The Application of Basal Area Control to a Virgin Northern Hardwoods-Hemlock Forest.

R.A.Ralston May 10, 1949.

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THE APPLICATION OF BASAL AREA CONTROL TO A VIRGIN NORTHERN HARDWOODS-HEMLOCK FOREST.

A Problem
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of Forestry.

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INTRODUCTION.

The following report represents an attempt to adapt the principles of forest management as presented in the Forest Management, Forest Valuation, and Forest Industry Economy at the University of Michigan School of Forestry to the preparation of a management plan for a block of northern hardwood timber in Eastern Wisconsin.

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I. STATEMENT OF THE PROBLEM.

A. "The attached stand table represents average conditions of stocking on a 5500-acre block of the Menominee Indian Reservation in Wisconsin. Under authorization of Congress, the timber on the reservation is to be harvested under a sustained yield plan of management and the logs manufactured in the Menominee Mill at Neopit,the products being sold for the benefit of the tribe.

Stocking. It is recognized that the heavy stocking that exists in the uncut virgin stands is not necessary or to be desired under management. Cutting plans will,therefore,aim to reduce current stocking in the light of anticipated growth. and existing overmaturity of the stands.

Cutting Cycle. An effective cutting cycle of 15 years is to be adopted on all areas. Areas for which plans are drafted may be cut over in a shorter period than the cycle when necessary but will not be cut again for a period of 15 years.

Objectives of Management.

A. Size of timber to be grown. Not definite. The reservation is large and an excess of mature timber is available.For the present, at least, timber from 25 to 30 inches d.b.h. is the objective.

B. Species composition. Hemlock is a low value species and therefore every effort will be made to reduce the representation of this species in the residual stands. Itis recognized that it may not be desirable silviculturally or possible economically entirely to eliminate this species."

The present composition of "other species" is as follows:

Maple	30%
Birch	30%
Basswood & Pine	20%
Elm & Misc.spp.	20%

Growth. Studies of growth for this block indicate that,under management, a growth rate of 0.2 inches per year can be anticipated.

a. Estimate the cut per acre of each species by size classes and by number of trees and volume in ft.b.m. that can be removed from the block during the first cycle.

b. Estimate in a similar manner the cut per acre at the time of the next cutting cycle.

c. The foregoing estimates and calculations are to be neatly prepared for attachment to a report to the Office of Indian Affairs."

PER ACRE STAND TABLE FOR BLOCK.
ft.b.m.

D.B.H.	Hemlock Trees	Hemlock B.A.	Other spp. Trees	Other spp. B.A.	Totals. Trees	Totals. B.A.
10	5.5	3.00	8.0	4.36	13.5	7.36
12	4.0	3.14	6.0	4.71	10.0	7.85
14	4.0	4.28	5.0	5.34	9.0	9.62
16	4.0	5.60	4.5	6.30	8.5	11.90
18	3.8	6.71	4.0	7.06	7.8	13.77
20	3.2	7.00	3.2	7.00	6.4	14.00
22	2.8	7.40	2.7	7.13	5.5	14.53
24	2.1	6.60	2.2	6.91	4.3	13.51
26	1.5	5.54	1.5	5.54	3.0	11.08
28	1.0	4.28	1.0	4.28	2.0	8.56
30+	1.0	5.59	1.0	5.59	2.0	11.18
Total	32.9	59.14	39.1	64.22	72.0	123.36

D.B.H.	Hemlock Vol/Tree	Hemlock Vol/Class	Other spp. Vol/tree	Other spp. V/Class	Stand Total Vol.
10	30	165	30	240	405
12	80	320	90	540	860
14	130	520	150	750	1270
16	190	760	210	945	1705
18	270	1025	280	1120	2145
20	360	1150	360	1150	2300
22	480	1345	440	1190	2535
24	620	1300	530	1170	2470
26	770	1155	630	945	2100
28	910	910	740	740	1650
30 +	1210	1210	1030	1030	2240
Totals		9860		9820	19680

III. SUMMARY OF REPORT.

A. Discussion of Management Plan.

1. Method of determining volume of cut in 1st. cycle.

The stand was classified into seven cyclic age-groups based on the percentage of basal area of the average size trees that would be present if the stand were a normal even-aged stand. The harvest cut that can be taken is the volume in ft.b.m. contained in the oldest age-class. Thinnings can be removed from the remaining groups at the same time of the harvest cut. Only enough trees are left in these younger age-classes to supply the proper sq.ft.B.A. at the time of the next harvest cut in 15 years. The .2" growth rate is assumed to include a deduction for mortality.

2. Method of estimating volume of cut in 2nd. cycle.

The harvest cut will come from the trees left in age-group VII at the time of the first cut. This group was number VI just before the 1st. cycle. Thinnings are assumed to remain approximately the same as before but are 16.5% less because of the reduction in stocking during the 1st. cycle. But as all defect is assumed to be eliminated at this time, the net effect is an increase of 3.5%. The percentage composition is now 70% hardwoods and only about 30% hemlock. The stand table attached will now apply without making any deductions for cull.

3. Silvicultural justification of cutting plan.

The cut during the first cycle takes approximately 50% of the stand by volume and about 70% of the hemlock. In the light of current literature, this does not appear to be too heavy a cut. A heavy improvement cutting comparable to the cut indicated by the basal area control method in a similar stand resulted in satisfactory reproduction and an increased growth rate.(Zillgitt,W.M.,1947.) This contention is also born out by the findings of other workers testing the applicability of the selection method of cutting northern hardwoods.(Eyre & Neetzel,1939). In actual practice the marking should attempt to practice good silviculture in following the basal area control methods.

B. Summary of the Estimated Stumpage Recovery Values.

1. First Cutting Cycle.

	per Acre	Total
Hemlock	$28.40	$156,200
Maple	5.50	30,250
Birch	7.80	42,900
Basswood & Pine	6.10	33,550
Elm & Misc.spp.	3.10	17,100
Totals	$50.90	$280,000

2. Second & Subsequent Cutting Cycles.

	per Acre	Total
Hemlock	$14.10	$ 80,900
Maple	22.20	122,000
Birch	29.80	164,000
Basswood & Pine	22.80	125,400
Elm & Misc.spp.	12.80	70,400
Totals	$102.30	$562,700

C. Recommendations as to Apportionment of Funds.

1. Credit to Tribal Profit Fund for Distribution.

60% of Total Stumpage Recovery = $168,000.

2. Reserve for Contingencies.

40% of Total Stumpage Recovery = $112,000.

D. Book Value at end of First Cutting Period.

60% of Present Worth after Cutting = $561,000.

IV. PREPARATION OF A BASAL AREA CONTROL TABLE.

A. Present stand condition.

The attached stand and stock table representing the average conditions on the entire 5500-acres indicates clearly that extreme overstocking obtains. Approximately 182 sq.ft.B.A. is occupying an acre that should carry a maximum of about 150 sq.ft. Also, 50% of the block by volume consists of low-value hemlock. The proposed plan will attempt to reduce stocking and to increase the percentage composition of the high-value hardwood species.

The full explanation of the use of even-age yield-tables in the preparation of all-age control tables is beyond the scope of this report, but can be found in the text, Management of American Forests, by D.M.Matthews.

B. In selecting the most feasible normal yield-table it was found that the above site and location most nearly matched the best site as described by Gevorkiantz and Duerr(Jour.For.vol.35,p.342). The following graph of the basal area over d.b.h. depicts the normal stand.

In accordance with the following data the control table was divided into seven cyclic age-groups:

1. Expected growth rate of .2" per year.
2. A cutting cycle of 15 years.
3. Minimum cruise limit of 10" d.b.h.
4. Present objective to harvest 25" - 30" timber.

$$\text{No. of cyclic age-groups} = \frac{30" - 10"}{15 \text{ yrs.} \times .2"} = 7 \text{ Age-Groups.}$$

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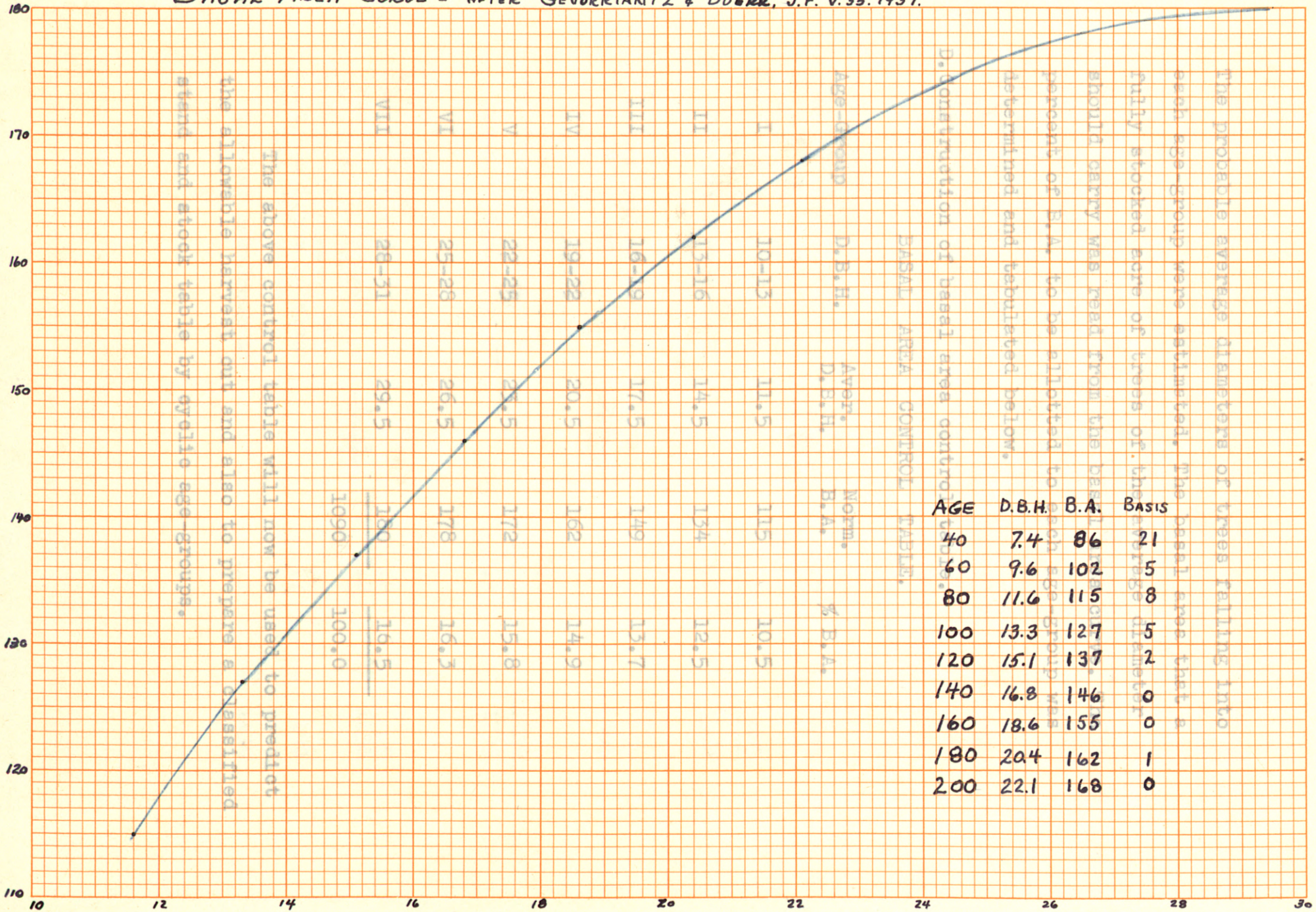

AGE	D.B.H.	B.A.	BASIS
40	7.4	86	21
60	9.6	102	5
80	11.6	115	8
100	13.3	127	5
120	15.1	137	2
140	16.8	146	0
160	18.6	155	0
180	20.4	162	1
200	22.1	168	0

The probable average diameters of trees falling into each age-group were estimated. The basal area that a fully stocked acre of trees of the average diameter should carry was read from the basal area curve. The percent of B.A. to be allotted to each age-group was determined and tabulated below.

D. Construction of basal area control table.

BASAL AREA CONTROL TABLE.

Age-Group	D.B.H.	Aver. D.B.H.	Norm. B.A.	% B.A.
I	10-13	11.5	115	10.5
II	13-16	14.5	134	12.5
III	16-19	17.5	149	13.7
IV	19-22	20.5	162	14.9
V	22-25	23.5	172	15.8
VI	25-28	26.5	178	16.3
VII	28-31	29.5	180	16.5
			1090	100.0

The above control table will now be used to predict the allowable harvest cut and also to prepare a classified stand and stock table by cyclic age-groups.

D. Calculation of harvest cut, 1st. cutting period and preparation of classified stand and stock table.

HEMLOCK.

Age-Group VII	B.A. sq.ft.	No. Trees	Vol. ft.b.m.
B.A. Required	9.76	1	1210
From 30" class	5.59		
Bal. from 28" class	4.17		
% from 28" class=.975			
No. trees from 28" class		1	910
Vol. from 28" class			
Totals: Age-Group VII		2	2120
Age-Group VI			
B.A. Required	9.64		
From 26" class	5.54	1.5	1155
B. from 24" class	4.10		
% from 24" class=.622			
No. trees from 24" class		1.3	805
Vol. from 24" class.			
Totals: Age-Group VI		2.8	1960
Age-Group V			
B.A. Required	9.35		
From 24" class	2.50	.8	495
Bal. from 22" class	6.85		
% from 22" class=.926			
No. trees from 22" class		2.6	
Vol. from 22" class			1250
Totals: Age-Group -V		3.4	1745
Age-Group IV			
B.A. Required	8.81		
From 22" class= .55		.2	95
From 20" class=7.00	7.55	3.2	1150
Bal. from 18" class	1.26		
% from 18" class=.188			
No. trees fromm 18" class		.7	190
Vol. from 18" class			
Totals: Age-Group IV		4.1	1435

HEMLOCK -con't.

	B.A. sq.ft.	No. Trees	Vol. ft.b.m.
Age-Group III			
B.A. Required	8.10		
From 18" class	5.45	3.1	835
Bal. from 16" class	2.65		
% from 16" class=.473			
No. trees from 16" class		1.9	360
Vol. from 16" class			
Totals: Age-Group III		5.0	1195
Age-Group II			
B.A. Required	7.27		
From 16" class	2.95	2.1	400
Bal. from 14" class	4.32		
% from 14" class=.987		4.0	520
No. trees from 14" class			
Vol. from 14" class			
Totals: Age-Group II		6.1	920
Age-Group I			
From 12" class	3.00	4.0	320
From 10" class	3.14	5.5	165
Totals: Age-Group I	6.14	9.5	485

"OTHER" SPECIES.

	B.A. sq.ft.	No.Trees	Vol.ft.b.m.
Age-Group VII			
B.A.Required	10.60		
From 30"class=5.59		1.0	1030
From 28"class=4.28	9.87	1.0	740
Bal.from 26" class	.73		
% from 26" class=.132			
No.trees from 26"class		.2	
Vol.from 26" class			125
Totals: Age-Group VII		2.2	1895
Age-Group VI			
B.A. Required	10.47		
From 26" class	4.81	1.3	820
Bal.from 24" class	5.66		
% from 24" class=.819			
No.trees from 24" class		1.8	
Vol. from 24" class			955
Totals: Age-Group VI		3.1	1775
Age-Group V			
B.A. Required	10.15		
From 24" class=1.25	8.38	.4	215
From 22" class=7.13		2.7	1190
Bal. from 20" class	1.77		
% from 20" class=.253			
No.trees from 20"class		.8	
Vol. from 20" class			290
Totals: Age-Group V		3.9	1695
Age-Group IV			
B.A. Required	9.56		
From 20" class	5.23	2.4	860
Bal.from 18" Class	4.33		
% from 18" class=.613			
No.trees from 18"class		2.5	
Vol. from 18" class			700
Totals: Age-Group IV		4.9	1560

"OTHER" SPECIES con't.

	B.A. sq.ft.	No.Trees	Vol.ft.b.m.
Age-Group III			
B.A. Required	8.80		
From 18" class	2.73	1.5	420
Bal.from 16" class	6.07		
% from 16" class=.964			
No.trees from 16"class		4.3	
Vol.from 16" class			905
Totals: Age-Group III		5.8	1325
Age-Group II			
B.A. Required	7.90		
From 16" class = .27	5.61	.2	40
From 14" class =5.34		5.0	750
Bal.from 12" class	2.29		
% from 12" class=.486			
No.trees from 12"class		2.9	
Vol. from 12" class			260
Totals: Age-Group II		8.1	1050
Age-Group I			
From 12" class	2.42	3.1	280
From 10" class	4.36	8.0	240
Totals: Age-Group I	6.78	11.1	520

CLASSIFIED STAND AND STOCK TABLE per Acre.

Age Group	%B.A. sq.ft	Actual B.A. Hemlock	Actual B.A. Others	No.of Trees Hemlock	No.of Trees Others	DBH Range Hemlock	DBH Range Others	Aver. DBH Hemlock	Aver. DBH Other	Volume ft.b.m. Hemlock	Volume ft.b.m. Other	Volume ft.b.m. Totals
I	10.5	6.21	6.74	9.5	11.1	10-14	10-12	11.0	10.5	485	520	1005
II	12.3	7.27	7.90	6.1	8.1	14-16	12-16	14.8	13.4	920	1050	1970
III	13.7	8.10	8.80	5.0	5.8	16-18	16-18	17.2	16.5	1195	1325	2520
IV	14.9	8.81	9.56	4.1	4.9	18-22	18-20	20.0	19.0	1435	1560	2995
V	15.8	9.35	10.15	3.4	3.9	22-24	20-24	22.5	22.0	1745	1695	3440
VI	16.3	9.64	10.47	2.8	3.1	24-28	24-26	25.2	25.0	1960	1775	3735
VIII	16.5	9.76	10.60	2.0	2.2	28 +	26 +	30.0	30.0	2120	1895	4015
Totals	100.0	59.14	64.22	32.9	39.1					9860	9820	19680

V. Estimation of cut per acre of each species by size classes and by number of trees during the 1st. cutting period.

A. Harvest Cut.

The harvest cut as indicated by the classified stand and stock table is 2120 ft.b.m. of hemlock and 1895 ft.b.m. from the "other" species. This cut is tabulated as follows:

Species	No.Trees	Volume
Hemlock	2.00	2120 ft.b.m.
Maple	.66	568
Birch	.66	568
Basswood & Pine	.44	379
Elm & Misc.spp.	.44	379
Totals	4.2	4015

This indicated cut is a gross volume based on a gross stand table, so the above volumes must be reduced by 20% because of defect presently existing in the stands. The net harvest cut will be approximately 3220 ft.b.m.

B. Thinnings.

1. Reduction to proper stocking.

The additional volume that can be removed in the form of thinnings will be governed by the degree of stocking that is deemed necessary to insure crown closure. The figure of 150 sq.ft.B.A. per acre has been put forward by D.M.Matthews (Mgmt.Am.For.p.30) as an average maximum density for similar stands. This figure is closely born out by the use of the data in our basal area control table based on work by Gevorkiantz and Duerr(1937). By averaging the results obtained from the above two sources,an average figure of 103 sq.ft.B.A. for the merchantable portion of our stand was selected . The percentages used in our control table are used to figure the following proposed basal areas for each age-group.

Age-Group	% B.A.	Proposed B.A.
I	10.5	10.8
II	12.3	12.7
III	13.7	14.1
IV	14.9	15.3
V	15.8	16.3
VI	16.3	16.8
VII	16.5	17.0
	100.0 %	103.0 sq.ft.

3. Estimation of number of trees to leave for next cut.

Trees in group VI now average 25" d.b.h.,and,as the growth rate is .2" per year, they should average 28" in 15 years. But this group is only required to carry 17.0 sq.ft.B.A. 15 years from now instead of the present 20.11 sq.ft. Thus the number of trees necessary to leave from group VI to carry over until the next cutting cycle can be calculated as follows:

$$\frac{\text{17.0 sq.ft.B.A.}}{\text{sq.ft.B.A. of a 28"tree}} = \frac{17.0}{4.26} = 4 \text{ Trees.}$$

The number of trees necessary to leave in each group has been calculated and tabulated on the following pages.

The estimated thinnings,coming as much as possible from the hemlock species, using the gross volumes from the stand table are tabulated and follow on the next pages.

TABLE NO. I

Number of Trees to Leave for 2nd. Cycle.

Age-Group Now	B.A. Req. 2nd C.C.	Exp.d.b.h. 2nd C.C.	B.A. per Tree	No. of Trees to leave
VI	17.0	28"	4.26	4.0
V	16.8	25"	3.41	4.9
IV	16.3	22"	2.64	6.2
III	15.3	19.5"	2.07	7.4
II	14.1	16.5"	1.47	9.6
I	12.7	13.5"	.994	12.8
	92.2			44.9

TABLE NO. 2

TOTAL ALLOWABLE CUT DURING THE 1st. CYCLE.

Harvest Cut:(Age-Group VII)	Gross Vol.ft.b.m.
Hemlock	2120
"Other" spp.	1895

Thinnings: All Hemlock.

Age Group VI (5.9 - 4.0),25"trees @690 x 1.9	1300
Age Group V (7.3 - 4.9),22"trees @480 x 2.4	1150
Age Group IV (9.0 - 6.2),19"trees @310 x 2.8	870
Age Group III(10.8 -7.4),16"trees @190 x 3.4	630
Age Group II(14.2 - 9.6),14"trees @130 x 4.6	600
Age Group I(20.6 -12.8),11"trees @ 55 x 7.8	430
Gross Total Cut	9000 ft.b.m.
Allowance for defect ---x .8	
Net Total Cut	7200 ft.b.m.

VI. Estimation of Cut during 2nd. and Subsquent Cycles.

A. Harvest Cut.

The harvest cut at the time of the 2nd. cycle will come from the 4 trees left in age-group VI at the time of the first cutting period. These trees will carry 17.0 sq.ft.B.A. and a volume of approximately 3100 ft.b.m. as indicated by the stand table aswe have assumed elimination of all defect by this time. The net harvest cut is:

Hemlock ---- .9 trees x 910 ft.b.m. = 819 ft.b.m.

"Other" ----3.1 trees x 740 ft.b.m. = 2294 ft.b.m.

Total Net Harvest Cut =3113 ft.b.m.

B. Thinnings.

Total stocking will be reduced by 16.5% during the 1st cutting cycle, thus the total amount available for thinning is correspondingly decreased. Stand composition has been altered because of our policy in thinning the hemlock so heavily. The present composition will be about 70% northern hardwoods and only 30% hemlock by species. Probable volumes available for thinnings can be calculated as follows:

Hemlock = 4980ft.b.m. x .835 x .30 = 1250 ft.b.m.

Other sp.= 4980ft.b.m. x .835 x..70 = 2910 ft.b.m.

Net Thinnings = 4160 ft.b.m.

C. Total Cut by Species.

Hemlock	2.0 M.ft.b.m.
Maple	1.5
Birch	1.5
Basswood & Pine	1.0
Elm & Misc. spp.	1.0
Total	7.0 M.ft.b.m.

Part II. Logging Plan and Basic Cost Data.

"The block comprises the timbered portions of Sections 19,20,21,28,29,30,31,32,and 33 of Township T30N R15E. The main logging road from the mill at Neopit has been constructed to the southeast corner of section 31 and located to run north from this corner following the west boundary of sections 31,30,and 19. The road distance from the S.W. corner of section 31 to the mill is 7 miles.

To log this area this main road will have to be constructed north to the N.W. corner of section 19 and spur roads constructed east into the aforementioned sections.

The timber will be skidded by tractors and teams to spur roads and loaded on trucks for transport to the mill. Loading will be accomplished by the ordinary A-frame jammers powered by teams. The topography is such that roads can be constructed on any desired spacing. Landings will be closely spaced and their cost will be negligible and therefore included in the following estimates of road construction cost. Due to the close spacing of landings all road spacing calculations can be based on direct skidding.

Felling and Bucking.

Two man crews will be used. Cost is estimated as below:

A. Direct labor	Cost per 8-hour day
2 men @ 80¢ per hour	$12.80
10% allow. portal to portal pay	1.28
20% indust.comp.,ins.,etc.	2.82
B. Indirect costs	
Supplies & Maintenance	1.00
Depreciation tools	.25
Direct Supervision & Overhead	3.00
	$21.15

Cost per man-hour =21.15/16= $1.32

Estimated production per man-hour:
Hemlock ----- 0.4 M.ft.b.m.
Other sp.---- 0.3 M.ft.b.m.

Skidding.

Machine Rate for Teams:	Per Hour
Teamster and ½-time swamper @80¢	$1.20
Social Security and IND.COMP. 20%	.24
10% allow.for portal to portal	.14
Depreciation team and harness	.20
Feed and care of team	.32
Total	$2.10

Rate per min.= 3.5¢

Average fixed time per turn ---------- 3.6 min.
Average round trip time per station ---------- 1.0 "
Average load --- 140 ft.b.m.

Machine Rate for Tractors:	Per Hour
Driver @ $1.25	$1.25
Hooker @ $ .90	.90
Social security,etc. @ 20%	.43
10% allowance for portal to portal	.26
Depreciation and supplies and maintenance	3.76
Total	$6.60

Cost per minute -- 11¢
average fixed time per turn ---- 7 min.
" round trip time per sta.-.8 min.
" load ---- 700 ft.b.m.

LOADING.

Skidding teams will power jammers as trucks arrive at loading points. The estimated loading rate is 15 minutes per M. ft.b.m. The regular skidding machine rate will apply to the cost of loading.

HAULING.

A machine rate for the trucks which will be used on the operation follows. Unloading and delay time at the mill is estimated to be 15 minutes per trip on the average.

Lake States Region Machine Rates for Logging Trucks:
Fixed Cost per hour ---------- $1.99
Operating Cost per hour --------- 1.26
Hauling Cost per Hour - $3.25

average load --- hemlock 2.5 M.ft.b.m.
other sp 2.0 "

ROAD CONSTRUCTION.

The main logging road already constructed cost $10,000 per mile and maintenance costs are $200 per mile annually. The additional main road required is to be built to the same standard and costs are estimated to be the same. As the operation is essentially on a sustained yield basis this road investment is not to be amortized. Maintenamce costs plus 6% on the capital cost are to be charged against the annual cut.

Trucks can maintain an average round trip speed on this main road of 20 m.p.h.

BRANCH ROADS.

These roads are to be semi-permanent in character and are estimated to cost $1000 per mile. An average round trip of 12 m.p.h. is estimated for these spur roads.

The entire cost of these spur roads is to be charged off against the cut of the first cycle. It is estimated that they can be put in condition for future use at the time of the next cut at a cost of $200 per mile.

OVERHEAD COSTS.

It is estimated that overhead and general supervision cost chargeable to the woods operations will be $30,000 per year.

The cost of the logs at the mill will be estimated separately for hemlock and "other" species on the basis of a net outturn of 80% of the gross scale and production at the rate required by the mill.

PRODUCTION.

The mill is estimated to require approximately 14,000 M.ft.b.m. net log scale per year for the next few years.

The stand is known to be over-mature and it is estimated that defect in the stands currently ready for cut will reduce the scaled volume at the mill to 80% of the gross log scale.

Therefore, all logging costs will have to be increased in proportion to the reduction of net scale to 80% of gross upon which logging costs have been calculated. Production will be planned to deliver approximately 14,000 M. ft.b.m. net logscale at the mill."

LOGGING COST CALCULATIONS.

First Cutting Cycle.

Felling & Bucking.

Hemlock ---- $\frac{\$1.32 \text{ per hour}}{.4 \text{ M per hr.}}$ = $3.30/M

"other" ---- $\frac{\$1.32 \text{ per hr.}}{.3 \text{ M per hr.}}$ = $4.40/M

LOADING.

$.035/min. x 15 min./M = $0.52/M

Standby and Delay at Mill.

Hemlock: $\frac{\$199/hr.}{60 \text{ min}} \times \frac{15 \text{ min/trip}}{2.5 \text{ M/load}}$ = $0.20/M

"Other": $\frac{\$1.99/hr}{60 \text{ min}} \times \frac{15 \text{ min}}{2.0 \text{ M/load}}$ = $0.25/M

Standby while Loading.

$\frac{\$ 1.99 \text{ per hour}}{60 \text{ min}}$ x 15 min per M. = $0.50/M

Fixed Skidding - Teams.

$\frac{\$.035 \text{ per min.}}{.140 \text{ M/load}}$ x 3.6 min per t. = $0.90/M

Variable Skidding - Teams.

$\frac{\$.035 \text{ per min.}}{.140 \text{ M/load}}$ x 1 min per sta. = $0.25/M

Fixed Skidding - Tractors.

$\frac{\$.11 \text{ per min.}}{.7 \text{ M/turn}}$ x 7 min per turn = $1.10/M

Variable Skidding - Tractors.

$$\frac{\$.11 \text{ per min}}{.7 \text{ M/load}} \times .8 \text{ min per sta.} = \$1.10/M$$

Road And Equipment Spacing - Combined Operation.

$$D = \frac{F' - F}{c - c'} = \text{Break-even skidding dist. between teams \& tractors.}$$

$$= \frac{\$1.10 - .90}{\$ .25 - .126} = 1.6 \text{ stations.}$$

Economic Road Spacing using Team & Tractor Skidding.

$$S = \frac{.33 - 1000¢}{9M \times 12.6¢} - \frac{4 \times 25¢ \times 1.6^2}{12.6¢} - (4 \times 1.6^2)$$

S = 16.8 Stations between roads.

Total Skidding Cost - Teams.

Fixed Charge ----------	$ .90
Variable Chg. $C \frac{D}{2}$ = .25x1.6/2	.20
	1.10

Weighted in % to vol.: $\frac{2D}{S} \times 1.10 =$ $ .21/M

Total Skidding Cost - Tractors.

Fixed Charge ----------	$1.10
Variable Chg. $C \times \frac{S/2 + D}{2}$ --	.63
	1.73

Weighted in % to vol.: $\frac{S - 2D}{S} = \$1.40/M$

Spur Road Construction Cost.

$$\frac{R}{12.1 \times 9m \times 16.8 \text{ sta.}} = \$ .55/M$$

Main Road Construction and Maintenance.

$$\frac{\$800 \text{ per yr.}}{9M \times 1833 \text{ acres/yr.}} \times 10 \text{ mi.} = \$ .48/M$$

Hauling Charge on Spur Roads.

Hemlock: $\left(\frac{2 \times HC}{\text{mph} \times \text{load}} \times \text{mi.}\right) =$

$$\frac{2 \times \$3.25}{12\text{mph} \times 2.5M} \times 1.5 \text{ miles} = \$ .32/M$$

"Other": $$\frac{2 \times \$3.25}{12\text{mph} \times 2.0M} \times 1.5 \text{ miles} = \$ .41/M$$

Hauling Charge on Main Road.

Hemlock: $8\frac{1}{2}$ miles $\times \frac{2 \times \$3.25}{20\text{mph} \times 2.5M} = \$1.10/M$

"Other": $8\frac{1}{2}$ miles $\times \frac{2 \times \$3.25}{20\text{mph} \times 2.0M} = \$1.38/M$

Overhead and Supervision.

$$\frac{\$30,000 \text{ per year}}{9 \text{ M/ acre} \times 1833 \text{ acres}} = \$1.82/M.$$

B. LOGGING COST CALCULATIONS - 2nd. & Subsq. Cycles.

" In calculating costs and recovery values for the 2nd. and subsequent cycles use the same basic costs as those for the first cycle but remember that branch roads will not have to be rebuilt, but only reconditioned at a cost of $200 per mile.

No reduction in gross scale need be made for defect in estimating the cut and value of the 2nd and subsq. cycles."

All costs previously calculated remain unchanged except those varying with volume per acre. A maintenance charge, only, can be charged against the cut for spur roads. The following costs must be recalculated.

Spur Road Maintenance.

$$\frac{\$200}{12.1 \times 7M \times 16.8 \text{ sta.}} = \$ .14/M$$

Main Road Construction & Maintenance.

$$10 \text{ mi.} \times \frac{\$800}{7M \times 1833 \text{ acres}} = \$ .62/M$$

Overhead and Supervision.

$$\frac{\$30,000}{7M \times 1833 \text{acres}} = \$2.34/M$$

SUMMARY OF LOGGING COSTS.
per M.

	Gross 1st C.C.		Net 2nd C.C.	
Felling and Bucking	$3.30	$4.40	$3.30	$4.40
Loading	.52	.52	.52	.52
Standby while Loading	.50	.50	.50	.50
Unloading & Delay at Mill	.20	.25	.20	.25
Team Skidding	.21	.21	.25	.25
Tractor Skidding	1.40	1.40	1.40	1.40
Spur Road Construction	.55	.55		
Spur Road Maintenance			.14	.14
Main Road Const.& Maint.	.48	.48	.62	.62
Hauling on Spur Roads	.32	.41	.32	.41
Hauling on Main Roads	1.10	1.38	1.10	1.38
Overhead & Supervision	1.82	1.82	2.34	2.34
Totals	$10.40	$11.92	$10.65	$12.17
	± .8	±.8		
Net Cost ----	$13.00	$14.90		

VIII. Stumpage Recovery Values per M ft.b.m. and per acre.

A. Log Values.

"For the purpose of appraising the value of this block of timber, logs will be charged to the mill at the following prices net log scale:

Hemlock ----------	$18.00	per M.ft.b.m.
Maple ----------	27.00	"
Birch ----------	32.00	"
Basswood & Pine ---------	35.00	"
Elm and Misc. ----------	25.00	" "

B. The stumpage recovery values calculated and tabulated on the following page are an estimate of the probable recovery values per M. and per acre. These values are seemingly conservative. Based on a gross harvest cut of 4 M.ft.b.m. per acre the cut allowed by the Von Mantel formula is 4.3 M.ft.b.m.

The cut for the 2nd and subsequent cycles and the recovery values resulting therefrom were predicted merely to provide a base for calculating the book value of the property after the first cutting period. Actually, by the time the second cut comes up, more complete data should be available as to stand composition and stocking. The tentative cut can then be adjusted to conform with conditions on the ground. Any short-cut method of determining the immediate volume to cut should not be considered inflexible, but should be used as a guide until more and better information is available.

NET STUMPAGE RECOVERY VALUES.

First Cutting Cycle.

	Rec./M	Vol/A.	Rec/A.	Total
Hemlock	$ 5.00	5.680M	$28.40	$156,200
Maple	12.10	.456	5.50	30,250
Birch	17.10	.456	7.80	42,900
Bass.& Pine	20.10	.304	6.10	33,550
Elm & Misc.	10.10	.304	3.10	17,100
Totals		7.200M	$50.90	$280,000

Second and Subsq. Cycles.

	Rec./M	Vol/A.	Rec/A.	Total
Hemlock	$ 7.35	2.0 M	$14.70	$ 80,900
Maple	14.83	1.5	22.20	122,000
Birch	19.83	1.5	29.80	164,000
Bass.& Pine.	22.83	1.0	22.80	125,400
Elm & Misc.	12.83	1.0	12.80	70,400
Totals		7.0 M	$102.30	$562,700

IX. Distribution of Stumpage Recovery - First Cutting Period.

A. Credit to Tribal Profit Fund.

$280,000 x .60 = $168,000 Total Credit.

$ 50.90 x .60 = $ 30.54 per acre Credit.

B. Reserve for Contingencies.

$280,000 x .40 = $112,000 Total Reserve.

$ 50.90 x .40 = $ 20.36 per acre Reserve.

X. Book Value of Block After First Cutting Period.

$$P.W. = \frac{\$102.3(1.04^3-1)}{.04 \times 1.04^{15}} + \frac{\$102.3(1.04^3-1)}{.04 \times 1.04^3 \times 1.04^{15}-1}$$

P.W. = $177 + $355

P.W. = $512/3 acres

P.W. = $170 per acre

Book Value = $170 x 5500 A. x .60 = $561,000.

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Problem Number 1

The attached stand table represents average conditions of stocking on a 5500-acre block of the Menominee Indian Reservation in Wisconsin. Under authorization from Congress, the timber on the Reservation is to be harvested under a sustained yield plan of management and the logs manufactured in the Menominee Mill at Neopit, the products being sold for the benefit of the tribe.

It will be assumed that the management at Neopit has adopted the policy of drafting a management plan for each block that it proposes to cut over and that a plan is to be drafted for this block in the light of the following data:

Stocking. It is recognized that the heavy stocking that exists in the uncut virgin stands is not necessary or to be desired under management. Cutting plans will, therefore, aim to reduce current stocking in the light of anticipated growth and existing overmaturity of the stands.

Cutting cycle. An effective cutting cycle of 15 years is to be adopted on all areas. Areas for which plans are drafted may be cut over in a shorter period than the cycle when necessary but will not be cut again for a period of 15 years.

Objectives of Management

A. Size of timber to be grown. Not definite. The reservation is large and an excess of mature timber is available. For the present, at least, timber from 25 to 30 inches d.b.h. will be the objective.

B. Species composition. Hemlock is a low value species and therefore every effort will be made to reduce the representation of this species in the residual stands. It is recognized, however, that it may not be desirable silviculturally or possible economically entirely to eliminate this species.

The present composition of "other species" is as follows:

Maple ---- 30%
Birch ---- 30%
Basswood & Pine --- 20%
Elm and Miscellaneous --- 20%.

Growth. Studies of growth for this block indicate that, under management, a growth rate of 0.2 inches per year can be anticipated.

A. Estimate the cut per acre of each species by size classes and by number of trees and volume in ft. b.m. that can be removed from this block during the first cycle.

B. Estimate in a similar manner the cut per acre at the time the next cutting cycle.

Logging Plan and Basic Cost Data.

The block comprises the timbered portions of Sections 19, 20, 21, 28, 29, 30, 31, 32, and 33 of Township T30NR15E. The main logging road from the mill at Neopit has been constructed to the southwest corner of Section 31 and located to run north from this corner following the west boundary of Sections 31, 30, and 19. The road distance from the S.W. corner of Section 31 to the mill is 7 miles.

To log this area this main road will have to be constructed north to the N.W. corner of Section 19 and spur roads constructed east into the aforementioned sections.

The timber will be skidded by tractors and teams to spur roads and loaded on trucks for transport to the mill. Loading will be accomplished by the ordinary A-frame jammers powered by teams. The topography is such that roads can be constructed on any desired spacing. Landings will be closely spaced and their cost will be negligible and therefore included in the following estimates of road construction cost. Due to the close spacing of landings all road spacing calculations can be based on direct skidding.

Felling and Bucking.

Two man crews will be used. Cost is estimated as follows:

	Cost per 8-hour day
A. Direct labor	
2 men at 80 cents per hour	$12.80
Plus 10% allowance for portal to portal pay	1.28
Plus 20% industrial comp. ins., etc.	2.82
B. Indirect costs	
Supplies and maintenance	1.00
Depreciation tools	0.25
Direct supervision and overhead	3.00
Total	21.15

Cost per man-hour -- 21.15/16 = $1.32

Estimated production per man-hour:

Hemlock -- 0.4 M ft. b.m.
Other spp. -- 0.3 M ft. b.m.

Skidding

Machine Rate for teams:

	Per Hour
Teamster and 1/2 time swamper @ $ .80	1.20
Social security and ind. comp. etc. at 20%	0.24
10% allowance for portal to portal pay	0.14
Depreciation team and harness	0.20
Feed and care of team	0.32
Total	2.10

Rate per min. - 3.5 cents

Average fixed time per turn	3.6 mins.
" round trip time per station	1.0 "
" load - 140 ft. b.m.	

Machine rate for tractor:	Per Hour
Driver @ $1.25	1.25
Hooker @ $ .90	.90
Social security, etc. @ 20%	0.43
10% allowance for portal to portal pay	0.26
Depreciation and supplies and maintenance tractor	3.76
Total	6.60

Rate per min. - $ .11	
average fixed time per turn	7.0 mins.
" round trip speed per station	0.8 "
Average load 700 ft. b.m.	

Loading

Skidding teams will power jammers as trucks arrive at loading points. The estimated loading rate is 15 minutes per M ft. b.m. The regular skidding team machine rate will apply to the cost of loading.

Hauling

A machine rate for the trucks which will be used on the operation is attached hereto. Unloading and delay time at the mill is estimated at 15 minutes per trip on the average.

Road Construction

The main logging road already constructed cost $10,000 per mile and maintenance costs are $200 per mile annually. The additional main road required is to be built to the same standard and costs are estimated to be the same. As the operation is essentially on a sustained yield basis this road investment is not to be amortized. Maintenance costs plus 6% on the capital cost are to be charged against the annual cut.

Trucks can maintain an average round trip speed on this main road of 20 m.p.h.

Branch roads. These roads are to be semi-permanent in character and are estimated to cost $1000 per mile. An average speed of 12 mph is estimated for these spur roads.

The entire cost of these spur roads is to be charged off against the cut of the first cycle. It is estimated that they can be put in condition for future use at the time of the next cut at a cost of $200 per mile.

Production

17500 M gross

The mill is estimated to require approximately 14000 M ft. b.m. net log scale per year for the next few years.

The stand is known to be over-mature and it is estimated that defect in the stands currently ready for cut will reduce the scaled volume at the mill to 80% of the gross log scale.

Therefore, all logging costs will have to be increased in proportion to the reduction of net scale to 80% of gross upon which logging costs have been calculated. Production will be planned to deliver at least 14000 M ft. b.m. net logscale at the mill.

Overhead costs

It is estimated that overhead and general supervisional cost chargeable to the woods operations will be $30,000 per year.

C. Estimate the cost of logs at the mill separately for hemlock and "other species" on the basis of a net outturn of 80% of the gross scale and production at the rate required by the mill.

Log Values

For purposes of appraising the value of this block of timber logs will be charged to the mill at the following prices net log scale:

Hemlock	$18.00 per M Ft. b.m.
Maple	27.00 " " " "
Birch	32.00 " " " "
Basswood and pine	35.00 " " " "
Elm and miscellaneous spp.	25.00 " " " "

D. Calculate the total stumpage recovery value from this block separately for the first and subsequent cutting cycles.

In calculating costs and recovery values for the subsequent cycles use the same basic costs as those for the first cycle but remember that branch roads will not have to be rebuilt, but only reconditioned at a cost of $200 per mile.

No reduction in gross scale need be made for defect in estimating the cut and value of the second and subsequent cycles.

E. The foregoing estimates and calculations are to be neatly prepared for attachment to a report to the Office of Indian Affairs.

This report is to include:

I. A brief discussion of the proposed management plan indicating or explaining:

   a. The method of determining the volume of the cut of the first cycle.

b. The method of estimating the volume of the cut of the second and subsequent cycles.

c. Silvicultural justification of the cutting plan.

II. A summary of the estimated stumpage recovery values.

III. Recommendations as to the handling of the funds which will be realized as a result of operations on this block of timber.

These recommendations have been requested by the Office of Indian Affairs. This block of timber is carried on the books of the Tribe at a value of $330,000 a figure based on a $3 per M stumpage value applied to the approximate gross volume on the block.

The Office of Indian Affairs desires advice specifically as to:

a. How much of the gross stumpage recovery of the first cycle may properly be credited to the Tribal Profit Fund for distribution?

b. What disposition should be made of the balance of the stumpage recovery revenue?

c. How and at what value the block should be carried on the books of the Tribe after cutting.

This portion of the report will involve appraisal of the block in the light of proper discount and allowance for risk and may be deferred until after discussion and assigned reading dealing with these matters. In other words, all computations are to be satisfactorily completed before preparing the report.

LAKE STATES REGION

MACHINE RATE FOR LOGGING TRUCK
(Based on 2000 Hour Year and 3 Year Life)

Fixed Cost per Hour

License and Insurance

Registration	$55.00	
Public liability: $50,000/100,000 plus $25,000 Property Damage	52.20	
Collision ($50 Deductible)	40.00	
Fire and Theft	32.00	
	$179.20	÷ 2000 hours = $0.09

Depreciation

Original cost	$3000.00	
Less tires	400.00	
	$2600.00	
Less wrecking value	200.00	
To be depreciated	$2400.00	÷ 6000 hours = 0.40

Labor (Michigan data)

Driver's wages	1.25
Social security, workmen's compensation, etc., at 20%	0.25
Total Fixed Cost per Hour	$1.99

Operating Cost per Hour

Oil at $0.30 per qt. - 10 qts. every 50 hours	0.06	
Repairs - average of $500.00 per year	0.25	
Greasing and general maintenance	0.05	
Fuel (average)	0.50	
Tires - $400.00 ÷ 1,000 hours	0.40	
Total Operating Cost per Hour		$1.26
Hauling Cost per Hour		3.25

Average load - Hemlock 2.5 M ft. b.m.
Other species - 2.0 M ft. b.m.

PER ACRE STAND TABLE FOR BLOCK X OF THE MENOMINEE INDIAN RESERVATION

	Hemlock		Other spp.		Total Stand		Hemlock		Other Species		Volume
D.B.H.	No. Trees	B.A.	No. Trees	B.A.	No. Trees	B.A.	Vol.per tree ft.b.m.	Total ft.b.m.	Vol.per tree ft.b.m.	Total ft.b.m.	Total stand ft.b.m.
10	5.5	3.00	8.0	4.36	13.5	7.36	30	165	30	240	405
12	4.0	3.14	6.0	4.71	10.0	7.85	80	320	90	540	860
14	4.0	4.28	5.0	5.34	9.0	9.62	130	520	150	750	1270
16	4.0	5.60	4.5	6.30	8.5	11.90	190	760	210	945	1705
18	3.8	6.71	4.0	7.06	7.8	13.77	270	1025	280	1120	2145
20	3.2	7.00	3.2	7.00	6.4	14.00	360	1150	360	1150	2300
22	2.8	7.40	2.7	7.13	5.5	14.53	480	1345	440	1190	2535
24	2.1	6.60	2.2	6.91	4.3	13.51	620	1300	530	1170	2470
26	1.5	5.54	1.5	5.54	3.0	11.08	770	1155	630	945	2100
28	1.0	4.28	1.0	4.28	2.0	8.56	910	910	740	740	1650
30+ (av.32")	1.0	5.59	1.0	5.59	2.0	11.18	1210	1210	1030	1030	2240
Total	32.9	59.14	39.1	64.22	72.0	123.36		9860		9820	19630

gross volume?