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White

Black

Isolated Characters

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MESH HALFTONE WEDGES

65

85

100

110

133

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APPLICATION OF BASAL AREA CONTROL TO AN UNDER-STOCKED STAND IN THE APPALACHIANS

by

Allan L. Hartong


FORESTRY

APPLICATION OF BASAL AREA CONTROL TO AN UNDER-STOCKED STAND IN THE APPALACHIANS

by

Allan L. Hartong

A Thesis

Presented to the Faculty

of the

School of Forestry and Conservation

University of Michigan

In Partial Fulfillment

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Master of Forestry

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CONTENTS

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To Professor D. M. Matthews, the writer wishes to extend sincere thanks and appreciation for invaluable assistance and advice rendered in preparing this paper. Without his help and suggestions, the construction of this thesis would have been difficult at best. Credit is due also to T. V. A.'s Department of Forestry Relations for furnishing copies of data collected by the writer while employed by that bureau.

INTRODUCTION

The purpose of this paper is to show how forest management may be applied to an under-stocked timber stand in the Appalachians. The whole theory of forest management is build upon the premise that the individual trees within a stand should have "room to grow, but none to waste." It follows quite naturally, therefore, that the most intelligent method of achieving a regulated forest condition is to allow only that number of trees upon a certain area which can effectively utilize the productive capacity of that area. This means that the number of individual stems (as expressed in the square feet of their basal area) is the best criterion of the degree of stocking which any particular area should be allowed to attain.

The procedure to be followed in this particular case is to determine the basal area that each of three different composition types can reasonably be expected to carry while maintaining optimum growth, and then restrict the removal of other than harvest and defective trees until the determined basal area has been attained.

DESCRIPTION OF THE AREA

The area presented here for discussion is classified as a Yellow-Pine-Hardwoods Type, and is located in the southern Appalachian region. The species of pine found are shortleaf and Virginia, and the more important hardwoods, from the standpoint of stand composition, are as follows: chestnut, red, black, white and scarlet oaks; yellow poplar;

hickory; beech; gum and maple. The entire ownership consists of 4,556 acres, 3,387 of which are wooded.

This area is owned by an institution, and, when purchased, was well stocked with a high proportion of old-growth yellow poplar and white oak. From all indications, the site is far above average in quality, and the rugged terrain precludes the area's use for purposes other than the growing of trees. Continuous practice of the so-called "high grading" method of logging, and recurrent fires, have changed the complexion of the stand to such an extent that inferior species now dominate the area. Nearly one-fourth of all the trees are defective, and should be removed within the next ten years if their total loss is to be averted.

The present owners have expressed their desire to place the stand on a sound management basis, and have indicated a willingness to install adequate forest fire protection and such other protective and forestry measures as may be needed. The institution owns and operates a small portable sawmill, as well as a wood-working shop capable of producing a wide variety of forest products. This sort of a set-up will permit of a higher degree of utilization than is practicable on most nearby areas of a similar character, and will greatly enhance the possibilities of developing good forestry practices.

Until quite recently, the institution was completely independent of the competitive lumber market for supplying it's own needs for construction and maintenance materials and other forest products (furniture,

posts, poles, etc.). Lately, however, the owners have become greatly concerned over their poorly-stocked timber resources, and their primary objective at the present time is to convert these resources, as quickly as possible, into such a condition as will assure them of a perpetual supply of raw materials.

COLLECTION AND INTERPRETATION OF CRUISE DATA

Due to the present low value of the stand and the small amount of funds allocated for the purpose, a comparatively low intensity (2%) of cruise was made. The cruise was made by tallying all trees 6" d. b. h., and up, on 1/5-acre plots spaced 10 chains apart on parallel strips spaced 10 chains apart. In addition, increment borings were made of the nearest merchantable (10" d. b. h., and up, for pine, and 12" d. b. h., and up, for hardwoods) tree to the center of each plot.

In order to provide a means of distinguishing between the several stand components, the following classification of Condition Classes and Types was established:

Condition Classes

O. Areas excluded from forest management in order to preserve aesthetic values.

I. Areas on which a cut of approximately 2 M ft., b. m., per acre can be made within the next 10 years.

II. Areas on which a cut of at least 2 M ft., b. m., cannot be made until 10 years from now.

III. Areas on which a cut of at least 2 M ft., b. m., cannot be made until 20 years from now.

Types

Pine. Areas with 75% or more of the merchantable volume in pine.

Pine-Hardwood. Areas with less than 75%, but more than 25%, of the merchantable volume in pine.

Hardwood. Areas with 25% or less of the merchantable volume in pine.

While making the cruise, each of the foregoing condition classes and types were mapped as they were encountered. Upon completion of the cruise, the areas of the various portions of the stand were determined by a planimeter. The results are presented in Table I.

Table I

Acreage

Type	Forest Land				Scenic Woodland
	Condition Class				Condition Class
	I	II	III	Total	O
Pine	117	132	152	401	
Pine-Hardwood	260	453	298	1,011	
Hardwood	486	597	726	1,809	
Totals	863	1,182	1,176	3,221	166
Entire Woodland, Total					3,387
Open Land					1,169
Entire Property, Total					4,556

Gross volume computation was accomplished by applying the data recorded in the tally sheets to Tables II, III and IV. These tables were assembled by the Forest Resources Division, TVA Department of Forestry Relations, and the following form classes were used: 76 for chestnut oak,

Table II

HARDWOOD VOLUME TABLE

BOARD FEET INT. $\frac{1}{4}$" LOG RULE

FORM CLASS 76

DBH	Number of 16-Foot Logs									
	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
10	19	36								
12	29	51	71	90						
14	42	72	100	130	150	170				
16	57	100	140	170	200	230	260	280		
18	74	130	180	220	260	300	330	360	380	
20	92	160	230	280	330	380	420	450	470	490
22	110	200	280	340	400	460	510	550	580	610
24	130	240	330	410	490	560	620	670	700	730
26	150	280	390	490	580	670	740	800	840	870
28	180	330	450	570	680	790	870	940	980	1020
30	210	380	530	660	790	910	1000	1080	1140	1180
32	240	440	610	770	910	1040	1140	1240	1310	1350
34	270	500	690	870	1030	1180	1300	1400	1490	1540
36	310	560	780	980	1160	1330	1470	1580	1680	1740
38	350	630	870	1090	1290	1480	1640	1770	1880	1950
40	390	700	960	1200	1430	1650	1820	1970	2090	2160
42	430	770	1060	1330	1580	1830	2020	2180	2310	2390
44	470	840	1170	1470	1740	2010	2220	2400	2540	2630
46	520	920	1290	1610	1910	2210	2440	2620	2790	2890
48	570	1010	1410	1760	2090	2410	2670	2860	3050	3160
50	620	1100	1530	1910	2270	2620	2900	3120	3320	3430

Table III

HARDWOOD VOLUME TABLE

BOARD FEET INT. 1/4" LOG RULE

FORM CLASS 78

DBH	NUMBER OF 16-FOOT LOGS								
	1 (16)	1 1/2 (24)	2 (32)	2 1/2 (40)	3 (48)	3 1/2 (56)	4 (64)	4 1/2 (72)	5' (80)
10	40	50	70						
12	60	80	100						
14	80	110	140	160	180				
16	110	150	190	220	250				
18	140	200	240	290	320	370	400		
20	170	240	300	370	400	480	510		
22	210	300	370	460	500	590	630		
24	250	350	450	540	610	700	750		
26	300	430	530	640	730	830	890		
28	350	500	620	750	850	960	1040	1090	1140
30	400	570	710	870	980	1120	1210	1250	1300
32	460	660	810	1000	1120	1290	1380	1440	1490
34	520	740	920	1120	1280	1450	1560	1630	1700
36	590	840	1040	1270	1440	1640	1760	1840	1920
38	660	930	1160	1420	1610	1830	1980	2050	2150
40	730	1040	1290	1580	1790	2050	2210	2300	2400
42	810	1160	1430	1750	1980	2260	2450	2510	2650
44	890	1270	1570	1920	2180	2490	2690	2800	2920
46	970	1390	1720	2110	2390	2740	2940	3060	3200
48	1060	1510	1870	2300	2600	2970	3210	3340	3500
50	1160	1650	2030	2510	2820	3240	3490	3660	3830

Table IV

CONIFER VOLUME TABLE

BOARD FEET INT. $\frac{1}{4}$" LOG RULE

FORM CLASS 80

DBH	NUMBER OF 16-FOOT LOGS								
	1 (16)	1½ (24)	2 (32)	2½ (40)	3 (48)	3½ (56)	4 (64)	4½ (72)	5 (80)
8	20	30	40	(45)	50				
10	40	50	70	80	80				
12	60	80	100	120	130	150	160		
14	80	120	140	160	180	210	220		
16	110	160	190	220	240	280	300		
18	140	200	250	280	310	360	380		
20	180	250	310	360	390	450	480		
22	220	310	380	450	480	560	590		
24	270	370	460	530	580	680	710		
26	320	440	540	630	690	800	840		
28	370	520	630	740	810	940	990	1120	1160
30	430	600	730	860	930	1080	1150	1290	1340
32	490	680	840	970	1060	1240	1320	1480	1530
34	550	770	950	1110	1210	1410	1500	1680	1730
36	620	880	1070	1250	1360	1590	1690	1890	1950
38	690	980	1190	1400	1520	1780	1890	2110	2190
40	770	1090	1320	1550	1690	1980	2100	2360	2440
42	850	1200	1460	1720	1870	2180	2320	2600	2700
44	940	1330	1610	1890	2060	2400	2550	2860	2970
46	1030	1430	1770	2080	2260	2630	2790	3150	3260
48	1120	1580	1930	2270	2470	2870	3040	3430	3550
50	1220	1730	2100	2470	2690	3120	3300	3710	3850

78 for all other hardwoods and 80 for all conifers. Net sawtimber volumes were obtained by observing the following deductions for defect:

Virginia Pine	4%	Basswood	12%
Hemlock	5	Cucumber Tree	12
Shortleaf Pine	6	Cherry	6
Black and Southern Red Oak	7	Black Gum	10
Scarlet Oak	8	Hickory	5
Chestnut Oak	10	Beech and Buckeye	10
Northern Red and White Oak	7	Maple	12
Post Oak	10	Yellow Poplar	5
Ash	5	Black Walnut	7

When tabulated, the distribution of volume was found to be as presented in Table V. (See page 10).

In spite of the recurrent fires that have devastate the area, present stocking of those trees below 6" d. b. h. is entirely satisfactory with one exception, and, if protected by the anticipated fire control system, should adequately meet all future requirements. The one exception is the 300 acres of the Pine-Hardwood Type in Condition Class III, and this area is to be planted with shortleaf pine within the very near future.

ESTIMATION OF FUTURE RATE OF GROWTH

Increment borings were tallied as radial growth for the last five-year period by measuring the distance between the last five growth rings to the nearest 0.05 inch. 254 trees were tallied with a total radial

Table V

Sawtimber Volume Summary-Total Area

(By International 1/4" Log Rule)

Forest Land

Type	Defective	Sound	Total Volume Defective	Total Volume Sound	Total Trees
Condition Class I					
Pine	89,679	142,271			
Pine-Hardwood	135,236	620,993			
Hardwood	538,915	1,468,712			
Totals	763,830	2,231,976	763,830	2,231,976	2,995,806
Condition Class II					
Pine	69,610	212,248			
Pine-Hardwood	239,283	651,566			
Hardwood	364,659	1,248,707			
Totals	673,552	2,112,521	673,552	2,112,521	2,786,073
Condition Class III					
Pine		47,374			
Pine-Hardwood	41,279	69,424			
Hardwood	86,426	376,239			
Totals	127,705	493,037	127,705	493,037	620,742
Forest Land Total (All trees)			1,565,087	4,837,534	6,402,621
Total by Types (Includes All Condition Classes)					
Pine			159,289	401,893	561,182
Pine-Hardwood			415,798	1,341,983	1,757,781
Hardwood			990,000	3,093,658	4,083,658
Forest Land Total (All trees)			1,565,087	4,837,534	6,402,621

Scenic Woodland (Condition Class 0)

All Types			67,614	863,583	931,197

growth of 252.50 inches. Dividing the total radial growth by the total number of trees, we obtain 252.50/254 or 0.994 inches of average radial growth per tree. In order to obtain the average annual rate of growth, we multiply 0.994 by 2 and divide by 5, and obtain 1.998/5 or 0.3976, say 0.4, inch per year. It is believed advisable to use this rate of growth for the whole area rather than a separate rate of growth for each condition class, because the condition classes represent past methods of logging and intensity of burn rather than quality of site. Inasmuch as the data used was obtained from trees with more than enough room in which to grow, and which, in a good many cases, have only recently recovered from the detrimental effects of a severe burn, it is believed that the estimated future rate of growth of 0.4 inches per year is as reasonable an estimate as can be made.

PRELIMINARY INVESTIGATIONS AND DECISIONS

The distribution of all the trees and volume, when reduced to a per acre basis, is found in Table VI. Inspection of this table (see pages 12 and 13) reveals that due to the very small quantity of trees and volume per average acre, the only practical method in which a satisfactory management plan may be formulated is to deal with each of the nine combinations of condition classes and types separately. The defective portion of the stand is not considered to be a reliable basis on which to make a decision regarding the maximum size that future harvest trees should be allowed to attain. Inspection of the data for the sound portion of the stand only, shows that the volume, in ft. b. m., per sq. ft. of basal area increases gradually up to 20" d. b. h. for pines, and up to 24" d. b. h.

Table VI

Volume and Tree Distribution per Average Acre

Defective Trees

D. B. H., Inches	Number of Trees	B. A. per dia.. class, sq. ft.	Vol., ft. b. m.	Volume, ft. b. m. per sq. ft. of BA
		Pines		
6	.28	0.06		
8	.25	0.09		
10	.29	0.16	12	75
12	.25	0.20	19	95
14	.10	0.11	12	109
16	.02	0.03	2	67
18	.01	0.02	3	150
24	.02	0.06	4	67
26	.01	0.04	6	150
Totals	1.23	0.77	58	
		Hardwoods		
6	.51	0.10		
8	.70	0.25		
10	.89	0.49		
12	.66	0.51	40	78
14	.57	0.61	51	84
16	.40	0.55	36	65
18	.41	0.73	78	107
20	.25	0.55	68	124
22	.14	0.37	44	119
24	.11	0.35	35	100
26	.06	0.22	32	145
28	.03	0.13	19	146
34	.02	0.13	7	54
Totals	4.75	4.99	410	

Table VI (Concluded)

Volume and Tree Distribution per Average Acre

Sound Trees

DBH, Inches	No. of Trees	B. A. per dia. class, sq. ft.	Vol., ft. b. m.	Vol. per sq. ft. of B. A.	Vol. per Tree
Pines					
6	3.06	0.60			
8	1.93	0.67			
10	1.55	0.85	64	75	41.3
12	1.35	1.06	107	101	23.7
14	.92	0.98	110	112	24.0
16	.53	0.74	90	122	26.7
18	.18	0.32	42	131	29.4
20	.03	0.07	10	143	30.7
Totals	9.55	5.29	423		
Hardwoods					
6	5.70	1.12			
8	3.91	1.37			
10	2.40	1.31	2	2	
12	2.13	1.67	133	80	65.8
14	1.83	1.95	178	91	103.0
16	1.47	2.05	222	113	163.8
18	.78	1.38	163	118	233.5
20	.40	0.87	117	135	320.0
22	.24	0.63	86	137	416.5
24	.19	0.60	87	145	475.0
26	.06	0.22	32	145	600.0
28	.05	0.21	23	110	500.0
30	.02	0.10	7	70	350.0
32	.03	0.17	28	165	933.3
Totals	19.21	13.65	1,078		

for hardwoods. The reduction of this ratio above 26" for hardwoods indicates defect in those hardwood trees larger than 26", and it is therefore decided to set a maximum average harvest diameter of 20" for the Pine Type and 24" for the Hardwood Type. Since the Pine-Hardwood Type is expected to gradually increase it's complexion towards that of the Pine Type, the harvest diameter set for the Pine-Hardwood Type is the same as for the Pine Type, i. e., 20".

The volume-per-tree columns in the "sound trees" part of the table were tabulated for the purpose of obtaining data with which to construct merchantable height-d. b. h. curves that are to be used in estimating future cuts. Since the volumes for chestnut oak were computed for a different form class than was the remainder of the hardwood volumes, they are excluded from the hardwood volume-per-tree column.

In order to form a decision on the number of square feet of basal area that each type should be allowed to carry when fully-stocked, the data presented in Tables VII and VIII on page 15 were obtained. These figures show the square feet of basal area that various fully-stocked stands would contain if all of the trees on one acre were of a certain average diameter. For example, if we refer to the Yield Table for Second-Growth Southern Pines (Table VII) we find that if one acre were fully-stocked with trees averaging 6.9 inches in diameter, the total basal area of the trees on that acre would be 146 square feet. Similarly, by referring to the yield table for Oak, which can reasonably be applied to all hardwoods, (Table VIII), we find that one fully-stocked acre of trees averaging 11.4 inches in diameter would contain 133 square feet

Table VII

Yield Table for Second-Growth Southern Pines (1)*

(One Acre for each Diameter or Size Class)

Age, years	Diameter in inches	Basal area in square feet
20	6.9	146
25	8.2	162
30	9.5	169
35	10.6	172
40	11.7	174
45	12.7	174
50	13.6	174
90	19.9	174
95	20.6	174
100	21.2	174

Table VIII

Yield Table for High Forest of Oak on I., or best, quality of Locality (2)

(One Acre for each Size Class)

Mean diameter in inches	Basal area in square feet
6.1	103
8.2	115
9.9	125
11.4	133
12.8	140
14.2	145
15.5	149
16.9	153
18.4	157
19.6	160
21.0	163
22.3	166
23.5	168

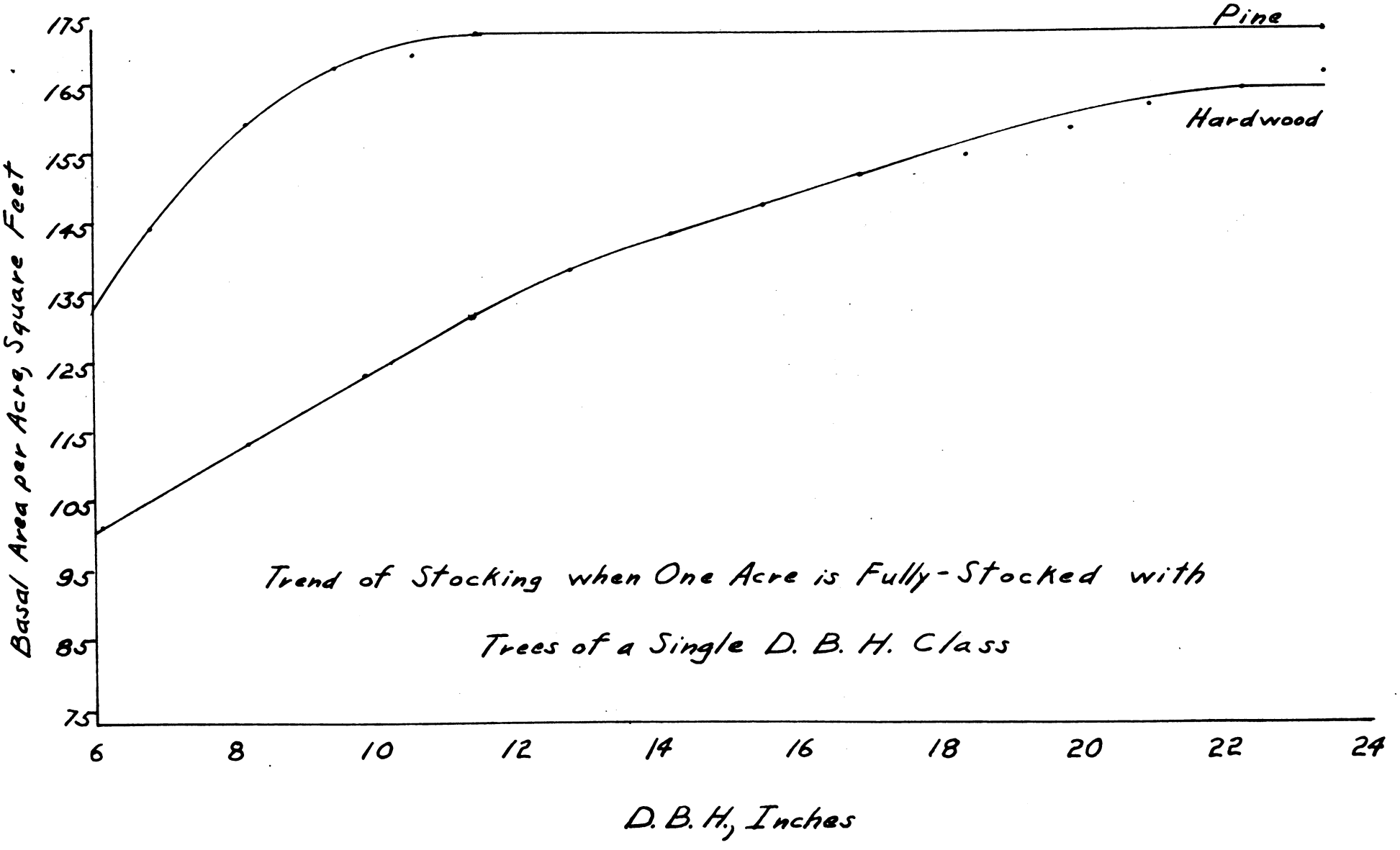
* Refer to the list of references at the end of this paper for the identification of numbers in parentheses.

of basal area. Now if we were to plot these various basal areas over their respective diameters, we would obtain a pair of curves from which the basal area of a fully-stocked acre for any given diameter could be read. These two curves have therefore been constructed; one for the pines and one for the hardwoods, and are found in Figure I on page 17.

By referring to these curves, and judging from their trends, it was decided that the Pine Type should be allowed to carry a stocking of 150 sq. ft. of basal area and the Hardwood Type 126 sq. ft. Inasmuch as the Pine-Hardwood Type is now composed primarily of hardwoods, with an expected increase in the proportion of pine, the basal area for this type was placed between the two foregoing types at 135 sq. ft.

Due to the present low degree of stocking on the area as a whole, it was felt that too short a cutting cycle would be neither feasible nor practicable. Conversely, too long a cutting cycle might result in the loss of trees now classed as sound but which will quite likely become defective if allowed to grow too long. Consequently, a cutting cycle of 10 years was selected.

Since the estimated future rate of growth was determined to be 0.4" per year, and the average maximum harvest diameter was set at 24" for the Hardwood Type and 20" for the other two types, the rotation for the former type would be 24"/0.4" or 60 years and 20"/0.4" or 50 years for the latter two.



Trend of Stocking when One Acre is Fully-Stocked with Trees of a Single D. B. H. Class

Figure I

Before we can proceed to formulate any decision regarding the treatment of each of the individual stand components, it is necessary to break each of these components down to a per acre basis for further inspection. The nine different portions then appear as presented in Table IX which follows.

Table IX

Stand and Stock Tables

(Average Acre)

D. B. H., Inches	Number of Trees		Basal Area per diam. class, sq. ft.		Volume, ft. b. m.	
	Total	Defective	Total	Defective	Total	Defective
Condition Class I						
Hardwood Type (representing 486 acres)						
6	8.2	0.4	1.61	0.08		
8	6.9	0.3	2.41	0.10		
10	5.1	1.6	2.78	0.87	12	
12	4.7	0.8	3.69	0.63	287	47
14	4.7	1.1	5.03	1.18	455	96
16	4.4	0.6	6.14	0.84	626	83
18	3.0	0.3	5.30	0.53	595	62
20	2.1	0.9	4.58	1.96	533	238
22	1.5	0.7	3.96	1.85	561	250
24	0.8	0.3	2.51	0.94	342	109
26	0.4	0.1	1.48	0.37	213	53
28	0.5	0.2	2.14	0.86	279	125
32	0.2		1.12		182	
34	0.1	0.1	0.63	0.63	46	46
Totals	42.6	7.4	43.33	10.84	4,131	1,109

Table IX (Continued)

Stand and Stock Tables

(Average Acre)

D. B. H., Inches	Number of Trees		Basal Area per diam. class, sq. ft.		Volume, ft. b. m.	
	Total	Defective	Total	Defective	Total	Defective
Condition Class I						
Pine-Hardwood Type (representing 260 acres)						
6	5.7	0.4	1.09	0.08		
8	6.7	1.0	2.34	0.35		
10	6.7	0.7	3.65	0.38	180	26
12	7.8	1.0	6.13	0.79	606	67
14	4.3	0.4	4.60	0.43	504	46
16	4.3	0.9	6.10	1.26	721	145
18	1.3	0.4	2.30	0.71	299	89
20	0.6		1.31		147	
22	0.4		1.06		129	
24	0.4		1.26		176	
26	0.3	0.3	1.11	1.11	147	147
Totals	38.5	5.1	30.95	5.11	2,909	520
Pine Type (representing 117 acres)						
6	10.5	1.5	2.06	0.29		
8	7.5	1.0	2.62	0.35		
10	8.9	4.5	4.85	2.46	235	94
12	6.0	2.5	4.71	1.96	494	181
14	4.0		4.28		506	
16	2.5	1.0	3.49	1.40	423	166
18	1.0	1.0	1.77	1.77	153	153
20	0.5	0.5	1.09	1.09	172	172
Totals	40.9	12.0	24.97	9.32	1,983	766

Table IX (Continued)

Stand and Stock Tables

(Average Acre)

D. B. H., Inches	Number of Trees		Basal Area per diam. class, sq. ft.		Volume, ft. b. m.	
	Total	Defective	Total	Defective	Total	Defective
Condition Class II						
Hardwood Type (representing 597 acres)						
6	10.5	0.9	2.06	0.18		
8	8.3	1.2	2.90	0.42		
10	5.5	1.1	3.00	0.60	18	3
12	6.1	1.5	4.80	1.18	387	97
14	4.7	0.8	5.02	0.85	476	75
16	2.7	0.4	3.76	0.56	415	41
18	2.5	0.9	4.41	0.44	550	173
20	0.9	0.2	1.96	1.59	314	56
22	0.5	0.1	1.32	0.26	143	17
24	0.6	0.2	1.89	0.63	259	54
26	0.3	0.2	1.11	0.74	140	95
Totals	42.6	7.5	32.23	7.45	2,702	611
Pine-Hardwood Type (representing 453 acres)						
6	10.1	1.5	1.98	0.29		
8	7.0	1.7	2.44	0.59		
10	7.8	1.8	4.25	0.98	171	33
12	6.1	1.3	4.80	1.02	427	90
14	4.1	0.9	4.38	0.96	418	82
16	3.4	0.8	4.74	1.11	541	90
18	0.8	0.4	1.41	0.71	168	92
20	0.7	0.4	1.51	0.86	178	108
24	0.1	0.1	0.31	0.31	33	33
30	0.1		0.49		53	
Totals	40.2	8.9	26.31	6.83	1,989	528
Pine Type (representing 132 acres)						
6	17.0	1.1	3.34	0.22		
8	14.1	1.8	4.92	0.63		
10	11.8	0.8	6.44	0.44	446	22
12	6.5	1.8	5.10	1.41	501	124
14	6.2	1.8	6.63	1.92	691	195
16	2.0	0.3	2.79	0.42	279	37
18	0.6	0.3	1.06	0.53	136	67
22	0.3	0.3	0.79	0.79	82	82
Totals	58.5	8.2	31.07	6.36	2,135	527

Table IX (Concluded)

Stand and Stock Tables

(Average Acre)

D. B. H., Inches	Number of Trees		Basal Area per diam. class, sq. ft.		Volume, ft. b. m.	
	Total	Defective	Total	Defective	Total	Defective
Condition Class III						
Hardwood Type (representing 726 acres)						
6	9.8	0.7	1.92	0.14		
8	6.0	0.8	2.09	0.28		
10	2.8	0.9	1.53	0.49	3	
12	1.5	0.2	1.18	0.16	75	12
14	1.8	0.5	1.92	0.53	128	42
16	0.8	0.1	1.12	0.14	123	13
18	0.9	0.3	1.59	0.53	105	52
20	0.2		0.44		58	
22	0.1		0.26		27	
Totals	23.9	3.5	12.05	2.27	519	119
Pine-Hardwood Type (representing 298 acres)						
6	4.8	0.7	0.94	0.14		
8	2.7	1.0	0.94	0.35		
10	1.9	0.2	1.04	0.11	35	7
12	1.9	0.2	1.50	0.16	130	14
14	0.4	0.2	0.42	0.21	24	12
16	0.8	0.2	1.12	0.28	96	19
24	0.4	0.4	1.26	1.26	87	87
Totals	12.9	2.9	7.22	2.51	372	139
Pine Type (representing 152 acres)						
6	16.2		3.18			
8	5.4		1.88			
10	1.7		0.93		67	
12	0.8		0.63		87	
14	1.3		1.39		158	
Totals	25.4		8.01		312	

DEVELOPMENT OF CONTROL TABLES

We now have a clear picture of each of the nine different components of the stand, and are able to tell how the number of trees, square feet of basal area and board feet of volume vary from size class to size class within each component. We are also able to determine the distribution of the defective portions of the stand throughout each individual group.

Although the data, as presented in this form, gives a much better picture of stand composition than when presented for the stand as a whole (on either a total or per-acre basis), such an arrangement does not lend itself readily as a useful tool with which to manage the stand. It is difficult to tell just what portion of the stand should constitute the present harvest cut, what thinnings should be made, if any, and what may be expected in the way of future cuts.

Since the stand is now in an unregulated condition, the distribution of the various size classes as they would appear in the anticipated fully-stocked and regulated stand is a better base to use in determining the present harvest and future cuts. But if we were to present the anticipated stand in the same manner as the present components of the stand have been presented, we would still have an unwieldy arrangement of data. Now since the estimated future rate of growth, cutting cycle and maximum harvest diameter have been determined, a series of "cyclic age groups" may be set up, each of which would carry an equal proportion of the diameter range from the average minimum diameter of the trees tallied in the cruise (6") to the maximum harvest diameter. The number

of cyclic age groups that is to be assigned to each of the three types is merely the number of cutting cycles required to raise trees from 6" to harvest size. This number may be found by subtracting 6" from the average maximum harvest diameter, and dividing the result by the product of the number of years in the cutting cycle and the estimated future rate of growth. For the Hardwood Type, the number of cyclic age groups would be (24"-6")/(10 X 0.4) or 4.5, say 5, and for the Pine-Hardwood and Pine Types it would be (20"-6")/(10 X 0.4) or 3.5, say 4. As stated in the introduction to this paper, basal area is the best criterion of the degree of stocking which any particular area should be allowed to attain. Since each cyclic age group would carry a certain range of diameters, it would also have an average diameter for which the corresponding basal area of that diameter (in a fully-stocked theoretical stand) may be read from the curves on page 17. As soon as the theoretical basal area for each of these average diameters have been totaled, we can immediately obtain the percentage of actual basal area that each average diameter, and, therefore, each cyclic age group should carry. These percentages can then be applied to the total basal area of that portion of the actual stand carrying trees from 6" to the harvest diameter, in order to obtain the actual basal area that should be applied to each of the age groups. It has previously been determined that the Hardwood Type should carry 126 sq. ft. of basal area; the Pine-Hardwood Type, 135 sq. ft.; and the Pine Type, 150 sq. ft. (See paragraph 2, page 16). Therefore, since the Hardwood Type contains five age groups in covering the diameter range from 8" to 24", it would take seven age groups to cover the diameter range from 0" to 24", and the total actual basal area as shown in the Hardwood Type Control Table

(Table X on page 25) would be 5/7 of 126 or 90 sq. ft. A similar procedure is followed in determining the actual basal areas for the Pine-Hardwood and Pine Types. By dividing the actual basal area assigned to each age group by the sq. ft. of basal area of the average diameter of that age group (as read from a basal area table), we obtain the number of trees that should be assigned to each age group. Volumes were obtained from the upper curves of Figures II and III on pages 36 and 37 by reading the corresponding merchantable heights for the average diameter of each age group, and then converting those heights to the appropriate volumes as given in the volume tables on pages 7 and 8.

By referring to Table X on page 25, we now have a picture of how the three different types will appear when the anticipated fully-stocked and regulated condition has been reached.

DEVELOPMENT OF CLASSIFIED STAND AND STOCK TABLES

The control tables which have just been developed may also be used in constructing "classified stand and stock tables" for the various stand components. These classified stand and stock tables are to be set up as the first step in bringing about a regulated forest condition, and the percentages of basal area for the various age groups in each type (with exceptions to be discussed later) will therefore be the same as those found in the control tables.

Due to the variations in stocking between the three condition classes, each condition class will necessarily be treated in a different manner.

Table X

Control Tables

(Average Acre)

Age Group	D. B. H., Inches Range	Average	Theoretical* BA, sq. ft.	Percent BA	Act. BA, sq. ft.	No. of Trees	Vol., ft. b. m.
			Hardwood Type				
I	6-10	8.0	114	15.6	14.04	40.3	
II	10-14	12.0	137	18.8	16.92	21.6	2,160
III	14-18	16.0	151	20.7	18.63	13.4	2,948
IV	18-22	20.0	162	22.2	19.98	9.2	3,680
V	22-26	24.0	166	22.7	20.43	6.5	4,550
Totals			730	100.0	90.00	91.0	13,338
			Pine-Hardwood Type				
I	6-10	8.0	117	20.1	18.09	51.8	
II	10-14	12.0	143	24.5	22.05	23.1	2,310
III	14-18	16.0	158	27.0	24.30	17.4	3,828
IV	18-22	20.0	166	28.4	25.56	11.7	4,680
Totals			584	100.0	90.00	104.0	10,818
			Pine Type				
I	6-10	8.0	153	22.6	22.60	64.8	2,592
II	10-14	12.0	174	25.8	25.80	32.9	3,948
III	14-18	16.0	174	25.8	25.80	18.5	4,070
IV	18-22	20.0	174	25.8	25.80	11.8	4,602
Totals			675	100.0	100.00	128.0	15,212

*It should be remembered that <u>each</u> of the individual figures presented in the <u>Theoretical Basal Area</u> column represents one full acre, and that the total of these figures represents five (or four in the Pine-Hardwood and Pine Types) fully-stocked acres. It should be remembered further that the figures presented in this column are shown merely for the purpose of determining the appropriate items to be placed in the <u>Percent Basal Area</u> column.

Condition Class I will have a harvest cut (as determined by the method now being developed) and all defective trees removed from it during the first cutting cycle. Condition Classes II and III will permit only the removal of defective trees during the first cutting cycle in what will actually amount to a salvage cutting. During the second cutting cycle, it should be possible to remove a harvest crop from Condition Class II, as well as a second harvest from Condition Class I, but Condition Class III will not be able to furnish a harvest cut until the beginning of the third cutting cycle.

Since Condition Class I is the only condition class to which the control tables may be applied directly, the construction of the classified stand and stock tables for that condition class will be discussed first. The age groups in both the control tables and classified stand and stock tables are spaced according to the length of the cutting cycle, and therefore, the highest-numbered age group in each type will contain the basal area, number of trees and volume which will constitute the harvest cut.

By referring to Table IX on page 18 (stand and stock table for the Hardwood Type of Condition Class I), and using both sound and defective basal area, number of trees and volume, we are now able to set up a classified stand and stock table for that component as shown in Table XI on page 27.

Table XII

Classified Stand and Stock Table

(Average Acre)

Condition Class I-Hardwood Type

Age Group	Percent BA	Act. BA, sq. ft.	Number of Trees		D. B. H., In.		Vol., ft. b. m.	
			Total	Defective	Range	Average	Total	Defective
I	15.6	6.76	20.2	2.3	6-12	7.8	13	
II	18.8	8.15	8.9	1.8	12-14	13.0	689	132
III	20.7	8.96	6.2	0.8	14-18	16.3	932	120
IV	22.2	9.62	4.6	1.5	18-22	19.6	1,157	400
V	22.7	9.84	2.7	1.0	22 +	25.8	1,340	457
Totals	100.0	43.33	42.6	7.4			4,131	1,109

The number of trees and volume to be assigned to each age group were determined as follows:

Age Group V	BA	No. of Trees	Vol., ft. b. m.
BA required	9.84		
34" class-0.63		0.1	46
32" class-1.12		0.2	182
28" class-2.14		0.5	279
26" class-1.48		0.4	213
24" class-2.51	7.88	0.8	342
BA from 22" class	1.96		
% BA from 22" class-1.96/3.96 or 49.5%			
No. of trees from 22" class-.495 X 1.5		0.7	
Volume " " " -.495 X 561			278
Totals		2.7	1,340

Age Group IV				
BA required		9.62		
Balance from 22" class				
BA-3.96-1.96 or 2.00			1.5-0.7 or 0.8	561-278 or 283
20" class	4.58	6.58	2.1	533
BA from 18" class		3.04		
% BA from 18" class-3.04/5.30 or 57.4%				
No. of trees from 28" class-.574 X 3.0			1.7	
Volume " " " -.574 X 595				341
Totals			4.6	1,157

Age Group III	BA	No. of Trees	Vol., ft. b. m.
BA required	8.96		
Balance from 18" class			
BA - 5.30-3.04 or 2.26		3.0-1.7 or 1.3	595-341 or 254
16" class 6.14	8.40	4.4	626
BA from 14" class	0.56		
% BA from 14" class-0.56/5.03 or 11.1%			
No. of trees from 14" class-.111 X 4.7		0.5	
Volume " " " -.111 X 455			52
Totals		6.2	932
Age Group II			
BA required	8.15		
Balance from 14" class			
BA - 5.03-0.56 or 4.47	4.47	4.7-0.5 or 4.2	455-52 or 403
BA from 12" class	3.68		
% BA from 12" class-3.68/3.69 or 99.7%			
No. of trees from 12" class-.997 X 4.7		4.7	
Volume " " " -.997 X 287			286
Totals		8.9	689
Age Group I			
Balance of trees and volume			
Balance from 12" class		4.7-4.7 or 0	287-286 or 1
10" class		5.1	12
8" class		6.9	
6" class		8.2	
Totals		20.2	13

Average diameters were determined by dividing the sq. ft. of basal area by the number of trees, and locating the quotient in a basal area table. The defective trees and volume to be assigned to each age group were computed on the same proportions of basal area in each age group as were the total trees and volume.

Classified stand and stock tables for the Pine-Hardwood and Pine Types were constructed in a similar manner, and may be found in Table XII on page 29.

Table XII

Classified Stand and Stock Tables

(Average Acre)

Condition Class I-Pine-Hardwood Type

Age Group	Percent BA	Act. BA, sq. ft.	Number of Trees		D. B. H., In.		Vol., ft. b. m.	
			Total	Defective	Range	Average	Total	Defective
I	20.1	6.21	17.8	2.0	6-10	8.0	146	21
II	24.5	7.58	9.6	1.1	10-14	12.0	704	78
III	27.0	8.36	6.9	1.0	14-16	14.9	953	143
IV	28.4	8.80	4.2	1.0	16 +	19.6	1,106	278
Totals	100.0	30.95	38.5	5.1			2,909	520

Condition Class I-Pine Type

I	22.6	5.64	19.8	3.4	6-10	7.3	46	19
II	25.8	6.41	10.3	4.9	10-12	10.7	453	201
III	25.8	6.41	6.7	1.2	12-14	13.2	729	55
IV	25.8	6.41	4.1	2.5	14 +	17.0	755	491
Totals	100.0	24.87	40.9	12.0			1,983	766

Only the defective trees are to be removed from Condition Class II during the first cutting cycle. Therefore, the basal area, number of trees and volume, as found ten years hence on the Hardwood Type, for example, will appear as shown in Table XIII.

As stated before, present stocking of trees under 6" appears to be adequate, and referring to the Hardwood Type control table*, we find that 10 years from now we may reasonably expect to find 40.3 trees with a basal area of 14.04 sq. ft. and averaging 8". The total basal area, therefore, will be 43.95 + 14.04 or 57.99 sq. ft. Since age group I would be fully stocked, the basal area of 43.95 sq. ft. for the other

*See Age Group I of Table X, Hardwood Type, on page 25.

Table XIII

Stand and Stock Table

(Average Acre)

Condition Class II-Hardwood Type

(10 years hence)

D. B. H., Inches	No. of Trees	BA per diam. class, sq. ft.	Vol., ft.. b. m.
10	9.6	5.24	384
12	7.1	5.58	426
14	4.4	4.70	484
16	4.6	6.42	690
18	3.9	6.89	936
20	2.3	5.02	690
22	1.6	4.22	736
24	0.7	2.20	378
26	0.4	1.48	256
28	0.4	1.71	300
30	0.1	0.49	87
Totals	35.1	43.95	5,367

four age groups cannot be proportioned over those age groups in the same manner as was done previously, because age group I would contain 14.04/57.99 or 24.2 percent of the basal area whereas it should contain only 15.6 percent if the Hardwood Type control table is to be used. It is therefore necessary to lower the percentages of basal area to be assigned to the other four age groups. The amount that each should be lowered is obtained by subtracting 15.6 from 24.2 and dividing by 4, or 8.6/4 is 2.15. Age group II percentage would then become 18.8-2.1 or 16.7, age group III-20.7-2.1 or 18.6, age group IV-22.2-2.2 or 20.0 and age group V-22.7-2.2 or 20.5. We now have the proper percentages that should be assigned to age groups II through V, and can proceed to construct a classified stand and stock table for the Hardwood Type of Condition Class II in the same manner as were the tables for Condition

Class I constructed. The classified stand stock tables for the Pine-Hardwood and Pine Types of Condition Class II would, of course, also be constructed in a similar manner.

Since a harvest cut is not to be removed from Condition Class III until 20 years from now, we should find both age groups I and II to be fully-stocked by that time. Adjustment of the percentages for age groups III, IV and V in the Hardwood Type (and III and IV in the Pine-Hardwood and Pine Types) would then be made on the same basis as in Condition Class II. Classified stand and stock tables for Condition Class II, 10 years hence, and Condition Class III, 20 years hence, would then appear as presented in Tables XIV and XV on pages 32 and 33, respectively.

ESTIMATION OF PRESENT CUT

The volume of timber that may safely be removed from the stand during the first cutting cycle (within the next 10 years) may be easily calculated from the classified stand and stock tables. For the Hardwood Type of Condition Class I, the total cut per acre during this period would be the volume, ft. b. m., in age group V plus the defective volume of age groups II, III and IV, or 1,340 + (132 + 120 + 400) is 1,992 board feet. (See Table XI on page 27) Since there are 486 acres in this component (see Table I on page 5), the total cut for the Hardwood Type of Condition Class I would be 1,992 X 486 or 968 M ft., b. m. Similarly, the respective cuts for the Pine-Hardwood and Pine Types in this condition class would be 350 M and 121 M, respectively, giving a total of 1,439 M for Condition Class I. Condition Classes II

Table XIV

Classified Stand and Stock Tables-Condition Class II

(Average Acre)

(10 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., In. Range	D. B. H., In. Average	Vol., ft. b. m.
			Hardwood Type			
I	24.2	14.04	40.3	6-10	8.0	
II	16.7	9.68	15.2	10-12	10.8	723
III	18.6	10.79	9.0	12-16	15.5	1,103
IV	20.0	11.60	6.9	16-20	17.6	1,540
V	20.5	11.88	4.0	20 +	23.3	2,001
Totals	100.0	57.99	75.4			5,367
			Pine-Hardwood Type			
I	33.5	18.09	51.8	6-10	8.0	
II	20.1	10.85	15.8	10-14	11.2	868
III	22.5	12.15	9.5	14-18	15.3	1,315
IV	23.9	12.91	6.0	18 +	19.9	1,865
Totals	100.0	54.00	83.1			4,048
			Pine Type			
I	31.6	22.59	64.8	6-10	8.0	
II	22.8	16.30	25.6	10-12	10.8	1,413
III	22.8	16.30	15.5	12-16	13.9	1,815
IV	22.8	16.30	9.2	16 +	18.0	2,205
Totals	100.0	71.49	115.1			5,433

Table XV

Classified Stand and Stock Tables-Condition Class III

(Average Acre)

(20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., In. Range	D. B. H., In. Average	Vol., ft. b. m.
Hardwood Type						
I	18.0	14.04	40.3	6-10	8.0	
II	40.6	31.62	40.3	10-14	12.0	4,030
III	12.7	9.97	9.3	14-16	14.0	1,027
IV	14.1	11.00	7.2	16-20	16.7	1,296
V	14.6	11.40	3.9	20 ≠	23.1	1,901
Totals	100.0	78.03	101.0			8,254
Pine-Hardwood Type						
I	24.2	18.09	51.8	6-10	8.0	
II	54.5	40.62	51.8	10-14	12.0	5,180
III	10.0	7.46	6.2	14-18	14.9	805
IV	11.3	8.42	3.8	18 ≠	20.2	1,238
Totals	100.0	74.59	113.6			7,223
Pine Type						
I	21.2	22.60	64.8	6-10	8.0	2,592
II	47.8	50.90	64.8	10-14	12.0	2,776
III	15.5	16.51	15.5	14-14	14.0	1,854
IV	15.5	16.51	9.9	14 ≠	17.5	2,036
Totals	100.0	106.52	155.0			9,258

and III will permit the removal of only the defective trees, and by obtaining the appropriate defective volumes and acreages of these two condition classes, we find that they will yield a total of 674 M and 155 M, respectively. This will give a total of 2,268 M for the whole area, or approximately 230 M ft., b. m. per year during the first cutting cycle. These calculations are shown in Table XVI on page 35. In addition, it will also be possible to obtain approximately 180 standard (128 cubic feet) cords of fuelwood per year during the first cutting cycle.

ESTIMATION OF FUTURE CUTS

Since the area has been subjected to recurrent fires, it is expected that those trees 12" and under will respond to adequate forest fire protection to the extent of one additional log-length of merchantable height per tree. In order to facilitate the calculation of what this will mean in the way of estimating future cuts, four curves of merchantable height over d. b. h. have been plotted; two for pines, and two for hardwoods. Data plotted on the lower of each of these two sets of curves were obtained from the volume-per-tree columns of the stand and stock tables for sound trees in Table VI on page 13. Data for the upper curves were obtained by adding 16 feet to each of the points on the lower curves. The curves were plotted to only 20" for pines and 26" for hardwoods, because the merchantable heights tend to flatten out at those diameters. These curves may be found in Figures II and III on pages 36 and 37, respectively.

Table XVI

Calculation of Present Cut

Age Group or Type	Volume, ft. b. m. (Per Average Acre)		Acreage		Vol. per Type, ft. b. m.	Total Vol., ft. b. m.
Condition Class I (Harvest Cut)						
Hardwood Type (refer to Table XI)						
II	132					
III	120					
IV	400					
V	1,340					
Total	1,992	X	486	or	968 M	
Pine-Hardwood Type (refer to Table XII)						
I	21					
II	78					
III	143					
IV	1,106					
Total	1,348	X	260	or	350 M	
Pine Type (refer to Table XII)						
I	19					
II	201					
III	55					
IV	755					
Total	1,030	X	117	or	121 M	
Total from Condition Class I						1,439 M
Condition Class II (Salvage Cut-refer to Table IX)						
Hardwood	611	X	597	or	365 M	
Pine-Hardwood	528	X	453	or	239 M	
Pine	527	X	132	or	70 M	
Total from Condition Class II						674 M
Condition Class III (Salvage Cut-refer to Table IX)						
Hardwood	119	X	726	or	86 M	
Pine-Hardwood	139	X	298	or	69 M	
Total from Condition Class III						155 M
Total Present Cut						2,268 M

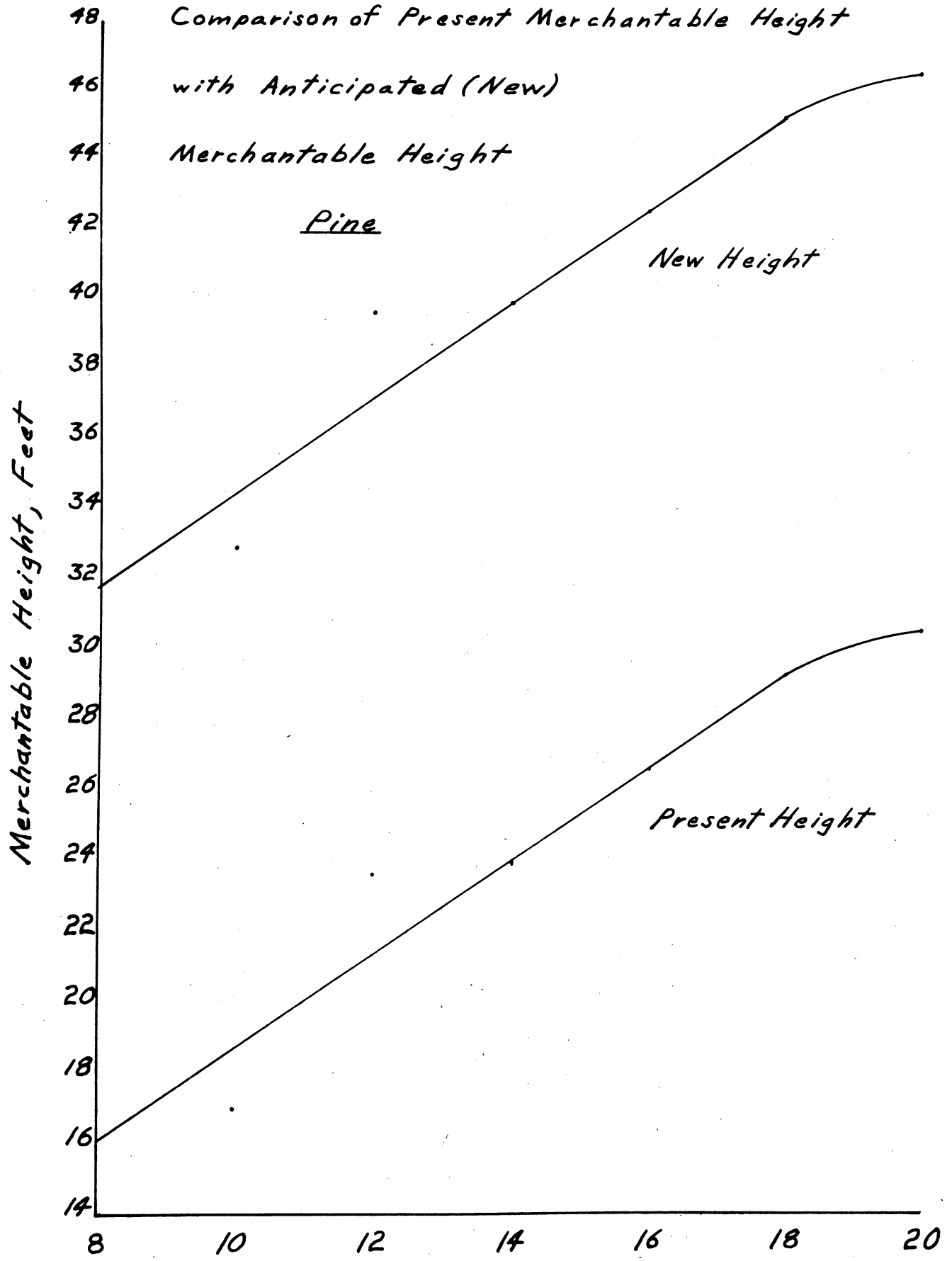

Comparison of Present Merchantable Height with Anticipated (New) Merchantable Height
Pine
New Height
Present Height
Merchantable Height, Feet
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
8
10
12
14
16
18
20
D. B. H., Inches

Figure II

Comparison of Present Merchantable Height with Anticipated (New) Merchantable Height

Hardwood

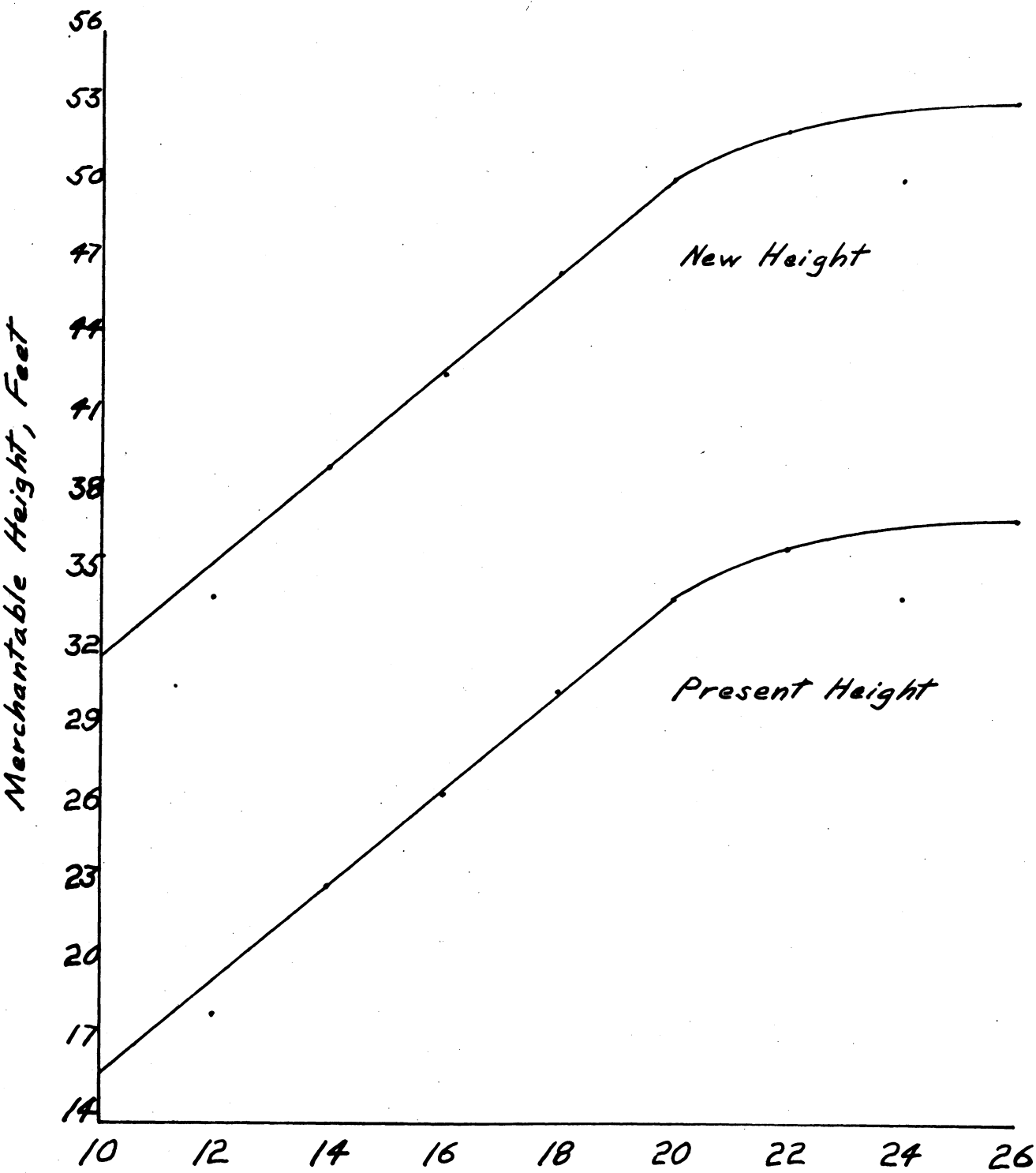


Figure III

Inasmuch as the primary objective of this plan is to achieve full stocking as quickly as possible, no thinnings are to be made in future cuts until the total basal area of each component approaches the basal area as set up in the control tables. Should the basal area threaten to become considerably greater than that set up in the control tables, then, of course, thinnings would be made in order to prevent overstocking with a resultant decrease in the rate of growth.

Once a certain number of trees has been assigned to a certain age group, that number of trees will remain assigned to a single age group until rotation age is reached. For example, we find that age group IV of the Hardwood Type of Condition Class I now contains 4.6 sound trees and 1.5 defective trees per acre. (See Table XI on page 27). Since the defective trees are to be removed during the first cutting cycle, there will be 4.6-1.5 or 3.1 trees left in age group IV. In ten years, these 3.1 trees will have advanced to age group V, and will constitute the harvest cut for that component during the second cutting cycle. (See Hardwood Type at end of first cutting cycle, in Table XVII, and refer to age group V). In order that this progression from age group to age group may be more easily visualized, classified stand and stock tables for the various stand components at different future periods are presented in Tables XVII, XVIII and XIX on the pages which follow. The expression (N) after some of the average diameter figures indicates those trees which have recovered from fire damage, and, therefore, have their volumes computed from the upper curves of the merchantable height-d. b. h. curves. It should be noted that the trees in Condition Classes II and III are not considered to have recovered as quickly as have those in Condition Class I due to greater intensity of past fires.

Table XVII

Classified Stand and Stock Table-Condition Class I

(Average Acre)

At end of first cutting cycle (10 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	23.5	14.04	40.3	6-10	8.0(N)	
II	23.9	14.30	17.9	10-14	12.1	1,074
III	21.2	12.69	7.1	14-??	18.1	1,704
IV	17.3	10.40	5.4	??-20	18.8	1,296
V	14.1	8.48	3.1	20 +	22.4	1,147
Totals	100.0	59.91	73.8			5,221
Pine-Hardwood Type						
I	33.7	18.09	51.8	6-10	8.0(N)	
II	23.2	12.41	15.8	10-14	12.0	948
III	22.1	11.86	8.5	14-18	16.0	1,275
IV	21.0	11.24	5.9	18 +	18.7	1,416
Totals	100.0	53.60	82.0			3,639
Pine Type						
I	46.0	22.60	64.8	6-10	8.0(N)	2,592
II	22.4	11.02	16.4	10-12	11.1	1,312
III	12.9	6.36	5.4	12-16	14.7	648
IV	18.7	9.19	5.5	16 +	17.5	1,375
Totals	100.0	49.17	92.1			5,927

Table XVII (Continued)

Classified Stand and Stock Table-Condition Class I

(Average Acre)

Immediately after second harvest cutting (10 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	16.4	7.33	21.0	6-10	8.0(N)	
II	32.0	14.30	17.9	10-14	12.1	1,074
III	28.3	12.69	7.1	14-??	18.1	1,704
IV	23.3	10.40	5.4	??-20	18.8	1,296
V						
Totals	100.0	44.72	51.4			4,074
Pine-Hardwood Type						
I	36.4	13.92	39.9	6-10	8.0(N)	
II	32.5	12.41	15.8	10-14	12.0	948
III	31.1	11.86	8.5	14-18	16.0	1,275
IV						
Totals	100.0	38.19	64.2			2,223
Pine Type						
I	54.4	20.77	59.5	6-10	8.0(N)	2,380
II	28.9	11.02	16.4	10-12	11.1	1,312
III	16.7	6.36	5.4	12-16	14.7	648
IV						
Totals	100.0	38.15	81.3			4,340

Table XVII (Continued)

Classified Stand and Stock Table-Condition Class I

(Average Acre)

At end of second cutting cycle (20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	15.6	14.04	40.3	6-10	8.0(N)	
II	18.3	16.48	21.0	10-14	12.0(N)	2,100
III	28.1	25.28	17.9	14-18	16.1(N)	3,938
IV	21.0	18.91	7.1	18-??	22.1	3,266
V	17.0	15.31	5.4	?? +	22.8	2,448
Totals	100.0	90.02	91.7			11,752
Pine-Hardwood Type						
I	20.1	18.09	51.8	6-10	8.0(N)	
II	34.8	31.37	39.9	10-14	12.0(N)	3,990
III	24.5	22.04	15.8	14-18	16.0(N)	3,476
IV	20.6	18.55	8.5	18-22	20.0	2,550
Totals	100.0	90.05	116.0			10,016
Pine Type						
I	22.6	22.60	64.8	6-10	8.0(N)	2,592
II	46.7	46.68	59.5	10-14	12.0(N)	7,140
III	20.4	20.40	16.4	14-16	15.1(N)	3,608
IV	10.3	10.29	5.4	16 +	18.7	1,350
Totals	100.0	99.97	146.1			14,690

Table XVII (Concluded)

Classified Stand and Stock Table-Condition Class I

(Average Acre)

Immediately after third harvest cutting (20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	16.4	7.54	21.6	6-10	8.0(N)	
II	23.2	10.52	13.4	10-14	12.0(N)	1,340
III	28.7	13.00	9.2	14-18	16.1(N)	2,024
IV	31.7	14.39	5.4	18 +	22.1	2,484
V						
Totals	100.0	45.45	49.6			5,848
Pine-Hardwood Type						
I	35.9	8.05	23.1	6-10	8.0(N)	
II	42.9	13.67	17.4	10-14	12.0(N)	1,740
III	21.2	16.32	11.7	14-18	16.0(N)	2,574
IV						
Totals	100.0	38.04	52.2			4,314
Pine Type						
I	27.2	11.48	32.9	6-10	8.0(N)	1,316
II	34.4	14.53	18.5	10-14	12.0(N)	2,220
III	38.4	16.28	13.0	14 +	15.1(N)	2,860
IV						
Totals	100.0	42.29	64.4			6,396

Table XVIII

Classified Stand and Stock Table-Condition Class II

(Average Acre)

Immediately after first harvest cutting (10 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
			Hardwood Type			
I	35.5	14.04	40.3	6-10	8.0(N)	
II	24.5	9.68	15.2	10-12	10.8	723
III	27.2	10.79	9.0	12-16	15.5	1,103
IV	12.8	5.07	3.0	16 +	17.6	720
V						
Totals	100.0	39.58	67.5			2,546
			Pine-Hardwood Type			
I	49.4	18.09	51.8	6-10	8.0(N)	
II	21.0	10.85	15.8	10-12	11.2	868
III	29.6	7.66	6.0	12 +	15.3	900
IV						
Totals	100.0	36.60	73.6			1,768
			Pine Type			
I	55.1	22.59	64.8	6-10	8.0(N)	
II	32.0	13.09	14.9	10-12	10.8	596
III	12.9	5.27	5.0	12 +	13.9	600
IV						
Totals	100.0	40.95	84.7			1,196

Table XVIII (Continued)

Classified Stand and Stock Table-Condition Class II

(Average Acre)

At end of second cutting cycle (20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	15.6	14.04	40.3	6-10	8.0(N)	
II	35.1	31.62	40.3	10-14	12.0(N)	4,030
III	20.1	18.17	15.2	14-16	14.8(N)	2,432
IV	20.7	18.68	9.0	16-20	19.5	2,700
V	8.5	7.64	3.0	20 +	21.6	1,110
Totals	100.0	90.15	107.8			10,272
Pine-Hardwood Type						
I	19.9	18.09	51.8	6-10	8.0(N)	
II	44.7	40.62	51.8	10-14	12.0(N)	5,180
III	22.0	19.91	15.8	14-18	15.2(N)	3,476
IV	13.4	12.19	6.0	18 +	19.3	1,200
Totals	100.0	90.81	125.4			9,856
Pine Type						
I	22.6	22.59	64.8	6-10	8.0(N)	2,592
II	50.9	50.90	64.8	10-14	12.0(N)	7,760
III	17.8	17.80	14.9	14-16	14.8(N)	2,384
IV	8.7	8.74	5.0	16 +	17.9	1,250
Totals	100.0	100.03	149.5			13,986

Table XVIII (Concluded)

Classified Stand and Stock Table-Condition Class II

(Average Acre)

Immediately after second harvest cutting (20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	17.7	7.54	21.6	6-10	8.0(N)	
II	24.6	10.52	13.4	10-14	12.0(N)	1,340
III	25.9	10.99	9.2	14-18	14.8(N)	1,472
IV	31.8	13.49	6.5	18 +	19.5	1,950
V						
Totals	100.0	42.54	50.7			4,762
Pine-Hardwood Type						
I	22.1	8.05	23.1	6-10	8.0(N)	
II	37.4	13.67	17.4	10-14	12.0(N)	1,740
III	40.5	14.74	11.7	14 +	15.2(N)	2,574
IV						
Totals	100.0	36.46	52.2			4,314
Pine Type						
I	28.6	11.48	32.9	6-10	8.0(N)	1,316
II	36.2	14.53	18.5	10-14	12.0(N)	2,220
III	35.2	14.10	11.8	14 +	14.8(N)	1,888
IV						
Totals	100.0	40.11	63.2			5,424

Table XIX

Classified Stand and Stock Table-Condition Class III

(Average Acre)

Immediately after first harvest cutting (20 years hence)

Age Group	Percent BA	Act. BA, sq. ft.	No. of Trees	D. B. H., Inches Range	D. B. H., Inches Average	Vol., ft. b. m.
Hardwood Type						
I	34.7	14.04	40.3	6-10	8.0(N)	
II	26.0	10.52	13.4	10-14	12.0(N)	1,340
III	24.5	9.94	9.3	14-14	14.0	1,027
IV	14.8	6.08	4.0	14 +	16.7	760
V						
Totals	100.0	40.58	67.0			3,127
Pine-Hardwood Type						
I	49.7	18.09	51.8	6-10	8.0(N)	
II	29.9	10.84	13.8	10-14	12.0(N)	1,380
III	20.4	7.40	6.2	14 +	14.9	805
IV						
Totals	100.0	36.33	71.8			2,185
Pine Type						
I	28.8	11.48	32.9	6-10	8.0(N)	1,316
II	36.6	14.53	18.5	10-14	12.0(N)	2,220
III	34.6	13.79	11.8	14 +	14.0	1,416
IV						
Totals	100.0	39.80	63.2			4,952

By the end of the third cutting cycle (30 years from now) all of the stand components should not only be fully stocked, but should very nearly approach the stand composition as set up in the control tables for the various types.

We can now estimate the cuts that might be expected during the second and third cutting cycles. (In the following calculations, 8" trees from the Pine Types are considered merchantable, because if they are removed as thinnings they would be treated as saw logs.) For the Hardwood Type of Condition Class I, we find that 5,221-4,374 or 847 ft., b. m., per acre may be removed from each of 486 acres during the second cutting cycle. This will amount to 556 M for the Hardwood Type, and, making similar calculations for the other two types, it is determined that 1,109 M may be removed from Condition Class I. For Condition Class II, the total would be 3,279 M, and since Condition Class III is not to be cut again until 20 years hence, the total cut during the second cutting cycle would be the sum of the cuts removed from Condition Classes I and II or 1,109 M + 3,279 M is 4,388 M. To be more realistic, it may be stated that an annual cut of approximately 400 M may be reasonably expected during the second cutting cycle. Making similar calculations for the third cutting cycle, we find that the anticipated annual cut has risen to approximately 1,800 M. These calculations are shown in Tables XX and XXI on pages 48 and 49, respectively.

Should it be possible that all of the conditions upon which this plan is based hold true, we might expect to obtain an annual cut of approximately 2,500 M when the entire area has become fully-stocked and regulated.

Table XX

Calculations of Second Harvest Cut

(10 years hence)

Type	Volume, ft. b. m. (Per Average Acre)	Acreage	Vol. per Type, ft. b. m.	Total Vol., ft. b. m.
Condition Class I (refer to Table XVII)				
Hardwood	5,221-4,074 or 1,147	X 486	is 556 M	
Pine-Hardwood	3,639-2,223 or 1,416	X 260	is 368 M	
Pine	5,927-4,340 or 1,587	X 117	is 185 M	
Total from Condition Class I				1,109 M
Condition Class II (refer to Table XVIII)*				
Hardwood	5,367-2,546 or 2,821	X 597	is 1,680 M	
Pine-Hardwood	4,048-1,768 or 2,280	X 453	is 1,030 M	
Pine	5,433-1,196 or 4,237	X 132	is 569 M	
Total from Condition Class II				3,279 M
Total Second Harvest Cut				4,388 M

*The first harvest cut from Condition Class II is included in the total second harvest cut from the whole area.

Table XXI

Calculations of Third Harvest Cut

(20 years hence)

Type	Volume, ft. b. m. (Per Average Acre)	Acreage	Vol. per Type, ft. b. m.	Total Vol., ft. b. m.
Condition Class I (refer to Table XVII)				
Hardwood	11,752-5,848 or 5,904	X 486	is 2,870 M	
Pine-Hardwood	10,016-4,314 or 5,702	X 260	is 1,480 M	
Pine	14,690-6,396 or 8,294	X 117	is 969 M	
Total from Condition Class I				5,319 M
Condition Class II (refer to Table XVIII)*				
Hardwood	10,272-4,762 or 5,510	X 597	is 3,290 M	
Pine-Hardwood	9,856-4,314 or 5,542	X 453	is 2,510 M	
Pine	13,986-5,424 or 8,562	X 132	is 1,130 M	
Total from Condition Class II				6,930 M
Condition Class III (refer to Table XIX)*				
Hardwood	8,254-3,127 or 5,127	X 726	is 3,720 M	
Pine-Hardwood	7,223-2,185 or 5,038	X 298	is 1,500 M	
Pine	9,258-4,952 or 4,306	X 152	is 655 M	
Total from Condition Class III				5,875 M
Total Third Harvest Cut				18,124 M

*The second harvest cut from Condition Class II, and the first harvest cut from Condition Class III, are included in the third harvest cut from the whole area.

FINANCIAL CONSIDERATIONS

Thus far, only that aspect of forest management pertaining to desirable stocking has been dealt with. Termination of a preliminary management plan may quite reasonably be made at this point if the owners of a forest property are interested only in determining what action should be taken in order that their timber holdings may produce the largest amount of growth possible. But in the vast majority of cases, the growing of trees is, or should be, a business, although it is quite apparent that not all owners of forest properties are aware of that fact. No genuine management plan can therefore be considered complete until the financial aspects of that plan have been determined.

On most going operations, this will mean the calculation of production costs and selling prices in order that the operator may determine his profit or loss. On areas which are to be purchased or sold, it will involve the valuation of the property, through stumpage appraisal, in order that the buyer (or seller) may obtain (or sell) the property at a fair price to himself. In all instances, however, the possibilities of increasing the potential income from a forest property should be thoroughly investigated through the examination of present (or contemplated) production costs and cutting practices, and comparison of these data with those of alternate methods which might be used.

The property under consideration in this particular case presents a unique situation. The financial success or failure of any plan

applied to the property would not be regarded in the same light as would be properties that are acquired solely for the purpose of making the maximum amount of profit obtainable from the raising and harvesting of the trees thereon. This is true, because the owners of this institution consider the business of growing trees entirely incidental to the financial soundness of the institution itself, and will quite likely retain title to all of the land they now own regardless of the fact that their timber-growing enterprise may, or may not, show a profit. Nevertheless, for the purpose of illustration, it is desirable to show what profit may be expected, if any, and how a value may be placed on the property.

In this effort the writer is hampered, because neither selling prices of the lumber produced, nor production costs of that lumber, are available for this particular piece of property. However, data prepared by R. A. Campbell (3) for Forest Resources Division, TVA Department of Forestry Relations in making stumpage appraisals on TVA reservoir properties, may be applied with reasonable accuracy, since the stand construction and density, topography and character of operation on this property are very similar to those for which the data were prepared.

CALCULATION OF LUMBER SELLING PRICES

Due to the complexity of the stand with which we are dealing, it is necessary to obtain weighted selling prices in order that true sale values for the finished product may be obtained. Table XXII (see page 52)

Table XXII

SELLING PRICES[1] BY SPECIES AND TREE SIZES (ROUGH GREEN)[2]

In Dollars per M b.f. for lumber produced

WPB No.	Species	Area[3]	DIAMETER BREAST HEIGHT CLASSES										
			10"	12"	14"	16"	18"	20"	22"	24"	26"	28"	30"	36"
	CONIFERS													
19 and amend.3	Shortleaf and loblolly	AAS	31.50	32.75	34.00	35.25	36.50	37.75	39.00	40.25				
219	Virginia Pine	AAS	26.75	28.00	29.25	30.50	31.50	32.50	33.50	34.50				
	White Pine - Log Rule[4]	A	39.00	39.00	39.00	39.00	39.00	39.00	39.00	39.00				
	HARDWOODS													
146	Basswood	A		41.50	42.50	45.50	47.00	48.50	49.50	50.50	51.50	51.50		
	Basswood	S		32.50	33.50	34.50	36.00	37.00	38.00	38.50	39.00	39.00		
146	Buckeye, Beech	A		33.00	34.00	35.50	37.00	38.50	39.50	40.50	41.50	41.00		
146	Chestnut	A		35.00	36.00	37.50	39.00	40.50	41.50	43.00	44.00	45.00		
97	Gum													
	Virgin Red	S		30.50	32.50	34.00	35.50	37.50	39.00	40.50	42.50	43.50	45.00	47.50
146	Maple													
	Sugar & Red	A		34.00	36.50	39.00	42.00	44.50	47.00	49.00	51.00	53.00	55.00	
	Oaks													
97	Bottomland	S		25.00	25.50	28.00	29.50	31.00	32.50	34.00	35.00	36.00	37.00	
146	Chestnut - Virgin	A		36.50	37.50	39.00	40.50	41.50	43.00	44.00	44.50	45.00	45.00	43.00
146	Cutover	A		38.00	38.50	39.00	39.50	40.50	41.00	41.50				
97	Chestnut-Virgin) Average	S		33.00	33.50	34.50	35.00	35.50	36.00	35.50	35.50	34.50	33.50	30.50
97	Cutover)	S												
146	Red & Black - (Average)	A		33.00	35.00	37.50	39.50	41.50	43.00	44.50	46.00	47.00	47.50	47.00
97	Red & Black - (Average)	S		25.00	27.00	29.50	31.50	34.00	35.50	38.00	39.50	41.50	43.00	45.00
146	Scarlet	A		28.00	29.00	31.50	33.50	34.00	35.00	35.50	36.00			
97	Scarlet	S		21.50	23.50	25.00	26.50	28.50	29.50	31.50				
146	White - Virgin	A			35.00	37.00	39.00	43.00	46.00	48.50	51.00	52.50	54.00	54.50	53.50
146	Cutover & B. Ash	A		35.00	37.00	38.50	40.00	41.00	42.00					
97	White - Virgin	S			31.00	33.00	35.00	36.50	38.50	40.50	42.00	43.00	44.00	44.00
97	Cutover	S		29.00	30.50	32.00	33.50	34.00	35.00					
	Yellow Poplar													
146	Virgin	A		38.50	41.50	43.50	46.00	48.00	50.00	52.00	54.00	55.50	56.50	57.50
146	Cutover	A		37.50	39.00	40.50	42.00	43.00	44.00					
97	Virgin	S		32.50	34.00	36.00	37.50	39.00	40.50	42.00	42.50	43.50	45.00	46.00
97	Cutover	S		31.50	33.00	33.50	34.50	35.00	35.50					

1/ All values shown are based on ceiling prices in effect December 1, 1943.
(Values have been rounded off to nearest $.25 per M b.f. for pine and $.50 for hardwoods.)

R. A. C.
Revised-7/25/44

2/ Values shown were read from Tree Value Curves for the respective species and reduced 10% in the case of hardwoods to allow for Rough Green prices.
Most of the Tree Value curves were based on grade yield studies by the U. S. Forest Products Laboratory in 1938 and published in "Overrun & Grade Yields Appalachian & Southern Hardwoods." Revisions are based on tabular data from U. S. Forest Service and dated 7-13-44.

3/ Area A refers to Appalachian territory as defined in WPB 146, S refers to Southern Hardwood territory as defined in WPB 97.

4/ Prices based on WPB 219, Table 2, as amended Sept. 7, 1943, and extended Oct. 2, 1943, to include the Appalachian Hardwood territory. U. S. F. S. wtd. ave. price (R.G) $50.00

from reference (3) is used as the basis for determining these selling prices. It should be remembered that the institution plans to use all of the lumber it produces in it's own building plant, and that the selling prices are used merely as a means of determining whether or not the operation could be conducted at a profit if the lumber produced was sold on the open market. By obtaining average weighted d. b. h. s for each species from the original stand and stock tables, and by using Table XXII, Tables XXIII and XXIV for the selling prices of the present cut were constructed. The latter two tables may be found on the pages which follow. The average weighted selling prices were thus determined to be $40.00 per M for Condition Class I, $35.50 for Condition Class II, and $33.50 for Condition Class III. Selling prices were computed for each condition class only instead of for all of the various stand components in order to facilitate future calculations. It should be noted that Basswood selling prices were used for Misc. species, because Basswood forms a very large proportion of that group. The price for Scarlet Oak-(S) was used for Hickory, because no value is given for Hickory. Since Hickory is such a very low value species when used as lumber, it was felt that the lowest value in the table, i. e., the value of Scarlet Oak-(S), would be comparable to the value that would be placed on Hickory if it could be sold.

Now since this plan is based upon a good many conditions, any or all of which are subject to change, it is not desirable to predict estimated future cuts beyond the end of the second cutting cycle, i. e., 20 years from now. Neither is it desirable to predict what selling prices and production costs will be beyond the end of that

Table XXIII

Calculations of Selling Prices for Present Cut

(Per M ft., b. m.)

Condition Class I-Harvest Trees

Species and Average Weighted d. b. h.	Selling Price from Table XXII		% of Species		Ave. Weighted Selling Price
Hardwood Type					
White Oak (Virgin) (28")	$54.00	X	.216	or	$11.68
Chestnut Oak (Outover) (26")	44.50	X	.528	or	23.50
Red and Black Oaks (26")	46.00	X	.057	or	2.62
Scarlet Oak (26")	36.00	X	.143	or	5.15
Yellow Poplar (Virgin) (24")	52.00	X	.056	or	2.91
Totals			1.000		$45.86
Pine-Hardwood Type					
Shortleaf Pine (20")	$37.75	X	.282	or	$10.64
Virginia Pine (18")	31.50	X	.038	or	1.20
White Oak (Outover) (18")	40.00	X	.102	or	4.08
Chestnut Oak (Virgin) (22")	43.00	X	.523	or	22.49
Red and Black Oaks (20")	41.50	X	.055	or	2.28
Totals			1.000		$40.69
Pine Type					
Shortleaf Pine (16")	$35.25	X	.226	or	$ 7.97
Red and Black Oaks (20")	41.50	X	.230	or	9.55
Scarlet Oak (16")	31.50	X	.117	or	3.69
Beech (14")	34.00	X	.307	or	10.43
Gum (18")	35.50	X	.120	or	4.26
Totals			1.000		$35.90

Type	Ave. Weighted Selling Price of Type		% of Type		Ave. Weighted Selling Price of Harvest Trees
Hardwood	$45.86	X	.418	or	$19.17
Pine-Hardwood	40.69	X	.346	or	14.08
Pine	35.90	X	.236	or	8.47
Totals			1.000		$41.72

Table XXIII (Continued)

Calculations of Selling Prices for Present Cut

(Per M ft., b. m.)

Condition Class I-Defective Trees

Species and Average Weighted d. b. h.	Selling Price from Table XXII		% of Species		Ave. Weighted Selling Price
Hardwood Type					
White Oak (Cutover) (20")	$41.00	X	.045	or	$ 1.85
Chestnut Oak (Virgin) (18")	40.50	X	.415	or	16.82
Red and Black Oaks (20")	41.50	X	.037	or	1.54
Yellow Poplar (Cutover) (22")	44.00	X	.062	or	2.73
Hickory (Scarlet Oak-S) (16")	25.00	X	.054	or	1.35
Maple (12")	34.00	X	.017	or	0.58
Beech (16")	35.50	X	.307	or	10.89
Gum (14")	32.50	X	.045	or	1.46
Misc. (Basswood) (16")	45.50	X	.018	or	0.82
Totals			1.000		$38.04
Pine-Hardwood Type					
Shortleaf Pine (12")	$32.75	X	.299	or	$ 9.79
Chestnut Oak (Virgin) (14")	37.50	X	.131	or	4.91
Red and Black Oaks (16")	37.50	X	.183	or	6.85
Scarlet Oak (14")	29.00	X	.116	or	3.36
Yellow Poplar (Cutover) (16")	40.50	X	.072	or	2.99
Hickory (Scarlet Oak-S) (14")	23.50	X	.100	or	2.35
Gum (16")	34.00	X	.099	or	3.37
Totals			1.000		$33.62
Pine Type					
Shortleaf Pine (10")	$31.50	X	.614	or	$19.35
Virginia Pine (12")	28.00	X	.140	or	3.92
Chestnut Oak (Virgin) (12")	36.50	X	.082	or	2.99
Beech (12")	33.00	X	.164	or	5.41
Totals			1.000		$31.67

Type	Ave. Weighted Selling Price of Type		% of Type		Average Weighted Selling Price of Defective Trees
Hardwood	$38.04	X	.558	or	$21.22
Pine-Hardwood	33.62	X	.207	or	6.96
Pine	31.67	X	.235	or	7.44
Totals			1.000		$35.62

Table XXIII (Concluded)

Calculations of Selling Prices for Present Cut

(Per M ft., b. m.)

Condition Class I-All Trees

Tree Condition	Average Weighted Selling Price of Tree Condition		% of Tree Condition	Ave. Weighted Selling Price of All Trees
Sound (Harvest)	$41.72	X	.733	$30.55
Defective	35.62	X	.267	9.51
Total for Condition Class I			1.000	$40.06 say $40.00

Table XXIV

Calculations of Selling Prices for Present Cut

(Per M ft., b. m.)

Condition Class II-Defective Trees

All Types

Species and Average Weighted d. b. h.	Selling Price from Table XXII		% of Species		Ave. Weighted Selling Price
Shortleaf Pine (12")	$32.75	X	.124	or	$ 4.06
Virginia Pine (12")	28.00	X	.009	or	0.25
White Oak (Cutover) (14")	37.00	X	.027	or	1.00
Chestnut Oak (Virgin) (18")	40.50	X	.370	or	15.00
Red and Black Oaks (16")	37.50	X	.085	or	3.19
Hickory (Scarlet Oak-S) (14")	23.50	X	.140	or	3.29
Maple (16")	39.00	X	.054	or	2.11
Beech (18")	37.00	X	.021	or	0.78
Scarlet Oak (14")	23.50	X	.033	or	0.78
Yellow Poplar (Cutover) (14")	39.00	X	.021	or	0.82
Gum (16")	34.00	X	.091	or	3.09
Misc. (Basswood) (12")	41.50	X	.025	or	1.04
Totals			1.000		$35.41
Total for Condition Class II					say $35.50

Table XXIV (Concluded)

Calculations of Selling Prices for Present Cut

(Per M ft., b. m.)

Condition Class III-Defective Trees

All Types

Species and Average Weighted d. b. h.	Selling Price from Table XXII		% of Species		Ave. Weighted Selling Price
Shortleaf Pine (12")	$32.75	X	.170	or	$ 5.56
Chestnut Oak (Virgin) (16")	39.00	X	.294	or	11.48
Red and Black Oaks (14")	35.00	X	.110	or	3.85
Scarlet Oak (12")	28.00	X	.023	or	0.64
Hickory (Scarlet Oak-S) (16")	25.00	X	.215	or	5.37
Beech (16")	35.50	X	.158	or	5.60
Gum (14")	32.50	X	.030	or	0.98
Totals			1.000		$33.48
Total for Condition Class III				say	$33.50

period, because they are far more difficult of estimation than are estimates of future cuts. About the only way that future selling prices can be estimated is to assume that each individual species will remain at more or less the same level, but that the average weighted selling price of the hardwood portion of the stand will be increased somewhat due to the removal of inferior species and general stand improvement. Since Virginia (scrub) pine forms only a very small portion of the total pine volume, it is assumed that shortleaf pine selling prices will be reasonably accurate for future pine cuts.

It was decided that the most practical method of setting an average weighted selling price on the hardwood portion of the stand for future cuts, would be to determine the present average weighted selling price and d. b. h., and then compare that selling price at

that d. b. h. with the present selling prices of the various species at that d. b. h. Accordingly, the calculations as presented in Table XXV, which follows, were carried out, and it was found that the average weighted selling price of the hardwood trees in Condition Class I is $41.50 per M.

Table XXV

Calculation of Present Average Weighted Selling Prices for Hardwoods

(Per M ft., b. m.)

Condition Class I-Harvest Trees (refer to Table XXIII)

Type	Selling Price of Hardwood Trees in Type		% of Type		Ave. Weighted Selling Price
Hardwood	$45.86	X	.346	is	$19.20
Pine-Hardwood	$\frac{\$40.69-(\$10.64 \neq \$1.20)}{1.000-(.282 \neq .038)}$ or $42.45	X	.418	is	14.70
Pine	$\frac{\$35.90-\$7.97}{1.000-.226}$ or $36.10	X	.263	is	9.50
Total for Harvest Trees			1.000		$43.40

Condition Class I-Defective Trees (refer to Table XXIII)

Hardwood	$38.04	X	.558	is	$21.22
Pine-Hardwood	$\frac{\$33.62-\$9.79}{1.000-.299}$ or $34.00	X	.207	is	7.04
Pine	$\frac{\$31.67-(\$19.35 \neq \$3.92)}{1.000-(.614 \neq .140)}$ or $34.17	X	.235	is	8.03
Total for Defective Trees			1.000		$36.49

Condition Class I-All Trees

Tree Condition	Average Weighted Selling Price of Tree Condition		% of Tree Condition	Ave. Weighted Selling Price of All Trees
Sound (Harvest)	$43.40	X	.733	$31.80
Defective	36.49	X	.267	9.75
Total for Condition Class I			1.000	$41.55 say $41.50

The average weighted d. b. h. of the hardwood trees to be included from Condition Class I in the present cut was determined to be 20" from the original stand and stock tables. (See Table XXVI below). Now referring to Table XXII, we find that 20" Virgin Chestnut Oak has a selling price of $41.50 per M, and since this value is somewhat above most of the other values for hardwoods, it is believed that the value of Virgin Chestnut Oak may be used as the selling price for hardwood trees in Condition Class I during the second and third cuts. Similar calculations show Virgin Yellow Poplar (S) and Cutover Yellow Poplar (S) to be the appropriate future selling prices for Condition Classes II and III, respectively. These latter two values run somewhat lower than does the one for Condition Class I, but it is believed that they will be applicable, since stand improvement is not likely to occur as quickly on Condition Classes II and III as on Condition Class I.

CALCULATION OF LOG AND LUMBER PRODUCTION COSTS

The first step in determining production costs is to calculate average weighted diameters and volume percents for the pines and hardwoods separately. For the present cut, they were computed from the original stand and stock tables, and are presented in Table XXVI, which follows.

Table XXVI

Average Weighted Diameters and Volume Percents for the Present Cut

Condition Class	Ave. Weighted Diam., In.		Volume Percent		Totals
	Hardwood	Pine	Hardwood	Pine	
I	20	14	.883	.117	1.000
II	16	12	.867	.133	1.000
III	16	12	.830	.170	1.000

For the second and third cuts, it was assumed that the trees found in the Pine Types of the three condition classes would be representative of the pine portion of the stand, and that those found in the Pine-Hardwood and Hardwood Types would reasonably represent the hardwood portion. Necessary computations were made, and the results are presented in Table XXVII, which follows.

Table XXVII

Average Weighted Diameters and Volume Percents for Future Cuts

Condition Class	Ave. Weighted Diam., In.		Volume Percent		Totals
	Hardwood	Pine	Hardwood	Pine	
Second Cut-10 years hence					
I (See Table XVII)	20	16	.833	.167	1.000
II (See Tables XIV & XVIII)	20	16	.826	.174	1.000
Third Cut-20 years hence					
I (See Table XVII)	18	14	.818	.182	1.000
II (See Tables XIV & XVIII)	14	12	.837	.163	1.000
III (See Tables XV & XIX)	16	14	.888	.112	1.000

Inspection of Table XVII at once reveals a serious decline in average weighted diameters for the third cut. This is due in part to the preponderance of the younger and smaller-sized trees which occupy more than their allotted share of the area as set up in the control tables. It is due also to the inclusion of this smaller-sized material as part of the harvest cut. A large share of the trees which should be marked for cutting during the third cutting cycle will, in reality, constitute nothing more than thinnings made for the purpose of preventing over-stocking. Removal of these trees will, of course, increase production costs and decrease selling prices to such an extent

that the unit profit will be appreciably decreased. But since the institution's owners desire to produce the maximum amount of lumber possible, and since this is only an illustrative case, we may proceed to treat hardwood trees, 10" and up, and pine trees, 8" and up, as merchantable, and carry out further calculations accordingly.

By map inspection, and making due allowance for actual field conditions as based upon the writer's personal knowledge of the area, the average slope was determined to be 30%. Average skidding distances, and round-trip hauling distances from loading point to the mill, were then determined, and may be found in Table XXVIII, which follows.

Table XXVIII

Average Skidding and Round-Trip Hauling Distances

Condition Class	Average Skidding Distance, Feet	Average Round-Trip Hauling Distance, Miles	
		Well-Graded Gravel Road	Hard Surface Road
I	1,000	1.5	1.5
II	950	1.7	3.0
III	750	2.0	3.0

The hourly rates for a 1½ ton truck as prepared by Campbell, and obtained from reference (3), are shown in Table XXIX on page 62. It is believed advisable, however, to develop the machine rate in the manner described by Matthews in reference (4). The actual machine rate used was therefore calculated by the latter method, and is presented in Table XXX on page 63. Reference to Table XXX shows the total fixed cost per hour to be $1.02, and this figure is used as the truck "stand-by" charge in calculating the loading, unloading and delay cost.

Table XXIX
HOURLY RATES

1½ Ton Truck	Woods Per 8 hr. Day	Highway Fixed Hourly Cost
A. Current Operating Costs[1]		
1. Direct labor costs		
(a) Driver @ 50¢	$4.00	.50
½ time of helper[2]	2.00	
(b) Industrial compensation, insurance, soc. sec. @ 8%	.48	.04
	6.48	.54
2. Other direct costs		
(a) Gas @ 1.0 gal. per hr. @ 25¢	2.00	
(b) Oil and greasing @ .06[3]	.50	
(c) Repairs - labor and supplies[3]	1.20	
(d) Tires[1]	2.40	
(e) Supervision and overhead	1.00	.12
	7.10	
B. Ownership Cost[4]		
1. Investment @ $900 without tires $300 trade in value = $600 to be depreciated in 2 yrs. = $300 / 250 days	1.20	
2. Interest @ 6% of average value Average Value = ($900 + 300) / 2 = $600. Interest per day = $600 x .06 / 250	.14	
3. License @ $30 + Insurance @ $40 = $70 ÷ 250 days	.28	
	1.62	.20
Total cost per day	$15.20	
Woods Operating cost per hr.	1.90*	.86
Highway Fixed Cost per Hr. (Rounded off)		.85

1/ Basic data for this part was taken from table 2 of "Roofer Operation---in South Carolina" study by Forest Products Laboratory adjusted to 1943 prices by Garver and Kirkland.

2/ It is assumed that without this helper that the skidder would be tied up during loading time and it is more economical to use a helper @ 50¢ (65¢) per hour than skidder @ $1.00 unless large logs are being loaded which require a cross haul. In the latter case a separate loading charge should be made.

3/ These costs are from the WPB publication entitled, "Hauling Cost Control--- In the Pulpwood Industry," December 1942.

4/ Basic data from reference given in footnote 3/ above and reference 15. Table 2 data using depreciated equipment was considered inappropriate.

* Add approximately 15¢ per hr. for log trailer but increase average volume hauled per load from 1 M b. f. to 1600 bd. ft. - Int. rule.

R.A.C.
Feb. 1944

Table XXX

Hourly Rates for a 1½ Ton Truck (refer to Table XXIX)

Fixed cost per hour			
Operating labor-$4.00/8 or	$0.500		
Industrial compensation, insurance, soc. sec. @ 8%-$0.32/8 or	0.040		
Depreciation-$2.40/8 or	0.300		
Interest @ 6%-$0.14/8 or	0.018		
License and Insurance-$0.28/8 or	0.035		
Supervision and Overhead-$1.00/8 or	0.125		
		$1.018	
Total fixed cost per hour			say $1.02
Operating cost per hour:			
Tires-$2.40/8 or	$0.300		
Repairs: Labor and Supplies-$1.20/8 or	0.150		
Gas-$2.00/8 or	0.250		
Oil and greasing-$0.50/8 or	0.063		
		$0.763	
Total operating cost per hour			say $0.76
		$1.781	
Total running cost per hour			say $1.78

The total running cost per hour of $1.78 is used in determining the hauling cost. It is believed that Campbell's purchase price of $900 for a 1½ ton truck, as used in calculating the depreciation on the investment could more reasonably be estimated to be $1,500 under present conditions, and the depreciation item has therefore been

increased to $0.30 per hour as found in Table XXX. Other data used in calculating production costs were also obtained from reference (3), and may be found in Tables XXXII and XXXIII and Figure IV on pages 66, 67 and 68, respectively. By using Tables XXX, XXXII and XXXIII and Figure IV, it is now possible to calculate production costs as illustrated for the present cut from Condition Class I in Table XXXI, which follows.

Table XXXI

Calculation of Production Costs (Present Cut)

(Refer to Tables XXVI and XXVIII)

Condition Class I

Pine Trees

Felling and Bucking-3.6 hrs. X $0.65 X 1.25	$ 2.93
Skidding (Tractor)-1st 250' @ 0.7 hrs.-0.7 hrs. Balance of haul-750' @ 0.28 per 250'-0.84 1.54 hrs. X $2.05 X 1.25	3.94
Loading, unloading and delay-$\frac{0.8 \text{ hrs. X } (\$1.02 \neq \$0.65)}{1.1 \text{ M}}$ X 1.25	1.52
Hauling-$\frac{\$1.78 \text{ X } (1.5 \text{ mi. X } 5 \text{ min.} \neq 1.5 \text{ mi. X } 9 \text{ min.})}{60 \text{ min. X } 1.1 \text{ M}}$ X 1.25	0.71
Milling-6.3 hrs. X $0.80 X 1.25	6.30
Gross cost per M	$15.40
Margin @ 20%	3.08
Direct cost of production for pine trees, per M	$18.48

Table XXXI (Concluded)

Calculation of Production Costs (Present Cut)

(Refer to Tables XXVI and XXVIII)

Condition Class I

Hardwood Trees

Felling and Bucking-3.8 hrs. X 1.10 X $0.65 X 1.33	$ 3.62
Skidding (Tractor)-1st 250' @ 0.4 hrs.-0.4 hrs. Balance of haul-750' @ 0.16 per 250'-0.48 0.88 hrs. X $2.05 X 1.33	2.39
Loading, unloading and delay-$\frac{0.8 \text{ hrs. X } (\$1.02 + \$0.65)}{1.0 \text{ M}}$ X 1.33	1.73
Hauling-$\frac{\$1.78 \text{ X } (1.5 \text{ mi. X } 5 \text{ min.} + 1.5 \text{ mi. X } 9 \text{ min.})}{60 \text{ min. X } 1.0 \text{ M}}$ X 1.33	0.83
Milling-6.2 hrs. X $0.80 X 1.33	6.60
Gross cost per M	$15.17
Margin @ 25%	3.79
Direct cost of production for hardwood trees, per M	$18.96

All Trees

Tree Type	Cost of Tree Type	% of Tree Type	Weighted Cost per M
Pine	$18.48	.117	$ 2.16
Hardwood	18.96	.883	16.72
Totals		1.000	$18.88

Direct cost of production per M for Condition Class I — say $19.00

It should be noted that production costs have been increased 25% and 33% for pine and hardwood, respectively, due to price increases and lowered labor and machine efficiencies since the production tables were released. (See reference 3). Production cost figures were rounded off to the nearest $0.25 per M in order to keep them in the same plane with the selling prices.

Table XXXII

PINE PRODUCTION COST FACTORS PER M B.F. 1/ - PRELIMINARY

COST ITEMS	REFERENCE	AVERAGE HOURLY RATE 2/	APPLICABLE RANGE FACTOR PER M B.F. 3/	D. B. H. CLASS 10"	12"	14"	16"	18"	20"	24"
A. VARYING WITH D. B. H.		Dollars	Hours	Hours per M b.f.						
Constants 4/										
1. Sawing (Falling and Bucking) 5/	C,D,K, & Curves	.65	.8 - 1.5	5.0	4.2	3.6	3.1	2.8	2.5	2.3
2. Lopping (Brush Disposal) 6/	H (P. 109)	.65	.8 - 1.2	1.0	1.0	.9	.9	.9	.8	.8
3. Cull Disposal 7/		.65	.7 - 1.5	4.4	4.1	3.9	3.6	3.4	3.2	3.0
4. Milling	A,C,D,G, & Curves	.80	.7 - 1.2	7.7	6.9	6.3	5.7	5.3	5.0	4.8
Variables 8/		Man & Team								
5. Bunching Logs (Average @ 50') (Add 80% for every added 100') 9/	C,D,J,K, & Curves	1.00	.7 - 1.5	1.1	.9	.7	.5	.4	.4	.3
6. (a) Loading & Haul (Wagon) @ 200' (Add .2 hr. per added 200') 9/	A,B,C,D, & Curves	1.20	.5 - 2.0	1.2	1.1	1.0	.9	.9	.9	1.0
		Man & Machine								
(b) Truck @ 400' (Add .1 hr. per added 400')	A,B,I,M, & Curves	1.90	.8 - 1.2	1.1	1.0	.9	.9	.9	.9	1.0
(c) Tractor @ 250' 10/ (Add 40% for every added 250')	E,K,L, & Curves	2.05	.8 - 1.5	1.2	.9	.7	.6	.5	.4	.3
B. INDEPENDENT OF D. B. H.			Dollars (per M b.f.)							
7. Improvements (Roads and Bridges) Total Costs ÷ Net M b.f. in sale			.00 - 5.00							
8. Mill Sets (1st @ $50 others $35) Total Costs ÷ M b.f. in sale	D, (TVA)		.10 - 1.50							
9. Stacking (for barge operation only)			1.00 - 2.00							
10. Lumber Haul to Market 11/	D,I		1.00 - 7.00							
11. Plus Margin @ 20%										

1/ Production figures shown are in Man Hours or Man and Team Hours per M b.f. (net lumber tally.) To use table; determine from Marking Tally the average size tree-properly weighted according to cut by d.b.h. classes, and apply appropriate rates to time indicated. Increase man hours by cull allowance (exclusive of cull trees), e.g., if cull allowance is 10% then sawing costs for 12" trees would be 90% of total sawing costs and the total would be 4.7 hours. Milling and bunching costs would also be increased but by smaller amounts due to leaving some 5% of the cull on the ground.

2/ Hourly rates based on unskilled labor @ 50¢ per hour. Remaining charges are for Social Security taxes, compensation insurance, supplies and supervision, and depreciation. Rates for 6(a), (b) include driver + ½ time of helper, 6(c) includes full time helper.

3/ Factors used to vary man-hour values according to the character of the operation, e.g., if sale is located near a large mill (20 M/da. plus) use .7 x hrs. shown (for ave. tree) for milling time, or if milling principally scrub pine, increase hrs. shown by 20%.

4/ These cost items are relatively constant for each operation - varying more by d.b.h. classes than by jobs. See Applicable Range Factor column for usual limits of variations.

5/ Sawing data based on average of several curves, shown by C. J. Telford, Reference B. Reduce time 20% for virgin timber. Increase 10% for light cut 2 M/A or less.

6/ Add 20% for lopping pure scrub pine.

7/ Since most culls are hardwoods, the hardwood costs are shown. (Pine cull disposal costs are approximately 75% of costs shown on line 1.) To determine C.D. costs calculate ave. size tree (to nearest d.b.h. class) and determine proportion of cull tree vol. to total volume exclusive of culls. Cull disposal costs can be reduced if cull have small tops or are largely hollow.

8/ These cost items vary greatly -- both by d.b.h. class and by job -- according to average length of skid, haul, slope, and method of handling (i.e., team or tractor).

9/ Increase costs for large boulders, numerous windfalls or slopes over 30% (See text). Under 150' average distance skid direct with team, beyond 150' use tractor up to 500' for 12" trees, 800' for 16" and 1500' for 20" trees. Use team and wagon from 500' to 1000' for 12" and smaller trees. Beyond 1000' use truck or move mill. See Page 7, Reference A.

10/ 30 h.p. tractor equiped with winch or "breakdown"-costs and output are similar. Costs shown include all logging costs from stump to mill or loading point.

11/ Use trucking costs of 8¢ per mile on hard-surfaced roads, 12¢ for graded dirt roads, & 16¢ for ungraded woods roads. Interpolate for variations. Add number miles driven per day at each rate plus fixed charges of 85¢ per operating hour for 1½ ton truck (includes driver's time at 50¢ per hr.) then divide (number trips per day x ave. vol. hauled per trip).

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C. Tables from R. D. Garver, USFS, January 1943
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I. Occasional Paper #94, Southern Forest Experiment Station, October 1940
J. Analysis of Log Production in the InTand Empire Region, Tech. Bul. #355, June 1933
K. Tractor Skidding Proves Most Economical in Car. Piedmont.. (Thesis summary by W. D. Wagenstein — Duke University 1931)
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R. A. Campbell Sept 1943
Forestry Relation Dept. T.V.A.

Table XXXIII

HARDWOOD COST FACTORS PER M B.F. 1/-PRELIMINARY

COST ITEMS	REFERENCES	AV. HOURLY RATES 2/	APPLICABLE RANGE FACTOR PER M B.F. 3/	D. B. H. CLASS							
				12"	14"	16"	18"	20"	22"	24"	28"
VARYING WITH D.B.H.		Dollars	Hours				Hours per M b.f.				
Constants 4/											
1. Sawing (Felling & Bucking) 5/	B and Graphs	.65	.8 - 1.5	5.0	4.6	4.3	4.0	3.8	3.7	3.6	3.4
2. Lopping (Brush Disposal)	G (b) & Graphs	.65	.8 - 1.5	3.2	3.1	2.9	2.8	2.7	2.5	2.4	2.4
3. Cull Disposal 6/		.65	.5 - 1.5	4.1	3.9	3.6	3.4	3.2	3.1	3.0	2.9
4. Milling	A,B (Table #7) E and Graphs	.80	.6 - 1.2	7.7	7.2	6.8	6.5	6.2	6.0	5.9	5.8
Variables 7/		Man & Team									
5. Bunching Logs (Average @ 50') 8/ (Add 80% per added 100')	C,D,E,H,I Graphs and Pine Table	1.00	.7 - 1.5	1.1	.8	.6	.5	.5	.4	.3	.3
6. (a) Loading & haul (Wagon) Av. @ 200' (Add .2 hrs. per added 200') 8/	A (Pages 5 & 7)	1.20	.5 - 2.0	1.3	1.2	1.1	1.1	1.1	1.1	1.1	1.2
(b) Truck @ 900' (Add .1 hrs. per added 900')	E & Pine Table A & Pine Table	Man & Machine 1.90	.8 - 1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
(c) Tractor @ 250' 9/ (Add 40% for every added 250')	D, H, & I	2.05	.8 - 1.5	.9	.7	.6	.5	.4	.4	.3	.4
INDEPENDENT OF D.B.H.			DOLLARS (per M b.f.)								
7. Improvements (Roads and Bridges) Total Costs ÷ M b.f. in sale			.00 - 5.00								
8. Mill Sets (1st @ $50; others $35 Total Cost ÷ M b.f. in sale	T V A		.10 - 1.50								
9. Stacking (for barge operation only)			1.00 - 2.00								
10. Lumber Haul to Market 10/	F		1.00 - 7.00								
11. Plus margin @ 20% - 30% 11/											

1/ Production figures shown are in Man Hours or Man and Team Hours per M b.f. (net lumber tally) unless otherwise designated. To use table: Determine from Marking Tally the average size tree properly weighted according to cut by d.b.h. classes, and apply appropriate rates to time indicated. Increase man hours by cull allowance (exclusive of cull trees), e.g., if cull allowance is 20% then sawing costs for 18" trees would be 80% of total sawing costs and the total would be 5.0 hours. Milling and bunching costs would also be increased but by smaller amounts due to leaving some 5% of the cull on the ground.

2/ Hourly rates based on unskilled labor @ 50¢ per hour. Remaining charges are for Social Security taxes, compensation insurance, supplies and supervision, and depreciation. For different base rates, proportion, i.e., if local labor can be hired @ 40¢, then hourly rate 40/50 = 80% x .65¢ = 52¢, rounded off = 50¢.

3/ Factors used to vary man-hour values according to the character of the operation; e.g., if sale is located near a large mill (20 M/d. plus) use .6 times man-hours shown -- apply to your average size tree to determine milling time.

4/ These cost items are relatively constant for each operation - varying more by d.b.h. classes than by jobs. See Applicable Range Factor column for usual limits of variations.

5/ Sawing data based on average of several curves. Reduce time 15% for pure stands of yellow poplar or basswood. Increase 10% for light cut 2M/A or less.

6/ Cull disposal costs represent approximately 50% of line #1 and 2 above (per M b.f.). To determine C.D. costs, calculate average size cull tree (to nearest d.b.h. class) and determine proportion of cull tree vol. to total vol. exclusive of culls. Increase item 1 charges by the % of cull vol. times appropriate hours for average size cull tree; e.g., average cull tree is determined @ 20" d.b.h. and cull volume equals 10% of total, then 10% of 3.2 hours (line 3) equals .3 hrs. to be added to line 1 & 2 costs for operating the stand.

7/ These cost items vary greatly -- both by d.b.h. class and by job -- according to average length of skid, haul, slope and method of handling (i.e., team or tractor).

8/ With costs as shown, for maximum economy in skidding from stump to mill or loading point use team when average skidding distance is under 150', beyond 150' use tractor up to 1000'. Beyond 1000' use truck or move mill. See page 7, Reference A, and Reference H.

9/ Costs shown include all logging costs from stump to mill or loading point. Production data shown are averages for 30 h.p. tractors.

10/ Use trucking costs of 8¢ per mile on hard-surfaced roads, 12¢ for graded dirt roads and 16¢ for ungraded woods roads. Interpolate for variations. Add number miles driven per day at each rate plus fixed charges of 85¢ per operating hour for 1½-ton truck (includes driver's time at 50¢ per hr.) then divide (no. trips per day times average volume hauled per trip.) Reference F.

11/ Usual margin 25%. Use higher margin for special products of high value, such as: ship timbers, yellow poplar veneer, etc., or where production costs are unknown or very high, such as cable logging jobs. (See text for margin exceptions).

REFERENCES

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R. A. Campbell November 1943
Forestry Relations Dept. T.V.A.

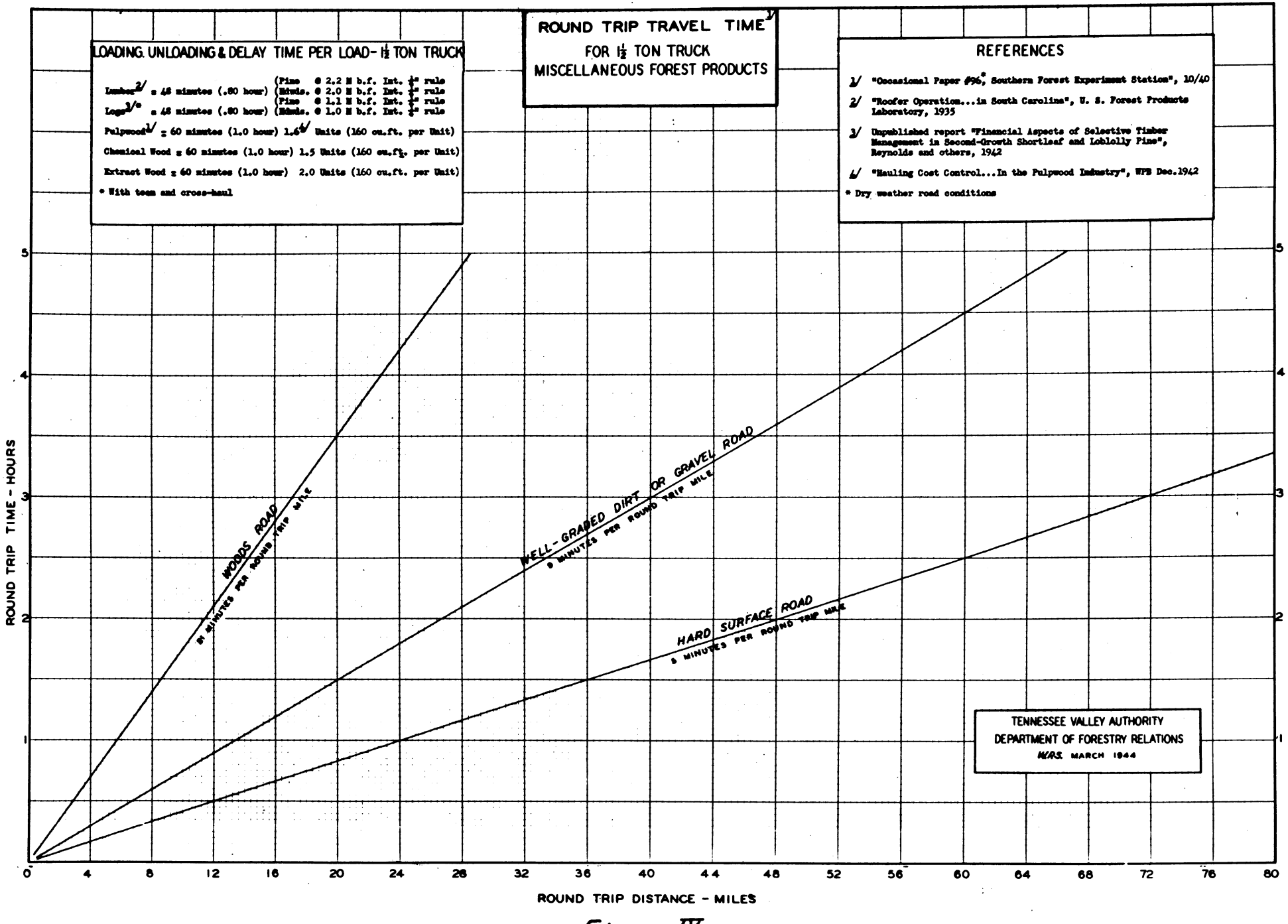
ROUND TRIP TRAVEL TIME 1/
FOR 1½ TON TRUCK
MISCELLANEOUS FOREST PRODUCTS
LOADING, UNLOADING & DELAY TIME PER LOAD - 1½ TON TRUCK
Lumber 2/ = 48 minutes (.80 hour) (Pine @ 2.2 M b.f. Int. ¼" rule (Hdwds. @ 2.0 M b.f. Int. ¼" rule
Logs 3/* = 48 minutes (.80 hour) (Pine @ 1.1 M b.f. Int. ¼" rule (Hdwds. @ 1.0 M b.f. Int. ¼" rule
Pulpwood 4/ = 60 minutes (1.0 hour) 1.6 Units (160 cu.ft. per Unit)
Chemical Wood = 60 minutes (1.0 hour) 1.5 Units (160 cu.ft. per Unit)
Extract Wood = 60 minutes (1.0 hour) 2.0 Units (160 cu.ft. per Unit)
* With team and cross-haul
REFERENCES
1/ "Occasional Paper #96, Southern Forest Experiment Station", 10/40
2/ "Roofer Operation...in South Carolina", U. S. Forest Products Laboratory, 1935
3/ Unpublished report "Financial Aspects of Selective Timber Management in Second-Growth Shortleaf and Loblolly Pine", Reynolds and others, 1942
4/ "Hauling Cost Control...In the Pulpwood Industry", WPB Dec.1942
* Dry weather road conditions
WOODS ROAD
20 MINUTES PER ROUND TRIP MILE
WELL-GRADED DIRT OR GRAVEL ROAD
9 MINUTES PER ROUND TRIP MILE
HARD SURFACE ROAD
5 MINUTES PER ROUND TRIP MILE
TENNESSEE VALLEY AUTHORITY
DEPARTMENT OF FORESTRY RELATIONS
MRS. MARCH 1944
ROUND TRIP TIME - HOURS
ROUND TRIP DISTANCE - MILES
0 4 8 12 16 20 24 28 32 36 40 44 48 52 56 60 64 68 72 76 80
1 2 3 4 5

Figure IV

By making similar calculations for the other condition classes and cuts, sawtimber values for the various cuts from the whole area were determined. These values may be found in Table XXXIV, which follows.

Table XXXIV

Sawtimber Values

(Annual Gross Income)

Condition Class	Selling Price per M		Production Cost per M		Value per M		Annual Cut	Total Value
				Present Cut				
I	$40.00	-	$19.00	or	$21.00	X	144 M	$3,022
II	35.50	-	22.25	or	13.25	X	67 M	887
III	33.50	-	21.50	or	12.00	X	16 M	192
Totals							227 M	$4,101
				Second Cut				
				(10 years hence)				
I	$40.75	-	$18.50	or	$22.25	X	111 M	$2,470
II	38.25	-	18.75	or	19.50	X	328 M	6,400
Totals							439 M	$8,800
				Third Cut				
				(20 years hence)				
I	$39.25	-	$19.75	or	$19.50	X	532 M	$10,380
II	33.75	-	23.25	or	10.50	X	693 M	7,270
III	33.50	-	21.00	or	12.50	X	588 M	7,350
Totals							1,813 M	$25,000

CALCULATION OF FUELWOOD VALUES

The past policy of the institution has been to sell fuelwood to it's employees at cost. For the purpose of including potential fuelwood

as a part of the forest property's value, however, it may be well to determine what value, if any, the fuelwood would have if produced. From the original stand and stock tables, it was found that Condition Class I contains an average of 0.6 standard (128 cu. ft.) cords per acre, Condition Class II-0.4 cords, and Condition Class III-0.7 cords. Revision of an appropriate table from reference (3) to meet conditions existing on this particular piece of property resulted in the construction of Table XXXV, which follows.

Table XXXV

Man-Hours Required per Cord of Fuelwood from Hardwood Tops and Cull Trees

Vol. of Cords Out per Acre	Skidding @ 100 ft. 1/	All Other Production Factors, Exclusive of Hauling 2/
0.1	1.3	8.6
0.6	1.3	8.1
1.3	1.3	7.6

Margin @ 10%

1/ Add 0.5 hr. for each added 100' of skidding distance. Use hourly rate of $2.05 for tractor and driver.

2/ Use hourly rate of $0.65 per hr.

Use hourly truck rate of $1.78

Average truck load-1.9 cords

Travel time-5 min. per round-trip mile on hard-surface road, 9 min. per round-trip mile on well-graded gravel road.

By using Table XXXV, and referring back to Table XXXI, we can now calculate the cost of fuelwood production for Condition Class I as found in Table XXXVI on page 71.

Table XXXVI

Cost of Fuelwood Production

(Per standard cord)

Condition Class I

Skidding-1st 100' @ 1.3 hrs.- 1.3 hrs. Balance of haul-900' @ 0.5 per 100'-4.5 5.8 hrs. X $2.05	$11.90
Other Factors-8.1 hrs. X $0.65	5.26
Hauling-$1.78 X (1.5 mi. X 5 min. + 1.5 mi. X 9 min.) / 60 min. X 1.9 cords	0.33
Gross cost per cord	$17.49
Margin @ 10%	1.75
Direct cost of production per cord for Condition Class I	$19.24

We can see at once that the cost of production for fuelwood is unreasonably high, and unless the wood could be sold to the employees for $19.25 per cord (very unlikely), the institution would lose money on the operation. If the wood could be sold as pulpwood at the mill, there is definitely no chance of making a profit, for the ceiling price of rough hardwood pulpwood is $8.10 per cord. (See reference 5). Assuming that the institution's owners can be shown that fuelwood can be produced only at a loss as the operation is now conducted, the value of the fuelwood will be disregarded in evaluating the forest property as a whole.

Further inspection of Table XXXVI reveals the excessively high skidding cost to be the main reason for the high fuelwood production cost. Reduction of the skidding cost would call for a reduction in

the skidding distance and the use of skidding equipment with a lower machine rate. The former could be accomplished through the construction of additional roads, provided, of course, that the unit saving effected through the medium of a shorter skidding distance would be greater than the unit cost of road construction. Specific illustration of how such a balance between skidding cost and road construction cost could be achieved is not considered to be within the scope of this paper, because road construction costs for this particular area are not immediately available. Should the owners be interested in producing the fuelwood at a profit, it would certainly pay them to investigate the possibilities of attacking the problem along the line just discussed. A change in the present method of operation so as to reduce fuelwood production costs, would, of course, reduce sawtimber production costs, and would measureably increase the value of the property.

VALUATION OF THE FOREST PROPERTY

The simplest way to place a value on the property is to calculate the present worth of the property in terms of the annual net incomes that are anticipated from the various cuts. The local construction superintendent has estimated that fixed-per-acre costs will be approximately $3.00 per acre per year for the first ten years and $2.00 per acre per year thereafter if the present plan of operation is adhered to. Net annual income for the present cut (See Table XXXIV) would thus be $4,101-($3.00 X 3,221 acres) or $4,101-$9,663 is -$5,562.

For the second cut, the net annual income would be \$8,800-(\$2.00 X 3,221 acres) or \$8,800-\$6,442 is \$2,358, and for the third and all future cuts the income would be \$25,000-\$6,442 or \$18,558.

For the first and second cuts, the formula for the present value of a terminable series of annual incomes is used. (See reference 6). This formula is written as: $Co = \frac{a(1.0p^n-1)}{.0p \times 1.0p^n}$, in which; Co is the present value, a is the annual net income, n is the period of years, (10 in this case), and p is the rate of interest. Since this is not a commercial venture, a safe (3%) rate of interest will be used. The formula, as written, may be used for calculating the present value of the net annual incomes expected during the first cutting cycle, but must be discounted to the present by dividing by $1.0p^{10}$ for the incomes to be received during the second cutting cycle, since those incomes will not commence until 10 years from now. The value for the third and all subsequent cuts is obtained by using the formula for the capitalization of a permanent annual income (See reference 6) in which $Co = \frac{a}{.0p}$. The terms used in this latter formula correspond to those used in the former. The value obtained by the capitalization formula must also be discounted to the present, but is divided by $1.0p^{20}$ since the net annual incomes received during the third and all subsequent cutting cycles will not commence until 20 years from now. Setting these three formulas up, we now have the following:

$$\text{Present Worth} = \text{Present Income} \times \frac{(1.0p^n-1)}{.0p \times 1.0p^n} + \frac{\text{Second Income} \times \frac{(1.0p^n-1)}{.0p \times 1.0p^n}}{1.0p^n} + \frac{\text{Third Income}}{.0p \times 1.0p^{2n}}$$

It should be noted at this point that the average annual income of the third cut is assumed to remain at the same level to infinity, because it is not desirable to predict the cuts that may be expected more than 20 years in the future.

When the appropriate values are inserted in the foregoing formulas, we shall obtain the present worth of all future incomes. From this value, however, must be subtracted those expenses peculiar to the forest property itself; namely: taxes, cost of fire protection and cost of planting.

The tax rate in the county in which the institution is located is 3%, regardless of the degree of stocking. The assessed valuation of the forest property is a flat $10.00 per acre. Therefore, the average annual tax for the property is 3,221 acres X $10.00 X .03 or $966.30. When capitalized at 3%, total taxes will be $966.30/.03 or $32,221.

Adequate forest fire protection is estimated by the State Department of Conservation to cost $0.10 per acre per year. Therefore, the annual cost of this expense would be 3,221 acres X $0.10 or $322.10, and, when capitalized at 3%, the total cost would be $10,737.

The cost of planting 300 denuded acres will not include the cost of planting stock, since this is to be furnished by TVA. Approximately 300,000 trees are to be planted, and it is estimated that 400 trees will be planted per man-day (8 hour day). Assuming an hourly rate of $0.65, this cost would be 300,000/400 X 8 hrs. X $0.65 per hr. or 750 X $5.20 is $3,900.

The value of the property can now be calculated as follows:

$$\underline{\text{Value}} = -\$5,562\frac{(1.03^{10}-1)}{.03 \times 1.03^{10}} + \$2,358\frac{(1.03^{10}-1)}{\frac{.03 \times 1.03^{10}}{1.03^{10}}} + \frac{\$18,588}{.03 \times 1.03^{20}}$$

$$-(\text{Taxes} + \text{Cost of Fire Protection} + \text{Cost of Planting})$$

$$= -\$5,562 \times 8.53 + \frac{\$2,358 \times 8.53}{1.3439} + \frac{\$18,588}{.03 \times 1.8061}$$

$$-(\$32,221 + \$10,737 + \$3,900)$$

$$= -\$47,500 + \$14,950 + \$342,500 - \$46,858$$

$$= \$357,450 - \$94,358$$

$$= \underline{\$263,092}$$

CONCLUSION

The value of any property is based upon the anticipated use of that property, and if a property has no plan for it's use, then it has no value. If the particular plan of management presented in this paper is followed, it has been determined that the present worth of the forest property is approximately $260,000. The mere fact that the property shows a positive value indicates that the use of this plan is justified from the economic standpoint alone. This is not to say that the property would not have a higher value if some other plan were to be devised for it's use. On the other hand, it should be remembered that this property has been evaluated under particularly favorable circumstances, i. e., the ownership is financially able to carry the negative profit which the operation will net it during the next 10 years.

Should the owners decide to adopt this plan of management, and should they decide to obtain the largest profit possible from their forest property, it would certainly pay them to investigate the possibilities of changing their present plan of logging operation so as to reduce logging costs.

Since this plan is considered to be only preliminary, a more intensive cruise should be made within the next 10 years, and certainly within the next 20 years. Such a cruise would serve as a check on the anticipated rate of growth, stocking and sawtimber volume as estimated at the present time. It is quite likely that the results of the "check" cruise would vary at least somewhat from the estimated future conditions, and revision of the present plan, or construction of a new plan, would, of course, be well worth-while.

It is recognized that most forested areas with similar stocking are not nearly as favorably situated financially as is this area, and it may quite reasonably be argued, therefore, that this plan has little, if any, real merit to justify it's composition. The writer believes, however, that the vast areas of non-agricultural land which are now idle, but which could be made to produce timber if adequately protected and encouraged, will eventually be put to their best economic use, and that a plan of this type would then prove to be quite useful.

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2. A Manual of Forestry-Volume III (Forest Management)-Sir William Schlich-1911.
3. Forest Management Handbook-Part II-B by R. A. Campbell, T. V. A. Department of Forestry Relations-1944.
4. Cost Control in the Logging Industry-D. M. Matthews-1942.
5. Maximum Prices for Pulpwood-R. M. P. R. 387, O. P. A.-Amendment 2, March 11, 1944.
6. Management of American Forests-D. M. Matthews-1935.

POOR VALLEY
PINE
MOUNTAIN
STONE MOUNTAIN
Doubling Mountain
Poor Valley
Sandy Valley
Scale 1:24000
1 ½ 0 1 2 Miles
5000 0 5000 10000 Feet
LEGEND
Hard Surface Road
Well-Graded Gravel Road
or (Black)
C.C.-Condition Class
H.-Hardwood Type
P-H.-Pine-Hardwood Type
P.-Pine Type
Enlarge this line
to 4" - so that
4" = 1 mile -
C.C.O
C.C.I, H.
C.C.I, P-H.
C.C.I P.
C.C.II, H.
C.C.II, P-H.
C.C.II, P.
C.C.III, H.
C.C.III, P-H.
C.C.III, P.
Open Land
N
Contour Interval-20'

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