REGULATION OF THE GROWING STOCK AND CALCULATION OF THE CUT ON THE GOODMAN WORKING CIRCLE BY BASAL AREA CONTROL.

H.F. Lathrop
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REGULATION OF THE GROWING STOCK AND
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by
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H. F. Lathrop

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Introduction

The future of American forests and of the lumber industry itself depends upon the inception and maintenance of sustained yield programs. Such programs necessitate the regulation of the growing stock by means of proper cutting plans which will remove only an amount of timber equal to the increment and will maintain the correct distribution of the remaining timber as to diameter and age classes.

Due to the existing lumber prices and logging methods, only certain areas can be handled on a sustained yield basis and still produce a suitable income. Areas having such possibilities are those which are accessible and near the markets and which, at the same time, have suitable site conditions to insure rapid growth following cutting. Most of the hardwood forests in northern Wisconsin and the Upper Peninsula of Michigan have the necessary characteristics as mentioned above and, since much mature vargin timber still remains, are at once adaptable to the practices which will result in continuous production.

The Goodman Working Circle, with which this report is concerned, is of the hardwood type mentioned in the previous paragraph and is located in northern Wisconsin. In addition to the natural attributes which obtain in this area due to location, several other factors make this Working Circle particularly well-suited to sustained yield. Before any plan can be formulated, rather extensive data must be available. On the Goodman area, this data has been provided by the United States Forest Service. During the winter of 1935-1936 an extensive cruise was made of the timber concerned, thus allowing compilation of stand and stock tables for each of the timber types. In addition, a mill study was conducted and from this, excellent volume tables were produced, again by the Forest Service. When these tables are supplemented by growth figures collected in this region by the Forest Service, sufficient data is present for the formulation of a fairly accurate cutting program leading to sustained yield.

Still another circumstance has made the Goodman Working Circle an excellent area for management for continuous production. Although the area is for the most part privately owned, the owners (namely, the Goodman Company) favor sustained yield and, in addition to having cut selectively for the past ten years, have cooperated in every manner possible in providing data so that a sustained yield plan might be developed for their timber lands. Thus, if a suitable plan can be produced, it is quite probable that it will be put into practice.

Description of the Area

The Goodman Working Circle is located in Florence, Forest, and Marinette Counties in Wisconsin and consists of a total area of 151,910 acres of timber land typical of this region. One third of this area supports merchantable timber stands containing a total net volume of 355,840 M bd. ft. The circle includes all of Townships 39 and 40 North, Range 16 East; most of Townships 36 and 38 North, Range 16 East, Townships 36, 39, and 40 North, Range 17 East, and Townships 39 North, Range 15 East; and part of Township 38 North, Range 17 East, and Township 41 North, Range 16 East. As previously noted, the Goodman Company is the principle land owner in this area, owning 42% of the area and 87% of the total sawtimber volume. The United States Government owns 37% of the area and 5% of the sawtimber volume, while the remaining 21% of the area and 8% of the sawtimber volume is owned by various individuals, companies, and local government.

The site conditions on the Working Circle are such as to favor timber-growing over all other forms of land use. The soil, for the most part, is a deep clay loam interspersed with numerous small rocks. Some sandy soils are found along the eastern edge and elsewhere in the area in scattered patches. Swamps occur throughout the circle but

Are you sure of this?

represent a relatively small portion of the total area. These swamps are well-drained and contain deep peat. The topography can be classified as gently rolling with occasional low hills and ridges. The temperature range is great with long, cold winters and a short growing season with rather high average temperatures. Precipitation is abundant with frequent showers in the summer and heavy snowfall in the winter.

The timber stand remaining on the Goodman area, due to unregulated cutting, is less than half the original volume. ? Except for the removal of the coniferous stand in the last of the 19th century, active cutting in this area did not start until 1908. At that time the Goodman Lumber Company began operations, taking from 15 to 21 million feet annually until 1927. At this time the Goodman Company classified its lands under the newly enacted "Forest Crop Law" of the State of Wisconsin and reduced its cut to approximately 12 million feet per year. Up to 1936 (the time of the cruise) the company had cut selectively 17, 515 acres of sawtimber land, removing from 40 to 60 per cent of the volume. There remains 24,093 acres of uncut sawtimber with a total volume of 214,186 bd. ft. As a result of the 20 years of clear-cutting, and of occasional areas with poor site conditions, there are 22,239 acres of pole size stands, 29,744 acres of

How much left in NF?

877.5

355 million ?

sapling size stands, 22,423 acres of reproduction stands, 23,439 acres of highland brush, 7,171 acres of non-productive land, and, in addition, 5,286 acres devoted to agricultural, residential, and industrial uses.

The uncut sawtimber has been divided into four types which, with their acreages, are as follows: Mixed Hardwood type, 12,365 acres; Eastern Hemlock type, 3,539 acres; Eastern Hemlock-Mixed Hardwood type, 3,980 acres; and Northern White Cedar type, 3,920 acres. Sugar Maple, Eastern Hemlock, and Yellow Birch predominate in the first three types, while Northern White Cedar makes up most of the type bearing its name. In addition to the above acreages, there are 289 acres of miscellaneous minor types which do not come under the major type classification given above.

The facilities for handling the timber on the Goodman Circle are rather well-developed. All of the timber cut by the Goodman Company is hauled to the town of Goodman, Wisconsin where the company maintains its utilization plants. These include a sawmill, rotary veneer plant, dimension plant, dry kiln, and a wood distillation plant. Most of the pulpwood cut is shipped to paper mills in the towns of Marinette, Rhinelander, or Appleton, Wisconsin. The labor supply is adequate and well-satisfied with the policies of the Goodman Company which, by the practice of selective cutting, has put employment on a more permanent basis. Transportation facilities are excellent, the area being served by two railroads: The Minneapolis, St. Paul and Sault Ste. Marie Railroad to the south; and the Chicago and Northwestern Railroad to the west. Runs thru Goodman

The foregoing paragraphs show the excellence of the Working Circle as to location and facilities which would favor some method of sustained yield. The United States Forest Service has previously developed a management plan as well as a financial plan for this area.[1] One of the purposes of this paper is to critically analyze the Forest Service plan. This is most easily done by developing a similar plan by different methods which have been used successfully in the past.

The Plan

The plan presented in this paper will deal only with the management of the sawtimber stands of which 24,093 acres are uncut and 17,515 acres have been selectively cut during the last ten years. As the remaining stands become large enough to produce sawtimber of suitable size, they may be added and the cut recalculated. Although considerable pulp, pole, and chemical wood exist on the area, sufficient data is not provided to allow such classes to be included in the

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1. U. S. Department of Agriculture, Timber Management and Financial Plans for the Goodman Working Circle, United States Forest Service, 1938. Bromley, W. S., Stott, C. B., and others.

formulation of a plan by the method used. This is relatively unimportant since the circle depends mainly upon the sawtimber cut to provide the nedessary income.

As stated in the title, the management plan is to be developed by means of the Basal Area Control method. This method is based upon the relationship between the basal area of a given forest and the basal area in yield tables for the same site and type. By the use of this relationship, a control table can be built up which will in effect be an all-age yield table for the forest in question and thereby allow calculation of the cut.

The advantages of the Basal Area Control method become quite apparent upon the consideration of the actual use and results of the method. One of the prime advantages of this method is its simplicity, both in calculation and later in use. The only data needed are stock and stand tables, volume tables, growth data, and a suitable yield table. The calculations are relatively simple, making use, for the most part, of arithmetical procedures. The methed is also advantageous because it is realistic. The results of the method give a true picture of the stand and make evident the reasons for taking the recommended cut. Thus it can be used readily in illustrating the prodedure to one who is not trained in forestry but who is interested in a sustained yield program. The method is also accurate since it is based upon accurate principles. The results given are

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purposely conservative and the cut recommended can be removed without any danger of over-cutting.

The procedure followed in the Basal Area Control method can be outlined as follows:

(1) A suitable rotation and cutting cycle are chosen.

(2) A yield table which is applicable to the forest type is selected.

(3) Diameter limits corresponding to the ages used are then determined.

(4) The normal basal area in each age class is calculated and these figures transformed into per cent (of total basal area).

(5) These per cents are applied to the actual basal area of the forest thus giving the basal area in each age class.

(6) Then must be calculated the number of trees necessary in each age class to supply the required basal area in that class.

(7) The volume in each class is determined by the application of figures representing bd. ft. per square foot of basal area.

(8) Thinnings are calculated, in the process of which the following steps are utilized:

(a) The number of trees in each age class is reduced to that of the following age classes with allowance in the latter for mortality and breakage.

(8) The basal area and volume to be removed from each age class are calculated, using the lowest diameter class in each age class as a basis for the thinnings in that class.

(9) The remaining stand (after the cut) is reduced sufficiently to allow for mortality and breakage.

(10) The growth is calculated, Reynold's method being recommended and used in this case.

(11) The stand is reclassified as it will appear at the beginning of the next cut, the same methods being followed in reclassification as in the first classification.

In order to illustrate clearly the technique of applying the Basal Area Control method to a stand, a demonstration must be carried out showing the complete procedure. The stand in the following demonstration is based on the average stand per acre of the 24,093 acres of uncut sawtimber as shown in the Stock and Stand Table[2.] (Table 2).

Before any calculations can be performed it is necessary to decide upon a rotation and a cutting cycle. A rotation of 160 years was chosen as most closely approaching the natural rotation. Experience figures show that in the Northern Hardwoods, the forest becomes mature at approximately 140 to 180 years. This is borne out by the yield table used for this type.[3.] This yield table shows that after the age of 160 years

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2. U. S. Department of Agriculture, op cit, Appendix, p. 45.

3. Gevorkiantz, S. R., and Duerr, W. A., A Yield Table for Northern Hardwoods in the Lake States, Journal of Forestry, April, 1937, p. 342.

Table 1 [4]
Yield Table for Northern Hardwoods
(Medium Site)

Age	Av. Diam.	No. of trees per acre	Basal area per acre	Volume per acre in bd.ft. (Scribner)
40	5.6	480	82	300
60	7.8	295	97	1600
80	9.5	220	109	3500
100	10.9	185	119	5350
120	12.2	155	128	7200
140	13.5	135	136	8850
160	14.8	120	143	10300
180	16.1	105	149	11500
200	17.4	95	155	12600

4. Gevorkiantz, S. R., and Duerr, W. A., A Yield Table for Northern Hardwoods in the Lake States, Journal of Forestry, April, 1937, p. 342.

is reached, the average annual growth in bd. ft. per acre is reduced.

A cutting cycle of twenty years was selected due to the fact that the balance between the rate of growth (which decreases as the cutting cycle is lengthened) and the cost of logging (which also decreases as the cutting cycle is lengthened) is best obtained by a cycle of 20 years. Table 1

Since the rotation is to be 160 years, the size of an average tree 160 years old must next be determined. This limit was set at 24 inches, maturity being indicated at this size by the tendency of the bd. ft. per square foot of basal area to decrease in larger diameters. This decrease shows that above 24" in diameter, decay and disease are entering the stand to such an extent that maximum production is no longer obtained. Say 14.8 ?

Because no yield table data are available for stands under 40 years of age, a limit must also be set as to D. B. H. at 40 years. Six inches was selected as the average diameter of a tree 40 years old. Thus, no trees under this size are included in the Stock and Stand Table (Table 2).

After the limits of the stand are set it is possible to proceed to classify the stand on the basis of a rotation of 160 years and a cutting cycle of 20 years. The first step is to obtain from the yield table for even-aged stands the normal basal area per acre which will exist in each of the six remaining age classes (Table 3, Column 2). These

Table 2
Stock & Stand Table[5]

1 D. B. H.	2 No. of Trees	3 Basal Area per Acre	4 Volume	5 Bd. Ft. per Sq. Ft. of Basal Area
6	33.69	6.603		
8	24.71	8.624		
10	21.94	11.957	403	34
12	17.09	13.416	705	53
14	13.67	14.613	1121	77
16	9.36	13.067	1225	94
18	7.18	12.687	1364	108
20	4.41	9.618	1145	119
22	2.78	7.339	913	124
24	1.90	5.970	737	123
26	1.18	4.354	546	
28	.59	2.525	333	
30	.32	1.571	223	
32	.13	.727	98	
34	.08	.504	77	

5. U. S. Department of Agriculture, op cit, Appendix, p. 45.

figures are compiled by calculating, for a given age class, the average basal area per acre for an even-aged stand of the same age. Thus, in the 40-60 age class the average basal area per acre from the yield table will be $\frac{82 \text{ plus } 97}{2}$ or 89.5 sq. ft. per acre. However, since there are eight age classes on an average acre $\left(\frac{160}{20}\right)$, only one-eighth of the basal area on an acre will be of trees 40 to 60 years old. Therefore, the basal area of the even-aged stand divided by the number of age classes equals $\frac{89.5}{8}$ or 11.2 which is the amount of basal area of trees 40-60 years old on an average all-age acre. This same calculation can be carried out for each age class, thus for the 60-80 class: $\frac{97 \text{ plus } 109}{2 \times 8}$ equals 12.9 square feet per acre; and for the 80-100 class $\frac{109 \text{ plus } 119}{2 \times 8}$ equals 14.3 square feet per acre. The result of this calculation as applied to the other age classes is shown in Column 2, Table 3.

To get these basal area figutes into a usable form they must be transformed into per cent. Column 3 of Table 3 shows the percentage which the basal area in each class represents of the total. These per cents are then applied to the total actual basal area (in the forest) for an average acre of all-age timber 160 years old, excepting the 0-40 year class. The results obtained indicate the basal area which exists in each of the six age classes used (Column 4, Table 3).

It is now necessary to determine the number of trees

Table 3
Control Table

1 Age class	2 Normal basal area	3 % of total basal area	4 % B.A x acutal B.A.	5 No. of trees	6 Diam. range	7 Net Volume	8 No. of trees / .90	9 No. of trees to be cut	10 Approx. diam.	11 Basal area removed	12 Volume removed
40-60	11.2	12.8	13.30	53.68	6-8						
60-80	12.9	14.7	15.27	28.45	8-12	470	31.62	6.33	10"	3.45	117
80-100	14.3	16.3	16.93	19.90	12-14	1012	22.12	2.99	12"	2.35	125
100-120	15.4	17.6	18.29	15.22	14-16	1551	16.91	2.47	14"	2.64	204
120-140	16.5	18.8	19.53	11.47	16-20	2065	12.75	2.57	16"	3.58	337
140-160	17.4	19.8	20.57	8.01	20-24	2515	8.90				
	87.7	100.0	103.89	136.73		7613					783

Cut

Overmature	1277	bd.ft.
Mature	2515	" "
Thinnings	783	" "
	4575	" "

in each age class. This can be done by calculating the number of trees of certain diameters (and therefore certain basal areas) required to complete the necessary amount of basal area as given in Column 4, Table 3. Starting with the 140-160 class, 20.57 square feet of basal area are required. From the Stand and Stock Table (Table 2) the trees in the 24" and 22" diameter class, when added, give a basal area of 5.97 plus 7.34 or 13.31 square feet and 1.90 plus 2.78 trees. This leaves 20.57 minus 13.31 or 7.26 square feet of basal area to be taken from the 20" diameter class. Since there are 4.41 trees in the 20" class, the number of trees placed in the 140-160 age class would be $\frac{7.26}{9.62}$ x 4.41 or 3.33 trees. Thus in the 140-160 class the basal area is 13.31 plus 7.26 which equals the required 20.57 square feet; and in this class there are 1.90 plus 2.78 plus 3.33 or 8.01 trees with a diameter range of 20 to 24 inches.

Proceeding to the 120-140 age class, a basal area of 19.53 square feet is required (Table 3, Column 4). Since only 7.26 square feet of basal area from the 20" class were placed in the 140-160 age class, 9.62 minus 7.26 or 2.36 square feet of basal area and the remainder of the trees, 4.41 minus 3.33 or 1.08 trees are placed in the 120-140 age class. Adding the basal area of the 18" trees to that of the remaining 20" trees gives a total of 12.69 plus 2.36

or 15.05 and leaves 19.53 minus 15.05 or 4.48 square feet of basal area to be taken from the 16" class, the total basal area in the 120-140 age class then being 12.69 plus 2.36 plus 4.48 or the required 19.53 square feet. The number of trees in this age class will then be:

From the 20" class			1.08
From the 18" class			7.18
From the 16" class	$\frac{4.48 \text{ (B.A. required from 16")}}{13.07 \text{ (B.A. in 16" class)}}$	x9.3	3.21
			11.47

Therefore there are 11.47 trees in the 120-140 age class with a diameter range of 16 to 20 inches. When this calculation is performed for the other age classes a figure is obtained which in each case represents the number of trees in the class. (Column 5, Table 3). When these are totaled, the result should equal the total number of trees in the 6"-24" diameter classes in the Stock and Stand Table (Table 2).

The volume in each age class can easily be obtained by multiplying the bd. ft. per square feet of basal area in each diameter class (Column 6, Table 2) by the amount of basal area of each diameter class in the age class. In the 140-160 age class there will be:

From the 24" diameter class		737
From the 22" diameter class		913
From the 20" diameter class	(119 x 7.26)	865
		2515

a total of 2515 bd. ft. In the 120-140 age class there will be:

From the 20" diameter class - (1145 minus 865) -- -		280
From the 18" diameter class - - - - - - - - - - - - -		1364
From the 16" diameter class (94 x 4.48) - - - - - -		421
		2065

a total of 2065 board feet. This calculation can be carried out for each age class and the total board foot volume determined (Column 7, Table 3).

It is now possible to determine the cut which will be taken from an average acre during the first cycle. This cut will be made up of three timber classes: (1) Overmature timber; (2) Mature timber; (3) Thinnings. The overmature timber includes all trees over 24 inches in diameter, these having a total volume of 1277 bd. ft. The mature timber is that in the 140-160 age class which has a total volume of 2515 bd. ft. In order to obtain the amount of thinnings which will be taken, another calculation must be performed. The general method is to reduce the number of trees in each age class to that of the next oldest age class by taking out the poorest and in most cases the smallest trees in the class. However, allowance must be made for breakage during logging and mortality during the 20-year period. Experience figures place this loss at 10%,[6] i.e. the stand will be reduced by 10% during the 20-year period. It is therefore necessary to reduce thinnings by this amount, this being most easily done by dividing the number of trees in each age class by .90 (Column

6. U. S. Department of Agriculture, Op Cit, p. 42.

8, Table 3). This gives the number of trees which must be left in any given age class in order to allow for a mortality of 10% during the following 20 years. The figures thus obtained are then subtracted from the actual number of trees in the preceding age class and the difference is the number of trees to be removed by thinning (Column 9, Table 3). In calculating the volume to be removed in each age class, the bd. ft. per square foot of basal area for the lowest diameter class in the age class is used. When this figure is multiplied by the amount of basal area to be removed in the class, the result is the volume which will be taken as thinnings (Column 12, Table 3). This volume represents a conservative figure for thinnings as it is probable that the trees removed in each age group will have an average volume higher than that of the lowest diameter class in the group. However, the use of a conservative figure eliminates the danger of over-estimating the cut which, if it happened, would be misleading in the financial calculations.

The total cut from the uncut sawtimber stands during the last half of the first cycle will equal the sum of the mature timber, overmature timber, and thinnings which is:

Overmature -	1277	bd. ft.
Mature -	2515	" "
Thinnings -	783	" "
	4575	" "

The cut is therefore 4575 bd. ft. per acre. Since the uncut sawtimber stands will be cut over in 10 years, an area of $\frac{24093}{10}$ or 2,409 acres will be cut each year. The annual cut will then be 2,409 x 4,575 or 11,020 M bd. ft.

It is now necessary to calculate the cut for the second and following cycles. The remaining stand per acre after the first cycle cut is shown in Table 5, Column 1 and 2. Because of breakage and mortality these figures must be reduced by 10% as shown in Columns 3 and 4 of the same table. Although this figure was used previously to determine the proper thinnings, it has not been applied to the remaining stand. In order to calculate the second cycle cut, the growth of the stands in the 20-year intervening period must be determined. This is done by means of growth figures furnished by the Forest Service[7] as shown in Table 4, which gives the average growth in diameter for each species for a 20-year period. In order to obtain a usable figure for the average acre the figure for each species must be weighted by the number of trees of that species occurring on the average acre. The figures for each species thus obtained are then added and that sum divided by the total number of trees in the average acre. This figure represents the average growth for the stand and can be applied to the average stand per acre.

In order to calculate the growth, use is made of Reynold's method. This method is approximately correct mathematically and is accepted by many foresters for such calculations. The

7. U. S. Department of Agriculture, op cit, p. 44.

Table 4

Growth Data[8]

Species	Growth in 10 years	Growth in 15 years	Growth in 20 years
Sugar Maple	1.5	2.2	3.0
East. Hemlock	1.7	2.3	3.1
Yellow Birch	1.1	1.7	2.3
Basswood	1.9	2.8	3.7
Elm	1.2	1.7	2.3
Red Maple	1.5	2.2	3.0
Ash	1.5	2.2	3.0
North. Cedar	1.7	2.5	3.4
Balsam Fir	2.0	3.1	4.0
North White pine	1.8	2.7	3.6
Bl. and Wh.Spruce	1.8	2.7	3.6

8. U.S. Department of Agriculture, Timber Management and Financial Plans, United States Forest Service, 1938, p. 44.

Table 5

Growth Calculations For
Second and Following Cycles

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortal-ity	No. of trees minus mort.	Radial Growth	Move two classes	Move one class	Total 20-yr. hence	Basal Aréa
6	33.69	3.37	30.32	1.52	17.77	12.55		
8	24.71	2.47	22.24	1.52	11.58	10.66	12.55	4.38
10	15.61	1.56	14.05	1.52	7.31	6.74	28.43	15.50
12	14.10	1.41	12.69	1.52	6.60	6.09	18.32	14.39
14	11.20	1.12	10.08	1.52	5.24	4.84	13.40	14.32
16	6.79	.68	6.11	1.52	3.18	2.93	11.44	15.97
18	7.18	.72	6.46	1.52	3.36	3.10	8.17	14.42
20	1.08	.11	.97	1.52	.50	.47	6.28	13.70
22							3.83	10.11
24							.50	1.52
26								
			102.92				102.92	104.31

theory behind the method is that on the average, the digit to the left of the decimal point of any growth figure indicates the number of diameter classes all of the trees in a given diameter class will advance, while the figure to the right of the decimal point gives the proportion of trees in the diameter class which will advance one more class than the left hand digit indicates during the period for which the growth figure is calculated. Thus in the average stand per acre remaining after the first cycle cut, the weighted average growth figure is 3.03 inches. The Forest Service has discovered that in this region all diameter classes will grow approximately the same amount following a cut which removes in the neighborhood of 50% of the volume, so that it is not necessary to obtain a separate figure for each class, and therefore the above figure applies to all diameter classes. Then, according to Reynold's method all of the trees in a diameter class will move at least three one-inch classes while 3% will move four one-inch classes in the 20-year period. However, since the data in the Stand and Stock Table is given in two-inch diameter classes, diameter growth can not be used but instead, radial growth, i. e. one-half of the diameter growth, must be utilized. The growth figure applied to each diameter class will advance at least one two-inch diameter class, while 52% of the trees will advance two two-inch diameter classes. The results of the application of this figure to the remaining stand are shown in Columns 6 and 7 of Table 5. The total number of trees in each diameter class as shown in Column 8 is obtained by adding the number of trees in the preceding diameter class which move one diameter class to the number of trees in the second preceding class which move two diameter classes.

The result of the preceding calculation gives the stand as it will appear 20 years in the future. By using the Basal Area Control method it is possible to reclassify the stand and again calculate the cut as shown in Table 6. Since the stand is 20 years older, the 40-60 class will have become the 60-80 class, the 60-80 class the 80-100 class, etc., and, since there was previously no data for the 0-20 class and 20-40 class, there is no data for the 40-60 class as it appears in the stand 20 years in the future. The classification is therefore done on the basis of five age classes with basal area taken from the yield table as shown in Column 2, Table 6.

The same procedure as previously outlined is followed in building up the new control table and obtaining the volume to be removed. Since there will be no overmature timber, the cut will be made up of mature timber and thinnings. The former as given in Column 7, Table 6, is 2772 bd. ft. The thinnings are calculated by subtracting the number of trees needed in each class, as previously determined (Column 8, Table 3) from the actual number of trees in the preceding age class (Column 5, Table 6). This procedure will thin the stand

Table 6

Control Table for Second

and Following Cycles
(last half)

1 Age class	2 Normal basal area	3 % of total basal area	4 % B.A. x actual B.A.	5 No. of trees	6 Diam. range	7 Net Volume	8 From Table 3 No. of trees .90	9 No. of trees to be cut	10 Approx. diam.	11 Basal area removed	12 Volume removed(bd.ft
0-40											
40-60											
60-80	12.9	16.9	17.63	36.57	8"-10"	450	31.62	14.45			
80-100	14.3	18.7	19.50	25.42	10"-14"	1057	22.12	8.51	10"	4.64	158
100-120	15.4	20.1	20.97	17.51	14"-16"	1764	16.91	4.76	14"	5.09	391
120-140	16.5	21.6	22.54	13.56	16"-20"	2372	12.75	4.66	16"	6.51	610
140-160	17.4	22.7	23.67	9.86	20"-24"	2772	8.90				
	76.5	100.0	104.31	102.92		8415					1159

__Cut__

Mature 2772 bd.ft.

Thinnings 1159 bd.ft.
3931 bd.ft.

down to the same stocking as was present following the previous cut. Thus, approximately the same amount will be removed by each cut beginning with the second cutting cycle, this being 2772 plus 1159 or 4096 bd. ft. The annual cut during the last half of the second and following cycles will therefore be $\frac{24,093}{10}$ x 3931 or 9480 M bd. ft. There is a possibility of an increased cut in the later cycles due to the effect of continued management on the forest. However, this increase cannot be calculated until after the results of the selective cut have become known.

The previous illustration presents the Basal Area Control method as applied to an average acre of the 24,093 acres of uncut sawtimber stands. This is more or less a guiding calculation to determine the feasibility of sustained yield management on this area and at the same time obtain an approximation of the cut which can be removed during the last half of each cutting cycle. In order to obtain the true cut which can be removed, the previous calculations must be carried out separately for each of the four major types present. Such calculations will establish different cutting practices in each of the four types, this being necessary because each presents a stand of different composition and stocking.

The results of the application of the method to each of the types are shown in Tables 7 to 22. In the Mixed Hardwood, Eastern Hemlock, and Eastern Hemlock-Mixed Hardwood types the same yield table methods are used. However, the Northern

White Cedar type requires slight variations in handling, although the basic method remains the same. The Northern Hardwoods yield table can no longer be used because the stand is for the most part made up of Northern White Cedar and its associated species. It is therefore necessary to obtain a yield table which will fit this forest type. Although it was impossible to locate a yield table for this specific type, a suitable substitute was found in a yield table for red spruce,[9.] which has somewhat the same silvicultural characteristics. Since proportional distribution of basal area among the age classes is all that is required from the yield table, no great error would be encountered even though the yield table is not directly applicable to the stand in question. It was also necessary to place new limits on this type, since growth habits are different. The minimum limit, i.e. the minimum size of trees 40 years old, was set at two inches, while the maximum size of trees 160 years old was placed at 20". The overmature timber was then considered as all that over 20" in diameter. The rest of the calculations were carried out as shown in the demonstration.

This completes the calculations for the uncut sawtimber stand. The next and final set of calculations pertains to the 17,515 acres of selectively cut stands. These stands

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9. Meyer, W. H., Yields of Second-Growth Spruce and Fir in the Northeast, U. S. Department of Agriculture, Technical Bulletin 142, 1929.

will not be cut until the beginning of the second cycle, ten years hence. It is necessary, therefore, to calculate the growth of these stands for the next ten years before classifying by basal area. Reynold's method is again brought into use as shown in Table 24. The stand as predicted forward ten years is then classified on an age class basis, following the same methods as previously used. The calculations and results are shown in Tables 23 to 27.

This completes the computations, and the cutting plan can be outlined as given in Table 28. A slight discrepancy is apparent between the cut in the first half of any cycle and that in the last half. This is due to the fact that a larger area (2,409 acres) is cut during the last ten years of each cycle than during the first ten years (1752 acres). If the difference between these cuts is sufficient to cause difficulty in planning the mill and woods operation as to labor, depreciation, etc., the situation can be improved by acquiring sufficient area, with approximately the same stocking as selectively cut stands, to balance the cut. If so desired, this purchase program could be minimized by disposing of a small portion of the uncut stands, thereby obtaining sufficient revenue to purchase the required stands and balance the cutting budget throughout each cycle.

The total cut as calculated by the use of the Basal Area Control method can now be compared with the total cut calculated by the method used by the Forest Service. This comparison is shown in Table 28. The results obtained by the two different methods agree very closely, the maximum variance being only 5%. It is not evident in the Forest Service report what method was used in determining the number of trees and volume to be removed from each diameter class. However, it is undoubtedly an accurate method and, since the results obtained by the Basal Area Control method show such slight variation from the Forest Service figures, it would seem that either method is sufficiently accurate to allow its use in developing sustained yield plans.

In all the calculations heretofore presented, an attempt is made to use conservative figures, therby avoiding an overestimation of the cut. As a result, the cut predicted by these methods can be said to be the absolute minimum which can be expected. This fact, coupled with the possibility of increased cuts due to the reaction of the stand to continued management, indicates that the cut in all probability will be larger than previously determined. Because of this possibility, the cutting budget must, especially after the second cycle, be taken only as a guide. It is necessary that data be collected continuously and the stand inspected frequently to determine the possibility of increased cuts and therefore more profitable operation. At the same time, the growing yield production is to be continued; in short, over-cutting must not be indulged in.

MIXED HARDWOOD TYPE--12,365 acres

Table 7

Stock & Stand Table[10.]

1 D. B. H.	2 No. of trees	3 Basal area per acre	4 Volume	5 Bd. ft. per sq. ft. of basal area
6	26.68	5.23		
8	17.85	6.23		
10	15.97	8.70	340	39.1
12	13.10	10.28	620	60.3
14	10.62	11.36	930	87.5
16	8.90	12.42	1214	97.1
18	6.87	12.11	1375	113.5
20	4.90	10.69	1299	121.5
22	3.32	8.76	1175	134.0
24	2.11	6.64	854	127.1
26	1.42	5.24	663	
28	.57	2.44	319	
30	.21	1.03	136	
32	.18	1.01	129	
34	.06	.38	49	
	112.76	102.52	9103	

10. U. S. Department of Agriculture, op cit, Appendix, p. 24.

Table 8

Control Table for Last

Half of First Cycle

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diam. range	Net Volume	No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed(bd.ft.)
0-40											
40-60	11.2	12.8	11.82	45.38	6"-10"	18	50.42	21.16	10"	11.52	18
60-80	12.9	14.7	13.58	21.80	10"-12"	704	24.22	4.18	10"	2.28	89
80-100	14.3	16.3	15.07	15.87	12"-14"	1052	17.62	3.09	12"	2.43	146
100-120	15.4	17.6	16.27	11.50	14"-18"	1616	12.78	1.49	14"	1.59	139
120-140	16.5	18.8	17.38	9.01	18"-20"	2035	10.01	1.50	18"	2.65	301
140-160	17.4	19.8	18.30	6.76	20"-24"	2382	7.51	6.76	20"-24"	18.30	2382
	87.7	100.0	92.42	110.32							

<u>Cut</u>

Overmature	1314	bd.ft.
Mature	2382	" "
Thinnings	693	" "
	4389	" "

Table 9

Growth Calculations For

Second and Following Cycles

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortality	No. of trees minus mort.	Radial growth	Move two classes	Move one class	Total 20-yr. hence	Basal area
6	26.68	2.67	24.01	1.45	10.65	13.65		
8	17.85	1.79	16.06	1.45	7.12	8.94	13.36	4.66
10	10.94	1.09	9.85	1.45	4.43	5.42	19.59	10.68
12	10.01	1.00	9.01	1.45	4.05	4.96	12.54	9.85
14	9.13	.91	8.22	1.45	3.70	4.52	9.39	10.03
16	8.90	.89	8.01	1.45	3.61	4.40	8.57	11.96
18	5.37	.54	4.83	1.45	2.17	2.66	8.10	14.31
20	3.57	.36	3.21	1.45	1.45	1.76	6.27	13.68
22							3.93	10.38
24							1.45	4.55
			83.20				83.20	90.10

Table 10

Control Table for Second

and Following Cycles

1 Age class	2 Normal basal area	3 % of total basal area	4 % of B.A. x actual B.A.	5 No. of trees	6 Diam. range	7 Net Volume	8 From Table 8 No. of trees / .90	9 No. of trees to be cut	10 Approx. diam.	11 Basal area removed
0-40										
40-60										
60-80	12.9	16.9	15.22	32.73	8"-10"	413	24.22	15.11	10"	8.24
80-100	14.3	18.7	16.84	19.19	10"-14"	1200	17.62	6.41	12"	5.03
100-120	15.4	20.1	18.11	13.23	14"-18"	1775	12.78	3.22	16"	4.50
120-140	16.5	21.6	19.47	10.13	18"-20"	2277	10.01	2.62	18"	4.63
140-160	17.4	22.7	20.46	7.92	20"-24"	2640	7.51	7.92	20"-24"	20.46
	76.5	100.0	90.10	83.20		8305				

<u>Cut</u>

Mature	2640	bd.	ft.
Thinnings	1469	"	"
	4109	"	"

EASTERN HEMLOCK TYPE

3,539 Acres

Table 11

Stock & Stand Table[11]

1	2	3	4	5
D. B. H.	No. of trees	Basal Area per acre	Volume	Bd. ft. per Sq. ft. of basal area
6	35.20	6.90		
8	28.90	10.09		
10	25.80	14.07	515	37
12	19.10	15.00	825	55.0
14	17.60	18.82	1488	79.0
16	10.50	14.65	1335	91
18	8.50	15.01	1539	103
20	4.70	10.26	1195	117
22	2.70	7.13	858	120
24	1.90	5.96	737	124
26	1.80	6.64	865	
28	1.00	4.28	577	
30	.30	1.47	254	
32				
34	.10	.63	84	
	158.10	130.91	10272	

11. U. S. Department of Agriculture, op cit, 1938, Appendix p. 25.

Table 12

Control Table for Last

Half of First Cycle

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. X actual B.A.	No. of trees	Diam. range	Net Volume	No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed (bd.ft.)
0-40											
40-60	11.2	12.8	15.09	58.66	6"-8"		65.30	22.05			
60-80	12.9	14.7	17.33	32.96	8"-12"	590	36.61	7.86	10"	4.28	158
80-100	14.3	16.3	19.22	22.59	12"-14"	1192	25.10	2.86	12"	2.25	124
100-120	15.4	17.6	20.75	17.77	14"-16"	1731	19.73	2.63	14"	2.81	222
120-140	16.5	18.8	22.16	13.62	16"-20"	2190	15.14	3.29	16"	4.59	418
140-160	17.4	19.8	23.34	9.30	20"-24"	2789	10.33				
	87.7	100.0	117.89	154.90		8492	172.21				922

<u>Cut</u>

Overmature	1780	Bd.Ft.
Mature	2789	" "
Thinnings	922	" "
	5491	" "

Table 13

Growth Calculations For

Second and Following Cycles

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortal-ity	No. of trees minus mort.	Radial Growth	Move two classes	Move one class	Total 20-yr. hence	Basal area
6	35.20	3.52	31.68	1.53	16.68	15.00		
8	28.90	2.99	26.01	1.53	13.79	12.22	15.00	5.24
10	17.94	1.79	16.15	1.53	8.56	7.59	28.90	15.75
12	16.24	1.62	14.62	1.53	7.75	6.87	21.38	16.79
14	14.97	1.50	13.47	1.53	7.26	6.21	15.43	16.50
16	7.21	.72	6.49	1.53	3.44	3.05	13.96	19.48
18	8.50	.85	7.65	1.53	4.05	3.60	10.31	18.21
20							7.04	15.37
22							4.05	10.69
							116.07	118.63

Table 14

Control Table for Second and Following Cycles

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diam. range	Net Volume	From Table 12 No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed (bd.ft)
0-40											
40-60											
60-80	12.9	16.9	19.94	41.97	8"-10"	544	36.61	16.87	10"	9.20	341
80-100	14.3	18.7	22.06	27.25	10"-14"	1296	25.10	7.52	10"	4.10	152
100-120	15.4	20.1	23.74	19.70	14"-16"	2112	19.73	4.56	14"	4.87	385
120-140	16.5	21.6	25.49	15.64	16"-18"	2530	15.14	5.31	16"	7.41	675
140-160	17.4	22.7	26.80	11.51	18"-22"	3155	10.33				
	76.5		118.03	116.07		9637					

Cut

Mature	3155 bd.ft.
Thinnings	1553 " "
	4708 " "

EASTERN HEMLOCK-MIXED HARDWOOD TYPE

3,980 Acres

Table 15

Stock & Stand Table[12]

1	2	3	4	5
D.B.H.	No. of trees	Basal area per acre	Volume	Bd. ft. per sq. ft. of basal area
6	22.96	4.50		
8	21.95	7.66		
10	23.53	12.82	478	37
12	18.41	14.46	817	57
14	15.56	16.62	1334	80
16	11.28	15.73	1478	94
18	8.98	15.86	1719	108
20	4.65	10.15	1198	118
22	3.16	8.35	1019	122
24	2.30	7.23	888	123
26	.92	3.40	434	
28	.46	1.97	259	
30	.65	3.19	424	
32	.18	1.01	126	
34	.09	.57	70	
	135.08	123.52	10244	

12. U.S. Department of Agriculture, op cit, 1938, Appendix p. 26.

Table 16

Control Table for Last

Half of First Cycle

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diam. range	Net Volume	No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed (bd.ft.)
0-40											
40-60	11.2	12.8	14.52	49.26	6"-10"	91	54.75	19.16			
60-80	12.9	14.7	16.67	27.08	10"-12"	734	30.10	4.76	10"	2.60	96
80-100	14.3	16.3	18.48	20.09	12"-14"	1293	22.32	2.64	12"	2.07	118
100-120	15.4	17.6	19.96	15.71	14"-16"	1786	17.45	2.33	14"	2.49	199
120-140	16.5	18.8	21.31	12.04	16"-20"	2311	13.38	2.48	16"	3.46	325
140-160	17.4	19.8	22.44	8.60	20"-24"	2722	9.56				
		100.0	113.40			8937					738

Cut

Overmature	1313	bd.ft.
Mature	2722	" "
Thinnings	738	" "
	4773	" "

Table 17

Growth Calculations For

Second and Following Cycles

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortal-ity	No.of trees minus mort.	Radial growth	Move two classes	Move one class	Total 20-yr. hence	Basal area
6	22.96	2.30	20.66	1.56	11.58	9.08		
8	21.95	2.20	19.75	1.56	11.07	8.68	9.08	3.17
10	18.77	1.88	16.89	1.56	9.45	7.44	20.60	11.05
12	15.77	1.58	14.19	1.56	7.94	6.25	18.51	14.52
14	13.23	1.32	11.91	1.56	6.67	5.24	15.70	16.79
16	7.82	.78	7.04	1.56	3.94	3.10	13.18	18.40
18	8.98	.90	8.08	1.56	4.53	3.55	9.77	17.25
20	1.51	.15	1.36	1.56	.76	.60	7.49	16.33
22							5.13	13.53
24							.76	2.39
			99.88				99.88	113.43

Table 18

Control Table for Second

and Following Cycles

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diam. range	Net Volume	From Table 16 No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed (bd.ft)
0-40											
40-60											
60-80	12.9	16.9	19.16	35.63	8"-10"	690	30.10	13.31	10"	7.25	268
80-100	14.3	18.7	21.21	23.10	12"-14"	1478	22.32	5.65	12"	4.44	253
100-120	15.4	20.1	22.79	17.45	14"-16"	2071	17.45	4.07	14"	4.35	348
120-140	16.5	21.6	24.50	13.30	16"-20"	2699	13.38	3.74	16"	5.22	491
140-160	17.4	22.7	25.77	10.40	20"-24"	3108	9.56				
	76.5	100.0	113.43	99.88		10046					1360

Cut

Mature	3108	Bd.Ft.
Thinnings	1360	" "
	4468	" "

NORTHERN WHITE CEDAR TYPE

3,920 Acres

Table 19

Stock & Stand Table[13.]

1 D.B.H.	2 No. of trees	3 Basal area per acre	4 Volume	5 Bd. Ft. per sq. ft. of basal area
2	175.91	3.87		
4	91.12	7.93		
6	66.67	13.07		
8	45.67	15.93		
10	36.57	19.92	535	27
12	26.94	21.15	860	41
14	17.60	18.82	1130	60
16	7.79	11.88	770	65
18	4.73	8.36	620	74
20	2.58	5.63	475	84
22	.74	1.95	190	
24	.64	2.01	200	
26	.18	.66	68	
28	.37	1.58	140	
30	.18	.88	78	
	477.69	133.74		

13. U. S. Department of Agriculture, op cit, 1938, Appendix p. 27.

Table 20

Control Table for Last

Half of First Cycle

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diam. range	Net Volume	No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed (bd.ft.)
0-40											
40-60	19.42	12.67	16.02	288.60	2"-6"						
60-80	24.84	16.21	20.52	78.56	6"-8"						
80-100	26.37	17.20	21.77	44.35	8"-10"	470	49.28				
100-120	27.20	17.73	22.45	29.95	10"-12"	879	33.28	6.72	10"	3.66	181
120-140	27.62	18.01	22.79	20.89	12"-16"	1359	23.23	6.17	12"	4.84	253
140-160	27.83	18.18	23.01	13.23	16"-20"	1682	14.72				
	153.28	100.00	126.56	475.58		4390					434

Cut

Overmature	676	bd.	ft.
Mature	1682	"	"
Thinnings	434	"	"
	2792	"	"

Table 21

Growth Calculations For

Second and Following Cycles

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortality	No. of trees minus mort.	Radial growth	Move two classes	Move one class	Total 20-yr. hence	Basal area
2	175.91	17.59	158.32	1.63	99.75	58.57		
4	91.12	9.11	82.01	1.63	51.65	30.36	58.57	5.10
6	66.67	6.67	60.00	1.63	37.80	22.20	130.11	25.50
8	45.67	4.57	41.10	1.63	25.90	15.20	73.85	25.77
10	29.85	2.99	26.86	1.63	16.92	9.94	53.00	28.88
12	20.77	2.08	18.69	1.63	11.78	6.91	35.84	28.14
14	17.60	1.76	15.84	1.63	9.98	5.86	23.83	25.47
16	1.87	.19	1.68	1.63	1.06	.62	17.64	31.17
18							10.60	18.72
							1.06	2.31
			404.50				404.50	191.06

Table 22

Control Table for Second

and Following Cycles

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diameter range	Net Volume	From Table 20 No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed(bd.ft)
0-40											
40-60											
60-80	12.9	18.6	35.54	202.83	4"-8"						
80-100	14.3	19.7	37.64	90.55	8"-10"	563					
100-120	15.4	20.3	38.79	56.18	10"-12"	1421	33.28	22.95	10"	12.51	338
120-140	16.5	20.6	39.35	32.69	12"-16"	1873	23.23	17.97	12"	14.1	578
140-160	17.4	20.8	39.74	22.25	16"-20"	2795	14.72				
	76.5	100.0	191.06			6652					916

<u>Cut</u>

Mature	2795	bd.	ft.
Thinnings	916	"	"
	3711	"	"

SELECTIVELY CUT STANDS

17,515 Acres

Table 23

Stock & Stand Table[14]

1	2	3	4	5
D.B.H.	No. of trees	Basal area per acre	Volume	Bd. ft. per sq. ft. of basal area
6	28.84	5.65		
8	20.61	7.19		
10	16.96	9.24	331	36
12	12.22	9.58	549	57
14	9.88	10.56	889	84
16	7.58	10.58	1101	104
18	5.22	9.22	1145	124
20	3.85	8.40	1165	139
22	2.15	5.68	852	150
24	1.47	4.62	736	159
26	.47	1.74	290	
28	.18	.77	134	
30	.08	.39	74	
32	.02	.11	22	
34	.02	.12	25	
	109.55	83.85		

14. U. S. Department of Agriculture, op cit, 1938, Appendix p. 23a.

Table 24

Growth Calculations For

First Half of Second Cycle

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortal-ity	No. of trees minus mort.	Radial growth	Move one classes	Move zero classes	Total 20-yr. hence	Basal area
6	28.84	1.44	27.40	.79	21.65	5.75	5.75	1.13
8	20.61	1.03	19.58	.79	15.48	4.10	25.75	8.99
10	16.96	.85	16.11	.79	12.72	3.39	18.87	10.28
12	12.22	.61	11.61	.79	9.18	2.43	15.15	11.90
14	9.88	.49	9.39	.79	7.42	1.97	11.15	11.92
16	7.58	.38	7.20	.79	5.69	1.51	8.93	12.47
18	5.22	.26	4.96	.79	3.92	1.04	6.73	11.89
20	3.85	.19	3.66	.79	2.89	.77	4.69	10.23
22	2.15	.11	2.04	.79	1.61	.43	3.32	8.77
24	1.47	.07	1.40	.79	1.11	.29	1.90	5.97
26	.47	.02	.45	.79	.36	.09	1.20	4.43
28	.18	.01	.17	.79	.13	.04	.40	1.71
30	.08	.00	.08	.79	.06	.02	.15	.74
32	.02	.00	.02	.79	.02	.00	.06	.34
34	.02	.00	.02	.79	.02	.00	.02	.13
36							.02	.14
			104.09				104.09	101.04

Table 25

Control Table for First

Half of Second Cycle

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. X actual B.A.	No. of trees	Diameter range	Net Volume	No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed(bd.ft.)
0-40											
40-60											
60-80	12.5	16.9	15.81	41.94	6"-10"	205	46.60	14.72			
80-100	14.3	18.7	17.49	24.51	10"-14"	927	27.22	6.89	10"	3.76	135
100-120	15.4	20.1	18.81	15.87	14"-16"	1739	17.62	2.85	14"	3.05	256
120-140	16.5	21.6	20.21	11.72	16"-20"	2471	13.02	2.60	16"	3.63	378
140-160	17.4	22.7	21.23	8.20	20"-24"	3167	9.12				
	76.5	100.0	93.55	102.24		8509					769

Cut

Overmature	1300	bd. ft.
Mature	3167	" "
Thinnings	769	" "
	5236	" "

Table 26

Growth Calculations For

Third and Following Cycles
(first half)

1	2	3	4	5	6	7	8	9
D.B.H.	No. of trees	Mortal-ity	No. of trees minus mort.	Radial growth	Move two classes	Move one class	Total 20*yr. hence	Basal area
6	5.75	.58	5.17	1.59	3.05	2.12		
8	25.75	2.58	23.17	1.59	13.67	9.50	2.12	.74
10	11.98	1.20	10.78	1.59	6.36	4.42	12.55	6.85
12	15.15	1.52	13.63	1.59	8.04	5.59	18.09	14.20
14	8.30	.83	7.47	1.59	4.41	3.06	11.95	12.78
16	6.33	.63	5.70	1.59	3.38	2.32	11.10	15.48
18	6.73	.67	6.06	1.59	3.58	2.48	6.73	11.89
20	1.71	.17	1.54	1.59	.91	.63	5.86	12.78
22							4.21	11.10
24							.91	2.86
			73.52				73.52	88.68

Table 27

Control Table for Third

and Following Cycles
(first half)

1	2	3	4	5	6	7	8	9	10	11	12
Age class	Normal basal area	% of total basal area	% B.A. x actual B.A.	No. of trees	Diameter range	Net Volume	From Table 25 No. of trees / .90	No. of trees to be cut	Approx. diam.	Basal area removed	Volume removed(bd.ft.)
0-40											
40-60											
60-80											
80-100	14.3	22.5	19.95	30.42	8"-12"	951	27.22	12.80	10"	6.98	251
100-120	15.4	24.2	21.46	19.19	12"-16"	1890	17.62	6.17	12"	4.85	276
120-140	16.5	26.0	23.05	14.09	16"-20"	2723	13.02	4.97	16"	6.94	722
140-160	17.4	27.3	24.22	9.82	20"-24"	3546	9.12				
	63.6	100.0	88.68	73.52		9110					1249

Cut

Mature	1249	bd.	ft.
Thinnings	3546	"	"
	4795	"	"

Table 28

Cutting Budget and
Comparison with Forest Service Results

First Cycle (last half: 1937-1946)

Annual Cut

Basal Area Control Method

$\frac{103640 \text{ M}}{10}$ or 10,364 M bd. ft.

Forest Service Method

$\frac{108720 \text{ M}}{10}$ or 10,872 M bd. ft.

Second Cycle (first half, 1947-1956)

Annual Cut

Basal Area Control Method

$\frac{91,700 \text{ M}}{10}$ or 9,170 M bd. ft.

Forest Service Method

$\frac{93920 \text{ M}}{10}$ or 9,392 M bd. ft.

Second and following Cycles (last half)

Annual Cut

Basal Area Control Method

$\frac{98,640 \text{ M}}{10}$ or 9,864 M bd. ft.

Forest Service Method (2nd cycle only)

$\frac{101,680 \text{ M}}{10}$ or 10,168 M bd. ft.

Third and Following Cycles (first half)

Annual Cut

Basal Area Control Method

$\frac{84,000 \text{ M}}{10}$ or 8,400 M bd. ft.

Summary and Conclusion

Sustained yield, based upon regulation of the growing stock by proper cutting practices, will ultimately solve the problems of American forestry. This type of production is especially suited to certain areas which combine optimum site conditions with a good location and a suitable timber stand. The Goodman Working Circle, located in the Northern Hardwood Region of northern Wisconsin, fulfills the requirements for an area which is to be managed for continuous production.

In order to obtain sustained yield, a plan must be formulated which will control the cutting so as to maintain the growing stock at a sufficient level. Because of its simplicity, realism, and accuracy, the Basal Area Control method is well-adapted to the development of a plan of regulation. This method, as has been shown in the preceding demonstrational calculation, is based upon the relationship between the basal area existing in the actual forest which is to be managed, and the basal area in a normal forest as determined from yield tables.

The Basal Area Control method relies upon comparatively simple arithmetical calculations. The prodedure which is followed may be summed up in several general steps, as given on pages 8 and 9. In order to obtain the correct total cut, these steps must be applied to each of the four major types recognized in the uncut sawtimber stands on the Goodman area, and also to the selectively-cut stands on the area. The latter must be predicted ahead ten years before classification, since cutting will not begin until ten years in the future.

After completion of the indicated calculations, a cutting budget may be drawn up for a number of years in the future. The budget in this case agrees very closely with that developed by Forest Service methods. The figures which this budget presents (as calculated by the Basal Area Control method) will, due to conservatism in calculations and also to the response of the forest to continued management, represent the minimum cut to be expected. By careful examination following the first few cuts it will probably be possible to take larger cuts than indicated by the cutting budget, and at the same time maintain a sufficient timber reserve. Thus, the case for sustained yield will be stronger than shown herein.

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