 bd.ft.

SECOND GROWTH STANDS WITH 25% STOCKING

The stand occupying the largest area, the 25% stocked second growth will now be considered. It is deemed inadvisable to make a cut on this area during the first cycle, because there is not enough volume over 16" so as to make the stand fall in the 0-70 age classification. An immediate thinning for the purpose of increasing the growth might be beneficial from the standpoint of reduced competition on the crop trees, and an increased growth.

Perhaps a slower growth rate will result before the stand is cut, but some can be allowed for and still be cheaper than making a thinning, which would be an out of pocket expense. The actual contrast is between a present expense and a reduced yield ten or fifteen years in the future.

Unless the site a stand is growing on is far above average, basal areas of over 90 or 95 square feet will be impossible. In the stand now being considered the present basal area is approximately 75 sq.ft. In ten years this will have increased to 90 or better. For that reason the stand is assumed not to grow while being cut, that is during the second cycle when the stand is first cut. Doubtless some growth will take place, particularly on the upper diameters where you would expect the trees to be more or less dominant. Purely as a matter of safety, growth is not allowed for.

The stand as it exists today is shown in Table XXIV, with first cycle growth predictions and classification for the 2nd cycle cut being shown in Tables XXV, and XXVI.

In this stand only 318 bd.ft. fall in the overmature classification. The first cycle cut excluding thinnings amounts to 6130 bd.ft., but thinnings are necessary if normal growth is to continue.

Tables XXVII and XXVIII show the growth predictions after the first cut, and reclassification for cutting during the third cycle. The third cycle cut exclusive of thinnings is calculated to be 5740 bd.ft. Such a cut doesn't seem particularly unreasonable, but thinnings with any appreciable volume in addition are highly problematical.

Table XXIV

STAND TABLE
Average Acre - Shortleaf-Loblolly Area
Second Growth Stands
25% + Stocking

Diameter Class	Shortleaf Pine			Loblolly Pine			Hardwoods	
	Main Stand	Suppr'd Stand	Total Volume	Main Stand	Suppr'd Stand	Total Volume	Main Stand	Sup. Stand
2	0.90	12.00		2.71	23.10		11.87	21.94
4	4.39	12.77		10.19	7.74		3.48	9.42
6	11.74	8.90		16.77	5.03		10.45	5.94
8	12.00	1.03		11.61	1.42		6.58	.65
10	8.13	.26	626	11.74	.65	728	4.52	.13
12	5.16		764	11.87		1484	2.71	.13
14	1.03		238	6.19		1343	1.42	
16	.39		126	2.58		844	.52	
18	.39		162	.90		407	.77	
20	.13		67	.39		220	.39	
22				.13		89	.26	
24							.26	
26	.13		118				.13	
28							.13	
30				.13		200		
Total	44.39	34.96	2101	75.21	37.94	5315	43.49	38.21

Total Pine Volume = 7416 bd. ft.
No. Trees, Pine = 119.60 (Main Stand only)
7416 bd.ft. reduced 10% for defect and utilization
= 6674 bd.ft.

Assessed Value $15 per acre

Table XXV

25% + STOCKING

Growth prediction during the first ten years, before cutting begins.

D.B.H. Class	No. Trees	% Mort.	No. Trees	Grth 10 yrs.	No. Tr. 10 yrs. Hence	Move 0	Move 1	Move 2	Volume
LOBLOLLY PINE									
6	21.80	3.0	21.15	1.48			11.00	10.15	
8	13.03	2.7	12.68	1.50	11.00		6.34	6.34	
10	12.39	2.6	12.04	1.49	16.49		6.14	5.90	1080
12	11.87	2.8	11.54	1.46	12.48		6.23	5.31	1560
14	6.19	3.4	5.98	1.38	12.13		3.71	2.27	2040
16	2.58	4.3	2.47	1.29	9.02		1.75	.72	2950
18	.90	5.6	.85	1.16	4.02		.71	.14	2270 1820
20	.39	7.2	.36	1.03	1.43		.35	.01	810
22	.13	9.2	.12	.87	.50	.01	.11		340
24					.12				100
Totals			67.19		67.19				11,690b.m.
SHORTLEAF PINE									
6	20.64	3.0	20.02	.98	.40	.40	19.62		
8	13.03	2.7	12.68	1.03	19.62		12.30	.38	
10	8.39	2.6	8.17	1.09	12.30		7.43	.74	950
12	5.16	2.8	5.02	1.10	7.81		4.52	.50	1150
14	1.03	3.4	1.00	1.10	5.26		.90	.10	1210
16	.39	4.3	.37	1.10	1.40		.33	.04	450
18	.39	5.6	.37	1.10	.43		.33	.04	180
20	.13	7.2	.12	1.10	.37		.12		190
22					.16				100
Totals			47.75 67.19		47.75 67.19				14830 b.m.

Table XXVI
25% + Stocking

Basal Area in 10 years

D.B.H.	Number of Trees	Total Basal Area
.60	.40	.08
8	30.62	10.68
10	28.79	15.70
12	20.29	15.73
14	17.89	18.60
16	10.42	14.55
18	4.45	7.86
20	1.80	3.93
22	.66	1.74
24	.12	.38
Totals	114.94	89.25

Basal Area Control Classification

Age Class	% B.A.	Actual B. A.	D.B.H. RANGE	Number of Trees	Volume
0-10	No Data				
11-20	"	"			
21-30	"	"			
31-40	23.5	20.98	6-10	49.71	
41-50	25.0	22.32	10-14	31.46	
51-60	25.6	22.83	14-16	20.18	
61-70	25.9	23.12	16-24	13.59	5683 b.m.
				Overmature	318

Cut beginning in 11th year = 6000 b.m

Thinnings will also be taken out.

25% + STOCKING

THINNINGS

Ten years from the present the probable basal area of this stand will be about 90 sq.ft., that is when growth is figured by Reynold's method. This is about the maximum that the stand can carry, and stagnation will result if it isn't thinned. Although the cut at that time would take out some 23 sq. ft., that much will have grown back before another cut is due. Therefore, it is deemed advisable to thin all of the younger age classes at the time the more mature timber is taken off, so that they will only reach the maximum basal area in time for the next cut. This is accomplished by figuring out the basal area the present trees would have if they grew in a normal manner.

It might seem that inasmuch as we are managing for loblolly pine, we would therefore cut out all of the shortleaf. Although this might be done, it seems to me that if it were, the result would be a stand with numerous holes in it and other places where stagnation had taken place, because the different species certainly don't, or aren't likely to grow in an even distribution throughout the stand. Undoubtedly more shortleaf could be taken out, proportionately than loblolly. I have selected a figure more or less arbitrarily, that is that an equal amount be taken out of the two species, although the loblolly pine now occupies approximately 70% of the area. In the younger age classes even more shortleaf can be cut, because there you have more shortleaf than loblolly. This will give a stand in the future that will have an even greater percentage of loblolly.

25% + STOCKING

THINNINGS-cont.

51-60 age class - The average tree in this class is 14.4" in diameter. The weighted growth figure for such a tree is 2.50" in ten years, which would make the average tree ten years from now16.9" in diameter. In order to hold the basal area in ten years down to what it now is in the 61-70 class only 14.8 trees would be required. We now have 20.18 trees in that class, so that 5.4 average trees should be cut, which is a basal area of 6.12 sq.ft.

41-50 age class - The average tree in this class is 11.4" in diameter. The weighted growth figure for such a tree is 2.60 inches in ten years, which would make the average tree ten years from now 14" in diameter. In order to hold the basal area in ten years down to what it now is in the 51-60 class only 21.35 trees would be required. We now have 31.45 trees in that class, so that 10.1 trees should be cut, or a basal area of 7.15 sq.ft.

31-40 age class - The average tree in this class is 8.8" in diameter. The weighted growth figure for such a tree is 2.55" in ten years, which would make the average tree ten years from now 11.35" in diameter. In order to hold the basal area in ten years down to what it now is in the 41-50 class only 29.8 trees would be required. We now 49.7 trees in that class, so that 19.8 trees should be cut, or a basal area of 8.80 sq.ft.

Undoubtedly some thinnings should be made in the lower age classes, but the amount would depend on the amount of reproduction present in the stand ten years from now.

Table XXVII

25% + Stocking -

Growth prediction for the second ten years for the purpose of finding the cut in the third cycle.

LOBLOLLY PINE D.B.H.	No. Trees	Growth 10 yrs.	no.tr. 10yrs hence	Move 1	Move 2	Volume
8	9.00	1.50		4.50	4.50	
10	12.04	1.49	4.50	6.14	5.90	280
12	8.48	1.46	10.64	4.58	3.90	1330
14	9.43	1.38	10.48	5.85	3.58	2240
16	3.86	1.29	9.75	2.74	1.12	3190
18			6.32			2850
20			1.12			630
Totals			42.81			10,520 b.m.
SHORTLEAF PINE						
8	9.00	1.03		8.73	.27	
10	7.85	1.09	8.73	7.14	.71	670
12	3.81	1.10	7.41	3.43	.38	1090
14	2.56	1.10	4.14	2.30	.26	960
16			2.68			860
18			.26			110
Totals			23.22			3690 b.m.

Table XXVIII

25% + STOCKING *

Basal Area at Beginning of 3rd cycle

D.BH. Class	Number of Trees	Total Basal Area
10	13.23	7.21
12	18.05	14.15
14	14.62	15.62
16	12.43	17.36
18	6.58	11.60
20	1.12	2.44
Totals	66.03	68.38 sq.ft.

Basal Area Control Classification

Age class	% B.A.	Actual B.A.	Diameter Range	Number of trees	Volume
0-10	no	Data			
11-20	"	"			
21-30	"	"			
31-40	"	"			
41-50	32.6	22.28	10-14	32.17	
51-60	33.5	22.90	14-16	29.57	
61-70	33.9	23.20	16-20	14.29	5740 b.m.

Cut during third cycle beginning in 21st yr.
5740 b.m.

Thinnings in the third cutting cycle will be made on the same basis as those in the first and will be shown below.

Table XXIX

LOBLOLLY PINE	2nd Cycle		3rd Cycle	
D.B.H.	No. Trees	Volume	No. Trees	Volume
8	2.00	[illegible]		
10	4.45	270	1.35	80
12	4.00	500	2.50	310
14	2.70	580	2.78	600
Totals	13.15	1350 b.m.	6.63	990 b.m.

Shortleaf pine

D.B.H.	No. Trees	Volume	No. Trees	Volume
8	11.02			
10	4.45	340	4.00	310
12	4.00	590	2.50	370
14	2.70	620	2.79	640
Totals	22.17	1550 b.m.	9.29	1320 b.m.

Second Growth Stands with Less than 25% Stocking

The stand table for this area is shown in Table XXX. This is another stand with very little stocking over 60 years of age and no overmature trees at all, so a wait of ten years is essential before a cut is possible.

This stand grows while it is being cut, but fewer predictions are required than was the case in the Culled Stand. To find the third cycle cut in this stand an average stand table is made by combining the stand left at the beginning of the first cut and the one at the end. This average stand in turn has the growth predictions made on it to determine the third cycle cut. The cut thus determined for the third cycle would be the average, but much laborious calculating has been saved.

Table XXXI and XXXII show the growth predictions and classification for the cut at the beginning of the second cycle. Tables XXXIII and XXXIV show the growth predictions and classification for the cut at the end of the second cycle. Table XXXV shows the growth predictions on the average stand after the first cut, and Table XXXVI shows the classification for finding the third cycle cut, which would naturally be the average cut during the third cycle. The cut in the second cycle averages 2955 bd.ft. and rises to 3680 bd.ft. in the third cycle, where for safety's sake it is assumed to be in subsequent cycles.

Table XXX

STAND TABLE
Average Acre - Shortleaf-Loblolly Area
Second Growth Stands
Less than 25% stocking

Diameter Class	Loblolly Pine			Shortleaf Pine			Hardwood	
	Main Stand	Supr'd Stand	Total Volume	Main Stand	Supr'd Stand	Total Volume	Main Stand	Supr'd Stand
2	9.98	12.74		6.27	7.31		16.00	16.54
4	7.36	3.60		3.11	1.78		3.15	4.05
6	9.09	1.33		4.25	1.43		10.96	2.62
8	4.94	.35		3.11	.35		5.98	.89
10	4.25	.05	264	2.81	.10	216	4.54	.25
12	5.14		642	2.32		343	4.15	.35
14	2.37		514	.74		171	2.62	.20
16	1.23		402	.10		32	1.63	.15
18	.79		357	.25		104	1.19	.05
20	.40		226	.05		26	.25	
22							.05	
24							.25	
26							.10	
28								
30							.10	
Total	45.55	18.07	2405	23.01	10.97	892	55.97	25.10

Total Pine Volume = 3297
No. Trees = 68.56 (Main stand only)
3297 bd.ft. reduced 10% for defect and util. = 2967 bd.f
Assessed Value $8 per acre

Table XXXI
LESS THAN 25% STOCKING
Cut at beginning of 2nd cycle, Growth predictions -
Loblolly Pine

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs.	No.Tr.: 10yrs.: hence	Move 1	Move: 2	Volume
6	10.42	3.0	10.11	1.48		5.26	4.85	
8	5.29	2.7	5.15	1.50	5.26	2.58	2.57	
10	4.30	2.6	4.19	1.49	7.43	2.14	2.05	460
12	5.14	2.8	5.00	1.46	4.71	2.70	2.30	590
14	2.37	3.4	2.29	1.38	4.75	1.42	.87	1030
16	1.23	4.3	1.18	1.29	3.72	.84	.34	1220
18	.79	5.6	.75	1.16	1.71	.63	.12	770
20	.40	7.2	.37	1.03	.97	.37		550
22					.49			340
Totals			29.04		29.04			4,960 b.m.

Shortleaf Pine

						M-0	M-1	M-2	
6	5.68	3.0	5.51	.98	.11	.11	5.40	.40	
8	3.46	2.7	3.37	1.03	5.40		3.27	.10	
10	2.91	2.6	2.83	1.09	3.27		2.58	.25	250
12	2.32	2.8	2.26	1.10	2.68		2.03	.23	400
14	.74	3.4	.71	1.10	2.28		.64	.07	530
16	.10	4.3	.10	1.10	.87		.09	.01	280
18	.25	5.6	.24	1.10	.16		.22	.02	70
20	.05	7.2	.05	1.10	.23		.05		120
22					.07				40
Totals			15.07		15.07				1,690 b.m.

Table XXXII
LESS THAN 25% STOCKING

Basal area at beginning of 2nd Cycle

D.B.H.	Number of trees	Basal Area
6	.11	.02
8	10.66	3.72
10	10.70	5.83
12	7.39	5.80
14	7.03	7.52
16	4.59	6.40
18	1.87	3.30
20	1.20	2.62
22	.56	1.48
Totals	44.11	36.69

Basal Area Control Classification

Age Class	% B.A.	Actual B.A.	Number of Trees	Diameter Range	Volume
0-10	No	Data			
11-20	"	"			
21-30	"	"			
31-40	23.5	8.62			
41-50	25.0	9.17		33% of 16"	
51-60	25.6	9.40			
61-70	25.9	9.51	5.14	16-22	2290 bd.ft.

Table XXXIII

LESS THAN 25% STOCKING

Growth predictions for the purpose of finding the cut at the end of the 2nd cycle -

LOBLOLLY PINE

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs	No.Tr.: 10yrs.: hence	Move 0	Move 1	Move 2	Volume
8	5.26	2.7	5.12	1.50			2.56	2.56	
10	7.43	2.6	7.24	1.49	2.56		3.69	3.55	160
12	4.71	2.8	4.58	1.46	6.25		2.47	2.11	780
14	4.75	3.4	4.59	1.38	6.02		2.85	1.74	1300
16	3.72	4.3	3.56	1.29	4.96		2.52	1.04	1620
18	1.71	5.6	1.61	1.16	4.26		1.35	.26	1930
20	.97	7.2	.90	1.03	2.39		.88	.02	1350
22	.49	9.2	.44	.87	1.20	.06	.38		820
24					.40				330
Totals			28.04		28.04				8,320

SHORTLEAF PINE

						Move 1	Move 2	
6	.11	3.0	.11	.98		.11		
8	5.40	2.7	5.25	1.03	.11	5.09	.16	
10	3.27	2.6	3.19	1.09	5.09	2.90	.29	390
12	2.68	2.8	2.60	1.10	3.06	2.34	.26	450
14	2.28	3.4	2.20	1.10	2.63	1.98	.22	610
16	.87	4.3	.83	1.10	2.24	.75	.08	720
18	.16	5.6	.15	1.10	.97	.14	.01	400
20	.23	7.2	.21	1.10	.22	.19	.02	110
22	.07	9.2	.06	1.10	.20	.06		120
24					.08			60
Totals			14.16		14.16			2860 b.m.

Table XXXIV
LESS THAN 25% STOCKING

Basal Area at End of 2nd Cycle

D.B.H.	Number of Trees	Total Basal Area
8	.11	.04
10	7.65	4.17
12	9.31	7.30
14	8.65	9.25
16	7.20	10.04
18	5.23	9.24
20	2.61	5.70
22	1.40	3.70
24	.48	1.51
Totals	42.64	50.95

Basal Area Control Classification

Age Class	% B.A.	Actual B.A.	Diameter Range	Number of trees	Volume
0-10	no	data			
11-20	"	"			
21-30	"	"			
31-40	23.5	11.97			
41-50	25.0	12.73	25% of 18"		
51-60	25.6	13.05			
61-70	25.9	13.20	18-24	5.80	3620 bd.ft.

Cut at beginning of 2nd cycle 2290
Cut at end of 2nd cycle 3620

Ave. cut = 2955 bd.ft.

Table XXXV
LESS THAN 25% STOCKING -
Growth predictions for the purpose of finding the cut in the third cycle.

D.B.H.	No. Trees	% Mort.	No. Trees	Grth 10yrs	No.Tr. 10yrs. hence.	Move 1	Move 2	Volume
LOBLOLLY PINE *								
8	2.63	2.7	2.57	1.50		1.29	1.28	
10	4.99	2.6	4.86	1.49	1.29	2.48	2.38	80
12	5.48	2.8	5.33	1.46	3.76	2.88	2.45	470
14	5.34	3.4	5.16	1.38	5.26	3.20	1.96	1140
16	4.34	4.3	4.15	1.29	5.65	2.95	1.20	1850
18	.71	5.6	.67	1.16	4.91	.56	.11	2220
20		7.2			1.76			990
22					.11			80
Totals			22.74		22.74			6730
SHORTLEAF PINE								
8	2.75	2.7	2.68	1.03	.	2.60	.08	
10	4.18	2.6	4.07	1.09	2.60	3.70	.37	200
12	2.87	2.8	2.79	1.10	3.78	2.51	.28	560
14	2.46	3.4	2.38	1.10	2.88	2.14	.24	665
16	1.55	4.3	1.48	1.10	2.42	1.38	.15	780
18					1.57			650
20					.15			80
Totals			13.40		13.40			29.35

* The numbers of trees used for this growth prediction are averages of the number of the different diameters at the beginning and at the end of the second cutting cycle.

Table XXXVI

LESS THAN 25% STOCKING -

Classification using the basal area control method for finding the average cut in the third cutting cycle.

3rd Cycle Basal Area

D.B.H. Class	Number of Trees	Total Basal Area
10	3.89	2.12
12	7.54	5.91
14	8.14	8.70
16	8.07	11.26
18	6.48	11.42
20	1.91	5.45
22	.11	.50
Totals	36.14	43.88 sq.ft.

Basal Area Control Classification

Age Class	% B.A.	Actual B. A.	Diameter Range	Number of Trees	Volume
0-10	no	data			
11-20	"	"			
21-30	"	"			
31-40	"	"			
41-50	32.6	14.27	91% of 18"		
51-60	33.5	14.72			
61-70	33.9	14.87	18-22"	7.92	3680 bd.ft.

average cut in 3rd CC = 3680 bm

OLD FIELD MERCHANTABLE STANDS

The stand table for this area is given as Table XXXVII. This area compares with the 25% stocked, in that it will have passed the probable maximum basal area growth before it is cut. For that reason the stand is not assumed to grow while being cut. Table XXXVIII shows the growth predictions, where it is calculated that there will be better than 20 M per acre at the end of ten years. This may be improbable, but little suppression is likely to result from an over dense stand in the larger trees. The thing that will probably happen is an increased mortality. Table XXXIX shows the classification for the first cut which will be made starting in the 11th year. 7.3M are to be cut per acre exclusive of thinnings, with a thinning cut calculated at 6.5M. These figures shouldn't be considered particularly reliable, so when the growth for the period is used in the future it has been scaled down to 8 M per acre. The difference would come out in the form of smaller trees in the thinning operation. Table XXXX shows the calculated thinnings if normal growth continued. The residual stand after the second cycle thinning is predicted ahead & reclassified in Tables XXXXI and XXXXII. It will be noted that there are no shortleaf trees in the third cycle cut and thinnings, because all the shortleaf were removed in the second cycle cut and thinnings.

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Table XXXVII

STAND TABLE
Average Acre - Old Field Stands

Diam. Class	Loblolly Pine			Shortleaf Pine			Hardwoods	
	Main Stand	Suppr'd Stand	Total Volume	Main Stand	Suppr'd Stand	Total Volume	Main Stand	Suppr'd Stand
2	.67	1.67			4.00		.33	5.00
4	1.00	8.33		2.33	4.33		1.33	3.67
6	20.00	15.33		10.33	7.00		2.00	3.00
8	38.00	2.00		12.33	1.67		2.33	.33
10	28.67	.33	1778	6.33	.33	487	.67	
12	17.00		2125	2.33		345	.33	
14	8.67		1881	.33		76		
16	1.67		546					
18	.67		303					
20	.33		186					
22	.33		224					
Total	117.03	27.66	7043	33.98	17.33	908	6.99	12.00

Total Pine Volume 7951 bd.ft.

No. trees, Pine 150.99 (Main stand only)

7951 bd.ft. reduced 10% for defect and utilization = 7156 bd.ft.

Assessed value = $20 per acre.

Table XXXVIII -
OLDFIELD STANDS-MERCHANTABLE -
Growth predictions during the first cycle for the purpose of determining the cut during the second.

LOBLOLLY PINE - D.B.H.	No. Trees	% Mort.	No. Trees:	Grth 10yrs:	No.Tr. 10yrs. hence.	Move More	Move 1	Move 2	Volume
6	20.00	3.0	19.40	1.48			10.09	9.31	
8	38.00	2.7	37.00	1.50	10.09		18.50	18.50	
10	28.67	2.6	27.92	1.49	27.81		14.25	13.67	1670
12	17.00	2.8	16.52	1.46	32.75		8.92	7.60	4100
14	8.67	3.4	8.38	1.38	22.59		5.10	3.28	4900
16	1.67	4.3	1.60	1.29	12.70		1.14	.46	4150
18	.67	5.6	.63	1.16	4.42		.53	.10	2000
20	.33	7.2	.31	1.03	.99		.30	.01	560
22	.33	9.2	.30	.87	.44	.04	.26		300
24					.27				230
Totals			112.06		112.06				17,910 b.m.
SHORTLEAF PINE									
6	10.33	3.0	10.02	.98	.20	.20	9.82		
8	12.33	2.7	12.00	1.03	9.82		11.64	.36	
10	6.33	2.6	6.17	1.09	11.64		5.62	.55	900
12	2.33	2.8	2.27	1.10	5.98		2.04	.23	880
14	.33	3.4	.32	1.10	2.59		.29	.03	600
16					.52				170
18					.03				
Totals			30.78		30.78				2550 b.m.

Table XXXIX -
OLDFIELD STANDS -MERCHANTABLE -
Classification to determine the cut in the third cycle -

Basal Area After 10 Years

D.B.H.	Number of trees	Total Basal Area
6	.20	6.97
8	19.91	20.95
10	38.45	30.40
12	38.73	26.95
14	25.18	18.45
16	13.22	7.85
18	4.45	2.16
20	.99	1.16
22	.44	.85
24	.27	
Totals	141.83	115.74 sq.ft.

Basal Area Control Classification

Age Class	% B.A.	Actual B. A.	Diameter Range	Number of trees	Volume
0-10	no	data			
11-20	"	"			
21-30	"	"			
31-40	23.5	27.18	6-10	57.22	
41-50	25.0	28.93	10-12	37.35	
51-60	25.6	29.62	12-16	28.21	
61-70	25.9	30.01	16-24	19.05	7290 b.m.
			97% of 16"		2nd Cycle Cut

OLDFIELD STANDS -MERCHANTABLE-

THINNINGS

This stand if it grows at the normal rate for ten years will have a basal area of 115 sq.ft. Such growth is decidedly unlikely in ten years, but it might take place in part of the stands during the second cycle before the cut is made. This stand will be thinned in the same manner as the 25% + stocking stand except that in this stand the shortleaf pine makes up only slightly more than ten percent, and it is thought possible to cut it out in its entirety. Some thinnings will also be necessary in the accompanying loblolly pine. Arbitrarily 22 sq.ft. has been chosen as the desired basal area in the upper three classes ten years after the first cut is made. It is deemed necessary to cut down to this in order to assufe a normal growth.

Table XXXX-

	Loblolly pine		2nd & 3rd C C		Shortleaf pine 2nd C C only	
D.B.H.	No. TREES.	Volume	No. Trees	Volume	No. Trees	Volume
8	3.27				10.02	
10	6.00	370			11.64	900
12	13.00	1620	5.43	680	5.98	880
14	10.58	2170	8.95	1940	2.59	600
Totals	32.85	4160bm	14.38	2620 b.m.	30.23	2380 b.m.

Table XXXXI
OLDFIELD STANDS -MERCHANTABLE- Growth prediction.
Classification using the basal area control method to determine the cut in the second third cycle -

LOBLOLLY PINE

D.B.H. Class	No. Trees	Grth Rate.	No. Trees. in 10yrs.	Move 1	Move 2	Volume
108	16.82	1.50		3.41	3.40	
10	21.81	1.49	3.41	11.11	10.70	210
12	19.75	1.46	14.51	10.67	9.08	1810
14	12.01	1.38	21.37	7.45	4.56	4640
16	.32	1.29	16.53	.23	.09	5400
18			4.79			2160
20			.09			50
Totals			60.70			14,270 bd.ft.

Table XXXXII-

D.B.H.	No. Trees	Total B.A.
10	3.41	1.86
12	14.51	11.40
14	21.37	22.82
16	16.53	23.08
18	4.79	8.47
20	.09	.20
Tot.	60.70	67.83

Basal Area

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Basal Area Control Classification

Age Class	% B.A.	Actual B.A.	Diameter Range	No. Trees	Volume
0-10	no	data			
11-20	"	"			
21-30	"	"			
31-40	"	"			
41-50	32.5	22.03	62% of 16"	26.06	
51-60	33.6	22.80		19.52	3rd CC Cut
61-70	33.9	23.00	16-20	15.12	5560 b. m.

Thinnings must also be taken out in the third cutting cycle.

OLD FIELD UNMERCHANTABLE STANDS

THe stand table for this type of stand, which comprises some 14 sections of the total area, is shown in Table XXXXIII. The largest trees are ten inches in diameter at the present time, but there are very few above six. Assuming maximum growth rates apply to this stand it will be about 40 years before this stand will be ready to cut. To assure maximum growth a thinning in the near future might be advisable. No calculations are shown for such a thinning, but one might be made to pay for itself in a few years, if the trees cut were utilizable for the expanding pulp industry in the South.

Table XXXXIII-

STAND TABLE
Average acre - Old Field Stands
Unmerchantable

Diam. Class	Loblolly Pine Main Stand	Loblolly Pine Suppr'd Stand	Loblolly Pine Total Volume	Shortleaf Pine Main Stand	Shortleaf Pine Suppr'd Stand	Shortleaf Pine Total volume	Hardwoods Main Stand	Hardwoods Suppr'd Stand
2	512.67	12.33		18.00	3.00		5.33	2.00
4	40.67	3.67		10.00	0.33		2.00	0.67
6	39.67			6.67			0.33	
8	3.67							
10	0.67		42					
Total	597.35	16.00	42	34.67	3.33		7.66	2.67

Total Volume of Pine = 42 bd ft

42 bd.ft. reduced 10% for defect and utilization = 38 bd.ft.

Assessed value = $3 per acre

CUTTING SUMMARY

Table XXXXIV shows the number of trees cut from each diameter class during the first three cycles, from the various areas. Thinnings are not included, as the number of trees cut by thinning have been shown previously.

Table XXXXV is a summary of the volume of the cuts, for the first three cutting cycles for the various areas, and for the property as a whole. These are the volumes found by the use of Reynold's Method. A 10% deduction for defect has been made in all the stands.

When determining the value of the cuts later on, there is no reliable way of determining just how much will be lost due to defect. For that reason a blanket deduction of 10% has been made on a per acre basis. This leads to the greatest error during the first cuts on each area, there being a much larger range of diameters at that time, whereas later on the diameters cut will all be from three age classes at the most, and the loss due to defect, if deducted on the basis of the total value produced per acre, will be fairly accurate.

Table XXXXIV -

NUMBER OF TREES ACTUALLY CUT FROM THE DIFFERENT DIAMETER CLASSES IN EACH STAND DURING THE FIRST THREE CYCLES DOES NOT INCLUDE THINNINGS

D.B.H.		STAND NUMBER					
		1st CC				2nd C C	
	sp.	Virgin 1	Culled 2	Virgin 1	Culled 2	25% - 3	25%- 4	Oldfield 5
16	L					5.17		12.38
	S		1.75		2.24	1.40		.52
18	L	.78	.92	2.16	2.19	4.02	1.75	4.42
	S	1.64	1.77	2.48	1.96	.43	.56	.03
20	L	.55	.12	1.03	.46	1.43	1.68	.99
	S	.73	.73	.24	.17	.37	.23	
22	L	.18		.08		.50	.85	.44
	S	.36	.22			.16	.13	
24	L	.73				.12	.20	.27
	S	.55	.44				.04	
26	L	.55						
	S	.18	.44					
28	L	.36						
	S	.18						
Totals		6.79	6.92	5.99	7.35	13.60	5.96	19.05
				3rd C C				
16	L					3.90		10.24
	S			.66	1.92	2.68		
18	L			2.27	2.38	6.32	4.33	4.79
	S			3.44	2.87	.26	1.57	
20	L			1.12	.80	1.12	1.76	.09
	S			.31	.52		.15	
22	L			.08	.05		.11	
	S							
Totals				7.88	9.25	14.28	7.92	15.12

Summary of Cuts by Years and Cycles

Western Tract	Acres per year	First C C Volume	First C C Total Cut	Second C C Volume	Second C C Total Cut	Third C C Volume Cut	Third C C Total
Virgin Area	1,152	5,150	5,933M	3,150	3,629M	4,070	4,689M
Culled	1,024	3,480	3,563	3,230	3,307	4,080	4,178
Second Growth 25% +	2,176			8,010	17,430	7,250	15,754
Second Growth 25% -	2,240			2,955	6,630	3,310	7,414
Oldfield Merchantable	576			7,320	4,215	7,360	4,420
Eastern Tract-							
Virgin Area	1,216	5,150	6,262M	3,150	3,830M	4070	4,950M
Second Grth 25% +	1,216			8,010	9,740	7,250	8,810
Oldfield Merchantable	768			7,320	7,320	7,360	5,650
Totals cut by Cycles			15,758M First		55,100M Second		55,685 Third

LOGGING PLAN FOR THE

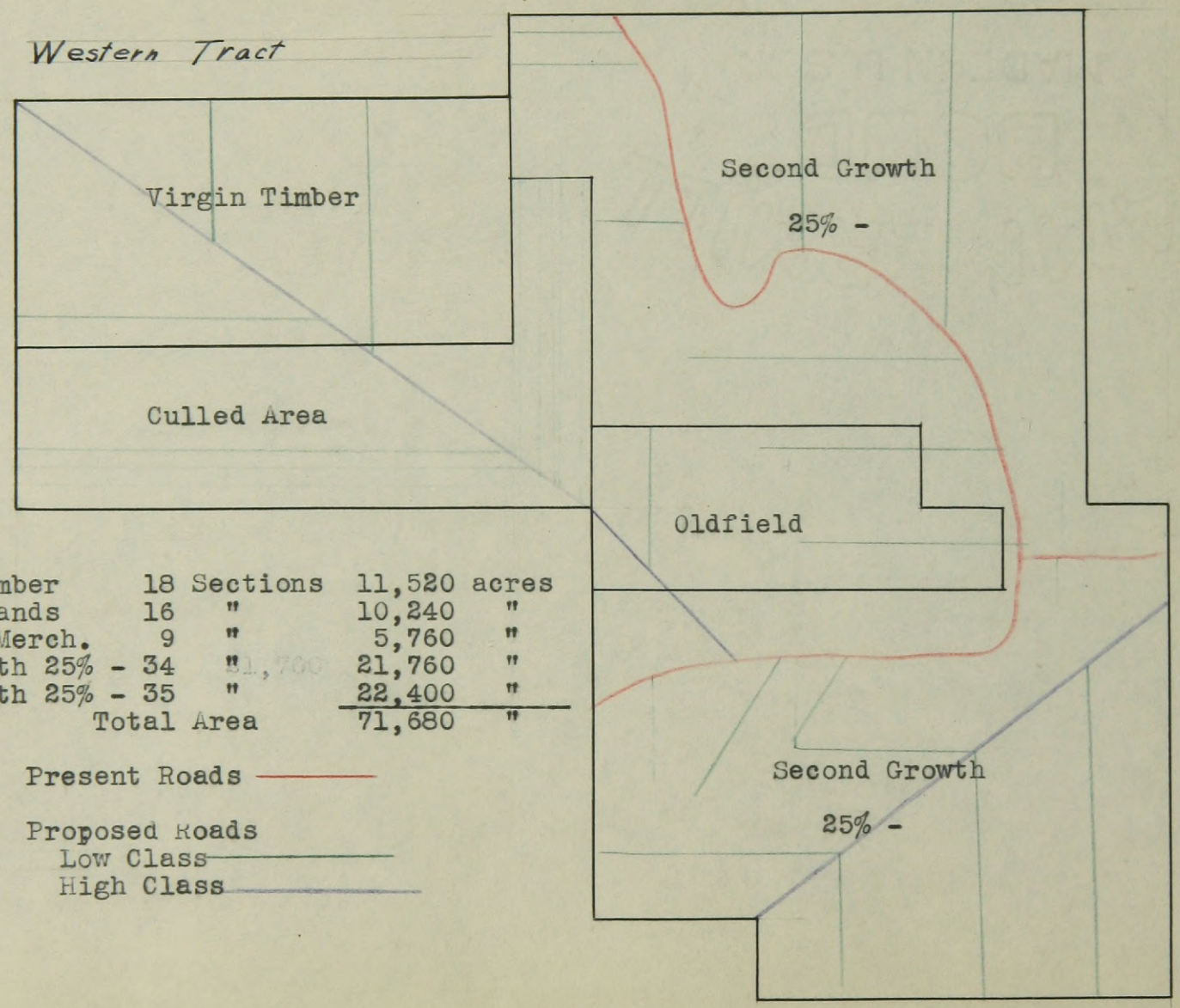
KAUL LUMBER COMPANY TRACTS IN ALABAMA

Logging Plan

On the following two pages are shown the maps of the eastern and western tracts. For an explaination as to why the roads are put in as indicated the reader is referred to the supplement on diagonal roads in the back of this paper.

Tables 46, 47, and 48, which follow the maps summarize the costs of logging and milling for the different cycles and for each of the areas. The derivation of the costs used are explained on subsequent pages.

These costs are based on a two hundred-fifty day working year. The reason that the time is so short is due to the seasonal weather prevalent in that section of the country. Logging practice would all be classed as a hot logging job. This is absolutely necessary, because of the blue stain organisims which attack green logs left in the woods for any considerable length of time. Logs should for safety's sake be removed to the mill within a week after being cut.

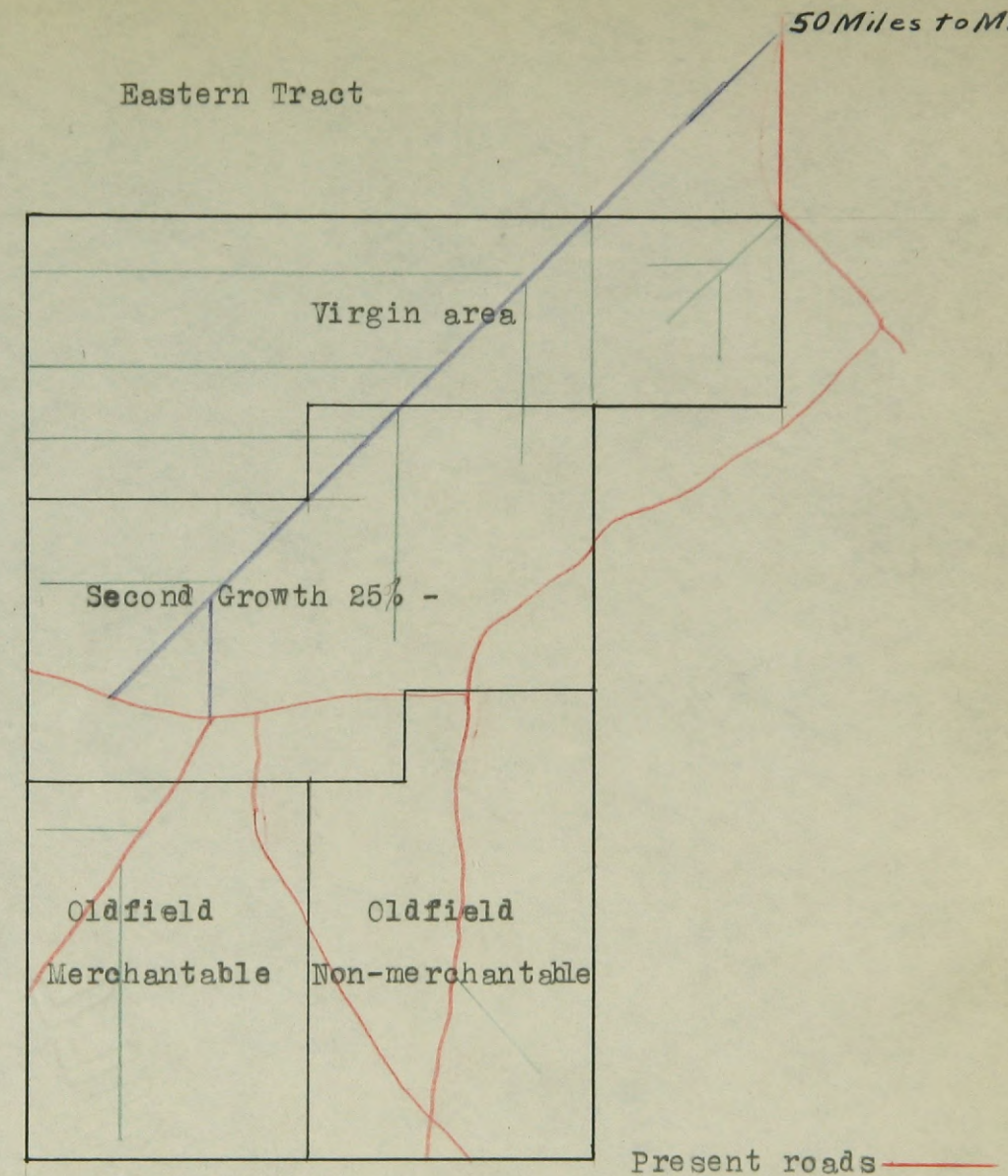


Virgin Timber	18 Sections	11,520	acres
Culled stands	16 "	10,240	"
Oldfield Merch.	9 "	5,760	"
Second Grth 25% - 34	"	21,760	"
Second Grth 25% - 35	"	22,400	"
Total Area		71,680	"

Present Roads ——

Proposed Roads
Low Class ——
High Class ——

Direction only



Scale 1/2 inch = 1 Mile

Proposed roads
High standard
Low standard

Areas:	Direction only		
Virgin timber	19 sections	12,160	Acres
2nd Grth 25% -	19 sections	12,160	"
Oldfield Mer -	12 sections	7,680	"
" Non " -	14 sections	8,960	"
Total area	64 "	40,960	"

Table 46

COST SCHEDULE FOR DIFFERENT SIZE TREES

Diameter of Trees DBH	10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"
SAWING	$1.03	$ .97	$ .93	$ .90	$ .87	$ .85	$ .84	$ .84	$ .84	$ .84	$ .84
Bunching	1.57	1.16	1.00	.63	.55	.46	.41	.39	.37	.35	.34
Skidding Spurs and fixed	3.75	2.96	2.00	1.29	.98	.85	.76	.65	.60	.56	.52
Loading	1.67	1.23	.92	.72	.59	.49	.43	.38	.34	.33	.30
Logging Miscellaneous Exp.	.70	.58	.50	.43	.39	.35	.34	.33	.32	.31	.31
Pond-Mill-Greenchain	2.81	2.73	2.64	2.55	2.47	2.38	2.29	2.21	2.12	2.04	1.95
Stacking-Kiln-Rough shed-Yard-Dock	2.05	1.91	1.80	1.74	1.70	1.68	1.66	1.64	1.63	1.61	1.60
Planer-Shipping & Selling	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41
Taxes- Discounts Insurance	.29	.30	.31	.32	.33	.35	.36	.37	.39	.40	.41
Yield Tax 10%	2.65	2.73	2.83	2.91	3.00	3.12	3.25	3.37	3.48	3.58	3.66
Total of costs not varying either with output or Tract	19.93	17.98	16.34	14.90	14.29	14.15	13.75	13.59	13.50	13.43	13.34
Sale Value	$26.46	27.34	28.34	29.07	30.02	31.21	32.50	33.72	34.84	35.81	36.56

Table 47

COSTS VARYING WITH OUTPUT AND WITH TRACT
GENERAL EXPENSE AND HAULING

	10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"
Hauling Costs											
Western tract first cycle	$8.20	6.90	6.10	5.44	4.88	4.40	4.00	3.72	3.47	3.24	3.07
Eastern tract first cycle	10.80	9.10	8.06	7.18	6.43	5.80	5.28	4.91	4.57	4.30	4.05
Western tract subsequent cycles	7.54	6.35	5.52	5.00	4.48	4.03	3.68	3.42	3.18	3.00	2.83
Eastern tract subsequent cycles	11.47	9.67	8.54	7.62	6.83	6.15	5.60	5.20	4.83	4.55	4.30
General Expenses first cycle	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48	5.48
general expenses subsequent cycles	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
General Expenses under a 45,000M per year liquidation	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36

Table 48 TOTAL VALUE OF CUTTING TREES OF THE VARIOUS DIAMETER CLASSES

	10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"
Western tract first cycle			$ .42	$3.25	5.37	7.18	9.27	10.93	12.39	13.66	14.67
Eastern tract first cycle				1.51	3.82	5.78	7.99	8.74	11.29	12.60	13.69
Western tract subsequent cycles	-3.77	+.25	3.72	6.41	8.49	10.27	12.31	13.95	15.40	16.62	17.63
Eastern Tract subsequent cycles	-6.73	-2.02	+.70	3.79	6.14	8.15	10.39	12.17	13.75	15.07	16.03
Western tract Liquidation plan			3.12	5.81	7.89	9.67	11.71	13.35	14.80	16.02	17.03
Eastern Tract Liquidation			.10	3.19	5.54	7.55	9.79	11.57	13.15	14.47	15.43

Logging Plan and Costs for the Kaul Lumber Co. Tract

Sawing:

The costs used in this plan for sawing are taken directly from the East Texas Area of Technical Bulletin No. 375, entitled, "Selective Logging in Shortleaf and Loblolly Pine Forests of the Gulf States Region", which was published in August 1933. The costs as given include labor and materials and supplies, the latter of which I assume to mean the tools used by the fellers and buckers, such as saws , axes, and wedges. This cost, that is the total sawing cost, varies from $1.03 for the ten inch trees down to $ .84 for the 30 inch trees. This is as would be expected, it requiring a larger number of cuts, and a great deal more waste motion to cut smaller trees. The surprising thing is that the differential isn't larger.

Bunching:

The figures used here are taken from a southern pine operation in Arkansas. The bunching is done by teams. The costs are figured out from the schedule given below, with interpolations for the missing diameters. Although tractors are used for skidding, experience has proven that both time and money are saved by having teams bunch the loggs for the tractors, and thus avoid unnecessary delay time on the part of the tractor, which has a higher per minute cost than the team.

Cost schedule for bunching logs with teams:

Based on an average cost 1.125¢ per minute for team and driver.

Ave. DBH OF STD INCHES	Load bd.ft. Doyle Scale	Hook and Unhook Time Mins.	Delay Time Mins.	Total Fixed Time Mins.	Fixed Time Cost ¢	Fixed Time Cost per M ¢	Mins. per 100' Dist.	Cost per 100' of Dist ¢	Cost per M ft.b.m. Per 100' of Dist ¢
12	60	2	3	5	5.6	93	2.00	2.25	37
16	150	2	4	6	6.8	45	2.50	2.8	18
20	280	2	5	7	7.9	28	4.4	5.0	18
24	430	2	6	8	9.0	21	6.8	7.7	18

Skidding:

Skidding costs have been worked out for a definite road spacing, because that is what determines total skidding cost. For the purpose of determining the correct road spacing, that is the spacing which gives the minimum cost for skidding and spurs, a formula worked out by Bruce Spike and simplified by D.M. Matthews was used.

The formula is as follows: $S = \sqrt{\frac{.33R}{VC}}$

Where

R = Cost of the road per mile in cents.

V = Volume per acre in thousands of board feet.

C = the running cost per hundred feet of distance skidded.

S = the spacing of the roads in hundreds of feet.

In words the formula would read as follows: The spacing of roads equals the square root of .33 of the cost of the spur roads in cents, divided by the product of the volume per acre in thousands

of board feet and the skidding cost per hundred feet.

On this area two types of spur roads are feasable, either a well swamped and low stumped line, leveled off sufficiently so that trucks can haul a fair sized load; such a road to cost an estimated $250 per mile, or an alternative graded road with the wheel tracks graveled, which is estimated to cost $800 per mile. On the first type of road trucks can average 13.3 miles per hour or a mile in 4.5 minutes, and on the second type an average speed of 20 miles per hour is possible or one mile in 3 minutes. It will not pay to build spur roads to the higher class unless they are atleast fifteen miles long. There being no such spur lengths on this tract, the higher class roads will be limited to tap and main line use. The volumes vary from 3 to 8M per acre. Skidding cost varies with the different size logs, ~~as does the fixed or delay cost.~~ For this operation with the low class spur roads the D 2 Caterpillar tractor gives the cheapest total skidding cost for the average size logs found on this area.

Inasmuch as roads will be used for future cuts it is assumed that the roads are spaced so as to give the lowest cost for the present and also the future cuts. This means that roads will be closer together than if spaced correctly for the first cycle only, because the roads are used for subsequent cuts , where the cost of the road will be less than the original cost. The first cycle cost is $250, and subsequent costs are $100 per mile, so effectively the present road has a value of $150 per mile ten years hence. A present value of $150 ten years hence is calculated, using 5%, and subtracted

from the present cost of the road. The difference is used for R in the formula. Using this for the virgin area we would have

$$S = \sqrt{\frac{.33 \times 16000}{4.5 \times 7.8}}$$ = between 12 and thirteen hundred feet. There would naturally be variations, because of adverse topography etc. It is assumed that all roads are put in on a 1300 foot spacing. For the most part this results in conservatism as roads in some areas will be closer together by 2 or 3 hundred feet. In this respect the larger volumes on some areas would be partially offset by a probable increase in road cost. So for safeties sake all spur roads and consequently skidding, which by the formula are equal costs per M are calculated on a 1300 foot spacing. To the total cost of spurs and skidding is added the fixed cost per M. The cost schedule given below was used to determine the costs for the various diameters, with graphic interpolations for the missing ones.

Cost of Skidding Logs with

a D 2 Caterpillar tractor

Ave. DBH of Stand. Inches	Load Bd.Ft. Doyle Scrib	Hook & Unhook Time Mins	Delay Time - Mins.	Total Fixed Time Per Turn	Cost at charge per min.of $ .0230	Fixed Time Cost Per M	Hauling Cost Per M ft.b.m. Per 100' of Hauling Dist
12	110	5	2	7	$.161	$1.46	$.230
16	230	4	2	6	.138	.59	.107
20	325	3	2	5	.115	.34	.078
24	395	2	2	4	.092	.23	.064
28	455	2	2	4	.092	.20	.055

*Note - The data given above are for skidding tree length logs.

Loading

The loading costs as given in Technical Bulletin 375 are not applicable to truck logging, that having been a railroad logging job. For the Kaul Lumber Company logging plan loading costs are taken from a Southern Arkansas operation. It is assumed that a load of 20 inch trees requires thirty minutes to put on, and that loading costs 1.125¢ per minute for team and driver making 33.8¢ loading cost plus a fixed cost for the idle truck of .75¢ per minute or 22.5¢. This makes a total loading cost of 55.3¢, or say 56¢. When reduced to a per M cost it becomes 49¢ for 20 inch trees.

Loading costs are assumed to vary in the same ratio as those for the railroad operation previously referred to, and are worked out on that basis.

The fact that loaders aren't used instead of the crosshaul is not an oversight. Costs are not available for loader loading, so it is impossible to say which type of loading would be the cheaper. By using the two formulas, that is the one for direct skidding and the one for skidding to landings, and adding to the total skidding and spur cost thus calculated the cost of loading by the method used, meaning crosshaul for the direct skidding and loaders for the landings, it is possible to find the cheaper method. The actual cost calculation would be as follows:

Direct skidding- $2 \times C\frac{S}{4}$ plus loading cost by crosshaul-

Skidding to landings- 2CS X .427 plus loader loading cost-

Hauling

Hauling would normally come here, but is put in at the end because of the number of variations due to having two areas with a change in cost for the different cycles. Because all of the costs that are not affected by the cycle, and which are the same for the entire operation are contained in this part of this paper hauling has be put in out of order.

Miscellaneous Logging Costs-

This item , although not definitely known, probably includes items such as scaling , and supplies& repairs. Th e costs used are taken direct from Technical Bulletin 375. The amounts might be more or less depending on what is included but because of a lack of information as to their exact nature they are used as given.

Pond, Sawmill, & Greenchain-

These costs are also from Bulletin 375. By far the largest portion of the cost is for labor charges, with the sawmill labor making up most of that. We are forced to assume that the mill is efficiently run, and that the same wage scale prevails. We must also assume that the same costs apply regardless of output. On that point, it would seem that if the cost is right for the first cycle, it might be too high for the second. It is readily conceivable that there would be some advantage in the volume of productions increasing.

Stacking-DryKiln-Rough Shed-Yard-timber Dock-

The costs used here are taken directly from Technical Bulletin 375, and should be the same, provided the same wage scale prevails. Here again, labor makes up a large percentage of the total cost.

Planer-shipping & Selling-

These costs are taken fron Technical Bulletin 375. This cost is given as a constand per M, regardless of diameter. This could only have been on the assumption that all lumber received the same finishing treatment, which might or might not be true.

Taxes-Insurance on Lumber & Discounts-

This cost was taken from Technical Bulletin 375. This is the only item that is higher for the larger diameters, and would be expected as the first two items are based on value, which increases with the diameter.

Yield Tax-

The state of Alabama has a forest tax law, which taxes land and timber separately, the timber being atten percent yield tax and the land on the basis of value. It is thought desirable in view of the delay in cutting certain areas, and the sustained yield plans to have the property listed under the aformentioned law, and pay taxes when money is available. This concludes the costs that are assumed to remain the same throughout the operation

Costs Varying With Output:

Under this heading are included such items as depreciation on the sawmill, office salaries & expense, insurance on plant, land tax, and mainline road cost.

Depreciation-

In the first cycle we assume an investment of $360,000 for ten years with a residual value of $250,000. This gives us an average annual depreciation of $11,000, to which is added 15% of the fixed investment of $310,500, or $46,600 making a total depreciation cost of $57,600. When this is divided by the annual cut of 15,758M, we find the cost per M to be $3.65.

In the second and subsequent cycles the annual cut increases to somewhat over 55,000M. The increase in sawmill investment is $400,000 making a total investment of $650,000 with an assumed life of 20 years. This reduces to a per M cost of $1.52. The increase in sawmill cost for the second cycle is made up by changing a single band mill to a double, and by putting in a resaw. Above this it would probably be necessary to work more shifts. That is why the life of the mill is considered to be 20 years instead of 40 which is oftimes used as the period of depreciation.

Office Salaries and Expense-

These costs are taken directly from Technical Bulletin 375. This cost amounts to 56¢ per M the first cycle and is assumed to drop to 50¢ in subsequent cycles. The reason for this is that it should be possible to keep office costs from

increasing directly with output.

Insurance-

This cost is taken from Technical Bulletin 375. This item is divided into insurance on plant and accident insurance, the cost being 22 and 26¢ respectively.

Land Tax-

On an assumed basis of 10¢ per acre per year this amounts to 71¢ in the first cycle and 21¢ in subsequent cycles, although the actual tax would be $11,264 every year.

Road Building and Maintainance-

This cost changes after the first cycle, because there are more roads to maintain, but less to build. In the first cycle we have an average yearly cost of $1,200, with an average building cost for 1.5 miles. This amounts to approximately 8¢ per M of cut.

During the second cycle with an increased use of the roads, due to a larger cut we have a road building cost of $800 for one mile per year, plus a road maintainance cost of $50 dollars per mile per year or about $1,600 in all. These costs have be leniently allowed for at 5¢ per M per year.

Hauling costs-

Under hauling we have four different costs per M, two for each tract, one for the first cycle and one for other cycles. On the western tract the distance decreases during the second cycle, due to the location of the area cut

during the first cycle, that is in the western side of the tract. On the eastern tract the average distance increases after the first cycle for the same reason. In tabular form the costs for the cycles are as follows.

First cycle- Western tract		Second cycle costs Truck Basis
2.42 miles of spur haul X 18.8¢ =	45.6¢	
9 miles of main road X 13.8¢ =	123.7¢	
30 miles to mill average speed of 30 miles per hour @ 11¢ per =	330 ¢	
Total cost per trip	$4.99	$4.60

First Cycle- Eastern Tract-		
2.5 miles of spur haul X 18.8¢ =	$ .42	
4.5 miles of main line X 13.8¢ =	.62	
50 miles of state highway @ 11¢ =	5.50	
Total cost per trip	$6.59	$7.00

It is necessary to convert these costs into per M costs, which is done by dividing the cost per load by the size of load in thousands of board feet. Below is given the average volume per load for the various diameters.

Ave. DBH of stand in inches-	Average loadin bd.ft.
10	610
12	725
14	820
16	920
18	1025
20	1135
22	1250
24	1345
26	1445
28	1545
30	1650

Values produced per acre

Table 49 shows the first cycle values per acre, and their distribution. These along with those for the other cycles are summarized on a yearly basis in Table 54. The yearly values are calculated by reducing the value per acre by 10% and multiplying by the number of acres cut.

Tables 50,51,52, and 53 show the values produced per acre during the second and third cycles. Table 54 summarizes the yearly income produced, which rises from $126,260 in the first cycle to $366,000 in the second cycle, when all of the areas are cut over. The third cycle incomes are slightly less, being $352,800 per year.

The capitalized value using 5% interest rate for the sustained yield management plan is given at the bottom of Table 54. The capitalized value of $5,369,000 does not represent the amount of money an operating company could be capitalized for, but is given only as a comparison for a liquidation plan. The safe capitalization value using a risk factor is shown after the liquidation summary.

Table 49

VALUE OF FIRST CYCLE CUTS PER ACRE

Western tract-

DBH	Value Per M	Volume per acre Vir. Std.	Value of virgin cut	Volume per are of Culled Stand	Value of Culled Stand Cut
14	$ .42	1285			
16	3.25	893		653 b.m.	$2.12
18	5.37	1285 b.m.	$6.90	1441	7.75
20	7.18	1893	6.40	580	4.16
22	9.27	474	4.39	190	1.76
24	10.93	1364	14.90	462	5.05
26	12.39	910	11.27	548	6.78
28	13.66	779	10.63		
30	14.67				
		Total value	$54.49		$27.62

Eastern tract-

D.B.H.	Value Per M	Volume Per Acre of Virgin Stand cut	Value of Virgin Cut
16	$1.51		
18	3.82	1285 b.m.	$4.92
20	5.78	893	5.16
22	7.99	474	3.79
24	8.74	1364	11.91
26	11.29	910	10.27
28	12.60	779	9.75
30	13.69		
			$ 41.80

Total Value Removed Per Acre

Table # 50

Value Per Acre of Second Cycle Cuts - Western Tract

DBH	Value per M	Cut of Virgin	Value of Virgin	Cut of Culled	Value of Culled	Cut of 25% +	Value of 25% +	Cut of 25% -	Value of 25% -	Cut of M	Value of M
10	-3.77					610					
12	- .25					1190	$ .30				
14	3.72					1200	4.46				
16	6.41			840	$5.38	2143	13.72				
18	8.49	2510bm	$21.30	2258	19.20	2000	16.98	1027	$8.72	4218	$27.00
20	10.27	1012	10.40	450	4.62	1000	10.27	1070	11.00	2012	17.10
22	12.31	73	.90			540	6.65	662	8.15	560	5.75
24	13.95					100	1.40	198	2.76	300	3.70
26	15.40					118	1.82			227	3.17
30	17.63					200	3.52				
	Totals		$32.60		$29.20		$59.12		$30.63		$57.72

Table 51

Value of
Second Cycle Cuts on the Eastern Tract

DBH	Value Per M	Cut of Virgin	Value of Virgin	Cut of 25% +	Value of 25% +	Cut of Oldfield	Value of Oldfield
10	-$6.73			610			
12	- 2.02			1190			
14	.70			1200	$ .84		
16	3.79			2143	8.13	4218	$15.96
18	6.14	2510	$15.35	2000	12.28	2012	12.35
20	8.15	1012	8.25	1000	8.15	560	4.56
22	10.39	73	.76	540	5.61	300	3.12
24	12.17			100	1.22	227	2.76
26	13.75			118	1.62		
30	16.03			200	3.20		
Total Value			$24.36		$41.05		$38.75

Table 52
Value of Third Cycle Cuts
Western Tract

DBH	Value Per M	Cut of Virgin	Value of Cut	Cut of Culled	Value of Culled	Cut of 25% +	Value of 25% +
10	-$3.77					390	
12	+ .25					680	$ .17
14	3.72					1240	4.61
16	6.41	250	$ 1.60	720	$4.61	2145	13.73
18	8.49	3060	26.00	2835	24.06	2970	25.20
20	10.27	1030	10.60	935	9.60	630	6.47
22	12.31	70	.86	45	.55		
	Total Values		$39.06		$38.82		$50.18

		Cut of 25% -	Value of Cut	Cut of Oldfield	Value of Cut
10	-$3.77				
12	+ .25			680	$ .17
14	3.72			1940	7.22
16	6.41			3350	21.43
18	8.49	2530	$21.50	2160	18.35
20	10.27	1070	11.00	50	.51
22	12.31	80	.98		
	Value of cuts		$33.48		$47.68

Table 53

Value of Third Cycle Cuts of Eastern Tract

DBH	Value Per M	Cut of Virgin	Value of Cut	Cut of 25%+	Value of Cut	Cut of Oldfield	Value of Cut
10	-$6.73					680	
12	- 2.02			390		1940	$ 1.35
14	- .70			680		3350	12.70
16	3.79	250	$ .95	1240	$ .87	2160	13.25
18	6.14	3060	18.80	2145	8.13	50	.41
20	8.15	1030	8.40	2970	18.22		
22	10.39	70	.73	630	5.13		
Value of Cuts			$28.88		$32.35		$27.71

Table 54

VALUE OF CUTS ~~PER~~ FOR THE VARIOUS CYCLES

	Acres per yr	First CC Value per Acre	First CC Value per Year	Second CC Value per Acre	Second CC Value per Year	Third CC Value per Acre	Third CC Value per Year
Western Area							
Virgin Stand	1,152	$54.49	$55,100	$32.60	$33,800	$39.06	$40,500
Culled Stand	1,024	27.62	25,460	29.20	26,900	38.82	35,800
2nd Grth 25% +	2,176			59.12	115,600	50.18	98,200
2nd Grth 25% -	2,240			30.60	61,600	33.48	67,500
Oldfield Merchant-	576			57.72	29,900	47.68	24,650
Eastern Area							
Virgin Stand	1216	$41.80	$45,700	$24.36	$26,600	$28.88	$31,600
2nd Grth 25% +	1,216		41.05	41.05	44 ,900	32.35	35,400
Oldfield Merchant-	768		38.75	38.75	26,700	27.71	19,150
Total value per year for different cycles			$126,260 First CC		$366,000 2nd C C		$352,800 Third C C

Capitalized value of property at 5 %

			Present Value
First Cycle	$126,260 per year	=	$ 975,000
Second Cycle	366,000 " "	=	1,734,000
Third Cycle & All Future Cuts	$52,800 " "	=	2,660,000
	Total		$5,369,000

Liquidation Plan as a Comparison of Value

In order to compare the value of the property with that which would result in the absence of a plan, namely a liquidation procedure, we must find the cost of production, under such a plan. It was decided to use a twenty year liquidation plan with an annual cut of slightly over 45,000M. Hauling costs as of the second cycle are used, as the entire area will be covered. General expense is estimated to increase by sixty cents per thousand, under this plan.

This plan is admittedly rough, volume being considered the same per acre as when cut under the sustained yield plan, with the lower diameters being utilized under liquidation. Trees less than fourteen inches are unprofitable to log when clearcutting.

The values per acre for the liquidation period are shown on the following two pages, which in turn is followed by a capitalization summary for the liquidation operation .

Table 55

Liquidation value of Western Tract - Per acre

	Value	Vir. Vol	Vir. Value	Culled Vol.	Culled Value	25% + Vol.	25% + Value	25% - Vol.	25% - Value	Oldfield Vol.	Oldfield Value
14"	3.12	1574	4.91	2008	6.26	3850	12.00	1735	5.40	5500	17.15
16	5.81	1933	11.22	1979	11.50	3400	19.72	1920	11.13	4300	24.95
18	7.89	1564	12.32	1400	11.03	2000	15.78	1585	12.50	2000	15.78
20	9.67	893	8.63	584	5.64	1000	9.67	1065	10.30	560	5.41
22	11.71	474	5.55	190	2.22	440	5.15	660	7.73	300	3.52
24	13.35	1364	18.23	462	6.17	100	1.33	195	2.60	230	3.07
26	14.80	910	13.45	548	8.10	118	1.75				
28	16.02	779	12.47								
30	17.03					200	3.08				
Total value			$86.78		$50.92		$68.80		$39.66		$69.88

Table 56

Liquidation value of Eastern Tract - per Acre

		Virgin		Culled		Oldfield Mer.	
		Vol.	Value	Vol.	Value	Volume.	Value
14"	.10	1574	.16	3850	.38	5500	.55
16	3.19	1933	6.16	3400	10.83	4300	13.70
18	5.54	1564	8.67	2000	11.08	2000	11.08
20	7.55	893	6.74	1000	7.55	560	4.23
22	9.79	474	4.64	440	4.30	300	2.93
24	11.57	1364	15.80	100	1.16	230	2.66
26	13.15	910	11.95	118	1.55		
28	14.47	779	11.27				
30	15.43			200	3.08		
Total Value			$65.39		$39.93		$35.15

Table 57

CAPITALIZED VALUE OF LIQUIDATION PLAN

Area	Period of Liquidation	Cap. Value @ 5% PermYear	Cap. Value @ 5%
Virgin West	2Yr. 4Mo.	$386,000	$828,000
Virgin East	2Yr. 2Mo.	325,000	577,000
Culled West	1Yr. 7Mo.	295,000	372,000
2nd Grth 25% + West	4Yr.10Mo.	278,000	864,000
East	2Yr. 8Mo.	163,000	231,000
Oldfield Mer West	1Yr. 6Mo.	312,000	227,000
East	1Yr. 9Mo.	163,000	127,000
2nd Grth 25%- West	3Yr. 2Mo.	204,000	330,000
Totals	20 Years		$3,886,000

The liquidation value of $3,886,000 is to be compared with a sustained yield value of $5,369,000, and shows a lower value to the extent of $1,483,000. This would be an extremely conservative estimate of the difference in capitalized value, because of the original assumption that the cuts would be the same as was obtained from the stands, during the first cut taken from them.

Financial Plan

The original East Texas Land Company was a real estate company. They were assumed to have had the lands, and have hired a forester to prepare a management plan, and help promote the company. The financial plan for the Kaul Lumber Company follows.

Let us first assume that the company had paid the assessed value for the various tracts. This would mean a total investment of $1,878,700. Using a risk factor of 5%, that is using the formula

$$Co = \frac{a}{.10 + \frac{.05}{1.05^{10} - 1}}$$

we find the present value of the property to be.

Value of 1st C C	= $703,400
Value of 2nd C C	=1,251,300
Value of 3rd C C and all future	=1,329,800
Total value	$3,284,500

Let us assume conservatively that the property is worth $3,250,000. It will take considerable capital to get the business under way, that is the main financing problem involved. There are several ways of raising the capital. For this plan the amount of money needed to get the business under way is as follows:

Teams 10 @ $500	5,000	
Trucks 30 @ 1,100	33,000	
Tractors 6 @ 2,000	12,000	
Mill	360,000	
Miscellaneous Log. Exp	5,000	
8 mO production @ $24	240,000	$655,000

Inasmuch as the cost of all the items listed above are figured in as a part of the logging cost, thereis duplication , and the actual production cost outlay would be less than that figured. Taking that into consideration $650,000 working capital would allow some leeway.in getting the business under way.

I propose to raise this money by issuing preferred stock for that amount, the stock to be 5% non-voting, preferred as to present earnings. The remaining value of the property or $2,600,000 would be in the form of common stock. This could either be held by the company, or sold to finish paying for the land if it isn't already free from debt. In any event the controlling interest should be held.

During the first cycle the annual income is $126,260, of which $32,500 would go to the preferred stock holders, and the rest paid to the common holders or 3% on the stock value. If the company did hold all the common the residual income of $93,760 would amount to 5% on the investment in the land of $1,878,700.

During the second cycle the preferred would still get $32,500, but the remainder would go to the common holders or 12.5%. That is providing the yearly income as determined held up. 5% could still be paid on the common if values dropped on the average of $2.70 per M, or 42.5% of the present average net return of $6.35 per M. On this basis the financing would appear to be fairly sound, the only weak point being the low first cycle income, which is in reality the most likely of realization, the cut taking high diameters where prices fluctuate the least.

THE USE OF DIAGONAL SPUR ROADS

AS AN

AID TO THE REDUCTION OF HAULING COSTS

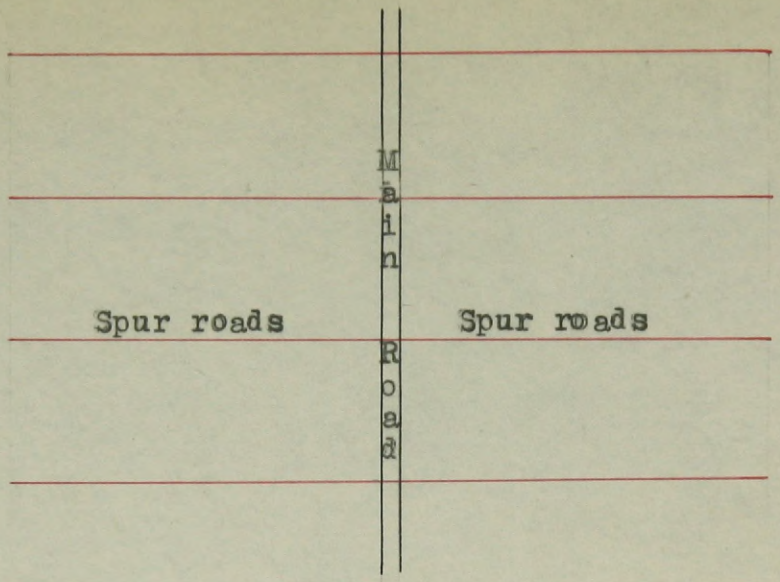


Fig. 1

In the past, and at the present time also, it has been and is customary when laying out a road system by which to log an area, to have the spur or usually inferior roads join the main or higher class roads at or approximately at right angles. A diagramatic illustration of this point is shown in Fig. 1 . It is the purpose of this supplement to investigate the practicabilities of laying out a road system by placing the spur roads on diagonals, rather than at right angles to the main road.

When considering such a road set up, the question immediately arises as to what type of diagonal road system should be used, that is should the roads be put in on a strictly diagonal arrangement or at a 45° angle with the main road, or precisely what type of angle will lead to the cheapest logging. Different possibilities of arrangement are investigated in this paper, using a township or a part thereof on which to experiment. These are taken up

in this paper by cases. It is quite evident that there are an unlimited number of arrangements possible in such a consideration. Admittedly only the simpler and more easily computed arrangements are considered here.

The object here is to find out just how much distance is actually saved by different types of arrangements. That is here computed on the basis of the average distance from the stump to the point where the logs leave the area to be logged.

The cases considered herein are as follows:

Case I a full township on a strictly diagonal arrangement or 45° angle set up.

Case II One-half township three by six mile area with a 45° angle arrangement.

Case III One-half township with a 60° from centerline diagonal spurs.

Case IV One-half township with a 30° from centerline diagonal spurs.

Case V Three by nine mile area on a strict diagonal arrangement.of

Case VI Three by nine mile area with 30° degree from centerline diagonal spurs.

Case VII Three by nine mile area with 45° from centerline diagonal spurs.

Case VIII Three by nine mile area with a 60° from centerline diagonal spurs.

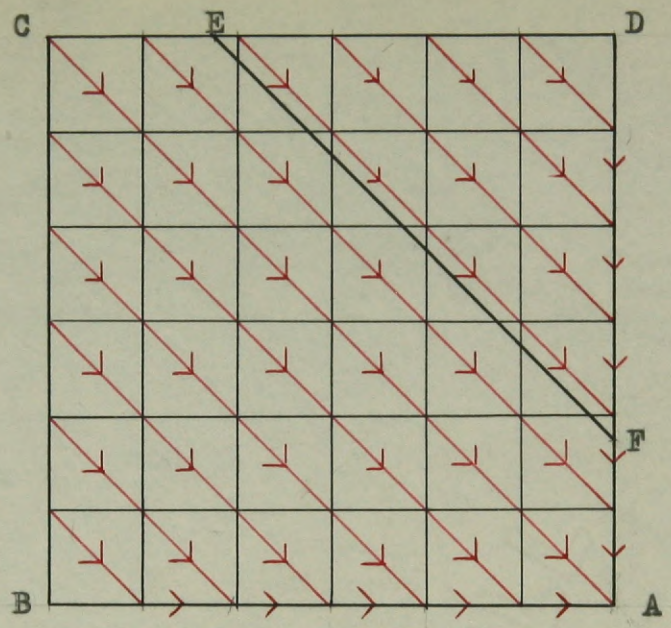


Fig. 2

Case I - Full township with 45° diagonal spurs.

* The diagonal lines are the assumed direction of the spurs in this case. Following the arrow from the nearest diagonal line shows you the path the log would take. This necessitates roads along the boundaries AB and AD as shown. The average distance from the stump to point A on the area is the objective. The only place where you would be likely to use such an arrangement would be when the area was tapped by a road which came to point A.

Computing the average haul is relatively simple, and is done by the use of the Pythagoreon Theorem, which states that the square of the hypotenuse equals the sum of the squares of the other two sides in a right angled triangle. The object here is to find the hypotenuse for all the cases

*Note - the red lines represent the direction of the actual spurs and not the spurs themselves, the spacing of which varies with the volume per acre.

and then add to it the distance traveled on the boundary roads to find the distance from the stump to point A on the diagram.

In this, and all succeeding cases, the average distance is found by taking the distance traveled from all of the section corners on the area to point A. This may or may not be exact, but it is good enough for the purpose desired here. There are in all 49 section corners counting the one at A. The total distance is computed to be 240.7 miles, which when divided by 49 shows the average distance to be 4.92 miles. The total average distance using right angle spurs would be half of the width or 3 miles plus half of the length of the boundary road or 3 miles more, making six miles in all. Thus a saving of 1.08 miles, in the average hauling distance, results.

It is also desirable to know how the average distance is split up, that is how much is on the actual spurs and how much on the boundary roads. This is done by finding the average distance hauled over the spurs and assume that the difference between it and the total is the average distance hauled on the boundary roads.

Turning back to Fig. 2 the average spur haul would be one-half of EF. Line EF is a line parallel to AC, which divides the area of Triangle ACD in half. Inasmuch as the amount of spur roads per acre is constant there will be as much spur road in trapazoid ACFE as there is in triangle EFD. Line Ef being the dividing line $\frac{1}{2}$ EF should be the average spur haul distance.

Line EF is drawn between two points 7/24ths of the way from corners A and C to D. Although this doesn't cut the triangle exactly in half it closely approximates it. The length of EF by the Pythagoreon Theorem is 6 miles, so the average haul is three miles on spur roads and the difference 3 from 4.92 miles on the boundary roads, or 1.92 miles.

The actual distance traveled on the spur and boundary roads, may seem unimportant, but that is the factor which ultimately determines the advisability of having diagonal roads, particularly when you have a cost differential from hauling on an improved boundary road as compared with an unimproved interior road.

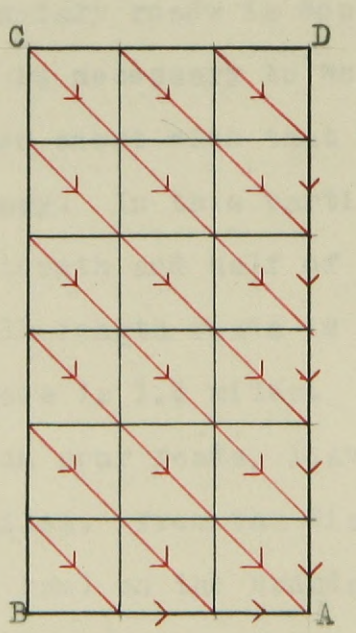


Fig. 3

Case II One-half township with a 45° spur arrangement -

The case considered here would arise when a township was tapped by a road which came to a central point A or perhaps passed through the center of it from A to D. The method of computing the average distance is the same as Case I. In this case the total distance from all the section corners to Point A is found to be 107.26 miles, divided by the number of section corners 28 shows the average hauling distance to be 3.83 miles. With right angled spurs the average distance is one-half the width or 1 ½ miles plus one half the length of the boundary road or 3, which gives an average of 4.5 miles. The diagonal roads show a saving in distance of .67 miles.

The process of finding the average distance on both the spur and on the boundary roads is done the same as in Case I, except that it is necessary to weight the average haul where the roads are short with that where they go from boundary to boundary. In this particular case, half of the roads are full length and half of them short. The average haul on the full length roads is 1.92 miles, and that on the shorter roads is 1.5 miles. The weighted average is 1.81 miles on spur roads, leaving a boundary road average of 2.02 miles. From the diagram it will be noted that the average haul on the boundary roads would also be split up. The greatest saving would occur on the boundary road AB where the haul would only be about a mile

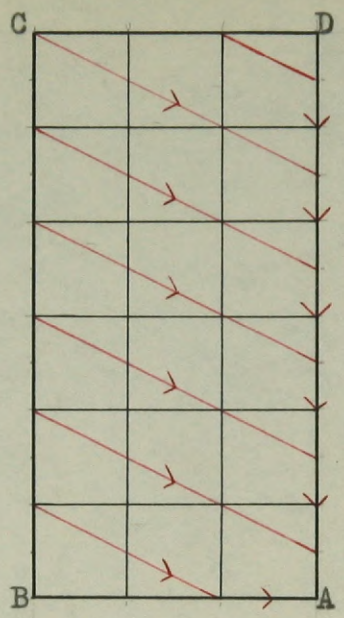


Fig. 4

Case III 1/2 township with 60° from centerline diagonal spurs.

The logging situation is the same here as Case II only here we have a different road arrangement. This case could be used under the same circumstances as case II and is given here merely to show the relationships existing.

The total distance from all of the section corners to point A is found to be 112.70 miles, which gives an average distance of 4.03 miles when divided by 28. That shows a saving of .47 miles over rigid right angle spur arrangement. Computing the average spur haul is similar to Case II except that a different weighting must be used. In this case 1/4 of the roads are short and 3/4 are full length. The average haul on the short roads is 1.19 miles and the average on the long is 1.68 miles , giving a weighted average of 1.56, and leaving 2.47 miles as the average haul on the boundary roads.

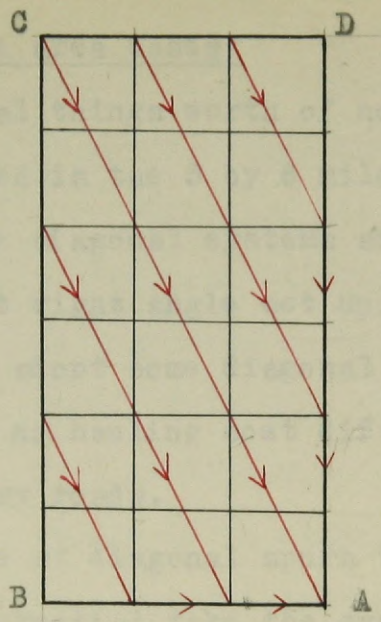


Fig. 5

Case IV 1/2 township with a 30° from centerline Diagonal spurs.

Fig. 5 shows the case in question. This is the same conditions as Cases II and III, with a different road arrangement of roads. A 3 by 6 mile area with roads on a 30° angle results in a strict diagonal arrangement. The average distance is computed in the usual manner and is found to be 3.82 miles, when the total of 107 is divided by 28. Thus a saving of .68 miles is shown. Weighting of the distances is not necessary here because of the strict diagonal set up. The average spur haul is found to be 2.37 miles, leaving a boundary road average of 1.45 miles. The average haul on boundary road AB is probably half of what it is on AD. There may not be much actual saving on AD, but there is enough on AB to offset it.

Summary of 3 by 6 mile area cases:

There are several things worth of noting as shown by the results obtained in the 3 by 6 mile cases. In the first place all of the diagonal systems show a shorter distance than a strict rightangle set up, so it would of a certainty pay to adopt some diagonal method of hauling if there were no hauling cost differential between spur and boundary roads.

As to which type of diagonal spurs to adopt, if there is no cost differential take the system showing the shortest distance, which in this case would be either the 30° or 45° arrangement, the distance being the same in both cases. The only difference is in the way that the total is split up between spur and boundary roads.

However if there is a cost differential between the types of roads it will always pay to use the one having the least proportional amount of of low standard roads, which would be Case II the 45° arrangement

Savings resulting from Diagonal Spurs. Cost figures are from the south with a 13.3 mile standard for spurs and a 20 mile standard for boundary roads.

1. Rightangled set up.

   Spurs 1.5 miles x 18.8 ¢ = 28.2 Total of 69.6 ¢
   Boundary 3 " x 13.8 ¢ = 41.4

2. 30° diagonal arrangement.
   Spurs 2.37 miles x 18.8 ¢ = 44.6 Total of 64.6 ¢
   Boundary 1.45 " x 13.8 ¢ = 20.0

3. 45° diagonal arrangement.
   Spurs 1.81 miles x 18.8 ¢ = 34.1
   Boundary 2.08 " x 13.8 ¢ = 27.9 Total of 62.0 ¢

4. 60° Cheapest
   Spurs 1.56 miles x 18.8¢ - 29.3
   boundary2.47 " x 13.8 - 34.1 total of 63.4 ¢

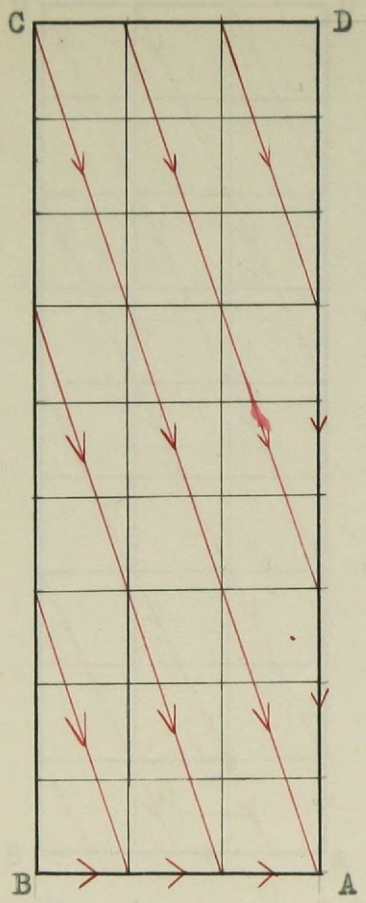


Fig. 6

Case V. 3 by 9 mile area on a strict diagonal arrangement.

This case and the next three to follow deal with four types of spur arrangements on the same 3 by 9 mile area. This type of case is probably just as likely to occur as any other. It should be understood that another area lying directly to the right of this of the same size would have the same logging costs.

The methods of computing the distances are essentially the same with several variations in the weighting of the full length as compared with the short spur roads. It hardly seems necessary to go into the details on each case. Therefore explainations will be held to the bare minimum.

Total hauling distance 209.77miles

Number of section corners 40.

Average haul, total distance 5.24 miles

Average haul on spurs = 3.36 miles

Average haul on boundary roads 1.88 miles

Average distance saved - .76 miles

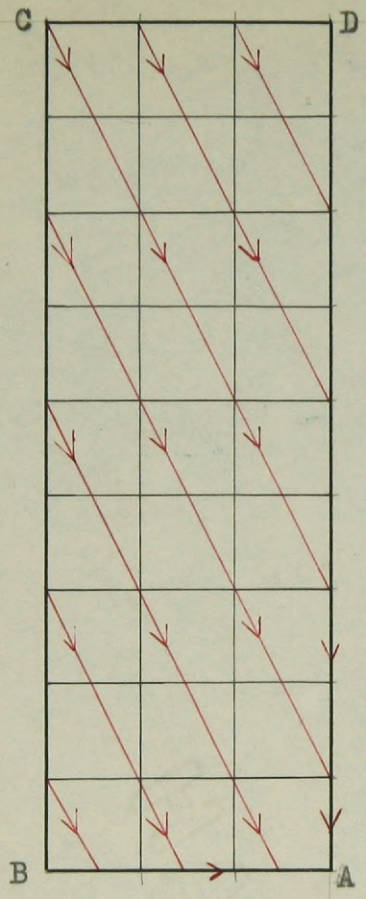


Fig.6

Case VI- 3 by 9 mile area with a 30 ° from centerline diagonal arrangement.

Total hauling distance - 207.30 miles

Number of section corners - 40

Average haul, total distance 5.18 miles

Average haul on spurs - 2.71 miles

Average haul on Boundary roads 2.47 miles

Average distance saved - .82 miles

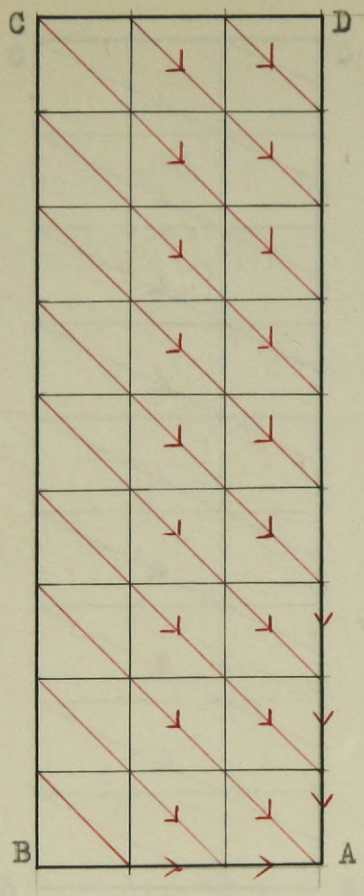


Fig. 7.

Case VII- 3 by 9 mile area with a 45° from centerline diagonal Arrangement.

Total hauling distance - 210.73 miles

Number of section corners- - 40

Average haul, total distance- - 5.27 miles

Average haul on spurs - 1.91 miles

Average haul on Boundary roads - 3.36 miles

Average distance saved - .73 miles

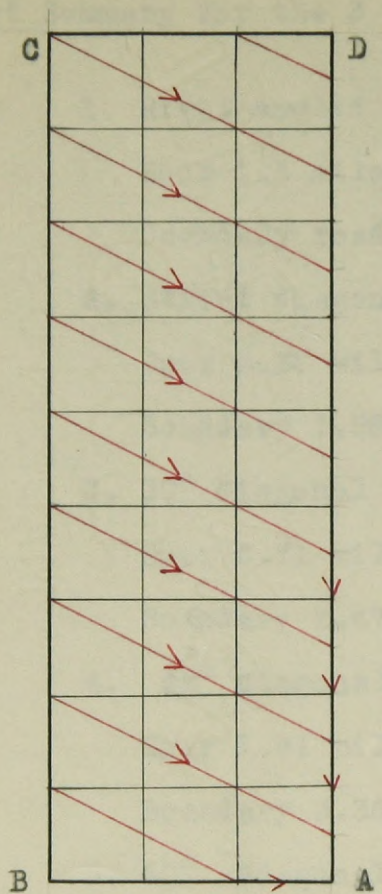


Fig. 8 -

Case VIII - 3 by 9 mile area with a 60° from centerline diagonal spur arrangement.

Total hauling distance - 219.86 miles

Number of section corners - 40

Average haul, total distance - 5.5 miles

Average haul on spurs - 1.6 miles

Average haul on boundary roads - 3.9 miles

Average distance saved - 1/2 mile

Cost Summary for the 3 by 9 mile area -

1. Right angled spurs.

   Spur 1.5 miles x 18.8 ¢ = 28.2 ¢

   Boundary road 4.5x13.8¢ = 62.1 ¢ Total = 90.3 ¢

2. Strict diagonal arrangement.

   Spur 3.36 miles x 18.8 ¢ = 63.2 ¢

   Boundary 1.88 " x 13.8 ¢ = 25.9 ¢ Total = 89.1¢

3. 30° diagonal arrangement.

   Spur 2.71 miles x 18.8 ¢ = 51.0 ¢

   Boundary 2.47 " x 13.8 ¢ = 34.1 ¢ Total =85.1¢

4. 45° diagonal arrangement.

   Spur 1.91 miles x 18.8 ¢ = 35.9 ¢

   Boundary 3.36 " x 13.8 ¢ = 46.4 ¢ Total = 82.3¢

5. 60° diagonal arrangement. **Cheapest**

   Spur 1.6 miles x 18.8 ¢ = 30.1 ¢

   Boundary 3.9 " x 13.8¢ = 53.9 ¢ Total = 84.0¢

CONCLUSIONS

1. Another point worthy of noting in both the three by six and in the three by nine mile areas is that the actual hauling distance varies little between the strict diagonal and the 30° and 45° set ups. The thing that does change is the proportion of each class of road in the total hauling distance.

2. The average hauling distance in any strict diagonal set up can be roughly taken as 32% of the average of the length of the two boundary roads.

3. 45° spurs will always be cheapest with the assumed cost differential of 5¢ per mile.

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