MANAGEMENT OF THE
FOREST LANDS
OF THE AHONEN LUMBER COMPANY
OF IRONWOOD, MICHIGAN

By

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THE GENERAL SITUATION

The northern hardwood and hemlock lumber industry is centered in northern Wisconsin and Upper Michigan. At the present time there are some 18 sawmills producing around 300 million feet of lumber in this area.[1] There are only eight large sawmills left in Upper Michigan that produce more than 5 million board feet of lumber annually. Several of these mills are expected to liquidate in the next five years.

With most large sawmills operating in the Upper Peninsula, the policy of liquidation has ensued since their beginning. Economic pressures added to the recent wartime demand for lumber and the high lumber prices in the post-war period have accounted for the preference of the average sawmill owner for this policy over one of sustained yield. The practice of sustained yield in Upper Michigan is followed largely by corporations owning considerable acreage of virgin timber bought at cheap stumpage prices years ago, among these are such corporations as Copper Range Company, Cleveland Clifts Iron Company, Oliver Iron Mining Company, and large paper mills (owning sawlog stumpage). These corporations have no voracious sawmills to devour a limited supply of timber. Instead they may either sell or hold stumpage depending on the market. The sawmill owner on the other hand, must cut part of his timber supply annually to satisfy the huge mill investment. Many of the larger lumber companies that own sawmills and timberland would like to change from a policy of liquidation to one of

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1/ Charles H. Stoddard, Jr., The "Two-Cut" System of Forest Liquidation in the Lake States Region, 3-4.

sustained yield, if such a change is at all possible.

Specific Situation

The Ahonen Lumber Company of Ironwood, Michigan faces the same problem that many of the mills of Upper Michigan and northern Wisconsin have had to face in the past two decades and are facing now. It is the problem of a company with a large investment in plant and equipment and small remaining supply of timber (small, from a sustained yield standpoint), whose mill was originally set up for liquidation. A company which has followed this policy for many years, and now, fully realizing that the years of operation are numbered must try to rejuvenate itself by changing over to a policy that would prolong the life of the company for a year at least, and possibly several decades.

The Ahonen Company never owned any great quantity of forest land until 1946, when they bought the holdings of the Ribb Lake Lumber Company.1/ For the past three years the company has been liquidating these forest lands at the rate of about 5% of the total volume per year.

However, Mr. Avrey A. Ahonen, president of the Company, fully realized that under a liquidation policy the years of operation were numbered. He wanted to know what forest management policy could best be adopted to prolong the profitable operation of this company. Mr. Ahonen initiated action which led to the organizing of a preliminary management survey in the spring of 1949. Briefly,

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1/ For a map of these holdings, see Map No. 1 in the pocket of the Appendix.

the survey evolved in the following manner. Mr. Roy Ahonen, son of the president, was, at that time, a senior in the School of Forestry at the University of Michigan, and had been doing some investigation on possible forest management changes. It so happened that the writer was looking for a master's problem at the same time. Mr. Roy Ahonen suggested to the writer that this would be an excellent problem for a thesis. The writer agreed wholeheartedly and immediate work was started. At first an attempt was made to construct a stand and stock table from the existing cruise data. It was soon found that these volumes were highly erratic and could not be used for sound management calculations; a new inventory (cruise) was needed to establish the true present condition.

The county and state regional foresters advanced information about the preliminary management surveys conducted by the Private Forestry Cooperation branch of the Michigan Department of Conservation (headed then by Mr. Ted Daw), and the State & Private Forestry Division of the United States Forest Service. Several visits to Mr. Daw's office in Lansing laid the groundwork for the survey to which, through the writer, the Ahonen Lumber Company fully agreed; the initial planning of the survey was started in June. During the month of August the survey was conducted by the company under the guidance of the three cooperating agencies (State & Private Forestry Division, Region 9 of the United States Forest Service, the Private Forestry Cooperation branch of the Michigan Department of Conservation, and the School of Forestry and Conservation of the University of Michigan-represented by the writer). The main objectives of the survey were to determine the volume inventory and growth rates which are basis for working out different forest management plans.

This thesis, which is largely based on the field data collected last summer (1949), should be credited to the field crews who collected it.[1/] Additional data were obtained from the Ahonen Lumber Company, the United States Forest Service, and the Copper Range Company. The purpose of the survey and of this thesis is to present the facts to the company with the various possible forest management policies that the company could follow. While a more intensive survey is needed to follow up either the two-cut liquidation or sustained yield plans, it is hoped that this thesis will serve as a basis for a policy decision for one of the two plans mentioned above. The writer has tried to be as unbiased as possible, with no attempt to present an evangelistic sustained yield Utopia sometimes adduced by "devoted" foresters.

The presentation of this thesis proceed in five major sections. First, the economic and social relations between this company and the town of Ironwood are analyzed. Second, the survey and its physiographic features are given detailed explanation and discussion. The basic data upon which the management plans are based appear here. Third, is an enumeration of management plans. Three major procedures of forest land management, liquidation, two-cut liquidation, and sustained yield are open to adoption. Fourth,

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1/ For a complete list of the field crew, see Page No. 1 of the Appendix.

logging plans are worked out for each major management plan. Fifth, a financial analysis of the management plans together with the various reasons which form the basis of company opposition to these plans, are presented.

Summary

The Ahonen Lumber Company in its infancy, some twenty-five years ago, consisted of a small gyppo logging outfit. Since then it has grown to be one of the largest industries in Ironwood, and has become an integral part of the economic and social pattern of the town. Since the company is family-owned, profits have not gone outside the community, but have been plowed-back into the business to expand the company, thereby further processing raw lumber and creating more employment. Lumber from other companies must be purchased to satisfy the requirements of some of these added processing units. The local wood using industries and many of the retail yards have become dependent on the company for their source of raw material. The wages paid to employees contribute to the flow of money in the community. Thus, many more people than those directly employed by the company benefit. In addition, taxes are paid to the local governments for roads, schools, and other public works.

From the picture presented, it is quite clear that liquidation of the company would have serious repercussions on the economic and social stability of the community.

A careful review of the physiographic factors indicates that the timberlands of the Ahonen Company, for the most part, are ideally suited to grow, produce, and regenerate northern hardwood-hemlock forests. This suitability is attested to by the fine growth and quality of the virgin forests and by excellent reproduction.

From the statistical analysis, it was found that volumes obtained from the survey are accurate only for top-level decisions of policy-making. A more intensive survey should be made if it is decided to follow either a two-cut liquidation or sustained yield plan. The volume figures arrived at are for the total acreage and cannot accurately apply to any particular section or forty. The total volume on 10,280 acres was found to be over 99 million board feet, Scribner Scale, with an average volume of nearly 10 M board feet per acre.

Selective cutting would be used for both sustained yield and the first cut of the two-cut liquidation plan. It was concluded that a 49% selective cut would be the best financially as well as silviculturally for the Ahonen forests. Straight liquidation at the rate of 6 million board feet annual cut will probably last the company around seventeen years. Two-cut liquidation with the first cut selective, would remove the same volume annually, and the operation would last nineteen years. Besides prolonging the period of operation two years, an additional 11.7 million board feet of timber would be removed, or an increase of 12.3% over straight liquidation. Under sustained yield, the annual allowable cut from the company's holdings was calculated to be 40% of the volume taken under either of the liquidation plans, roughly 2.4 million board feet (for the first cycle). The second and third cycles were calculated to yield only 25% of the 6 million board feet quota, 1.4 million feet annually in the second cycle, and 1.6 million feet in the third and subsequent cycles.

Cost and time analyses showed that the new system of logging, tree-length skidding, would be much more profitable than the present system of ground skidding. Total logging costs calculated for each plan of management indicate clear cutting (straight liquidation) is cheaper by $1.03 per M than selective cutting (two-cut liquidation or sustained yield). However, in calculation of these costs no attention was paid to diameter, and therefore these costs may be erroneous.

Sustained yield, although the most desirable form of forest management from the standpoint of conservation, stabilization of the industry and the community, does not appear financially feasible under present conditions. The main obstruction is the lack of adequate timberland to fulfill the required economical minimum cut of 6 million feet annually from company lands. With the heavy investment in plant and equipment and the present capacity of the mill, it is not economically possible to cut production back to meet the annual allowable cut (2.4 million board feet) of sustained yield.

From all evidence, a two-cut liquidation policy seems more financially advisable than sustained yield. Since two-cut liquidation would provide the amount of timber needed to satisfy the mill demand and would be much better than straight liquidation because of the larger volume taken off and a longer period of operation, this plan is recommended for adoption.

By following a two-cut plan the company still has eight years (the length of the initial cut) to decide on whether or not to convert to sustained yield. Meanwhile, by selective cutting, the forest will not be injured to such a degree that future growth, on which sustained yield depends, will be retarded. If sustained yield is contemplated, the company may choose one of the following lines of action: either revampment of their mill to a smaller capacity, or acquisition of additional land through outright purchase (or agreements with other companies), or a combination of both.

Company officials are inclined to believe selective cutting is more expensive than clear cutting. They fear also, that mortality, in a selectively cut stand, will be increased because of exposure and wind throw. They are particularly skeptical of sustained yield because of the reduction of income, difficulty of conversion, and the many other risks that go with such long term investments.

ECONOMIC AND SOCIAL ASPECTS

The economic and social features of this problem are inseparable, since every community must have an economic base for its foundation. If a portion of the economic base is taken away, that part of the community dependent on it will fall.

The business activity of this company is of major importance to the city of Ironwood.1/ The annual payroll and number of people gainfully employed, and the amount of taxes paid by the company to the local governments are evidence of a "community dependence". Neither the economic value of the goods produced and their part in the total national product, nor the value of the company's timber resources and manufacturing facilities should be slighted. All of these interdependent factors are presented here to clarify the economic and social importance of this industry.

The Ahonen Company benefits the community to a greater extent, in proportion to its investment, than the other industries in the community because it is home-owned, and the profits it accrues remain in the community and contribute directly to the social and economic growth of the community. The profits in past years have not been drawn out of the community, but have been plowed back into the business to provide more jobs, greater job security, and greater economic activity for the Ironwood area.

Moreover, the products manufactured by this company are used by other industries in the vicinity, such as the Peninsula Woodenware, Mt. Zion Ski Factory, Becker Trailer Company, and the

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1/ Town Population 13,569, Area Population 35,000 - Industrial Location Advantages of Michigan's Upper Peninsula.

many retail lumber yards in the community. Thus the presence of the Ahonen Lumber Company promotes and encourages the development of other wood using industries in the area, whereas the other leading industry, mining, contributes very little to the community directly, other than its payroll.

<u>History of the Company</u>

In order that the "character" of the company may be portrayed, a brief history is presented.

The Ahonen Lumber Company has made great progress in a relatively short time. It has only been through the honest business policy and sound economic management of the president and founder, Mr. Arvey A. Ahonen, that this company, starting out years ago as a small "gyppo" logging outfit, has become one of the largest lumber companies operating in the Upper Peninsula.

The company had its origin back in the early twenties when Mr. Ahonen started in the logging business with a crew of only five or six men. Through efficient logging and reinvestment of earnings, he was able to accumulate enough capital to purchase an old sawmill in 1936. The company was legally formed at that time, employing around thirty people in the mill and woods. During the war years, extraordinary profits were made. Soon after the war ended, when industrial goods were easier to obtain, Mr. Ahonen reinvested these wartime profits in new processing equipment (dry kilns and flooring plant), and replaced some of the older equipment with more efficient, up-to-date machinery (grain door plant and planing mill). Today this mill has grown to be one of the largest remaining in the Upper Peninsula, with one and one-half million dollars worth of timber resources and gross annual sales of over one million dollars worth of timber products, manufactured in plants worth three-fourths of a million dollars, employing some 230 people full time.

Economic Aspects

It is difficult to separate the economic and social aspects of this problem for they overlap. The economic aspect concerns more the financial position of the company itself than the benefits the community derives from it. The status of the following reflects the economic conditions of the company: extent of timber resources; manufacturing facilities (i.e. size, description, condition, and requirement of sawmill and other installations connected with the mill); and the annual amount and value of the products produced since 1946.

Timber Resources

The source of supply, or the owned and operated forest holdings, is under the name of a subsidiary, the Tula Forest Products Company. The Ahonen Lumber Company owns controlling interests in this subsidiary. The timberland which is owned outright and land where the company has cutting rights amounts to 16,184 acres.[1] This total acreage is divided into three main blocks: The Porcupine block, containing 2,162 acres, located on the southern boundary of Michigan's Porcupine State Park and three miles west of White Pine, Michigan; the Gogebic block, containing 5,450 acres, located about one mile east of the east side of Lake

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1/ See Page No. 2 in the Appendix for complete acreage breakdown.

Gogebic, and three miles due south of highway M-28; and the Tula block, containing 8,576 acres, located three miles due north of Tula, Michigan. Tula is situated on highway M-28 approximately eight miles northeast of Wakefield, Michigan.

Tula Forest Products has cutting rights until September 28, 1955 on the Porcupine block, at which time the land must be turned over to the State Park. Therefore, this land cannot be counted in the actual supply of timber resources for a sustained yield program; however, it acts as a supplementary timber supply during the present period of flux. The other two blocks contain both cut-over and virgin forest land. The actual working acreage was arrived at by subtracting muskeg, non-productive, and cut-over land acreage from the total acreage of the two blocks. This calculation left a working figure 1/ of 10,282 2/ acres of virgin hardwood timber. This 10,282 acres has 99,491 M board feet of sawtimber (Scribner Scale), 7,226 cords of pulpwood and 10,414 cords of cedar. 3/ At todays stumpage and land prices the value of all these forest holdings will total approximately $2,840,389.50. 4/ The Porcupine block has a negligible amount of pulpwood on it, but has 12,403 M board feet of sawtimber. This, added to the other blocks, makes a total sawtimber stand of 111,894 M board feet.

1/ This working figure is the total acreage of the Tula and Gogebic blocks upon which merchantable timber is found.
2/ See Page No. 2 in the Appendix for complete acreage breakdown.
3/ See Page No.49, Total Stand Table, Table X.
4/ See Page No. 3 in the Appendix for calculation of this value.

Manufacturing Facilities

Sawmill: The company operates a single-band mill which is relatively old but has been progressively modernized. This mill saws an average of ten million board feet annually, of which 60% is hardwood and 40% softwood lumber, with an average[1] operating year of 260 days, or 38,000 board feet per day. The mill is equipped with a resaw, an edger, and a trimmer, and is steam operated for the most part, having a "shot-gun-feed" carriage and having its own steam engine as a power source for almost all the sawmill machinery. Saw kerf from the sawmill and other producing units is utilized in the boilers. The economic production requirement for the sawmill, which is the minimum amount required to operate the mill and still yield a profit under present conditions, is eight million board feet annually.

Connected directly to the sawmill are the grain door plant and the planing mill.

Grain Door Plant: The grain door plant is seasonal, running from May thru December. The plant represents a small investment ($8,000.00) but yields a high profit during its period of operation. The plant was remodeled in early 1947 and has an average[2] annual production of 89,000 doors. The economic requirement is production of at least 100,000 doors.

Planing Mill: The planing mill is in constant operation and new equipment was installed this past summer (1949) at the cost of $15,000.00. The mill has an average[3] production of four million board feet of lumber a year. The economic requirement is around three million board feet annually.

1/ Based on four year period, 1946 to 1949 inclusive.
2/ Based on a four year period, 1946 to 1949 inclusive.
3/ Based on 1-3/4 year period, April 1, 1948 - December 31, 1949.

Dry Kilns: In the yard are four modern Moore dry kilns having an average 1/ production of 5.4 million board feet annually. These were installed in early 1948 at a cost of $83,000.00. The economic requirement of the kilns is six million board feet annually.

Flooring Plant: Under a separate roof is the flooring plant, a subsidiary of the Ahonen Lumber Company, called the Ironwood Flooring Company. It was built in September 1947 at a cost of $56,000.00 and has an average 2/ annual production of one and one-half million feet of hardwood flooring. The economic requirement of this plant is one and one-half million feet annually.

With the exception of the sawmill, all of these producing units are less than four years old, and in excellent condition. Only the grain door plant has been geared to the annual production of the sawmill. The other units demand more lumber (of a specific nature) than the sawmill produces. The following amounts are procured annually for the dry kilns, flooring plant and planing mill: one and one-half million, 250 thousand, and one-half million board feet respectively.

The aggregate replacement or selling value of all of these producing units plus yard equipment such as, trucks, bulldozer, lumber pilers, clam, and the garages, offices and repair shops is close to $750,000.00.

1/ Based on a 1-3/4 year period, April 1, 1948 - December 31, 1949.
2/ Based on a one year production, September 1, 1948 - August 31, 1949.

Rail transportation is provided by a spur line of the Chicago and Northwestern Railroad, running directly into the company's yard. Trucks haul logs and other timber products from the forest properties to the sawmill.

Amount and Value of Annual Products

The total amounts and values for products sold in 1946-1949 are listed in Table I. The table shows that the largest volume of sales of the post-war period was recorded in 1948. The 1949 figures are for a ten month period but are sufficient to show the general leveling off condition during that year. There is no immediate drop foreseen for 1950, but it is expected that sales will be about the same as in 1949. The 1949 figure is higher than that in 1946, but lower than for 1947.

Not included in this table is the production of the Ironwood Flooring Company, formed in late 1947. The following is the volume produced and sold for the period of one year ending August 31, 1949.

Ironwood Flooring Company Statement
September 1, 1948 to August 31, 1949

Amount produced .... 1,516,604 lineal feet

Sales $256,983.33

Table I indicates that in recent years the company has done over a million dollars worth of business annually. This fact is important economically to the productivity of the town and its contribution to the national product. Annually, the value of the products produced by this company may seem slight to the Gross National Product, but to the people of Ironwood it is a sizeable amount to make for a prosperous community.

TABLE I - <u>AMOUNT AND VALUE OF PRODUCTS PRODUCED</u>

Ahonen Lumber Company

ITEM	1946 Amount	1946 Value	1947 Amount	1947 Value	1948 Amount	1948 Value	1949* Amount	1949* Value	Yearly Average Based on 3 years 10 months Amount	Yearly Average Based on 3 years 10 months Value
Logs (board feet)										
Veneer	213,160	$20,928.89	279,940	$ 29,637.08	237,260	$ 24,731.68	175,242	$ 19,346.60	236,100	$ 24,690
Other	23,880	688.60					241,730	10,815.41	69,400	4,660
Lumber (board feet)										
Hardwood	4,656,128	414,867.31	4,990,532	480,411.15	8,608,555	781,040.21	5,172,999	462,965.16	6,119,000	549,950
Hemlock	5,946,206	259,143.32	3,283,060	243,582.50	4,861,701	241,154.62	3,231,770	147,862.27	4,550,000	233,000
Ties (Pieces)										
Hardwood	11,782	17,734.43	4,341	22,561.33	11,543	24,387.51	9,254	16,011.77	9,640	21,080
Cedar	4,251	4,927.05	5,063	6,251.97	2,086	3,180.03	2,045	3,638.40	3,670	4,700
Slabs (Loads)	1,300	10,306.58	1,854	14,809.16	2,889	19,818.46	2,467	14,588.93	2,225	15,530
Chips (Tons)	9,374.96	37,665.40	5,048.20	20,195.22	5,109.35	20,520.79	3,023.12	11,978.15	5,885	23,580
Grain Doors (Pieces)	97,522	144,669.22	85,075	135,735.00	102,128	135,688.90	59,070	62,491.00	89,700	125,000
Cedar (Pieces)										
Post and Poles	6,199	10,561.11	4,530	10,798.20	4,176	4,565.50	7,915	3,837.35	5,960	7,770
Lagging (Cords)	2,356.195	40,109.51	3,016.731	53,971.69	1,381.155	25,623.69	1,639.047	29,503.85	2,189	39,010
Mining Timber (Pieces)	32,490	47,236.00	21,340	63,322.80	35,255	65,828.89	26,453	56,341.41	30,180	60,800
Pulpwood (Cords)	2,188.07	31,010.38	2,314.64	22,203.16	1,379.18	23,341.99	280.12	4,770.12	1,610	21,230
Flooring										
Wholesale Lumber (bd.ft.)					324,858	23,503.77	78,890	6,677.02	220,500	16,470**
Flooring (Lineal)					1,317,003	241,333.10	1,083,129	184,646.70	1,312,000	232,500**
Hemlock Bark (Tons)							28.85	360.63	28.85	360.63
		1,003,100.32		1,103,489.26		1,434,619.14		1,035,834.77		1,195.00

* - Only a 10 month period January 1, 1949 to October 29, 1949.

** - Average for 1 year and 10 months only.

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Social Aspects

Social benefits to the community of Ironwood are derived from company actions which directly or indirectly profit the people of that area. Employment, money contributed to the town's income in the form of annual pay rolls, and the taxes paid to local governments are among these actions. Employment makes possible not only a means of livelihood to the persons directly employed and their families, but also results in income to merchants, to professional people, and to public utilities and others who benefit by the turnover of money paid to the company employees in the forms of wages and bonuses. Another profitable function is the paying of tax to local governments, in support of schools, roads, snow removal, highway improvements, lighting, fire protection, and salaries of public officials, not only in the town itself, but also in the sparsely settled communities where the timberlands of the company lie.

Number of People Gainfully Employed

The total number of people employed is broken down into four complementary units that form the whole industry. These components are the Ahonen Lumber Company, Ironwood Flooring Company, Tula Forest Products Company, and Logging Contractors. Listed in Table II are the number of employees and their families. The number of families is listed to point out "community dependence" on the company, and the type of employee found working in today's lumber industry. Gone are the days when the lumberjack and mill worker were single, irresponsible itinerants. Nowadays the average worker is usually found living in a stable community and developing a sense of social responsibility.

The post-war increase of further lumber utilization, grain door plant, flooring plant, dry kilns, and planing mill has increased the number of people gainfully employed. It is hoped that more intensive utilization practices will expand in the future.

<u>Amount of Annual Pay Roll</u>

The pay roll is an average annual figure for a three year period, 1946 through 1948. The gross average annual pay roll before deductions equals $656,511.00 (See Table III, Page No. 21). After deductions it equals $588,420.33. This is the payment to all the 234 people who were gainfully employed directly by the company and its subsidiaries. In the three post-war years recorded in Table III, 1948 was the largest pay roll. Reference to Table I, Page No. 16, indicates that in 1948 the most goods were produced, and the largest volume of sales were recorded. Naturally, wages have not always been at this high level. But it should be pointed out that when the increase in pay roll, that has occurred since the early days of the company, is multiplied by the average turnover in any community of from seven to eleven times 1/, it is easy to see the effect the growth of this industry has on the economic life of the community.

1/ Richard Ruggles, <u>An Introduction to National Income and Income Analysis</u>, 208.

TABLE II - NUMBER OF PERSONS GAINFULLY EMPLOYED

(As of December 24, 1949 pay roll)

COMPLEMENT	CATEGORY	NO.	TOTAL FAMILIES
Ahonen Lumber Company	Sawmill	29	
	Planing mill	3	
	Grain door plant	5	
	Dry Kiln	1	
	Lumber Yard	32	
	Wood & Chips	6	
	Logging	10	
	General Labor	5	
	Maintenance	1	
	Clerical	4	
	Management	5	
	Total	103	87
Ironwood Flooring Co.	Clerical	1	
	Production and Bldg. Construction	9	
	Total	10	9
Tula Forest Products Co.*	Clerical	1	
	Management	3	
	Total	4	2
Logging Contractors (includes mining timber operators, pulpwood operators, etc.)	Total	120	50
	GRAND TOTAL	237	148

* - There is a larger number of men working for Tula Forest Products Company, but they are paid by the Ahonen Lumber Company and then charged to Tula Forest Products Company.

The explanation of Table III: The pay roll figures of 1949 for the Ahonen Lumber Company were not available at this time. The Ironwood Flooring Company was not formed until September 1947. Hence the small amount of wages shown for 1947. In 1948 it operated at full capacity, but in 1949 it only operated with one-half the normal crew because of a decline in demand and a stock-pile of inventories built up in 1948. Tula Forest Products Company's pay roll shows a large yearly decline, the highest single pay roll being the six month period from June to December 31, 1946. This decline is due to a change in the accounting system (as explained in the footnote of Table II, Page No. 19 rather than any decreased production or number of employees. No figures were available for the 1949 pay roll. Only an average figure for the past four years was obtainable concerning logging contractors, so this was applied to each year to obtain annual pay roll amounts.

<u>Amount of Annual Taxes Paid to Local Governments</u> (See Table IV)

<u>Timberland Taxes</u>: The average tax rate on private lands varies among the four political townships that the company's land is in. These townships are Matchwood, Bergland, and Carp Lake in Ontonagon County and Wakefield in Gogebic County. The average tax rate was 21.56 mills, or 2.156% of the assessed value, during 1948. This tax rate was higher than in 1946 or 1947. The estimated value of the forest land for tax purposes was $298,680.00. This assessed value is less than 30% of the market value. The taxes on forest land have averaged $6,131.88 annually for a three year period 1946 to 1948.

TABLE III - AMOUNT OF ANNUAL PAYROLL

Complement	1946		1947		1948		1949		Average	
	Gross	Net	Gross	Net	Gross	Net	Gross	Net	Gross	Net
									3 years	
Ahonen Lumber Company	$242,279.74	$221,260.04	$321,482.77	$296,844.66	$397,482.77	$371,432.49			$320,415.09	$263,179.06
									2 years 3-1/2 months	
Ironwood Flooring Company			6,699.66*	6,455.06*	57,024.67	53,708.44	$36,866.11**	$34,745.63**	44,350.00	41,450.00
									3 years	
Tula Forest Products Co.	38,711.53	33,429.65	29,576.30	24,302.63	6,275.61	5,405.35			29,580.00	24,510.00
									4 years	
Logging Contractors average figure	290,000.00	249,140.89	290,000.00	249,140.89	290,000.00	249,140.89	290,000.00	249,140.89	290,000.00	249,140.89
									3 years	
TOTAL	$570,991.27	$503,830.58	$647,758.73	$576,743.24	$750,783.05	$679,687.17			$656,511.00	$588,420.33

* - 3-1/2 month period only

** - 1/2 of full crew only

__Property Tax__: The Property tax is applied to the various buildings and equipment owned by the company. It averaged $5,099.79 for the three year period 1946-1948. Reference is made to Table IV below. The large increase from 1946 to 1947 is due to new installations such as the grain door plant and the flooring plant. In 1948 the new dry kilns and other improvements were the reason for the large increase that occurred.

TABLE IV - __AMOUNT OF ANNUAL TAXES__*

YEAR	TIMBERLAND TAX	PROPERTY TAX
1946	$6,034.54	$2,902.09
1947	6,312.78	4,916.90
1948	6,443.01	7,480.38

* - See Page No. 5 Table D in Appendix for breakdown of tax rate by blocks.

__Effect on Community if this Particular Industry was Liquidated__

Although the question of the effect on the community upon liquidation of the Ahonen Lumber Company seems remote at the present time because of the 17-19 year supply of timber under liquidation, one should not lose sight of social responsibilities as a part of long range forest management.

As Stoddard 1/ has pointed out in connection with the concept of time preference, human nature is "impatient for the satisfaction of immediate and near future wants without particular regard for the somewhat distant future". Impatience seems very logical,

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1/ Charles H. Stoddard Jr., __op. cit.__, Page 7.

especially when it is applied to this case and the more distant future is seventeen to nineteen years.

However, some effects will be felt before this time is reached. Revenue to the local governments will diminish year by year as more land is cut-over. Much of this land will be sold to small "gyppo" pulpwood and mining timber operators who will scavenge the last merchantable crop off and then let the land go as tax delinquent, the administration of which is generally taken over by the National Forest or the State. This administration of potential forest land must be borne at public expense even though private industry created the state of non-productiveness.

One of the more important effects of this liquidation is the problem of employment. The Ahonen Lumber Company's sawmill and other plants provide full time employment for 125 people. The logging operations go on during both summer and winter, usually providing year round employment for 120 more men connected with logging. (See Table II, Page No. 19). It should be remembered that a high percentage of these employees are skilled and semi-skilled labor. This percentage is significant when it is pointed out that this is one of the few remaining large scale operations in the immediate vicinity of Ironwood. Upon liquidation, many of these people with a definite trade will not be able to find employment in Ironwood; therefore a shift of this population to some area where their skill is employable may be necessary in order for them to keep the high wage rate of the skilled-unionized logging and sawmill worker. A fair share may be absorbed by other industries in Ironwood at this future date, but at present there seems to be insufficient number of (or variety of) employment opportunities to offer the younger age group.

The "folk depletion"[1] of 234 employees and their families with an annual pay roll of over one-half million dollars would be a severe blow to the economic stability of the town of Ironwood. If the annual pay roll has a turnover of from seven to eleven times, it is evident that local merchants would suffer a sharp decline in business. The Chicago Northwestern Railroad would lose a good customer, as would many of the local sawmill and logging equipment suppliers. The nearby wood using industry and local retail lumber yards dependent on the company for their basic material would have to revert to bringing their needs in from outside areas, presumably at higher prices.

A brief summary of the economic and social aspects of the problem discloses that the Ahonen Lumber Company is very important to the economic stability of Ironwood, Michigan. The company has grown from a small gyppo logging outfit to one of the largest business establishments in the community. Being family owned, its profits have continually been plowed back into the business, thereby furthering the process of lumber utilization and creating more employment. Other wood using industries have become dependent on the company as a source of raw material.

The company has physical assets valued at $2,840,369.50 present market value in the 16,184 acres of timberland, including some 110 million board feet of northern hardwoods, and at $750,000.00

1/ A. E. Wood, Community Problems, 7.

present market value in the sawmill, planing mill, dry kilns, grain door and flooring plants. A variety of products are produced such as hard and softwood lumber, ties, poles, posts, lagging, flooring, mining timbers, and pulpwood, which have an average annual sales value of over $1,000,000.00.

The company provides employment for 237 people representing 148 families, an an average annual gross pay roll of $656,511.00. Property taxes on timberland and mill were approximately $14,000.00 in 1948.

From the facts presented, it is very clear that the community is partially dependent on the company for employment, income, taxes and business activity, and liquidation of the company would have a disastrous effect on its economic stability.

BACKGROUND FOR MANAGEMENT AND LOGGING PLANS

This section covers: (1) the legal description, physiography, and forest type, of the land which indicates the probable extent of profitable forest management, and (2) the description and results of the survey, including the method of survey outlined in the body of the report, which is elaborated in the Appendix, and the results drawn from the field data.

Description of Land

The land is described legally for purpose of location and ownership, physiographically for silvicultural background, and by forest types for management planning.

Legal Aspects

The Ahonen Lumber Company owns a total of 16,184 acres of land divided into three blocks: the Tula, the Porcupine, and the Gogebic blocks.

The Tula block encompasses parts of and whole sections in the following townships:

T 48 N, R 44 W Section 4[1/]
T 49 N, R 44 W Sections 4,6,7,18,20[1/],28,29,30,31,32,33
T 50 N, R 44 W Sections 28[1/],29,32[1/]
T 49 N, R 45 W Sections 2,12[1/]
T 50 N, R 45 W Section 34[1/]

The Porcupine block encompasses parts of and whole sections in the following townships and sections:

T 50 N, R 43 W Sections 3[1/],4
T 51 N, R 42 W Sections 32,33

The Gogebic block encompasses parts of and whole sections in only one township:

T 48 N, R 42 W Sections 13[1/],14[1/],15[1/],20,22,23,24[1/],25[1/],26,
27[1/],28,35[1/],36[1/]

1/ Ahonen Company owns only a portion of section.

A breakdown by sections appears in the Appendix (See Table A, Page No. 2). The lands for the most part lie in Ontonagon County with the exception of seventeen forties which are located in three sections lying in Gogebic County. Table V shows how the acreage of the three blocks is divided into virgin timber, cut-over, and "no-value" land.

The Porcupine block is the smallest of the three and includes parts of four sections. It is less than 2 miles from north to south and less than 3 miles across. The Tula block extends some 8-1/2 miles from its northern to southern boundaries, and 2-1/2 miles from east to west. This block is the most checkerboarded one. The Gogebic block is very compact: 4 miles from north to south and 3 miles from east to west.

TABLE V - AGGREGATE ACREAGE

BLOCK	No. OF SECTIONS	MERCHANTABLE ACREAGE	No. OF FORTIES	CUT OVER ACREAGE	No. OF FORTIES	NO VALUE ACREAGES	No. OF FORTIES
Porcupine	4	1320	33	920	23	0	0
Tula	18	7720	193	1200	30	0	0
Gogebic	11	3000	75	1320	33	120	3
TOTAL	33	12040	301	3440	86	120	3

GRAND TOTAL 16,184 Acres 390 Forties

Physiography

The three physiographic features taken into account here are climate, topography and drainage.

Climate: The Ahonen Lumber Company's timberland situated in a latitude of 46° North has cool summers and long, cold winters.[1] The climate is principally influenced by two factors: nearness of Lake Superior and the altitude[2] variation of from 600 feet above sea level in the Gogebic block to a 1000 to 1200 feet in the Tula and Porcupine blocks. The proximity of Lake Superior is the more important factor, resulting in temperature moderation, reduction of frost occurrence, and consequently a longer growing season, and in addition, low percentage of sunshine, low wind velocity, low evaporation, and low humidity exist.

The average growing season is 82 days. Mean annual precipitation is 32 inches, with the largest amount, 14 inches, coming during the growing season; precipitation is otherwise fairly well distributed throughout the year. The probability of rain increases for any ten day period until the first of July, and decreases thereafter until the early fall rains. Total snowfall averages 140 inches, usually settling about the three foot mark. Although the mean annual temperature is 40° F., temperature ranges from 47° below zero to 100° F. above.

1/ U.S. Department of Agriculture, Forest Service, Management Plan Paint River Working Circle, 3.

2/ An Analysis of the Potentialities, Physical, Economic, and Social of the Management of the Timberland of Gogebic and Ontonagon Counties, Michigan, 2.

Killing frosts have been recorded for each week of the year, although the average date of the last killing frost in the spring is June 10th; the average date of the first killing frost in the fall occurs September 1st. The winters are long and frequently extremely severe, with normal mean temperature below freezing until March.[1] Snow usually covers the ground from mid-November to the first week in April, and usually comes early enough to prevent freezing of the soil. The period of warm weather is correspondingly short and is characterized by a moderate temperature with a seasonal average, June to August, of 61° F. Prevailing winds are westerly.

"Freeze-ups" may be expected at any time after October 15th, but occur on the average about November 1st. The temperature begins to moderate in late March, resulting in what is known in the Northern Lake States as "spring breakup". This period, during which the frost is coming out of the ground, lasts from 4 to 6 weeks. The growing season for forest trees begins about May 10th and lasts until late August; "shoot" growth is completed by mid-June.

1/ J. O. Veatch and James Tyson, Reconnaissance Soil Survey of Ontonagon County, 76-77.

Topography and Drainage: Most of the Porcupine block is located in rugged, semi-mountainous land, consisting of many hills, basins, and high ridges roughly parallel separated by valleys filled in deeply with glacier debris. This block does not lie in the main part of the Porcupine Mountains, but rather on one of the ridges and series of detached knobs which rise a few hundred feet above the plains southeast of the main branch of the Porcupine Mountains.

The northernmost part (two northern sections) of the Tula block lie just within the extreme southern range of the Porcupine Mountains. Extending south from the northernmost part of the Tula block for 3 to 4 miles, the land becomes rolling and hilly, being part of the range of rock knobs that have a northeast-southwest trend across this area (just south of the Porcupine Mountains). Although many of the rock masses exhibit bold slopes 100 to 300 feet high facing south or southwest, the range on the whole does not rise to any great height above the plains. These knobs must have been the higher outstanding features of the old pre-glacial topography in this part of the country. Their tops are but thinly covered, there is a noticeable absence of trees of any size on the topmost parts, even though the stocking seems quite heavy on the slopes on all sides below the tops. The general elevation of the knobs is 1200 to 1400 feet above sea level. This rolling and hilly character gradually gives way to fairly level terrain with dry, flat-bottom, filled-in valleys. Basins containing dried lakes and swampy tracts are also characteristic.[1]

1/ J. O. Veatch and James Tyson, op. cit., 73-75.

The Gogebic block is level, with hardly any slope. This area is composed largely of swamp land, some productive and some non-productive. "Islands" or "fingers" of higher land reach out into the swamps.

The Porcupine block is not drained by any large sized stream, but rather by numerous small intermittent streams which flow into the Iron River and into other large streams that eventually reach Lake Superior.

The Tula block is drained principally by the Presque Isle River, only large stream in the block. The small streams, intermittent and continuous, generally flow in a southwest direction into the Presque Isle, which flows in a northwest direction into Lake Superior.

The Gogebic block is drained only in the northern part, by small intermittent streams which eventually flow into Bergland Creek and the West Branch of the Ontonagon River. The presence of stagnated swamps in the southern part of the block indicates very poor drainage.

Soil: Surface geological formations in the Ontonagon and Gogebic County area are glacial deposits of several kinds, origin, topographic expression, such as moraines, till plains, sand and gravel plains of aqueological origin, and deposits of old glacier lakes.[1]

1/ J. O. Veatch and James Tyson, op. cit., 83.

The soil varies from the Gogebic stony plains to larger areas of the Porcupine rock knob type. The principal soils in the uplands are sandy loams and light loams. In addition, there are several large swampy areas with the usual peat and muck soils. Conifers take up the drier sandy sites, and hardwoods the rougher loam and clay soils.[1/]

On well drained sand soils, which are pervious in structure and therefore low in absolute content of moisture, the dominant tree is (or was originally) white pine. Generally, where the clay type of soil predominates, the forest growth is characterized by an association of white pine, balsam fir, and white spruce, with a scattering of hardwoods. Aspen or popple form an unusually dense cover on this type of land soon after logging or after a burn. Deep sandy loam or loamy sands are soils of medium high fertility and where well drained are occupied by mixed hardwoods and hemlock stands. The moist areas of such soils are characterized by the absence of basswood and by an increase in the amount of yellow birch and eastern hemlock. Where these soils are not well drained, that is, where water stands stagnant for a portion of the year, the area is occupied chiefly by soft maple, black ash, and American elm, and takes the character of the swamp hardwood type. An association of hardwoods, mainly hard maple and yellow birch, with less basswood and elm, generally denotes a well drained, loamy, deep and penetrable soil, naturally the most fertile. This land

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1/ An Analysis of the Potentialities, Physical, Economic, and Social of the Management of the Timberland of Gogebic and Ontonagon Counties, Michigan, op. cit., 2 may be very stony and steep. Where hemlock is dominant or comprises a large portion of the forest association with hardwoods, the soil is generally sandy and intermediate in texture, structure, moisture content and fertility. The drier peaty soils of the swamps are characterized by a growth of northern white cedar, white spruce, and a few scattered white pine. Wetter soils support black spruce and tamarack, as well as willows, alder, cassandra, and blueberry. Still wetter soils and open bogs are characterized by sedges and other herbaceous aquatic vegetation. The peat and muck soils of the swamp areas are usually fertile but productivity is determined largely by drainage features. The drier areas support white cedar and balsam fir, while the wetter areas support black spruce and tamarack. The undrained stagnated swamps or muskeg are usually devoid of tree growth, and such trees as do occur are dwarfed and never produce merchantable timber.[1/]

The soils of the three blocks are classified as follows as to productivity and fertility.[2/]

Class A, lands of from moderate to high fertility, possessing good drainage.	Ontonagon Clay Ontonagon Silt Loam Ontonagon Fine Sandy Loam
Class B, lands of from low to moderate fertility, in part stony and otherwise unfavorable.	
Fair drainage	Porcupine Loam
Poor drainage	Bergland Clay Ewen Fine Sandy Loam

1/ J. O. Veatch and James Tyson, op. cit., 84-87.
2/ Ibid. 82

Class C, lands of from extremely low fertility, and poor drainage	Rough Stony Land Peat and Muck Soils

A brief discussion of these soils follows:[1]

Ontonagon Silt Loam occurs in the southern part of the Porcupine block, which is made up of gently rolling plains, trenched by northward flowing streams, and has good drainage. The forest growth is mixed hardwood-coniferous. There appears to be a relation between the variation in texture, the drainage and the moisture of the soil, and the dominance of one particular species. The principal hardwoods are hard maple, yellow birch, and basswood, with a few ash, elm and ironwood. The principal conifer is hemlock with northern white cedar, white spruce, and white pine trees occurring less frequently. The tree growth is so dense as almost to inhibit herbaceous or shrubby undergrowth.

Ontonagon Fine Sandy Loam is found in the northeastern section of the Porcupine block only, which is nearly level but generally has sufficient slope to provide adequate drainage. The forest growth is mixed hardwood-conifer type in which hemlock apparently is the dominant species. There is a scattering of white pine which attains a large size.

Rough, Stony Land found in the northern portions of the Porcupine block and in the two northernmost sections of the Tula block. If the existing growth can be used as an indicator, the value of this land for forestry purposes is low. On account of the shallowness

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1/ J. O. Veatch and James Tyson, op. cit., 86-97.

of soil and the impenetrable bedrock, which resists root development, neither rapid growth nor large growth can be expected. This land embraces most of the thinner and stonier soils of the rock knobs of the Porcupine Mountains. The tree growth consists of a mixture of hardwoods and conifers, with hardwoods predominant, especially on the deeper soil or that which approaches the Porcupine Loam type. Soft maple and rock elm are more abundant on this type of soil than elsewhere. Probably the stand is thinner and the individual trees are smaller here than on any other land, because of the scantiness of soil rather than the lack of fertility in what is present. On the thinnest soil on rocky slopes the conifers seem to predominate. White pine, spruce, balsam fir, and northern white cedar grow here, although their growth is stunted, particularly that of white pine. Red oak is found in places on the crests of knobs of the Porcupine Knob type.

Porcupine Loam is the most widespread of the soil types, being found in small quantities in the Porcupine block, almost entirely covering the Tula block, and covering about one-fourth of the Gogebic block. The soil is characterized at shallow depths by a reddish bed of stone, gravel, sand, silt, and clay, moderately pervious and penetrable, but apparently not excessively dry. The soil is fertile, producing a dense forest of hardwoods, and of a very rough and stony character. The dominant species is hard maple, with yellow birch and basswood. There are scattered conifers, principally hemlock and some white pine, the proportions of the latter apparently increasing with the sandiness and perviousness of soil.

Ontonagon Clay is found in the Gogebic block. The clay is compact in structure, relatively impervious, and difficult to penetrate; it is highly retentive but it is probable that a very high percentage of water held is unavailable for plant use. It is strongly cohesive when saturated and becomes extremely hard or very tough upon drying. Because of the abundance of this soil type, it is necessary to winter log the whole block. The land in this tract is completely flat and does not have sufficient slope to carry off excess rainfall. The original forest was dense and consisted mainly of white pine with variable percentages of hardwoods, spruce, and balsam fir. Where the soil is characterized by relatively greater thickness of the gray layer and by coarse texture, there is more hardwood; on the less well-drained land and darker soil there is a higher percentage of white pine, spruce and fir.

Bergland Clay type soil occurs in scattered areas only in the Gogebic tract and is closely associated with Ontonagon clay. It occurs in the shallow depressions of flat land, which are poorly drained but not permanently wet enough to allow accumulation of any considerable thickness of peat.

Ewen Fine Sandy Loam is found only along the Presque Isle River in two sections in the southern part of the Tula block. It is a recent alluvial soil occurring at the flood plane of the river. The surface varies from level to slightly hummocky, and the land is high enough above stream level to be dry and well aerated ordinarily, but is subject to occasional inundation.

Peat and Muck exists in the Cogebic tract, mostly in combination with Bergland clay; they are intermingled in the larger areas of Ontonagon Clay and Porcupine loam. This soil appears in separate bodies or in narrow elongated strips having no drainage outlets. Some of the larger bodies apparently are former lakes filled by vegetation; others are simply an accumulation of humus on the flatter and more poorly drained land which may be only slightly depressed below the surrounding country. The forest growth in the drier swamps is chiefly cedar, white spruce, fir, and in a few scattered places, pine; in the wetter and more permanently saturated parts black spruce and tamarack may predominate, along with willow and several species of shrubs.

Forest Types

Some of the terms used in the Acreage Tables (Tables VI and VII), and in the discussion of Timber Types, definitions of Size or Age Classes and of Stocking terms as follows:

Description of Size or Age Classes

REPRODUCTION - trees 1' in height to 1" d.b.h.

SAPLINGS - trees 1" in d.b.h. to 4.9" d.b.h. (2 & 4" d.b.h. classes)

POLES - trees 5.0" d.b.h. to 8.9" d.b.h. (6 & 8" d.b.h. classes)

SMALL SAWTIMBER - trees 9.0" d.b.h. to 14.9" d.b.h. (10, 12 & 14" d.b.h. classes)

LARGE SAWTIMBER - trees 15.0" d.b.h. and larger (16" and larger d.b.h. classes)

Stocking

GOOD - area well stocked (70% plus), little or no growing space wasted.

MEDIUM - area moderately well stocked (40-70%), trees more widely spaced or bunched so that considerable growing space is utilized.

POOR - area lightly stocked (10-40%), trees widely spaced or large openings present.

Acreage: Table VI presents the acreage of the three blocks, broken down by tree types into age or size classes as defined above. Since the mixed hardwood-coniferous type is an all-age forest, there is usually more than one age class present on any given acre. However, the acreage is classified on the basis of the predominant size class, whatever type it may be. Table VII shows the total acreage, regardless of block, of the various timber and non-timber types. In making up these tables, the degree of stocking was disregarded.

TABLE VI - ACREAGE OF TIMBER TYPES BY AGE CLASSES*

Block	Total Acreage	Mature Sawtimber					Small Saw Timber		Poles			Saplings						Non-Productive**		
		NH	H	SH	WC	WP	BS	WC	BS	WC	A	NH	BS	WC	A	SF	T	MK	BR	O
Porcupine	1192	1164	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	1192																		
Gogebic	3000	947	977	98	-	40	37	12	156	314	17	18	76	31	84	2	11	207	-	-
	Total	2062					49		461			222						207		
Tula	7531	6551	580	77	195	-	-	-	44	-	17	-	9	13	11	-	-	-	22	12
	Total	7403							61			33						34		
Total Tula & Gogebic	10,531	9465					49		521			255						241		
TOTAL ALL BLOCKS	11,723	10,657					49		521			255						241		

NH - Northern Hardwoods
H - Hardwood-Hemlock
SH - Swamp Hardwoods
WC - Northern White Cedar
WP - White Pine
BS - Black Spruce
A - Aspen
SF - White Spruce-Balsam Fir
T - Tamarack
MK - Muskeg
BR - Brush
O - Open

* - For type map of area see maps of Logging Plans (Nos. 4-6) in pocket of Appendix.

** - Does not include cut-over, non-productive land classified by forties.

TABLE VII - AGE CLASSES OF TIMBERLAND

TYPE	MATURE SAWTIMBER	SMALL SAWTIMBER	POLES	ACREAGE SAPLING	TOTAL
Northern Hardwoods	8662	-	-	18	8680
Hemlock	1585	-	-	-	1585
Swamp Hardwoods	175	-	-	-	175
White Cedar	195	12	322	44	573
White Pine	40	-	-	-	40
Black Spruce	-	-	200	103	303
Aspen	-	-	34	95	129
White Spruce-Balsam Fir	-	37	-	2	39
Tamarack	-	-	-	11	11
Total	10657	49	556	273	11535
Black Spruce stagnated swamp (Muskeg)					154
Brush					22
Open					12
Total non-productive					188
GRAND TOTAL					11723

Timber types: The forest land of the Ahonen Lumber Company falls into three broad classifications: virgin timber, cut-over, and non-productive. The last includes brush, open or grassy land, muskeg, and stagnated swamps where black spruce and tamarack may grow but not to any merchantable size. This non-productive area is found dispersed throughout the virgin timber and includes land classified by forties as non-productive. The virgin timberlands have been typed as follows: northern hardwoods, hemlock, swamp hardwoods, white cedar, white pine, black spruce, aspen, white spruce and balsam fir, and tamarack. A brief description of each of these types follows:1/

Northern Hardwoods consist of sugar maple and yellow birch in different proportions, sometimes with smaller and varying admixtures of basswood, soft maple, hemlock, red oak, white ash, white pine, balsam fir, black cherry, paper birch, American elm, and white spruce. At times the maple appears in almost pure stands. The northern hardwoods contain the highest percent of mature sawtimber acreage (81%), but little sapling acreage (only .2%). There is no pole or small sawtimber acreage; however, practically all the areas of hemlock (and some northern hardwood) have sapling and pole understory of Northern hardwoods. Of the total productive land the northern hardwoods occupy 76%. Volumes range from 1 M bd.ft. to 26 M bd.ft. per acre, averaging around 10 M bd.ft. for the overall area. The northern hardwoods are exceptionally well stocked and are classified for the most part as good stocking. The stocking of the sapling age is typical "dog-hair" wherever it occurs.

1/ Management Plan Paint River Working Circle, op. cit., 8-13.

Hemlock occurs in pure stands or predominates over any single associate. The sugar maple, yellow birch, basswood, soft maple, black cherry, white ash, balsam fir, white spruce, white cedar, white pine, paper birch, and red oak may be associates. Next to the northern hardwoods, of which maple is the most numerous, hemlock predominates, occupying 14% plus of the total mature saw-timber acreage and 13% of the total productive land in the Ahonen tracts. This acreage may seem relatively small, but there is considerable hemlock scattered throughout the northern hardwood type. There is very little hemlock reproduction, which is favorable, because hemlock is a relatively low valued species, and most of the areas have been seeded in quite heavily by the northern hardwoods. Some of the best hemlock grows in the Gogebic tract in pure stands or in combination with very high quality yellow birch, both of which seem to grow in the finger-like peninsulas extending into the black spruce and tamarack swamp areas. For the most part, the hemlock areas are classified as good stocking.

Swamp Hardwoods are mainly composed of black ash, American elm, and soft maple in different proportions, which predominate over any other species in the mixture. Associates are balsam fir, aspen, yellow birch, and, less commonly, white pine, tamarack, northern white cedar, and basswood. The swamp hardwoods occupy a very minute amount of Ahonen acreage amounting to 1.6% of the mature sawtimber acreage and 1.5% of the total productive land. However, they are intermingled with the northern hardwoods and hemlock in many of the moist areas and their volume is much higher than the acreage percentage indicates. Reproduction of the swamp hardwoods seems to be slightly increasing. Most of the reproduction is coming in under swamp hardwood virgin timber with small amounts coming in on wetter northern hardwood and drier cedar-spruce sites. The reproduction is not as thick as that of northern hardwood "dog-hair". These areas can mostly be classified as good stocking.

White Pine occurs in pure stands or predominates over associate species, and it may have red pine, aspen, paper birch or other northern species admixed principally as subordinates. White pine appeared very widely scattered in the Tula block and was chiefly concentrated in part of the Porcupine block and the southern part of section 36 of the Gogebic block. At no place was the concentration heavy enough to be classified as a pure stand. The predominating mature acreage is only classified in the Gogebic section and is .4% of the mature sawtimber area and only .35% of the total productive acreage.

White Cedar occurs in pure stands or predominates over the associate species, however associates are usually coordinate and include tamarack, balsam fir, yellow birch, paper birch, black ash, soft maple, black spruce, white pine and hemlock. Sometimes there is an undergrowth of alder. White cedar is more evenly distributed among age classes than any other type. While the mature saw logs are used for lumber, smaller cedar has the advantage of being able to command fair prices at lower age classes as posts and poles. The total amount of all ages of cedar represents 5% of the total productive acreage, 1.8% of the mature sawtimber, 25% of the small sawtimber (which would probably be utilized as poles), 58% of the pole size (many of these could be utilized as posts), and 16% of saplings. Much cedar reproduction is coming in on many of the swamp sites now occupied by the sapling and pole size black spruce and spruce-fir. The stocking of the mature cedar is good but there is a high percentage of other species mixed with it. The small sawtimber, poles, and saplings are usually of medium stocking.

Black Spruce is found in pure stands or mixed with minor proportions of balsam fir, tamarack, northern white cedar, black ash, soft maple, and occasionally paper birch. Black spruce is not important except as a pulpwood species, most of which is found in the Gogebic block. It occupies 2.6% of the total forest acreage, having 36% of the pole age class acreage and 38% of the sapling age class acreage. The pole age class is considered the merchantable age class for this species. In most places, the stocking is medium. A large stagnated black spruce swamp occurs in section 26 of the Gogebic tract.

Aspen type may contain aspen, large-tooth aspen, and balsam poplar, single or in combination, or predominating. Principal associates are paper birch and soft maple, but any of the northern forest species may occur. The majority of aspen is concentrated in the Gogebic block although some is found in scattered places in the Tula block. Aspen occupies 1.1% of all the productive acreage, 6% of the merchantable pole size, and 35% of the sapling age. The stocking varies from good to medium.

Spruce-Fir type, (usually pertaining to white spruce) contains balsam fir, white spruce, and paper birch; there are mixtures of these species in which white spruce and balsam are the key species although they may not always predominate. Aspen, black spruce, may also occur in the mixture, and less commonly, white pine, northern white cedar, sugar maple, ash, and yellow birch. There is very little of spruce-fir located on the Ahonen land; what there is, is located in the Gogebic block and only occupies .34% of the productive land. However, it accounts for 75% of the small sawtimber. This is mostly white spruce over 9" d.b.h. and some balsam and accounts for .7% of the sapling acreage. Since spruce and balsam are very widely distributed among the other types, especially northern hardwoods, hemlock and swamp hardwoods, the actual stocking except in the small area in the Gogebic tract is very scattered.

Tamarack exists in pure stands or as the predominating species. Common associates are either black spruce or northern white cedar or less commonly both. Other associates, mostly subordinate, include soft maple, black ash and aspen. There is only one small stand of sapling size of pure tamarack. This is .1% of the whole area and 4% of the sapling acreage, and this occurs in the Gogebic tract. The stocking is medium. Tamarack occurs in varying degrees as an associate of the black spruce in many of the swamps in the Gogebic tract.

The following terms are applied to the non-timber types:

Muskeg refers to open bogs. Predominating vegetation is leather leaf or sometimes Labrador tea. There may be a few stunted black spruce or tamarack of insufficient density to be considered a timber type. The stagnated black spruce swamp is closely related to this type and occurs only in the Gogebic tract on a large portion of section 26 occupying 1.3% of the total land.1/

Brush refers to lands without forest cover, often supporting alder in swamps and willows on highlands. This type occupies .27% of the total land; it occurs mostly along streams in the Tula block or in association with the open type.

Open refers to lands without forest cover, usually supporting grass or similar growth as the major vegetation. Such lands may be either highland or swamp occuring along streams in the northern part of the Tula block and occupying .14% of the total land area.

Site: There were no specific data gathered during the survey to establish site quality. The site appeared (from the total height of trees measured) to vary from fair to good throughout. In the Tula block on the tops of rocky knobs the site was very poor; it was also poor for sugar maple on the rough stony land in this area. The best site for hemlock and birch seemed to be in the Gogebic block.

1/ "Total land" in the non-timber types refers to the total area of virgin timberland plus those areas of non-productive land included within the virgin timberland and not the non-productive forties.

Survey

The survey conducted by the Ahonen Lumber Company with the cooperation of the Michigan Department of Conservation, the University of Michigan Forestry School, and the United States Forest Service, had as its objectives the determination of the following:

(1) The total volume of standing timber.

(2) Its vigor characteristics.

(3) The growth potential of good vigor trees following a selective cut.

(4) The species represented in the stand.

(5) The apparent quality of the low vigor portion of the stand.

Survey Plan

A statistically controlled survey consisting of 45 random plots, one-fifth acre in size, was used.[1/] This method was worked out by William W. Barton and C. B. Stott[2/] of the Forest Service, and was checked by the formula set down by the late Professor D. M. Matthews during the time the writer took Forestry 196 under Professor Matthews.

For the determination of the number of one-fifth acre plots and method employed in planning a random sample survey, see Pages No. 7 through No.12 in the Appendix.

1/ See Map No. 2 in the pocket of the Appendix for location of sample plots.

2/ W. W. Barton and C. B. Stott, "Simplified Guide to Intensity of Cruise", Journal of Forestry, vol 44, October 1944, pages 750-54.

Survey Operations

Type of Instruments and Equipment Used: From past experience it has been found that the three greatest errors in cruising are erroneous estimations of plot size, height of trees, and diameters of trees. The greatest error occurs in plot size, next greatest in height, and the third greatest in diameter estimate.

Errors in plot estimation were eliminated as far as possible by using steel tapes to determine location of the perimeters of circular one-fifth acre plots. Sample heights were "measured" trigonometrically to the height it was believed the company would utilize the material. The heights were measured with the pocket cruiser stick, which is a modification of the Merrit type of hypsometer. Use of localized cumulative volume tally sheets eliminated the necessity of constantly estimating individual tree or log heights; because relatively few trees were measured for height, the work was done with the utmost care and results were felt to be satisfactory. Diameter tapes were used to reduce the error in judgment of tree diameters. Each tree was measured at d.b.h. (diameter breast high - 4-1/2 feet above the ground) in 2" diameter classes, i.e. 16" d.b.h. class included all trees from 15.0" through 16.9".

Localized Cumulative Volume Tally Sheets were used. United States Department of Agriculture form 70-R-9, Scribner scale, was used for sawlog species, and form 65-R-9, Standard Cords, was used for pulpwood and cedar. (See explanation in Appendix, Pages No. 14 through No. 24)

<u>Field Methods and Procedures</u>: A discussion of the magnetic declination used and of the methods of tallying sawtimber and pulpwood species is in the Appendix, see Page No. 13.

All tallied trees were graded as to vigor characteristics, either as high or low vigor (see Pages No. 18 and No. 19 in Appendix). In addition butt logs of the hardwood trees that were classified as low vigor were graded as either veneer, No. 2 or No. 3 sawlogs.

<u>Statistical Check on Accuracy</u> (See Table I, Page No. 25 in Appendix for calculation)

A reliability of 15% plus or minus in the total volume was sought. A check of the field records indicates that the actual sampling reliability attained was about 14.9% plus or minus. This degree of reliability means that there is little chance (only 1 in 22) that the actual total volume is outside the limits of a maximum of 114 million and a minimum of 84 million board feet, Scribner C Log Scale. For the total volume of the stand, the volume calculated by the Scribner C log rule, used throughout this thesis, underruns the volumes calculated by the International 1/4" kerf Log Rule by about 11%.

Results of Survey

The basic tables upon which the management plans are based are: Per Acre Stand Table and the Growth Rates, Total Stand Table, Per Acre Stock Table, Quality Table of Low Vigor Hardwoods. These tables are derived from the Localized Cumulative Volume Tally Sheet (See Appendix, Pages No. 26 through No. 30 for derivation).

Stand Tables and Growth Rates

The following tables present the basic figures developed from the survey. Calculated figures have not been rounded off. Greatest reliability is in total volume. As quantities by species and other groupings become smaller, the percent of reliability of the figure becomes less.

Per Acre Stand Table: There are two Per Acre Stand Tables, one (Table VIII) showing number of trees, net volume and board foot growth rate, the other (Table IX) showing gross volume, basal area, and basal area growth rate.

Total Stand Table: Table X gives the total, high, and low vigor net volumes, and the percentage of total volume in high and low vigor by species.

Stock Tables

Table XI is a Per Acre Stock Table for the total stand. A more detailed Per Acre Stock Table may be found in the Appendix (Table K, Page No. 32). Table K breaks Table XI down into low and high vigor trees. This breakdown will enable closer marking policies by showing the number of low vigor (or harvest) trees that should be taken out of a certain species and diameter class.

Chart I shows the distribution of trees spread over the d.b.h. classes, and allows a clearer picture of what size classes of the low vigor trees should come out on a selective cut.

TABLE VIII - PER ACRE STAND TABLE

(Showing number of trees, net volume in total, high and low vigor trees, and board foot growth rates of high vigor trees)

Sawtimber (trees 12" d.b.h. and up) net log scale by Scribner C Log Rule.

Pulpwood and Cedar (trees 6" d.b.h. and up) net volume in standard cords.

SPECIES	TOTAL STAND No. trees per acre	TOTAL STAND % total number trees	TOTAL STAND Net volume bd.ft.	TOTAL STAND % total net volume	LOW VIGOR TREES No. trees per acre	LOW VIGOR TREES % total number trees	LOW VIGOR TREES Net volume bd.ft.	LOW VIGOR TREES % low vigor net volume	HIGH VIGOR TREES No. trees per acre	HIGH VIGOR TREES % total number trees	HIGH VIGOR TREES Net volume bd.ft.	HIGH VIGOR TREES % high vigor net volume	Compound bd.ft. growth rate (on high vigor trees) (%)
All Sawtimber	62.2	100.0	9,678	100.0	28.0	45.0	5,218	100.0	34.2	55.0	4,460	100.0	2.44
Maple	22.6	36.3	3,138	32.5	9.8	15.7	1,575	30.2	13.0	20.9	1,563	35.0	2.22
Hemlock	17.8	28.6	2,995	31.0	8.1	13.0	1,409	27.0	9.7	15.6	1,586	35.6	2.40
Birch	10.2	16.4	2,013	20.8	5.1	8.2	1,307	25.1	5.2	8.4	706	15.8	1.48
Ash	4.3	6.9	470	4.9	1.9	3.1	250	4.8	2.4	3.9	220	4.9	3.33
Elm	1.9	3.1	430	4.4	.8	1.3	289	5.5	1.2	1.9	141	3.2	2.74
Basswood	1.6	2.6	311	3.2	1.1	1.8	236	4.5	.6	1.0	75	1.7	3.32
Soft Maple	3.3	5.3	275	2.8	1.2	1.9	152	2.9	2.1	3.4	123	2.8	5.89
Spruce	1.3	1.8	46	0.4			—		1.3	2.1	46	1.0	6.76
All Pulpwood	11.5	100.0	(cords) 0.703	100.0	3.7	32.2	(cords) 0.297	100.0	7.8	67.8	(cords) 0.406	100.0	6.51
Balsam	5.8	50.4	0.319	45.4	1.4	12.2	0.091	30.6	4.6	40.0	0.228	56.2	5.76
Aspen	3.6	31.3	0.294	41.8	1.5	13.0	0.146	49.2	2.2	19.1	0.148	36.4	7.74
Spruce	2.1	18.3	0.090	12.8	.8	7.0	0.060	20.4	.8	6.9	0.050	7.4	5.67
Cedar	9.7	100.0	1.013	100.0	5.7	58.8	0.638	100.0	4.2	41.2	.375	100.0	1.45
Total	83.4				37.4				46.0				

TABLE IX - PER ACRE STAND TABLE

(showing Gross Volume, Basal Area in total, high and low Vigor trees, and Basal Area Growth rates of high vigor trees)

Sawtimber (trees 12" d.b.h. and up) gross log scale by Scribner C Log Rule.
Pulpwood and Cedar (trees 6" and up) gross volume in standard cords.

SPECIES	TOTAL STAND: Gross volume (bd. ft.)	TOTAL STAND: % of total gross volume	TOTAL STAND: Basal area (sq. ft.)	TOTAL STAND: % of total basal area	LOW VIGOR TREES: Gross volume (bd. ft.)	LOW VIGOR TREES: % of low vigor gross volume	LOW VIGOR TREES: Basal Area (Sq. ft.)	LOW VIGOR TREES: % of total basal area	HIGH VIGOR TREES: Gross volume (bd. ft.)	HIGH VIGOR TREES: % of high vigor gross volume	HIGH VIGOR TREES: Basal area (sq. ft.)	HIGH VIGOR TREES: % of total basal area	Compound Basal Area Growth rate (on high vigor trees) (%)*
All Sawtimber	12,449	100.0	105.8	100.0	7,483	100.0	58.9	55.7	4,966	100.0	46.9	44.3	1.9
Maple	3,987	32.0	34.4	32.5	2,250	30.0	17.7	16.8	1,737	35.0	16.7	15.7	1.7
Hemlock	3,930	31.6	31.0	29.3	2,168	27.9	16.7	15.8	1,762	35.5	14.3	13.5	2.0
Birch	2,527	20.3	22.2	21.0	1,743	23.3	14.4	13.6	784	15.8	7.8	7.4	1.7
Ash	556	4.5	5.3	5.1	312	4.8	2.8	2.6	244	4.9	2.7	2.5	3.5
Elm	611	4.9	4.8	4.6	445	5.9	3.3	3.1	166	3.3	1.7	1.5	1.8
Basswood	451	3.6	3.1	3.0	363	4.8	2.3	2.2	88	1.8	0.8	0.8	1.3
Soft Maple	337	2.7	3.6	3.5	202	2.3	1.7	1.6	137	2.8	1.9	1.9	3.5
Spruce	48	0.4	.9	1.0					48	0.9	1.0	1.0	2.1
All Pulpwood	(cords) 0.800	100.0	3.7	100.0	(cords) 0.364	100.0	1.5	40.6	(cords) 0.436	100.0	2.2	59.4	4.6
Balsam	.354	44.3	1.9	51.4	0.114	31.3	.5	13.5	0.240	55.1	1.3	37.9	4.4
Aspen	.347	43.4	1.4	37.8	0.183	51.3	.7	18.9	0.164	37.6	.7	18.9	5.6
Spruce	.099	12.3	.5	10.8	0.067	18.4	.3	8.2	0.032	7.3	.2	2.6	4.1
Cedar	1.293	100.0	6.2	100.0	0.851	100.0	4.4	71.0	0.442	100.0	1.8	29.0	3.1
Total			115.1				64.5				50.6		

* - These rates were figured in the same manner the board foot rates were, only they are based on basal area of gross volume.

TABLE X - TOTAL STAND TABLE

(Net volumes on 10,282 acres of virgin timber in Scribner C Log Scale and Standard Cords).

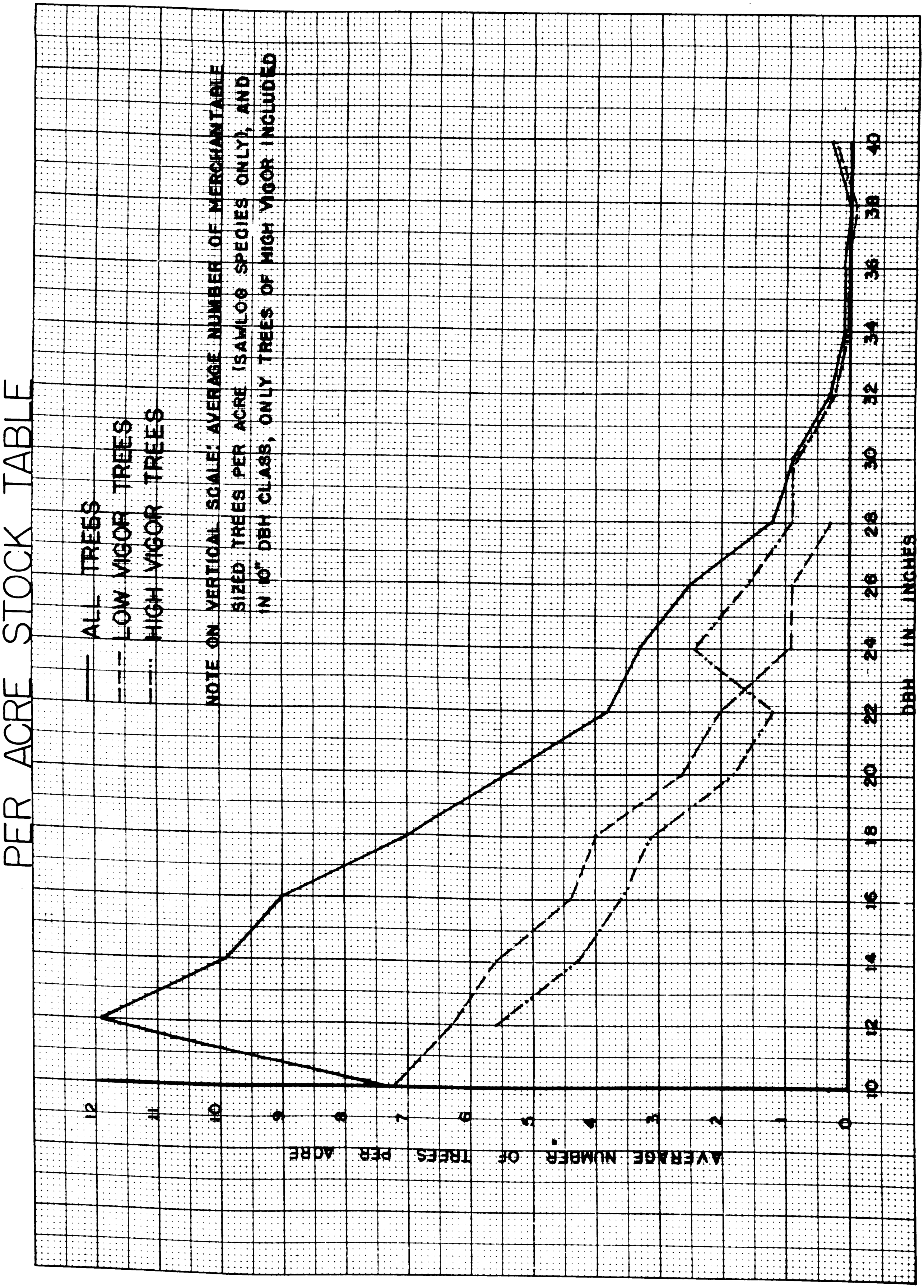
SPECIES	TOTAL STAND Net Volume (M bd.ft.)	TOTAL STAND % of Total Net Volume	LOW VIGOR Net Volume (M bd.ft.)	LOW VIGOR % of Total Net Volume	HIGH VIGOR Net Volume (M bd.ft.)	HIGH VIGOR % of Total Net Volume
All Sawtimber	99,491	100.0	53,642	53.9	45,849	46.1
Maple	32,259	32.5	16,191	16.3	16,068	16.2
Hemlock	30,789	31.0	14,485	14.5	16,304	16.5
Birch	20,694	20.8	13,436	13.5	7,258	7.3
Ash	4,832	4.9	2,570	2.6	2,262	2.3
Elm	4,420	4.4	2,971	3.0	1,449	1.4
Basswood	3,197	3.2	2,426	2.4	771	0.8
Soft Maple	2,827	2.8	1,563	1.6	1,264	1.2
Spruce	473	0.4	--		473	0.4
	(cords)		(cords)		(cords)	
All Pulpwood	7,226	100.0	3,053	42.3	4,173	57.7
Balsam	3,279	45.4	935	12.9	2,344	32.5
Aspen	3,022	41.8	1,501	20.8	1,521	21.0
Spruce	925	12.8	617	8.5	308	4.3
Cedar	10,414	100.0	6,559	63.0	3,855	37.0

TABLE XI - PER ACRE STOCK TABLE BY SPECIES AND DBH

Average Number of Trees and Basal Area Per Acre

ALL TREES	DBH	SUGAR MAPLE No.	SUGAR MAPLE B.A.	HEMLOCK No.	HEMLOCK B.A.	YELLOW BIRCH No.	YELLOW BIRCH B.A.	ASH No.	ASH B.A.	ELM No.	ELM B.A.	BASSWOOD No.	BASSWOOD B.A.	SOFT MAPLE No.	SOFT MAPLE B.A.	CEDAR No.	CEDAR B.A.	BALSAM FIR No.	BALSAM FIR B.A.	SPRUCE No.	SPRUCE B.A.	ASPEN No.	ASPEN B.A.	TOTAL B.A. BY DIAMETER CLASS
2.0	4															0.3	0.0	1.7	0.1					0.2
5.3	6															2.3	0.5	1.3	0.3	0.8	0.2	0.9	0.2	1.1
5.3	8															1.9	0.7	1.4	0.5	0.3	0.1	1.7	0.6	1.9
10.0	10	3.3	1.8	0.1	0.1	0.8	0.4	0.9	0.5	0.6	0.3	0.1	0.6	0.6	0.3	0.9	0.5	0.9	0.5	1.1	0.7	0.7	0.4	4.5
14.0	12	4.9	3.8	2.9	2.3	1.3	1.1	1.1	0.9	0.2	0.2	0.2	0.2	1.0	0.8	1.4	1.1	0.4	0.3	0.3	0.3	0.3	0.3	11.2
11.3	14	2.9	3.1	3.8	4.4	1.3	1.4	0.3	0.4	0.2	0.2	0.1	0.1	1.3	1.4	1.3	1.4	0.1	0.2					11.3
9.9	16	3.1	1.2	3.3	4.3	1.3	3.1	0.9	1.9	0.1	1.2	0.2	0.2	0.1	0.2	0.9	1.2							12.4
7.6	18	3.4	6.1	1.2	2.2	1.2	2.2	0.3	0.6	0.2	0.4	0.6	1.0			0.6	1.0			0.1	0.2			13.6
5.4	20	1.1	2.4	2.6	4.6	0.9	1.9	0.6	1.2	0.1	0.2			0.1	0.2									11.6
3.8	22	1.3	3.4	0.8	2.1	1.2	2.9	0.2	0.6			0.2	0.6	0.1	0.3									10.0
3.4	24	1.4	4.5	1.2	3.5	0.3	1.1			0.2	0.7	0.1	0.3	0.1	0.3	0.1	0.3							10.8
2.5	26	0.9	3.3	0.7	2.5	0.9	3.3																	9.0
1.2	28	0.3	1.4	0.6	2.4	0.3	1.4																	5.2
0.9	30			0.4	2.2	0.4	2.2					0.1	0.5											4.9
0.3	32			0.2	1.2					0.1	0.6													1.9
0.1	34					0.1	0.7																	0.7
0.1	36					0.1	0.8																	0.8
	38																							2.9
0.3	40					0.1	1.0			0.2	1.9													
85.4		22.6	34.4	17.8	31.0	10.2	22.2	4.3	5.3	1.9	4.8	1.6	3.1	3.3	3.6	9.7	6.2	5.8	1.9	2.6	1.4	3.6	1.4	115.1

55


PER ACRE STOCK TABLE
ALL TREES
LOW VIGOR TREES
HIGH VIGOR TREES
NOTE ON VERTICAL SCALE: AVERAGE NUMBER OF MERCHANTABLE SIZED TREES PER ACRE (SAWLOG SPECIES ONLY), AND IN 10" DBH CLASS, ONLY TREES OF HIGH VIGOR INCLUDED
AVERAGE NUMBER OF TREES PER ACRE
DBH IN INCHES
0
1
2
3
4
5
6
7
8
9
10
11
12
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40

Quality Table

The basis of this table was the grading of the butt log of the low vigor trees by the forester in each field party. Through grading, a better knowledge of the quality of the trees is obtained. Hence, in selective cutting, a closer estimate of the grade of tree cut is established. From past experience it has been found that it is difficult to grade sugar maple veneer because of the black heart it has in this area. Accordingly, the 25% shown in the veneer grade for low vigor sugar maple is somewhat high. There was no grading of No. 1 sawlogs used in this survey. The Forest Products Laboratory at Madison, Wisconsin has found that there is only a 5% difference in the grades of veneer and No. 1 sawlog. This minute percentage did not warrant the labor to separate the two grades.

Table XII shows the quality of the low vigor sugar maple, hemlock and yellow birch trees for the total acreage (10,280 acres).

Charts II, III and IV, Pages No. 59 through No. 61 show quality distribution by d.b.h. of hemlock on the average acre, and yellow birch and sugar maple on 10,280 acres.

TABLE XII - QUALITY OF LOW VIGOR TREES - MAJOR SPECIES

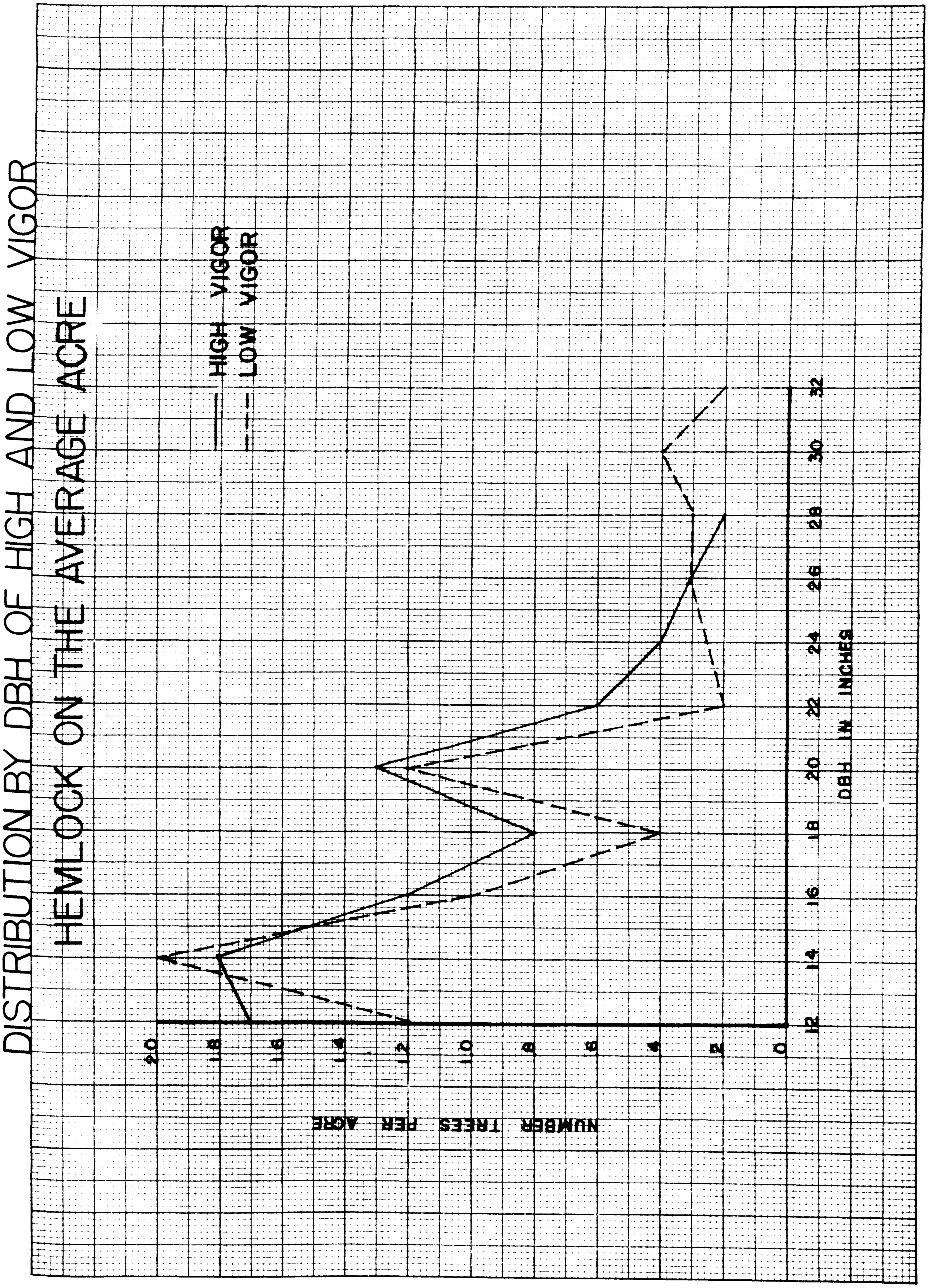
(Figures blown up from tally total to approximate total number in hundreds of trees on 10,280 acre tract)

Hundreds of trees by size and butt log quality*

DBH	HEMLOCK	YELLOW BIRCH			SUGAR MAPLE		
		Veneer	2	3	Veneer	2	3
12	126	-	11	23	-	57	228
14	206	34	11	23	11	69	11
16	160	11	23	11	11	57	69
18	46	46	-	-	57	69	57
20	126	34	34	-	34	-	-
22	23	11	34	34	34	11	-
24	80	34	-	-	57	46	23
26	34	34	11	-	46	-	34
28	34	11	11	11	-	11	11
30	46	23	-	23	-	-	-
32	23	-	-	-	-	-	-
34	-	11	-	-	-	-	-
36	-	-	11	-	-	-	-
38	-	-	-	-	-	-	-
40	-	-	11	-	-	-	-
Total	904	249	157	125	250	320	433
% within species	100%	47%	29%	24%	25%	32%	43%

Total No. Trees	Hemlock	Yellow Birch	Sugar Maple
	90,400 trees or 47% of the hemlock volume	53,100 trees or 49.4% of the maple volume	100,300 trees or 65% of the birch volume

* - Butt logs graded by Standard veneer and log grades of the Northern Hardwood and Hemlock Manufacturers Association and the Forest Products Laboratory.


DISTRIBUTION BY DBH OF HIGH AND LOW VIGOR
HEMLOCK ON THE AVERAGE ACRE
HIGH VIGOR
LOW VIGOR
NUMBER TREES PER ACRE
20 18 16 14 12 10 8 6 4 2 0
12 14 16 18 20 22 24 26 28 30 32
DBH IN INCHES

QUALITY BY DBH OF LOW VIGOR SUGAR MAPLE

ON 10,280 ACRES

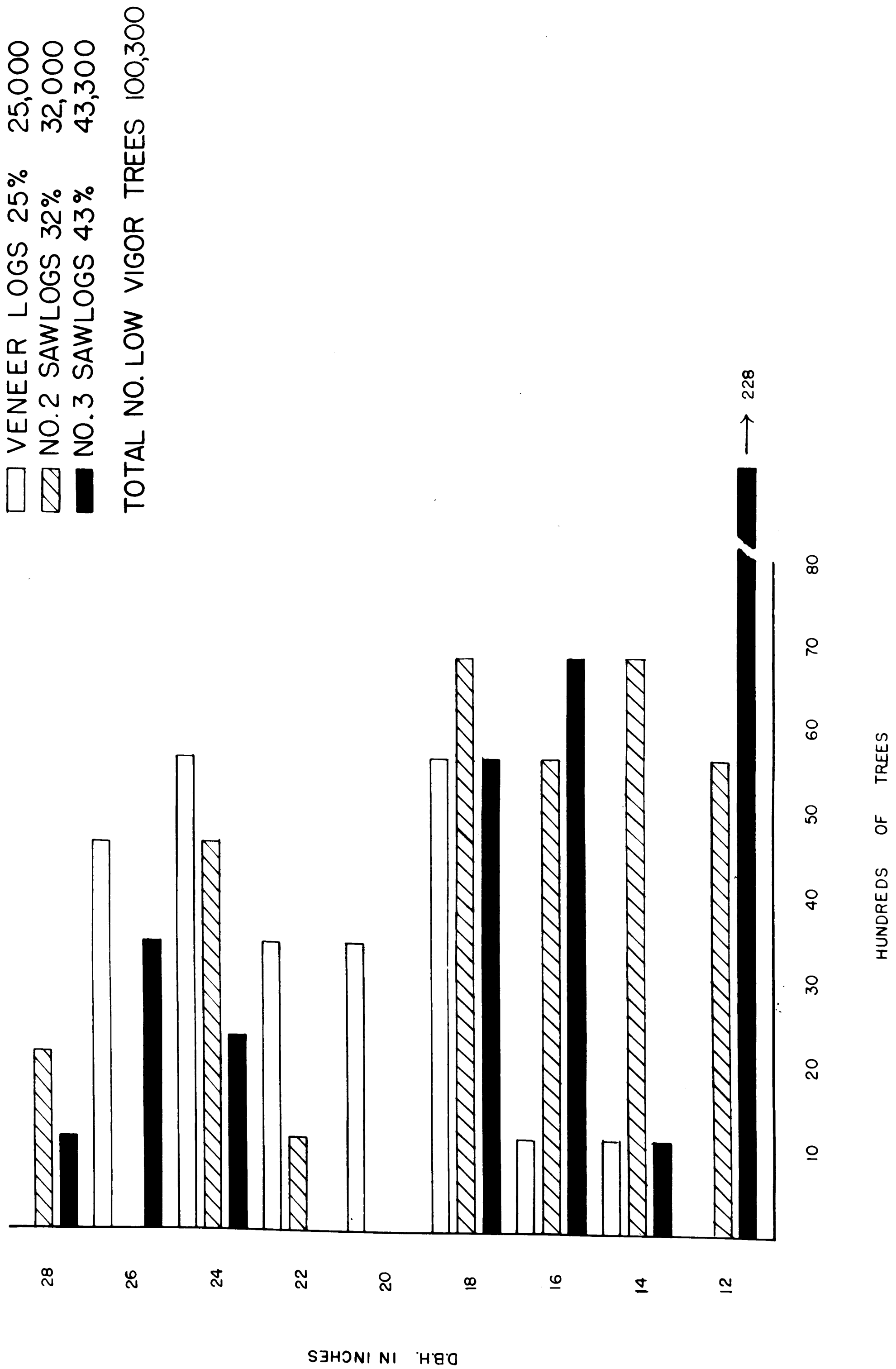
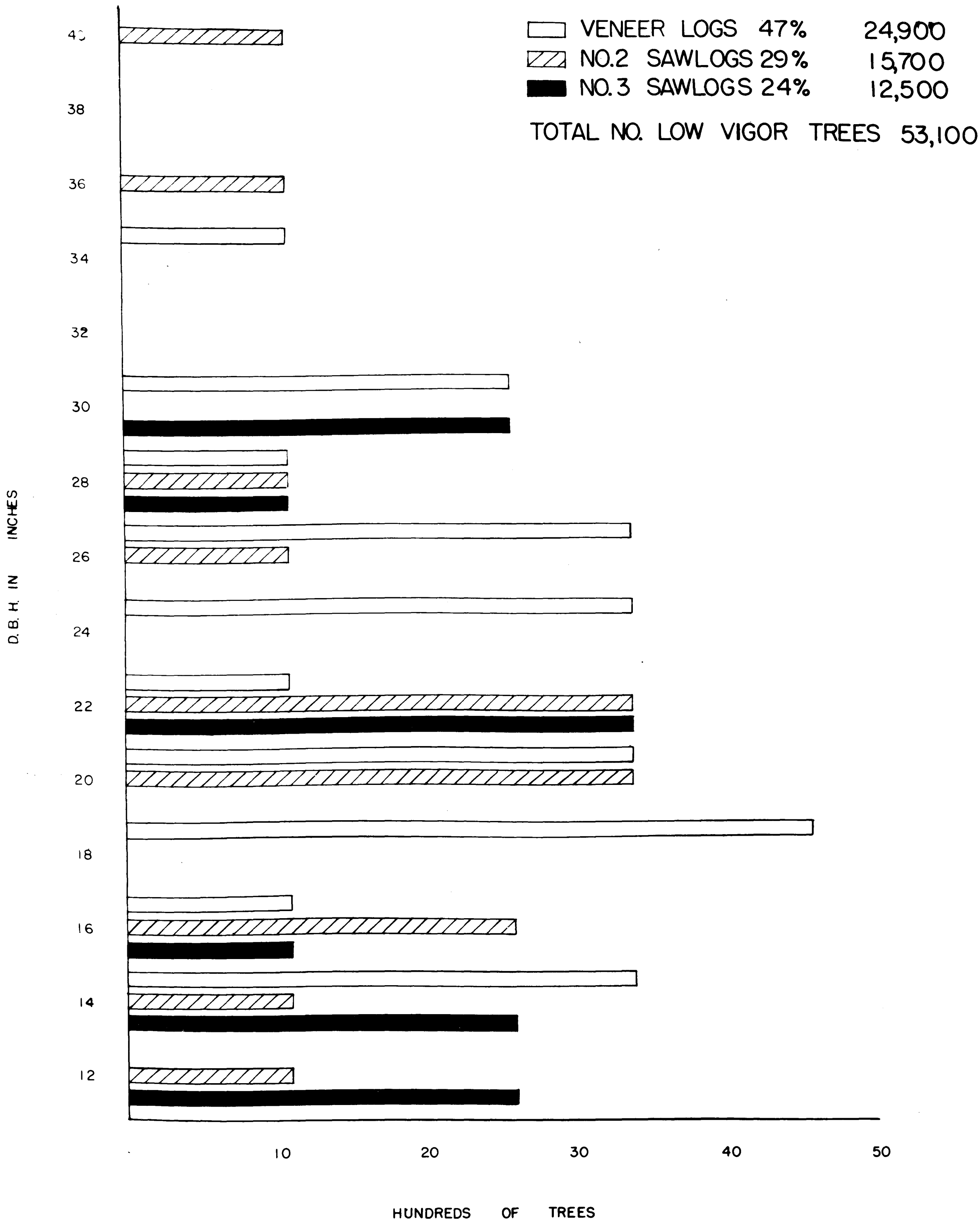


CHART IV

QUALITY BY DBH OF LOW VIGOR YELLOW BIRCH

ON 10,280 ACRES



A review of climatic, topographic, and soil type features indicates that the Ahonen Lumber Company's land, for the most part, can grow and regenerate the northern hardwood and coniferous forest. This capacity is attested to by the fine growth and quality of the virgin timber forests and by its excellent reproduction. Unfortunately, the Porcupine block with its high caliber timberlands will not remain in the company's hands long enough to be put under any form of management.

The forest size class is predominantly mature sawtimber (9645 acres or 92% of the total area). Pulpwood and poles occupy 570 acres (5.5%) and saplings occupy the remaining 247 acres (1.5%) of the 10,280 merchantable acreage. Most of the 570 acres are occupied by cedar poles with some spruce and aspen pulpwood. With the sapling acreage excluded, there are 10,035 acres that have a merchantable crop on them at the present time. The stocking is quite heavy on the sawtimber land, providing an average yield of 10 M bd.ft. per acre.

The survey was made to facilitate a forest management policy decision, and was found to be statistically correct in determining the volume inventory and growth for the area as a whole. Caution must be used in relying on these figures for volumes other than the total area. An accuracy of 15% cannot be expected on volumes when these figures are applied to any individual section or forty. Once a forest management policy decision has been made, a more intensive survey should be undertaken to supplement the existing knowledge of volumes on each forty and section.

In addition to providing stand and stock tables for the whole area, classifying the trees as high and low vigor (cut and leave) provided a basis for judging the quality of the stand. Furthermore, the low vigor or harvest trees of the valuable hardwoods were classified by grading the butt log, thus giving a clearer indication of the quality of these low vigor trees which would be the first to come out if selective cutting were practiced.

MANAGEMENT PLANS

There are three major possible procedures (management plans) of handling the Ahonen Lumber Company's timberland. They are straight liquidation, sustained yield and two-cut liquidation. Straight liquidation is probably the simplest, since the company is now following that plan, in which the cutting policy is clear cutting. Two-cut liquidation and sustained yield can be worked out in numerable ways because of the following variable factors: length of cutting cycle, amount cut and residual stand, composition, time of next cut, growth rate, and many other minor factors. The writer has tried to select the variation of these plans that the company would be most likely to adopt under present conditions.

The annual capacity of the sawmill is around 10 million feet. 1/ In some years 50% or more of this amount is purchased on the open market and through cooperative logging agreements with mining and other companies. On the basis of such past purchases, the company has set up a 6 million board feet quota to be met from their own timberlands. The company feels that 2 to 4 million feet can, with reasonable assurance, be purchased on the open market. During periods of low demand the mill production will average close to 8 million board feet per year.

Since the company has the cutting rights only on the Porcupine block until 1955, a policy of straight liquidation must be followed. This timber will supplement the quota during this present period of flux.

1/ Based on a four year average 1946-1949 inclusive.

The problems involved in selective cutting are briefly reviewed in this section and tentative marking guides adduced. The protection of the forest from the various decimating agencies, and timber stealing is also discussed.

Straight Liquidation Plan

The company is now following a straight liquidation plan. The following calculations manifest the conditions under such a policy. It must be remembered that any change in policy must be proven financially better than the straight liquidation plan now in operation.

For the purpose of comparing this plan against the others, the Porcupine block will be worked out separately because the policy for this block is liquidation regardless of how the other land is managed First, however, to determine the actual length of time the company would operate without change in policy, a liquidation plan covering the whole area will be briefly worked out.

Growth is generally very small in virgin timber, and may even be negative. For practical purposes therefore, it will be assumed that the growth in virgin areas equals mortality under this plan.

Length of operation of Total Sawtimber:

$$\frac{\text{Total volume all 3 tracts}}{\text{annual cut}} = \text{total years of operation}$$

$$\frac{111{,}894 \text{ M bd. ft.}}{6{,}000 \text{ M bd. ft.}} = 18.7 \text{ or } 19 \text{ years of operation}$$

For a straight liquidation policy this is a long period of operation under present conditions.

Operation on Porcupine Block alone.

Period of operation:

$$\frac{\text{Total volume}}{\text{Annual cut}} = \text{years of operation}$$

$$\frac{\text{12,403 M bd.ft.}}{\text{6,000 M bd.ft.}} = \underline{\underline{\text{a little over 2 years}}}$$

Annual cutting acreage:

$$\frac{\text{Total (merchantable) Area}}{\text{Years of operation}} = \text{cutting area}$$

$$\frac{\text{1192 Acres}}{\text{2 Years}} = \underline{\underline{\text{596 Acres}}}$$

Disregarding the Porcupine block, the straight liquidation plan for the Gogebic and Tula blocks is shown below. This calculation will be considered the straight liquidation plan when comparison to the other plans are made.

Operation on Tula and Gogebic Blocks.

Period of operation:

$$\frac{\text{Total volume}}{\text{Annual cut}} = \text{years of operation}$$

$$\frac{\text{99,491 M bd.ft.}}{\text{6,000 M bd.ft.}} = \underline{\underline{\text{16.6 years of operation}}}$$

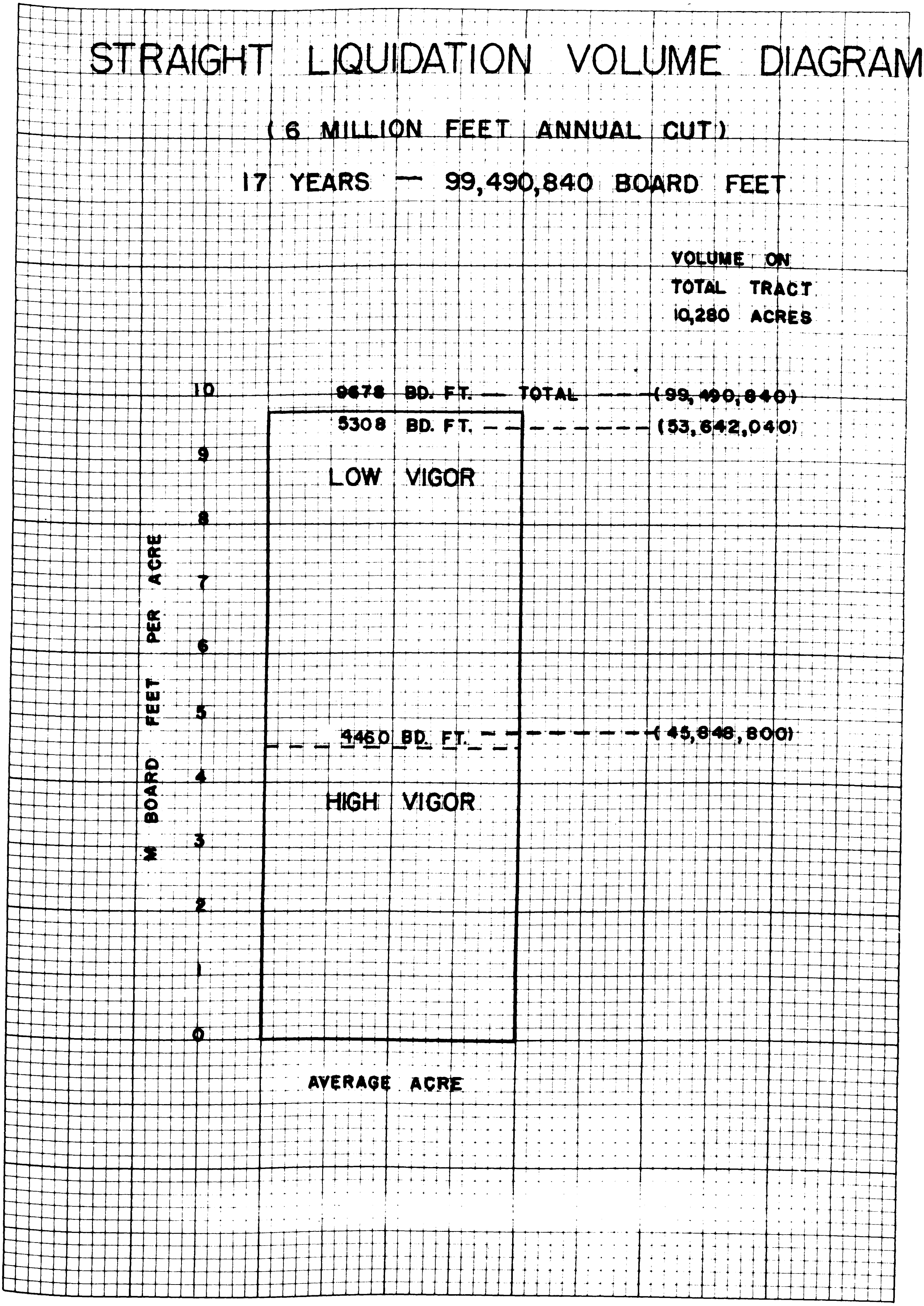
Annual Cutting acreage:

$$\frac{\text{Total (merchantable) Area}}{\text{Years of operation}} = \text{cutting area}$$

$$\frac{10,282}{16.6} = \underline{\underline{\text{620 Acres}}}$$

Summary: Straight Liquidation Plan for the Tula and Gogebic Blocks.

Total volume removed	99,491 M bd.ft.
Annual cut	6,000 M bd.ft.
Period of operation	16.6 years
Annual Cutting area	620 acres


STRAIGHT LIQUIDATION VOLUME DIAGRAM
(6 MILLION FEET ANNUAL CUT)
17 YEARS — 99,490,840 BOARD FEET
VOLUME ON TOTAL TRACT 10,280 ACRES
9678 BD. FT. — TOTAL — — — (99,490,840)
5308 BD. FT. — — — — — — — — — (53,642,040)
LOW VIGOR
4460 BD. FT. — — — — — — — — — (45,848,800)
HIGH VIGOR
M BOARD FEET PER ACRE
0
1
2
3
4
5
6
7
8
9
10
AVERAGE ACRE

Sustained Yield Plan

In view of the possibilities of sustained yield management, there are numerous vexing items requiring consideration: the percentage of volume to be removed, amount of growth, length of cutting cycle, silvicultural problems, profitable logging volume, and other minor considerations. Of primary importance is the determination of the length of the cutting cycle.

Determination of Cutting Cycle

In determining the length of the cutting cycle there are two forces, the financial and the silvicultural, that appear to be working against each other and must be brought to a compromise or break even point for the cutting cycle to serve its purpose best. The financial factor demands the maximum dollar return with the least dollar expenditure. This demand favors a heavy cut and a long cutting cycle. On the other hand, the silvicultural factor demands maximum volume growth; this demand in turn favors a light cut and therefore a short cutting cycle.[1/] The silvicultural factor will be discussed first.

Silvicultural: The amount of material (growth) which may eventually be harvested from this tract under any plan involving selective cutting depends upon (1) the growth rate, and (2) the amount of good growing stock left on this land to do the growing.

1/ U.S. Department of Agriculture Forest Service, Timber Management and Financial Plans for the Goodman Working Circle, 29.

The average board foot growth rate expressed as compound percent is 2.44 (Table VIII, Page No. 52). The good growing stock (high vigor trees) on the average acre amounts to 4460 board feet (Table VIII, Page No. 52). This is the stock that will grow at a compound rate of 2.44% annually. Table XIII combines the two and shows the various amounts of growth of this 4460 board feet at five year intervals from 5 to 35 years; also, the annual growth averaged, for any of the five year periods. The growth of the basal area, although not as important as board foot growth, is an excellent means of judging stocking and marking timber for cutting, if presented with the board foot growth. Chart VI, Page No. 71 illustrates the potential growth of this 4460 board feet for a period of 1 to 35 years after cutting at any given time (growing stock plus growth).

TABLE XIII - SAW TIMBER GROWTH ESTIMATE

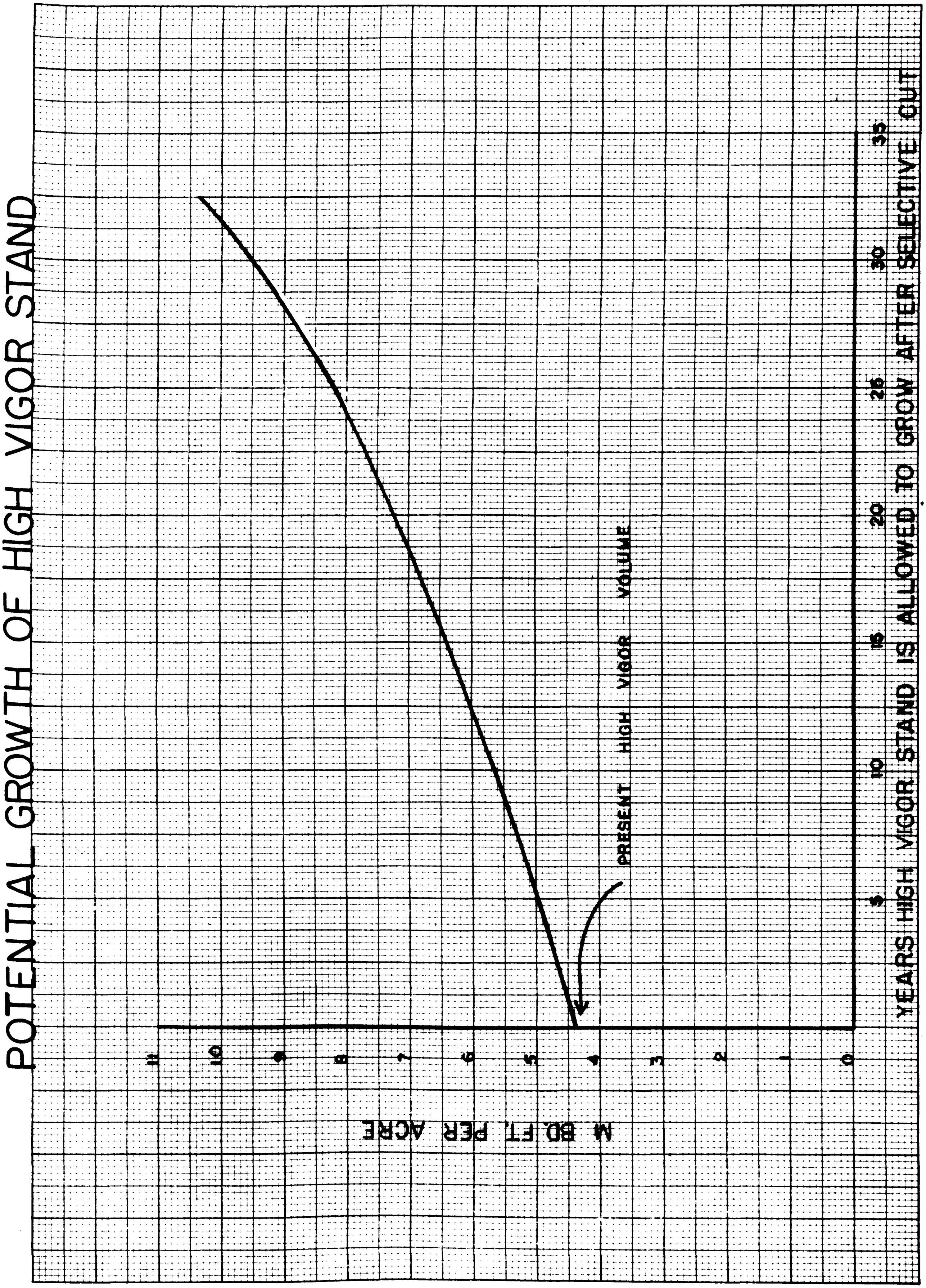
(1) All species board foot growth rate at 2.44% compound rate on base of 4460 board feet (net) per acre in high vigor trees (Scribner C Log Rule).

(2) All species basal area growth rate at 1.91% compound rate on base of 46.6 square feet per acre in high vigor trees.

PERIOD (in years)	GROWTH PER ACRE OVER PERIOD (in bd.ft.)		AVERAGE ANNUAL GROWTH PER ACRE (in bd.ft.)	
	(in bd.ft.)	(in sq.ft.)	(in bd.ft.)	(in sq.ft.)
5	570	4.7	114	.94
10	1212	9.9	121	.99
15	1940	15.6	129	1.04
20	2761	21.8	138	1.09
25	3684	28.7	147	1.15
30	4720	36.7	157	1.22
35	5902	44.5	169	1.27

CHART VI

(Plotted from Table XIII)

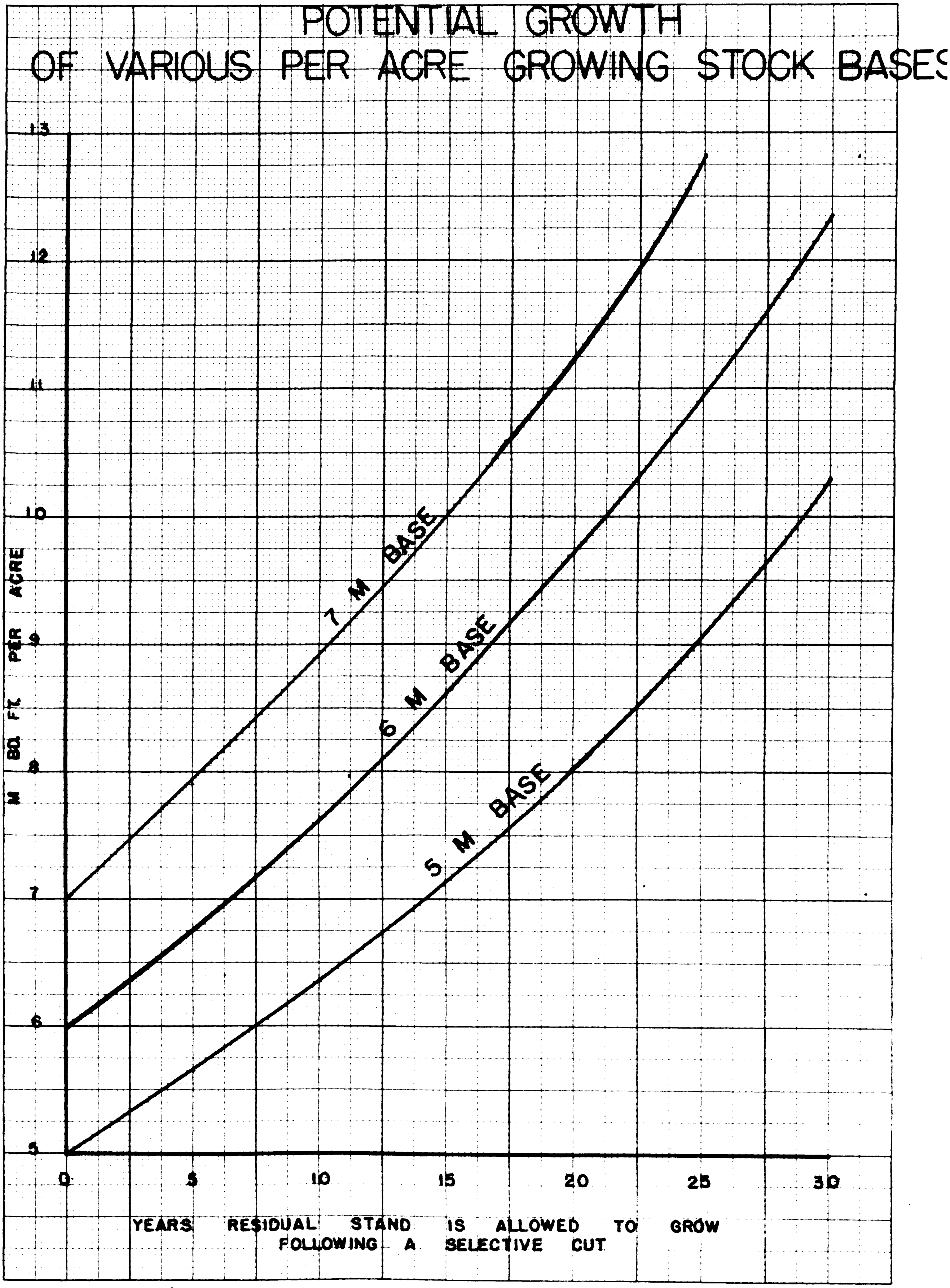


It is apparent that to fulfill the silvicultural demand of maximum board foot growth, a higher volume of good growing stock should be sought than the 4460 board feet there at present. Obviously, in any given period of time and at a constant rate of growth, 4000 board feet per acre in good growing stock will produce only half as much volume as 8000 board feet of good growing stock. Hence, as large a growing stock as is practical should be left following a partial cut in order to obtain maximum board foot growth per acre.

Table XIV indicates the potential growth of good growing stock bases other than 4460 board feet (present base). These range from 4500 to 8000 board feet per acre. The compound growth rate of 2.44% has been applied to them and the various amounts of board foot growth have been tabulated at five year intervals of from 5 to 30 years, which represent prospective cutting cycles. Similarly, Chart VII, Page No. 74, shows the potential growth of bases 5, 6 and 7 M bd.ft. per acre for this same period, and as on Chart VI, the total volume can be read from the curves for any given time.

TABLE XIV - POTENTIAL GROWTH ON VARIOUS GROWING STOCK VOLUMES

BASIC GOOD GROWING STOCK (Bd.ft.)	PERIOD OF YEARS (Bd.ft.)					
	5 yrs.	10 yrs.	15 yrs.	20 yrs.	25 yrs.	30 yrs.
4500	576	1224	1958	2790	3722	4770
5000	640	1360	2157	3100	4135	5300
5500	704	1496	2392	3410	4548	5830
6000	768	1632	2610	3720	4962	6360
6500	832	1768	2828	4030	5376	6890
7000	896	1904	3045	4340	5789	7420
7500	960	2040	3262	4650	6202	7950
8000	1024	2176	3480	4960	6616	8480


POTENTIAL GROWTH
OF VARIOUS PER ACRE GROWING STOCK BASES
M BD. FT. PER ACRE
13
12
11
10
9
8
7
6
5
0
5
10
15
20
25
30
7 M BASE
6 M BASE
5 M BASE
YEARS RESIDUAL STAND IS ALLOWED TO GROW
FOLLOWING A SELECTIVE CUT

A number of points should be considered in calculating the optimum length of cutting cycle from the silvicultural point of view. Since trees grow at a compound rate, the longer the residual growing stock is left to grow following a selective cut, the more rapid the rate of growth. At a constant yearly increase in diameter a stand of 5000 board feet per acre will grow more board feet during the second five years than it will the first five years. Therefore, it is not advisable to make the cutting cycle (growing period between cuts) too short.

If a long cutting cycle is used, a slowing down of the growth rate develops as the stand becomes crowded, and the amount of cull material in the stand increases. The quality and quantity of the residual growing stock and the height growth of such stock is reduced. The quantity is reduced because of increased mortality from exposure, the quality is affected because of the branchy character of trees growing in stands of low density, and the height growth is retarded because of the non-competitive condition existing in such stands.

Financial: Financially the determination of the cutting cycle rests largely on the cost of logging. The paramount factor to be considered is the amount or volume of timber to be removed from the average acre.

Mr. Ahonen felt that during the present trend of business and production costs, a cut of 3500 board feet per acre would be necessary in the average northern hardwood stand to justify a selective logging operation. The reason for this large cut is that the initial cost of a permanent road system would have to be borne by the first cut. It is very difficult to forecast what an economic cut would be in the second cycle ten to twenty years hence, but since the roads would already be in and the timber would be of higher quality, he thought that a cut of 2500 board feet per acre would probably be economically justified.

The next important financial consideration is the investment in plant and equipment. Because of the heavy investment in the sawmill and other equipment, the company would like to take as great a volume as possible during the first cycle. By the end of the first cycle the mill would be completely written off the books. Providing conditions were favorable (at the end of the first cycle) the mill could be revamped and geared more closely to the annual growth of their forest.

Calculation of Cutting Cycle: According to the specifications of the economic cut in the first cycle, the maximum base that a cutting cycle could be figured on is 6000 board feet to the acre (9678 - 3500 or 6138). The 15 and 20 year cycles are the shortest cycles allowing an initial cut of 3.5 M bd. ft. per acre and a growth of 2.5 M bd. ft. per acre (Table XIV, Page No. 73), 2.5 being the required economic cut in the second cycle. Further study of Table XIV reveals that a base of 6000 board feet in the 15 year cutting cycle or a base of 4500-6000 in the 20 year cutting cycle would fulfill both of these volume requirements.

Unfortunately, the basic good growing stock is only 4460 board feet at present and in 15 years will only grow 1940 board feet, not enough to satisfy the economic logging requirement of the second cut. Since in 20 years this 4460 board feet will produce 2761 board feet in growth which is adequate to justify the logging operation. The 20 year cycle is the shortest possible cutting cycle satisfying the economic logging requirement of both the first and second cycles.

The range of bases (4500-6000 board feet) that satisfy all the financial requirements of the 20 year cycle, cut from 38 to 54% of the total net volume. Table XV indicates the possible cut and leave in volume and percent of total volume.

TABLE XV - POSSIBLE CUT AND LEAVE
(By volume, percent of total volume & basal area)

RESIDUAL VOLUME OR BASE	CUT				LEAVE		
(bd.ft.)	(bd.ft.)	(%)	(Basal Area)	(%)	(%)	(Basal Area)	(%)
4500 (4460)	5218	54	58.9	55.7	46	46.9	44.3
5000	4678	49	52.9	50.0	51	52.9	50.0
5500	4178	43	45.5	43.0	57	60.3	57.0
6000	3678	38	40.3	38.0	62	65.5	62.0

Any of the residual volumes (Table XV) left in the 20 year cycle will give the growth necessary to justify logging in the second cycle. Therefore, the objective is to remove the largest percentage of volume now within these limits (4500-6000 board feet) and still not cause excess mortality. By removing the greatest percentage of volume, the sawmill is supplied with the largest amount of timber possible under sustained yield, and the smallest investment in the residual stand is left. It should be remembered that the company wishes to obtain 6 million board feet annually from their lands. Just what percentage of volume will best fit these objectives is difficult to ascertain.

According to Zillgitt[1] the largest board foot growth per acre is obtained by leaving a volume of 6 M bd.ft. per acre (64 square feet of basal area), but highest interest growth rates are obtained at lower residual volume figures of 3.5 M bd. ft. (44 square feet of basal area). Interest rate is high at lower residual volume because there is a small number of trees per acre and any accelerated growth shows a high percentage of increase in relation to the residual volume but does not make much volume on a per acre basis.

A residual 6 M bd. ft. per acre would be ideal from the standpoint of board foot growth per acre on the Ahonen lands, but leaving 6 M bd. ft. would mean that only 38% of the net volume would be taken out during the first cut. By cutting the residual stand down to 3.5 M per acre, a portion of the good growing stock (4460 - 3500 = 960 board feet) would be depleted. Logically, the 4500 (4460) board foot base would seem to satisfy the objectives but would mean a removal of 54% of the net volume.

Bulletins published by the Upper Peninsula Experiment Station at Dukes, Michigan, reveal that it would be silviculturally possible to take such a cut. However, there is a much higher risk involved in the stand concerned here than in the one at Dukes, because of the large amount of hemlock and yellow birch in the Ahonen stand.

1/ W. M. Zillgitt, Optimum Stocking for Northern Hardwoods, 12.

On the Experiment Station's various cuttings 81% of the number of trees [1/] and 87% of the volume [2/] is in hard maple on good sites. [3/] In contrast, the composition of the company's stand is only 27% of the trees and 33% of the volume in hard maple, and (this is the higher risk) 21% of the trees, and 31% of the volume in hemlock and 12% of the trees, and 21% of the volume in yellow birch. Together, the birch and hemlock comprise 39% of the trees and 52% of the volume. Graham [4/] states that yellow birch and hemlock are the most sensitive to exposure of the major species comprising the mixed northern hardwood stands, yellow birch being more sensitive than hemlock.

Hall [5/] states that the "severity of the injury following logging depends upon the character of the forest and intensity of the cut". He further recommends a cut of not over 50% of the total basal area to reduce post logging injury.

In seeking a balance between the demands for as large a present volume as possible and not opening up the stand too much for fear of high mortality in birch and hemlock, it seems that a removal of 50% of the volume on the average acre would suffice, with the stipulation that the marking come closer to taking 60% of the net volume in the maple and 40% of the net volume in the hemlock and birch. The base of 5000 board feet will be used because it cuts 49% of the net volume (and approximately 50% of the basal area), see Table XV, Page No. 77.

1/ Trees as used in this comparison are trees 5" d.b.h. and over.
2/ Volumes as used in this comparison are merchantable (net)volumes.
3/ W. M. Zillgitt, Stocking in Northern Hardwoods Under the Selection System, 320.
4/ S. A. Graham, Causes of Hemlock Mortality in Northern Michigan, 56-57.
5/ R. C. Hall, Post-Logging Decadence in Northern Hardwoods, 58,61.

This proposal is in harmony with Zillgitt's[1] recommendation of leaving 4500-7000 board feet or 50 to 75 square feet of basal area per acre in trees 10" d.b.h. and larger.

Annual Allowable Cut

Chart VII, Page No.74, shows that in 20 years a good growing stock of 5000 board feet per acre building volume at a net annual compound rate of 2.44%, will grow to 8100 board feet.

Cutting acreage

$$\frac{\text{Total acreage}}{\text{Cutting cycle}} = \text{Cutting area}$$

$$\frac{\text{10,280 acres}}{\text{20 years}} = \underline{\underline{\text{514 acres}}}$$

Annual volume removed (Second cycle)

Growth x cutting acreage = volume removed

3100 bd.ft. x 514 acres = 1,519,000 bd.ft.

Since, as shown in Chart VI, Page No. 71 there are only 4460 board feet per acre in good growing stock now, which in 20 years will have increased to only 7221 board feet, it will be necessary to store a small amount of low vigor material during the first cutting cycle. This storing is necessary in order (1) to allow the good growing stock to build up to the requisite 5000 board feet, (2) to have enough material on hand at the beginning of the second cutting cycle to make a cut economical, and (3) to avoid opening the stand too much because of the high post logging decadence in the birch-hemlock type.

1/ W. M. Zillgitt, Stocking in Northern Hardwoods Under Selection System, 327

A 49% cut of the volume in the present stand (Table XV, Page No. 77) would result in removal of 4678 board feet per acre on 514 acres per year, or 2,400,000 board feet per year and would leave a residual stand of 5000 board feet. This cut would include 540 board feet in low vigor trees on which there would probably be no net growth, and 4460 board feet of good growing stock, which, in 20 years, would increase to 7221 board feet (Table XIII, Page No. 70, 4460 + 2761 = 7221).

In the second cycle cut, beginning 20 years later, there would be 7221 board feet of good growing stock plus the 540 board feet of low vigor stored for the second cut, or a total of 7761 board feet. At that time a 36% cut would leave 5000 board feet per acre in good growing stock needed for the sustained yield program outlined above. The cut during the second cycle would be 7761 - 5000 or 2761 board feet, which on 514 acres gives an annual yield of 1,420,000 board feet.

In the third and subsequent cycles (beginning 40 years later) there would be on the land 8100 board feet all of good growing stock. At that time a 38% cut would leave 5000 board feet in good growing stock needed for the sustained yield program. The cut during the third and all subsequent cycles would be 8100 - 5000 or 3100 board feet on 514 acres giving an annual yield of 1,590,000 board feet. Table XVI shows the calculations of this sustained yield program. Charts VIII and IX, Pages No.84 and No.85, serve to illustrate this proposed sustained yield program by means of growing stock diagrams.

TABLE XVI - A SUSTAINED YIELD PROGRAM

(20 year cutting cycle on 10,280 acres = partial cut on 514 acres each year.)

First Cutting Cycle (20 years):

Present volume	9678	bd.ft. per acre
Residual volume	- 5000	bd.ft. per acre (540 low vigor)
Volume to cut	4678	bd.ft. per acre (49% cut)
	x 514	acres
Total annual volume cut	2,400,000	bd.ft. per year (1st 20 years)

Second Cutting Cycle (20 years):

Maximum volume	7761	bd.ft. per acre (540 carried as low vigor)
Residual volume	- 5000	bd.ft. per acre (all good stock)
Volume to cut	2761	bd.ft. per acre (36% cut)
	x 514	acres
Total annual volume cut	1,420,000	bd.ft. per year (2nd 20 years)

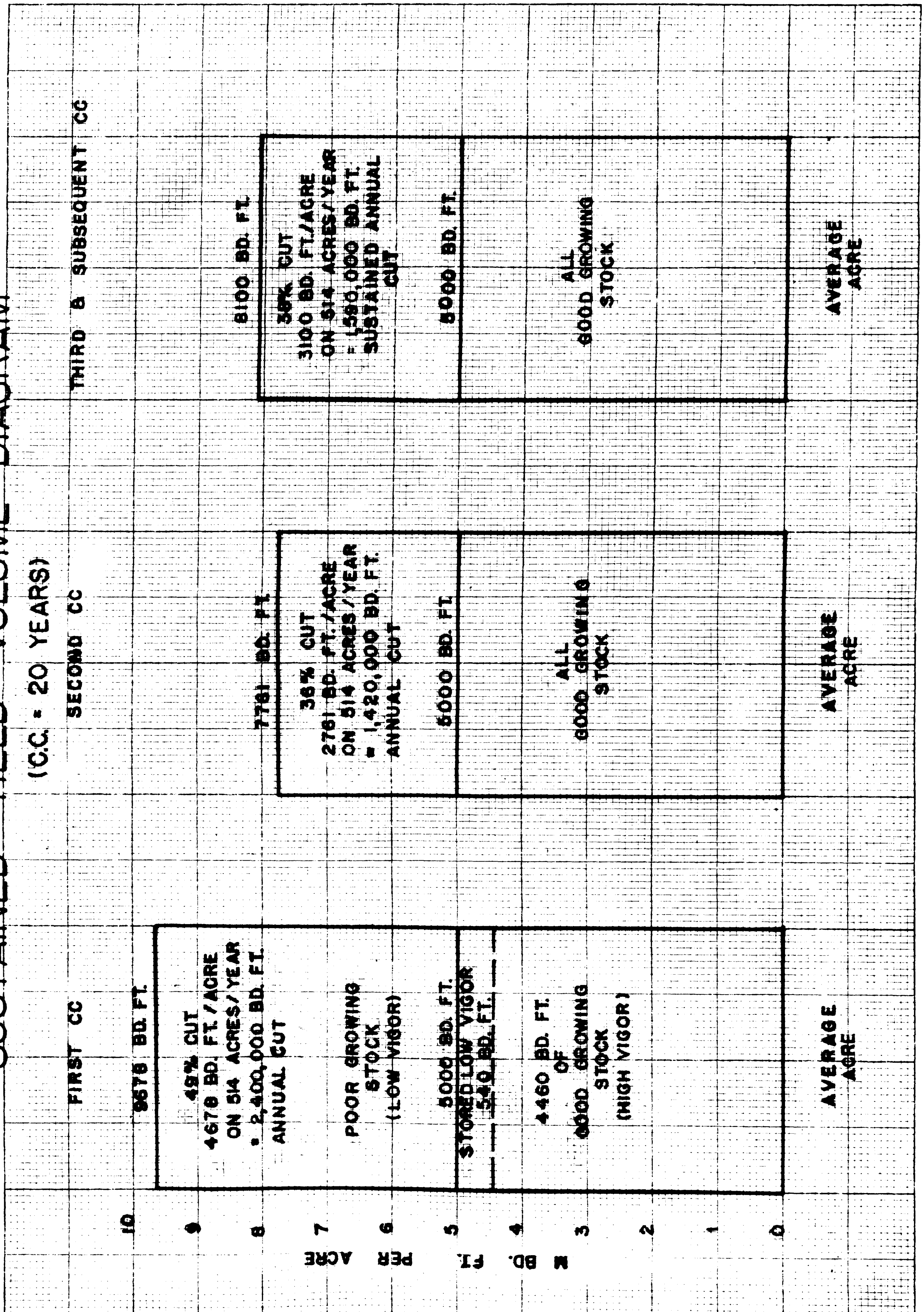
Third and Subsequent Cutting Cycles (20 years each):

Maximum volume	8100	bd.ft. per acre
Base volume	- 5000	bd.ft. per acre
Volume to cut	3100	bd.ft. per acre (38% cut)
	x 514	acres
Total annual volume cut	1,590,000	bd.ft. per year (sustained)

SUMMARY: Sustained Yield Plan for Tula and Gogebic Blocks

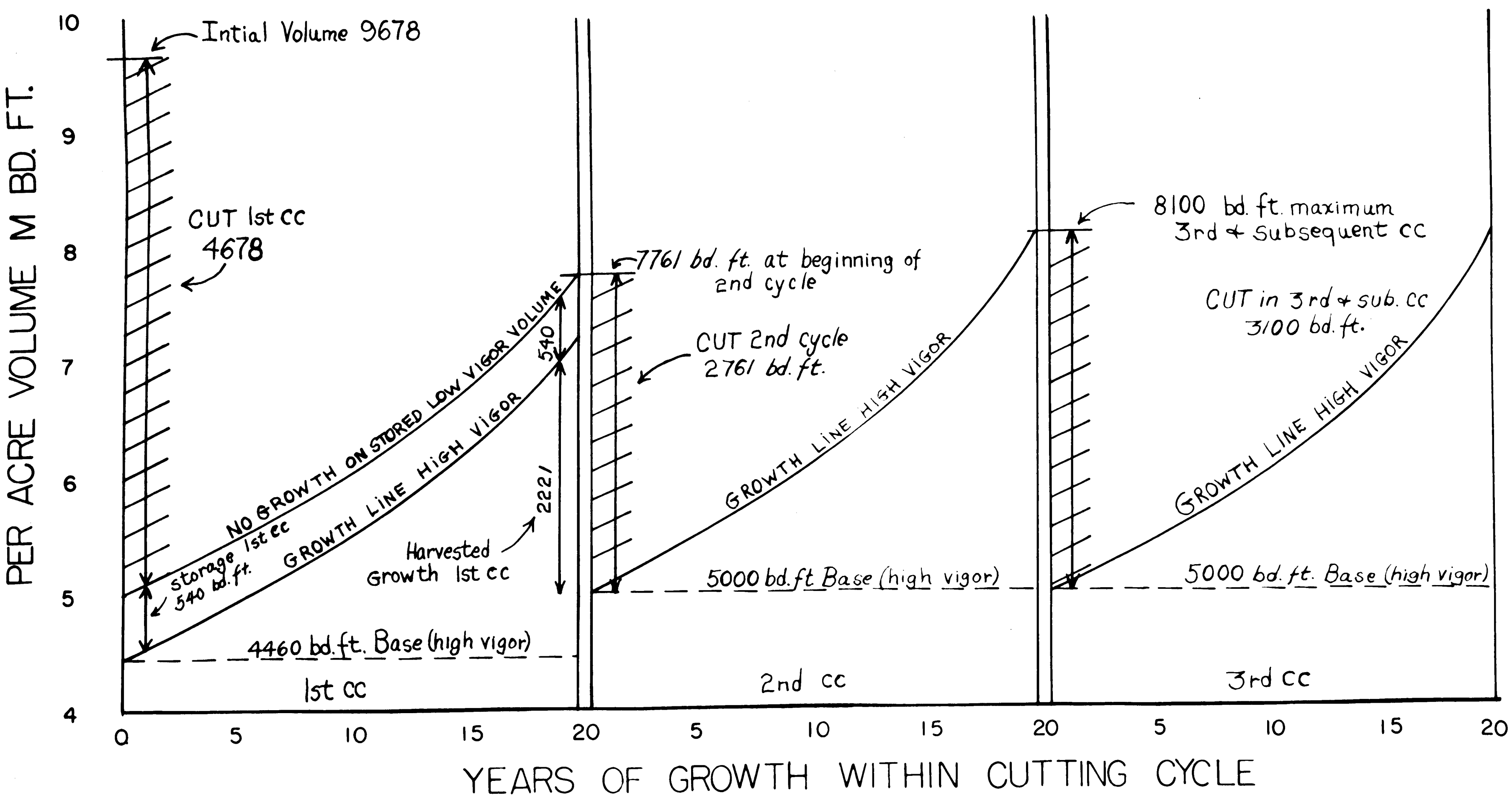
	1st Cycle	2nd Cycle	3rd Cycle
Total Volume Removed or Annual Cut	2,400,000 bd. ft.	1,420,000 bd. ft.	1,590,000 bd. ft.
Period of Operation	20 years	20 years	20 years
Annual Cutting Area	514 acres	514 acres	514 acres

Of the 6 million board feet the company wanted from their own timberlands, the first cycle on this sustained yield program yields only 2,400,000 board feet or 40% of the required amount. This is the largest possible cut the writer wishes to recommend, which will not injure the stand excessively.


SUSTAINED YIELD VOLUME DIAGRAM
(C.C. = 20 YEARS)
FIRST CC
9678 BD. FT.
49% CUT
4678 BD. FT./ACRE
ON 514 ACRES/YEAR
= 2,400,000 BD. FT.
ANNUAL CUT
POOR GROWING
STOCK
(LOW VIGOR)
5000 BD. FT.
STORED LOW VIGOR
540 BD. FT.
4460 BD. FT.
OF
GOOD GROWING
STOCK
(HIGH VIGOR)
AVERAGE
ACRE
SECOND CC
7761 BD. FT.
36% CUT
2761 BD. FT./ACRE
ON 514 ACRES/YEAR
= 1,420,000 BD. FT.
ANNUAL CUT
5000 BD. FT.
ALL
GOOD GROWING
STOCK
AVERAGE
ACRE
THIRD & SUBSEQUENT CC
8100 BD. FT.
38% CUT
3100 BD. FT./ACRE
ON 514 ACRES/YEAR
= 1,590,000 BD. FT.
SUSTAINED ANNUAL
CUT
5000 BD. FT.
ALL
GOOD GROWING
STOCK
AVERAGE
ACRE
M BD. FT. PER ACRE
0
1
2
3
4
5
6
7
8
9
10

SUSTAINED YIELD AVERAGE ACRE DIAGRAM

49% CUT - 20 YEAR CUTTING CYCLE



Two-Cut Liquidation

The two-cut liquidation program is undesirable because it does not provide for continuous production, but useful because it will enable an extension of time and an increase in total volume harvested. Used when it is impossible to go immediately into a sustained yield program because of requirements of more volume per year than the land can produce, this system of operation during the first cut treats the stand in the same manner as sustained yield but cuts over a larger area per year. Any time during the first cut or before the second cut is started, it is possible to change to a sustained yield program if a sufficiently large alternate supply may be found or an adjustment can be made to stay within the productive capacity of the land.

In the two-cut liquidation, the second cut removes all merchantable material. The amount per acre has been increased from the residual volume left after the first cut by growth which has accrued during the period of years used to make the first selective cut. About twice as much growth will have been added to the last acre reached in the second cut. It will require a longer period to complete the second or liquidating cut than was required in the selective first cut.

Determination of Volume to Remove (Initial Cut)

There are a multitude of ways of working out a two-cut liquidation program. The first problem is deciding what percent or amount of volume to take in the initial cut. For the purpose of flexibility, and with hope of the possibility of adoption of sustained yield in the future, the writer has selected the same percent of cut as the sustained yield program called for (49% cut leaving residual stand of 5000 board feet per acre). In the event of a change to the more permanent type of forest management, by leaving the same residual stand, the most utile sustained yield program could more easily be adopted than if a smaller residual volume were left. Actually, a heavier cut would cause excessive mortality in the birch and hemlock, but since the second cut comes within ten years after the first under the two-cut program, much of the decadent material would be salvaged at a minimum amount of loss.

Annual Allowable Cut

Table XVII shows a two-cut liquidation plan for 6 million board feet annual cut, developed using the same 49% cut as the sustained yield plan previously. Chart X, Page No. 91 shows this plan in terms of growing stock diagrams.

TABLE XVII - TWO-CUT LIQUIDATION PLAN

Taking 6 million board feet annually.

First Cut (selective 49%)

Present volume		9678 bd.ft. per acre
Residual volume	-	5000 bd.ft. per acre (540 low vigor)
Volume to cut		4678 bd.ft. per acre (49% cut)

Total volume removed during first cut:

Total acreage x per acre cut = total volume

10,280 acres x 4678 bd.ft. = 48,100,000 bd.ft.

Period of operation (1st cut):

$\frac{\text{Total volume}}{\text{Annual cut}}$ = years of operation

$\frac{48,100,000 \text{ bd.ft.}}{6,000,000 \text{ bd.ft.}}$ = 8 years

Annual cutting acreage (1st cut):

$\frac{\text{Total area}}{\text{Length 1st cut}}$ = cutting area

$\frac{10,280}{8}$ = 1285 acres

TABLE XVII Continued

Second Cut (liquidating)

Volume per acre at beginning of second cut

Residual low vigor volume	540	bd.ft. per acre
Residual good growing stock	4460	bd.ft. per acre
Growth added in 8.2 years	946	bd.ft. per acre (Chart VI, Page No.71)
Volume at start of second cut	5946	bd.ft. per acre

Approximate period of second cut

Volume at start of second cut	5946	bd.ft. per acre
	x 10,280	acres
Total second cut minus growth	61,150,000	bd.ft.
Divided by annual cut ÷	6,000,000	bd.ft.
Approximate period of second cut	10.2	years

Approximate volume at end of second cut

Residual low vigor volume	540	bd.ft. per acre
Residual good growing stock	4460	bd.ft. per acre
Growth added in 10.2 years	1240	bd.ft. per acre (Chart VI, Page No. 71)
Approximate volume end of second cut	6240	bd.ft. per acre

Closer approximation of period of second cut

Volume at beginning of second cut	5972	bd.ft. per acre
Approximate volume at end of second cut	6240	bd.ft. per acre
	2)12312	
Approximate average volume	6106	bd.ft. per acre
	x 10,280	acres
Approximate total volume of second cut including growth	62,800,000	bd.ft.
Divided by annual cut ÷	6,000,000	bd.ft.
New approximate period of second cut	10.5	years

TABLE XVII Continued

Final estimate of volume and period of second cut

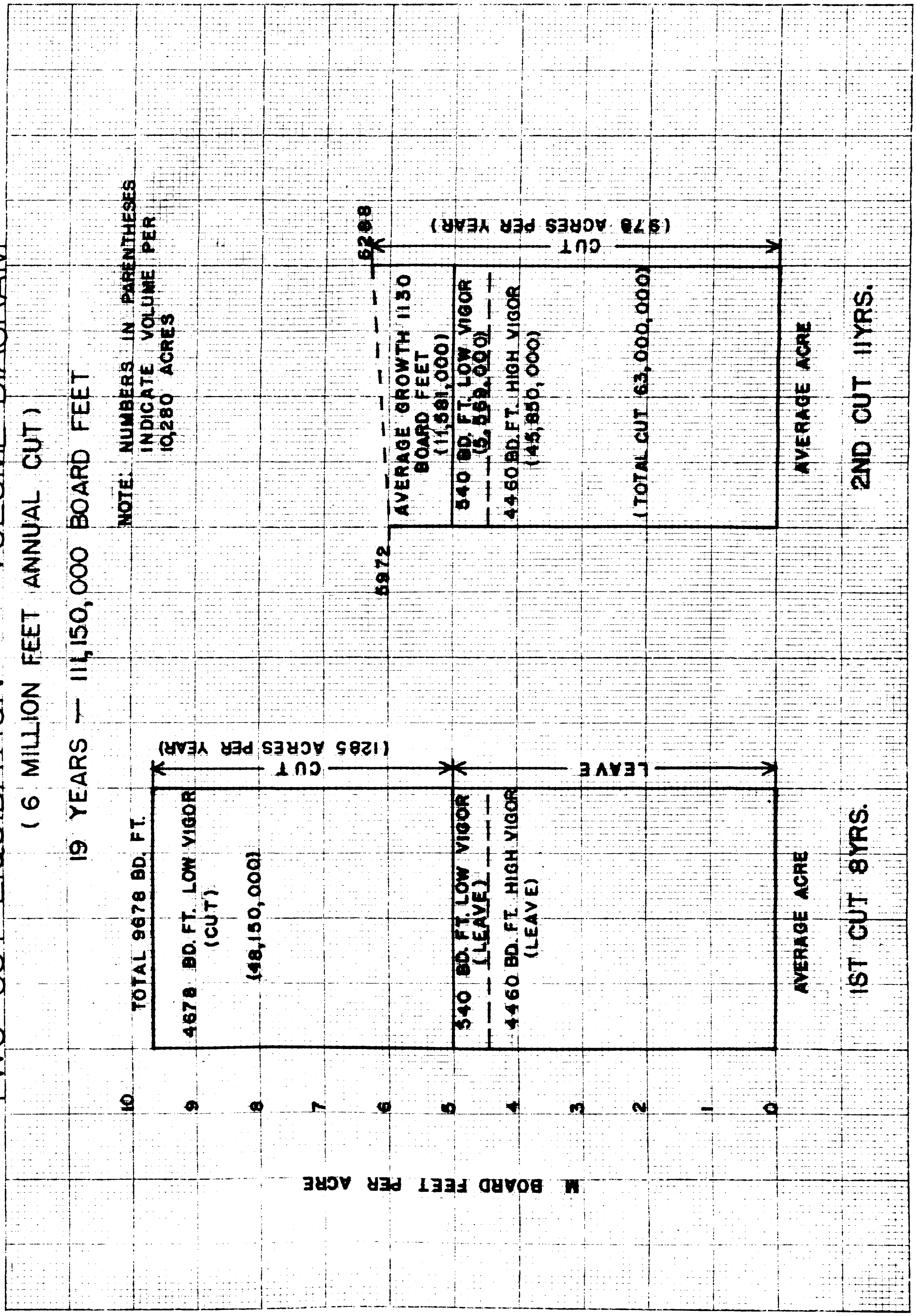
Residual low vigor volume	540 bd.ft.	per acre
Residual good growing stock	4460 bd.ft.	per acre
Growth on good stock 10.5 years	1288 bd.ft.	per acre(Chart VI, Page No.71)
Volume at end of second cut	6288 bd.ft.	per acre
Volume at start of second cut	5972 bd.ft.	per acre
	2)12260	
Average volume of second cut	6130 bd.ft.	per acre
	x 10,280 acres	
Total volume second cut	63,000,000 bd.ft.	
Divided by annual cut	÷ 6,000,000 bd.ft.	
Period of second cut	10.5 years	

Annual cutting acreage (of second cut)

Total area	10,280 acres
Divided by length of second cut	÷ 10.5 years
Annual cutting area of second cut	978 acres

SUMMARY: Two-Cut Liquidation Plan for the Tula and Gogebic Blocks

	1st Cut	2nd Cut	Total
Total volume removed	48,150 M bd.ft.	63,000 M bd.ft.	111,150 M bd.ft.
Annual cut	6,000 M bd.ft.	6,000 M bd.ft.	--
Period of operation	8 years	10.5 years	18.5 or 19 years
Annual cutting area	1285 acres	978 acres	--



TWO-CUT LIQUIDATION VOLUME DIAGRAM
(6 MILLION FEET ANNUAL CUT)
19 YEARS — 111,150,000 BOARD FEET
NOTE: NUMBERS IN PARENTHESES INDICATE VOLUME PER 10,280 ACRES
M BOARD FEET PER ACRE
10
9
8
7
6
5
4
3
2
1
0
TOTAL 9678 BD. FT.
4678 BD. FT. LOW VIGOR (CUT)
(48,150,000)
540 BD. FT. LOW VIGOR (LEAVE)
4460 BD. FT. HIGH VIGOR (LEAVE)
CUT
LEAVE
(1285 ACRES PER YEAR)
AVERAGE ACRE
1ST CUT 8YRS.
5972
6288
AVERAGE GROWTH 1150 BOARD FEET (11,581,000)
540 BD. FT. LOW VIGOR (5,559,000)
4460 BD. FT. HIGH VIGOR (45,850,000)
(TOTAL CUT 63,000,000)
CUT
(978 ACRES PER YEAR)
AVERAGE ACRE
2ND CUT 11YRS.

Considerations Under Selective Cutting

In this particular situation, with its high percentage of birch and hemlock in the stand composition, the silvicultural knowledge of how these trees react to a selective cut is the first consideration. A discussion of the silvicultural influence on marking and the approximate cost of marking follows.

In case of sustained yield, the marking crew can either make or break an operation in northern hardwoods. The marking policy must be guided by general principles rather than cut and dry rules, and must be aimed at ameliorating the growing conditions and stimulating reproduction with due regard to economic logging and without depleting the growing stock upon which the growth is accrued.[1/] Without the capital of growing stock there can be no interest in growth. These statements hold true under any selective cutting where the future cut is based on present and future growth. Under a two-cut system, a poor job of marking during the first cut results in poorer quality and lower volumes in the second cut and, therefore, a financial loss. In sustained yield such a loss also occurs, but the prospect of a degenerating future is even more important for a lumber concern that has planned for permanent operation and suddenly finds itself in the red. A company having a two-cut liquidation policy would not find this prospect as hard to face as one having hopes for a permanent sustained industry.

1/ Robert Martin, "Timber Marking for Second Cycle Cutting in Northern Wisconsin". Journal of Forestry, Volume 43, 655.

In marking this particular forest, it must be remembered that maple is the most tolerant and least sensitive to increased exposure of the maple-hemlock-birch type. Hemlock and birch on the other hand, are very susceptable to exposure. Graham[1/] found that the yellow birch was more sensitive to exposure than hemlock, especially with trees of small crowns, regardless of height. It is recommended that in the birch-hemlock type, trees be marked with the idea of what the reaction will be of these trees to exposure.

The individual tree selection method of marking allows flexibility of marking in taking a cut of 49%. In some of the over mature pure maple stands in the Tula block as much as 60% of the volume may be removed without materially injuring the stand, while in the thrifty birch-hemlock of the Gogebic tract, as little as 40% should be removed to reduce the amount of post logging decadence.

The yellow birch and hemlock high mortality in selectively cut stands is the result of (1) excessive exposure to solar radiation, and (2) drying out of the site.[2/] Because of these two facts and also because yellow birch is more sensitive to exposure than hemlock, these procedures should be followed: birch and hemlock exposed to a drying out site because of road building and other reasons should be cut. As much as possible, the south and west sides of the thrifty hemlock and birch should be kept sheltered by other trees, especially birch, because it is the most valuable species in the forest.

1/ Samuel A. Graham, <u>op</u>. <u>cit</u>., 56-57.
2/ Samuel A. Graham, <u>op</u>. <u>cit</u>., 59-60.

If sustained yield is the management plan, birch reproduction should be stimulated. However, if the management plan is two-cut liquidation, those trees most likely to put on good growth should be favored. Zillgitt and Eyre[1/] point out that birch reproduction is best secured under group selection method and requires ample seed supply from the mature trees not over 300-400 feet distance, exposure of mineral soil through summer or fall logging, and, because of intolerance, provision for sufficient light by the creation of small openings (up to 0.1 acre) in the canopy throughout the tract. Other than the fact that the Gogebic tract, because of the poor drainage and the soil type, must be logged in the winter; all three of these suggestions could easily be followed to produce birch in this area under sustained yield. Zillgitt and Eyre further point out that the group selection method is not the only silvicultural way of handling northern hardwoods, and the "unbroken canopy" belief could be modified so that openings could be created by "removing mature timber in the vicinty of yellow birch seed trees." They also say, that the supposedly cull birch could be left as seed trees rather than taken out or girdled.

The reaction of a species after a selective cut sometimes is the deciding factor in marking a tree cut or leave. Zon and Scholz[2/] found that hemlock responds more quickly than the other species, reaching its peak of growth ten years after cutting.

1/ W. M. Zillgitt and F. H. Eyre, "Perpetuation of Yellow Birch in Lake States Forests", Journal of Forestry, Volume 43, 660.
2/ Raphael Zon and H. F. Scholz, How Fast Do Northern Hardwoods Grow?, 18, 19.

Sugar maple and basswood reach their maximum twenty years after selective cutting, and yellow birch, although never showing much response, reaches its peak ten years after logging but continues to grow at the small accelerated rate for thirty years or more. Since yellow birch respond only slightly to release, they should be cut if mature.

Cost of Marking Timber

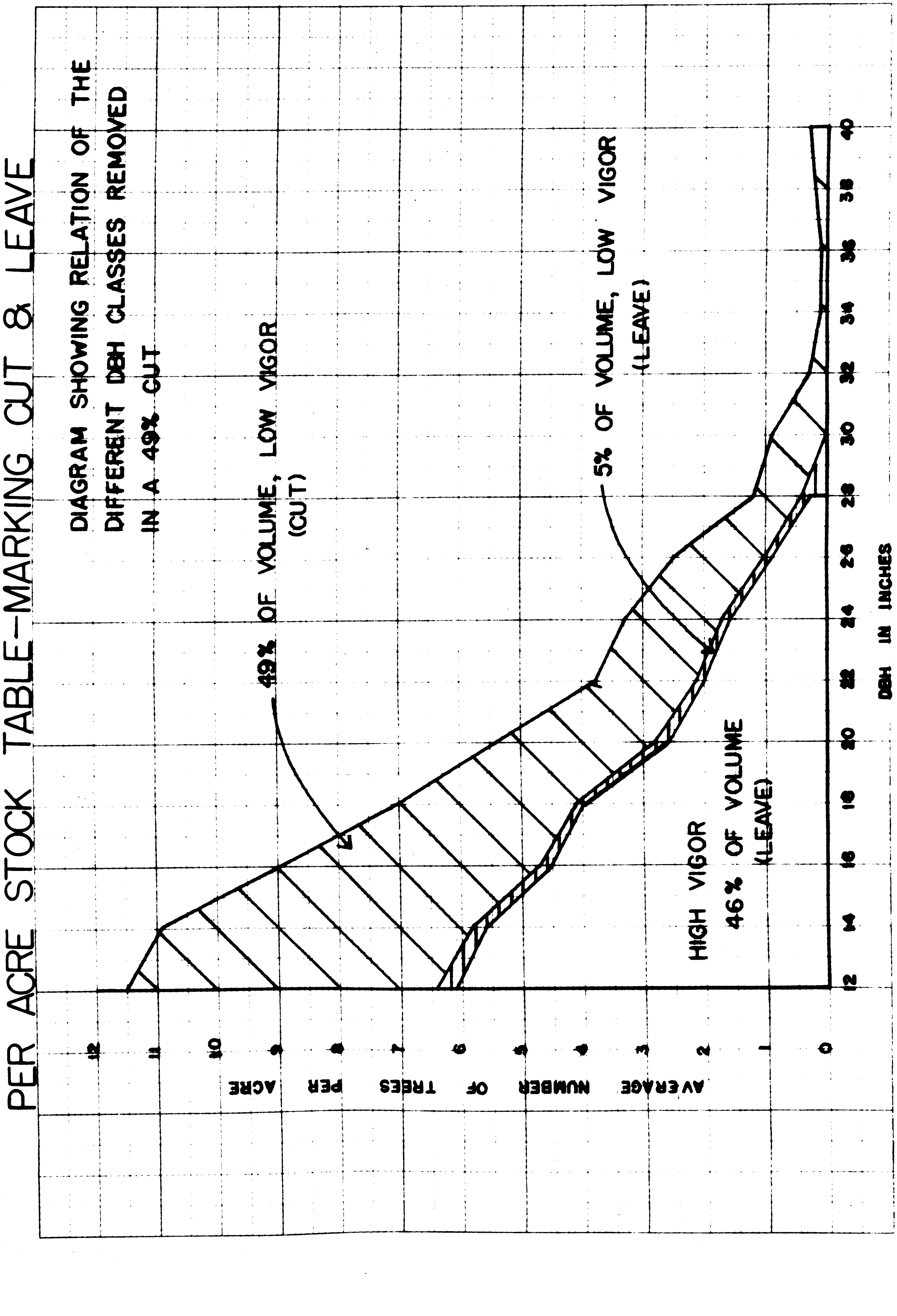
The cost of marking timber in the selective cutting under a sustained yield or two-cut liquidation plan is an additional cost over straight liquidation. Any operator thinking of changing from a clear-cutting policy to one of selective cutting would be interested in these costs. These costs must also be calculated in the operating expenses of the two-cut and sustained yield plans.

Past experience[1/] proves that the most efficient procedure in marking is the use of a three man crew, one running the line and tallying and two marking. Between twenty and thirty acres a day can be marked (50% cut) at a cost of between 20¢ and 30¢ a thousand board feet[2/].

1/ Method employed by R. Ewalt, forester, Cleveland Clifts Iron Company, Negaunee, Michigan.
2/ Costs are figures obtained from Cleveland Clifts Iron Company and Copper Range Company, Houghton, Michigan.

Marking Guide for Average Acre

Chart XI indicates the high and low vigor trees on the average acre and shows the proportion of d.b.h. classes that will be removed in the first cut. The bulk of the number of trees cut should come from the 12-16" d.b.h. classes. Chart XII, Page No. 98 and Table XVIII, Page No. 99, show the per-cent of net volume of cut and leave for each species on the average acre. These two charts and this table are built up from the per acre stock table and serve only as a rough guide for marking. Further marking guides with reference to number of trees per acre and basal area cut and leave are given in the Appendix, Tables L, M and N, and Charts A, B and C, Page No. 33 to No. 38.


PER ACRE STOCK TABLE-MARKING CUT & LEAVE
DIAGRAM SHOWING RELATION OF THE
DIFFERENT DBH CLASSES REMOVED
IN A 49% CUT
49% OF VOLUME, LOW VIGOR
(CUT)
5% OF VOLUME, LOW VIGOR
(LEAVE)
HIGH VIGOR
46% OF VOLUME
(LEAVE)
AVERAGE NUMBER OF TREES PER ACRE
DBH IN INCHES

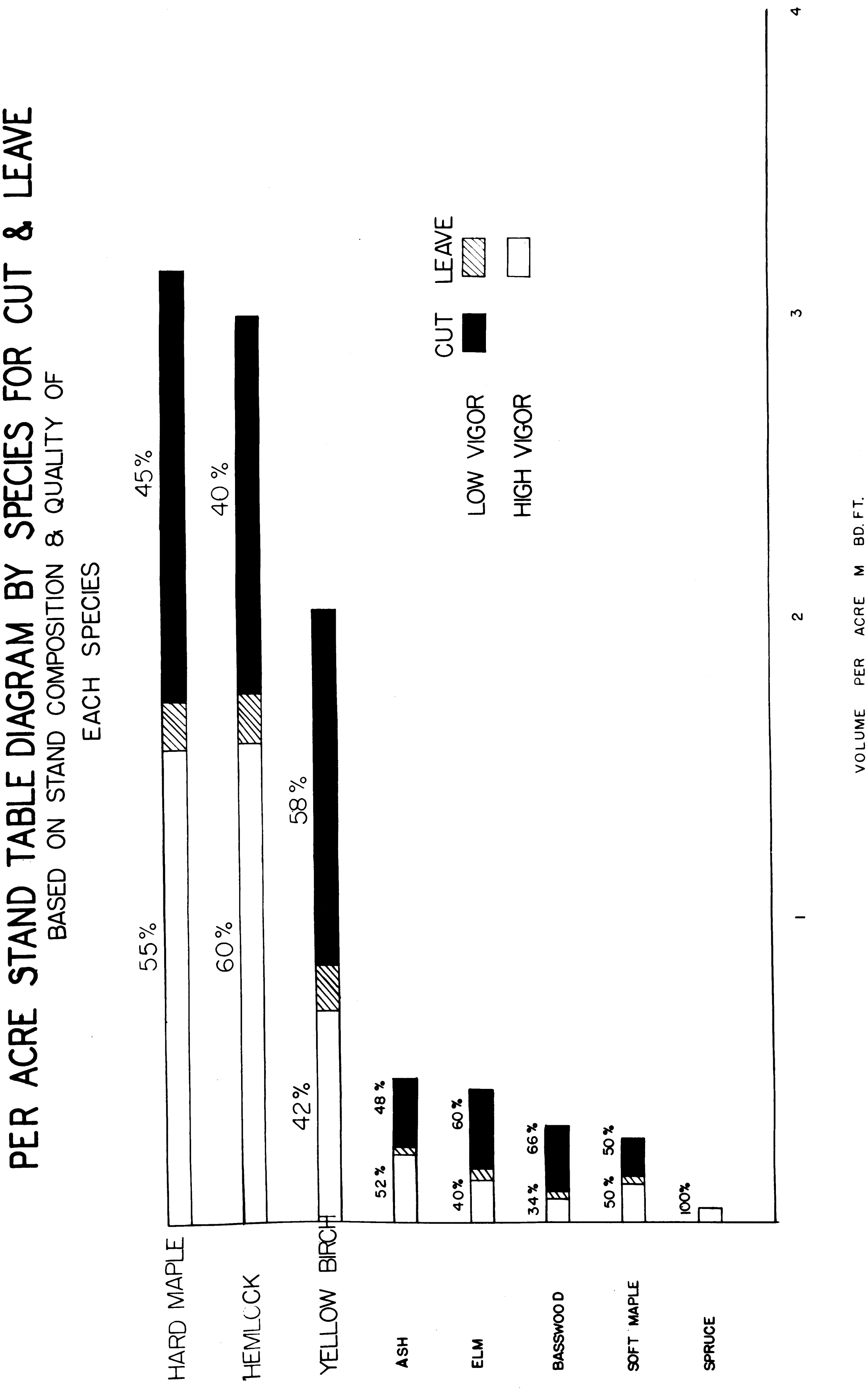

PER ACRE STAND TABLE DIAGRAM BY SPECIES FOR CUT & LEAVE
BASED ON STAND COMPOSITION & QUALITY OF
EACH SPECIES
HARD MAPLE
HEMLOCK
YELLOW BIRCH
ASH
ELM
BASSWOOD
SOFT MAPLE
SPRUCE
55%
45%
60%
40%
42%
58%
52%
48%
40%
60%
34%
66%
50%
50%
100%
CUT
LEAVE
LOW VIGOR
HIGH VIGOR
1
2
3
4
VOLUME PER ACRE M BD. FT.

TABLE XVIII - MARKING GUIDE FOR CUT AND LEAVE NET VOLUME (By Species)

Based on Per Acre Stand Table
(Trees 12" d.b.h. and over only)

SPECIES	LEAVE						CUT	
	High Vigor		Low Vigor		Total Leave		Low Vigor	
	Net volume in bd.ft.	% volume of species	Net volume in bd.ft.	% volume of species	Net volume in bd.ft.	% volume of species	Net volume in bd.ft.	% volume of species
Hard Maple	1563	49.7	161	5.1	1724	54.9	1414	45.1
Hemlock	1586	54.7	145	4.8	1731	59.5	1214	40.5
Yellow Birch	706	35.1	134	6.7	740	41.8	1173	58.2
Ash	220	47.8	26	5.5	246	52.3	224	47.7
Elm	141	32.8	32	7.4	172	40.2	257	59.8
Basswood	75	24.0	26	8.4	91	32.4	210	67.6
Soft Maple	123	44.7	16	5.8	139	50.5	136	49.5
Spruce	46	100.0	0	0			0	0
TOTAL (All species)	4460	46.1	540	4.9	5000	51.0	4678	49.0

Under selective logging the following table presents the annual allowable cut by species upon removal of 49% of the net volume in the two-cut liquidation and sustained yield plans.

TABLE XIX - ANNUAL ALLOWABLE CUT BY SPECIES

SPECIES	% CUT	PER ACRE NET VOLUME BD.FT.	TOTAL VOLUME TWO-CUT CUTTING AREA 1285 ACRES	TOTAL VOLUME SUSTAINED YIELD CUTTING AREA 514 ACRES
Hard Maple	45.1	1,414	1,815,000	726,000
Hemlock	40.5	1,214	1,628,000	643,000
Yellow Birch	58.2	1,173	1,506,000	605,100
Ash	47.7	224	287,500	115,800
Elm	59.8	257	339,300	132,100
Basswood	67.6	210	269,500	108,050
Soft Maple	49.5	136	174,500	69,950
Spruce	---	---	---	---
All Species	49.0		6,000,000	2,400,000

Timber Stand Protection

In this paper the term "timber stand protection" means the protection of the forest from wildlife, insects, disease, timber stealing, and fire. The last two are the most important. There was no particular information sought on wildlife, insects, or diseases during the survey, and the statements here are based on the observations of the field parties.

Timber Stealing

Timber stealing is quite prevalent in this area and the company has been compelled to allocate part of their cruiser's time to frequent and numerous checks on all sawtimber holdings.

<u>Fire Protection</u>

The hazard and risk of fire is very low in the virgin hardwood stands,[1] although it must be taken into consideration. There seems to be adequate protective facilities from State and Federal sources.[2] The U.S. Forest Service maintains a ranger station at Bergland and Bessemer, Michigan, and a guard station at White Pine. The State Department of Conservation has a conservation headquarters at Wakefield. The White Pine guard station is about six miles from the Porcupine block; the Bergland ranger station is five miles from the Gogebic block; the conservation headquarters at Wakefield are about twelve miles from the Tula block. There are also state and federal fire towers strategically located to give an adequate detection system to all three blocks. Bergland lookout is located some six miles south of the Porcupine block; the Porcupine lookout is located in one of the adjacent northern sections of the Tula block; Matchwood lookout is four miles southeast of the Gogebic block. There is a fairly good road system in all the blocks at present and should the company go on a sustained yield or two-cut liquidation, the mileage of roads would be augmented, and they would be serviceable for a longer period of time.

Slash is not a great problem on these forest lands because of the high percentage of hardwoods; the Forest Service Experiment Station has found that hardwood slash up to 2" in diameter rots fast enough to reduce the hazard of fires from two to three years after logging. Cull logs, larger limbs and coniferous slash remain a hazard for five to fifteen years. The Station has also found that

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1/ Management Plan Paint River Working Circle, <u>op. cit.</u>, 22.
2/ See Map No. 1 in the pocket of the Appendix for location.

the hazard on slash on selectively cut areas is reduced considerably in period and in intensity.

Wildlife

The most important damage observed as the result of disease, insect, or wildlife, was deer damage (browse). The composition of the Ahonen forest land, with its scattered patches of hemlock in the northern hardwood areas, offer excellent deer cover. This cover plus the large amount of maple and birch reproduction for spring and summer browse have helped in keeping the deer population very high, too high for good reproduction of these valuable hardwood species. Acre after acre of this dense reproduction was observed to have the main shoots or terminal branches continually eaten off, making for poorly formed trees, and therefore, lowering of the value. Another factor favoring high deer population are the cedar swamps intermingled with the northern hardwood and hemlock areas. These swamps are intensively used as winter deer yards, thus keeping many of the cedar from reaching maturity. A lower deer population should be maintained in order to give the northern hardwood and cedar reproduction a chance for survival, especially if selective cutting is going to be practiced.

Other forms of wildlife damage that were cursorily observed were porcupine damage to hemlock and some Snowshoe Hare damage to spruce, cedar, and several of the hardwoods. According to the Wisconsin Deer Damage Survey[1/] the Snowshoe Hare injury to yellow

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1/ Ernest Swift, Wisconsin's Deer Damage to Forest Reproduction Survey, Final Report, 7.

birch was as much as the deer damage (2 out of every 5 seedlings). The extent of this damage on the Ahonen tracts was not estimated, but similar areas in Wisconsin[1/] show considerable loss due to the Snowshoe Hare.

Insects and Disease

Since most of the sawtimber is hardwood, relatively little insect damage was found. By selective cutting the risk and hazard of the hemlock borer, *Melanophia fulvoguttata*, and the bronze birch borer, *Agrilus anxius*, will be materially reduced because both of these insects are secondary and attack only over-mature or decadent trees. The white pine on the areas was free from blister rust, probably because of its low proportion in the stands. Because of the intermingled relationship of the balsam fir and spruce with the hardwoods, very little spruce-bud worm damage was noticed. The shoestring fungus, *Armillaria sp.*, was observed on occasional low vigor hemlock. Other than the minor infestations mentioned above, the stand appeared quite healthy.

1/ Ernest Swift, *op. cit.*, 10-23.

To recapitulate, the selective cut of sustained yield and the initial cut of the two-cut plan were analyzed both financially and silviculturally. It was determined that a 49% removal would be best under existing conditions. A brief guide to timber marking was developed, but more information is needed before a definite marking policy can be established. Basically, the important factor in marking the Ahonen stands is that the volume removed in the hemlock and birch type should be held to 40% while up to 60% may be removed in the pure maple stand. Timber stand protection, although less important in the liquidation plans, must be considered. The fire protection system seems to be adequate at present, and disease and insect damage are not great. Wild life damage is becoming a problem, especially deer browse to reproduction. Timber stealing exists and calls for continual vigilance.

There were three management plans presented, straight liquidation, sustained yield, and two-cut liquidation. The annual quota of six million board feet can be met by either of the liquidation plans. Straight liquidation having a span of seventeen years would produce a total of 99,491,000 board feet. Two-cut liquidation having a span of nineteen years would produce a total of 111,150,000 board feet. Sustained yield, although theoretically perpetual, can only supply 2,400,000 board feet or 40% of the quota during the first cycle and less during the second, third and subsequent cycles.

LOGGING PLANS

Of the total amount of money expended to produce a thousand board feet of lumber, the logging cost is usually the greatest. It behooves any company, regardless of their forest management policy, to control this cost through economic planning. The control of cost in the present and new systems of logging will be discussed in this section, as well as the actual physical conditions involved in logging.

Logging Conditions

The time of year of the logging operation on a specific area is largely determined by two interdependent factors, climate and ground condition. "Ground condition" means both the topography and soil condition of the ground. In the Lake States, logging is carried on in two seasons, winter and summer. As a general rule, the flat, wet areas are logged in the winter to take advantage of the frost and frozen ground and to avoid exorbitant graveling costs of summer logging. The higher and drier areas are logged in the summer. There are exceptions, however. Areas that are low and wet are usually avoided in summer logging, but if this same area receives an excessive amount of snow in the winter, the company would be forced to log it in the summer to avoid the heavy snow.

Winter Logging

Because snow is usually expected in late October, frequently before the ground freezes, and usually remains on the ground until the spring breakup in late March, much of the logging is done in the winter. The total snowfall averages slightly over six feet, but its settling during the course of the winter produces a depth of only three to four feet at any one time. Such accumulated depth may be expected after January 15, and interferes considerably with felling and skidding operations. Logging roads are dragged and plowed-out, thus permitting the ground and snow to freeze solid and allowing truck haul of timber products to continue until the spring breakup regardless of the character of the terrain under the roads. Logging of pulpwood, cedar and other products from the swamp areas can be carried on most advantageously during the winter. The state, county and many private roads are kept open throughout the winter months. During the spring breakup period, forest roads usually become impassable except in the lightest traffic, and the hauling of timber products must cease.

Summer Logging

After the short spring breakup, usually from four to six weeks, summer logging commences as soon as roads are passable, and continues until the fall rains again make roads impassable. The degree to which logging must be discontinued during the spring breakup and fall rains is dependent upon the character of the soil (ground conditions) and degree to which the road is drained. During periods of heavy rainfall, spur roads may become impassable for short periods, particularly on poorly drained areas. The Ahonen Company has overcome this by graveling most of the summer-haul roads.

<u>Logging Category of the Ahonen Tracts</u>

The Ahonen Lumber Company's holdings vary a great deal in ground condition, and this variance permits logging the year round. The company's spur roads are classified as either III, winter-haul road, or IV, summer-haul road. Class V, the main-haul road is kept open all year, (see Map No. 3 in the pocket of the Appendix).

The gradient of all roads is seldom more than 8%. Winter roads are constructed 24 feet wide to allow space for the plowed snow. Summer roads are constructed 20 feet in width and graveled. Quite a bit of machine grading is necessary to keep graveled roads smooth. Summer roads must also be ditched and provided with adequate drainage. The main-haul road is constructed 26 feet wide, graveled, ditched, and provided with excellent drainage.

The Gogebic block, because of its low, flat, wet terrain must be logged in the winter. Most of the Tula block can be logged in the summer, though there are several swamp areas that necessitate winter logging. The company used to log the Porcupine block throughout the year, hauling north through Silver City during the summer months, a distance of 59 miles, and directly to White Pine during the winter, a distance of 49 miles, (see Map No. 3 in the pocket of the Appendix). The winter logging route was much shorter than the summer route and saved approximately 20 miles per round-trip haul. Unfortunately, on the winter route between Nonesuch and White Pine, the hills were found to be too steep for the heavily ladened logging trucks and the company had to revert to summer logging, hauling north through

Silver City. The Porcupine block is now considered to be strictly a summer logging proposition.

Logging Systems

The history, advantages, disadvantages, methods, personnel and equipment requirement, of the present system, contractor-operated log-length skidding, and the new system, company-operated tree-length skidding, will be explained in this section.

Present System

Since 1937, when the union first tried to organize the Ahonen Company's logging crews, the company has contracted logging out to "gyppo" operators. The immediate result of this action was the halting of union interference for organization. The union could not attempt to organize the small gyppo outfits of a few men working for themselves. Since then, the gyppo logging contractors have proven very successful. One reason for this is that under the gyppo system there is more control over cutting, or closer supervision, than under the buck-passing system of company crews. The gyppo contractor is a man in business for himself and must live up to his contract. Because of this obligation and the small size of their crews, the contractor supervises his crews very closely, and the efficiency of logging is increased. The contractor is better satisfied because he makes a wage plus profit, and the company is satisfied because this plan is cheaper than the use of the old company crews. The incentive of a greater profit, obtained through cheaper production, within the limits of the contract, increase the efficiency of these gyppo operations far beyond that obtained from company crews. The Ahonen Company has partially subsidized many of these operators by renting them company equipment, financing them, and supplying supervision. This parental relation has helped start and stabilize many of these operators. The gyppo contractor today profits far more by working for the Ahonen Company (and other similar companies) and being partially subsidized than being independent and having to bid on high Forest Service stumpage.

One of the biggest headaches the company had before the infiltration of the gyppo contractors was that of keeping the company-operated logging camps on a break-even basis. Inefficient, wasteful cooks could turn a break-even camp into a costly, money-losing affair, and constant supervision of camps was necessary to prevent that from happening. Today these camps are still more costly, even though each man is assessed $1.50 a day for room and board, the company would still have to add another $1.50 to this in order to offset the high cost of food. With the increased number of roads, many of the men are now able to live at home with their families and drive to work, although in some cases camps are still necessary. Under the gyppo system, the contractor has the responsibility of maintaining the camps, thus eliminating one of the company's problems.

At the present time the company is using International TD-14 tractors (54 drawbar horsepower) for road construction work and International TD-9 tractors (39 drawbar horsepower) for ground skidding. Under the present ground skidding system, roads are usually spaced two tallies (10 chains) apart, while landings are spaced 1-1/2 tallies (7-1/2 chains) apart, but alternated on opposite roads, (see Chart XIII, Page No. 113). These landings are constructed approximately 40' x 40'. A little less than 8 miles of road and 88 landings are constructed on a typical section with this system. Average skidding distance is 216 feet. Felling and bucking are done with crosscut saws, and loading is done with "A" frame and power jammers. International K-7, two and three ton, standard axle trucks are used for hauling. A woods crew of eighteen men composed of five gangs of sawyers, three tractor operators, two choker-setters, one loader operator, and two hookers, is necessary to produce 25 M board feet per day.

New System

There has been an increasing trend in the post-war period toward tree-length skidding with arches. The felling is usually done with power saws instead of crosscuts to reduce the number of sawyers in the operation. The advantage of tree-length skidding is that it decreases logging costs by reducing the number of sawyers, tractors and tractor operators, choker-setters, and others. Not only is the amount paid in direct wages eliminated, but the additional 17.2% of total wages that goes to the governments for social taxes ceases. With fewer employees as a result of this increased mechanization, the labor problem is not of great consequence, and supervision is made easy. Other items that decrease the cost are: fewer roads and landings are needed to log an area; a larger number of logs, which means a greater volume, can be skidded per turn; skidding efficiency is increased because the butt end of the logs are elevated above the ground, thus (1) allowing the tractor to travel in a higher speed range, which in turn reduces the skidding time and hence the skidding cost per M bd.ft., (2) keeping the logs freer of imbeded stones and dirt, and (3) reduces the strain on the equipment because there is less "drag" or resistance.[1]

Clean logs have been the object of the Ahonen Company for quite sometime. During the summer logging in rough terrain, the increased amount of dirt and stones gathered on logs by ground skidding have cost the company considerable money in time lost at the sawmill. This lost time is caused by the band saw's hitting a rock or stone in the log, and its causing a momentary shut-down while the saw is changed. To obviate this delay the company has put an additional man at the top of the jack ladder to hose the logs as they come up out of the log pond, but even this precaution has failed to clean the logs thoroughly.

At the present time there is a controversy as to whether tree-length skidding harms the residual stand more or less than log-length skidding in a selective logging operation. Cleveland Clifts Iron Company, which is on a sustained yield program, has allowed its loggers to use the tree-length system and is apparently satisfied that this method of logging does not do any more damage than ground skidding. Hooker[2] has shown in one

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1/ N. C. Brown, Logging, 165-167.
2/ L. W. Hooker, Logging Damage: Tree-length Skidding vs Log-length Skidding.

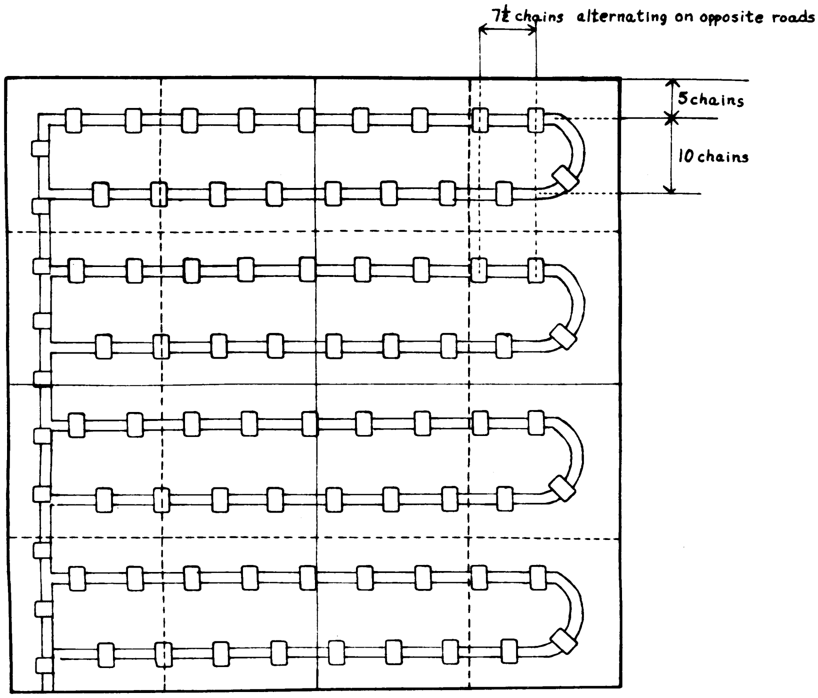
instance that the damage inflicted by tree-length skidding was actually less than that of log-length skidding. In employment of either method of skidding, extreme care should be used on the part of the logging crew, especially the tractor operator, to avoid damaging the residual stand. Care on the part of the tractor operator is probably the most vital factor in the amount of damage inflicted by either system of logging. Selective logging calls for very close supervision to avoid excessive damage to the residual stand.

The Ahonen Company is planning to revise its logging policy by taking over the operations itself, and using the tree-length skidding system. It plans to use 9 man crews, which will have two 2-man power-saw gangs for felling and limbing, one International TD-14 tractor (equipped with a Hyster winch and arch, and Caterpillar tracks) and operator, one choker-setter, and a 3-man crew at the landing which will buck up the trees into log lengths and do the loading with a power jammer. An average production of 22,000 board feet per day for each crew is expected. Under such a plan the roads would be spaced 1/2 mile apart (40 chains), and landings would be spaced 1 tally (5 chains) apart and have dimensions of 50' x 50'. A total of 2-1/4 miles of road and 25 landings will be built on the average section, (see Chart XIII, Page No. 113), and the average skidding distance will be 666 feet.

Comparison of the Two Systems

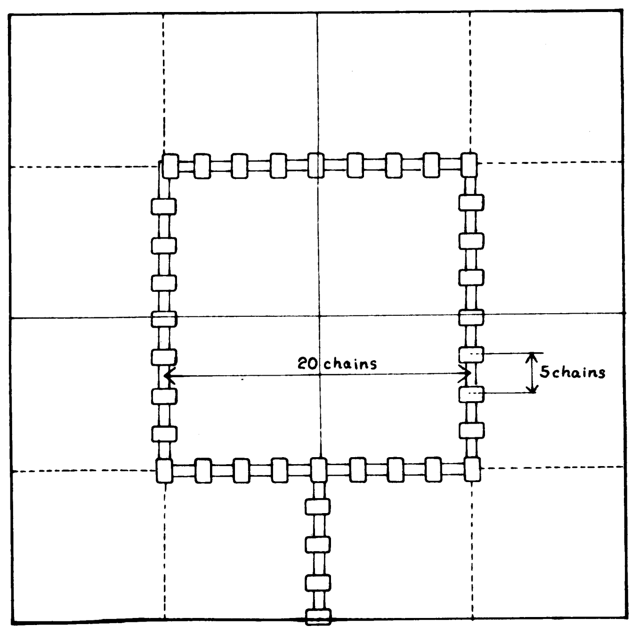
The total logging cost under each of the systems described is the ultimate test of which system is the most economical.

DIAGRAMS SHOWING COMPANY ROAD AND LANDING SPACING ON A TYPICAL SECTION



PRESENT PLAN – GROUND SKIDDING

APPROXIMATE SIZE OF LANDINGS 40'X40'
APPROXIMATE WIDTH OF ROADS 20'-24'



PROPOSED PLAN – ARCH SKIDDING

APPROXIMATE SIZE OF LANDINGS 50'x50'
APPROXIMATE WIDTH OF ROADS 20'-24'

Many of the costs, such as hauling, scaling, supervision, road and landing construction (per station), loading and unloading will be the same under both systems. The crux of this comparison is the total costs of felling, skidding, and construction of roads and landings per M bd.ft. The skidding and construction costs will be analysed first to find the operational costs of the skidding unit and the per mile road construction cost. Second, the cost per M bd.ft. of skidding, and road and landing construction under the present spacing for ground skidding and the proposed spacing for arch skidding will be calculated. Third and last, the total logging costs per M bd.ft. for each system will be calculated. All cost calculations will be made on the assumption that the timber is to be clear cut and an average volume of 9.7 M bd.ft. per acre will be removed.

Construction Costs - Machine Rates

The cost of logging road construction, and skidding equipment operation is based on the machine rate and performance (productivity) of the unit in question. Cost and Time Analysis A (see Pages No. 39 through No. 42 in the Appendix) shows that the construction of Class III (winter-haul) roads is $523.26 per mile, and the Class IV (summer-haul) roads amounts to $1105.84 per mile. (Note: both figures include cost of landings). Cost and Time Analysis B (see Pages No. 43 through No. 45 in the Appendix) shows the fixed cost of ground skidding with an International TD-9 tractor to be $2.36 per M bd.ft. The variable cost is 15.8¢ per M bd.ft. for 100 feet of round-trip travel. Cost and Time Analysis C (see Pages No. 46 through No. 48 in the Appendix) shows the fixed cost for the tree-length skidding with an International TD-14 tractor and Hyster winch and arch to be $2.45 per M bd.ft., and the variable cost of 10.2¢ per M bd.ft. for 100 feet of round-trip travel.

In a summary of these Cost and Time Analyses, it is evident that road and landing construction per mile for both summer and winter roads is constant regardless of what system of logging is used. The actual cost hinges on the amount of roads and landings necessary to construct under each system. This cost will be discussed in the next portion "Road-Landing Layout and Cost".

The fixed operating cost for ground skidding is $2.45 - $2.36 = $0.09 less per M bd.ft. than tree-length skidding. However, the variable cost for ground skidding is 15.8¢ - 10.2¢ = 5.6¢ per M bd.ft. for 100' of round-trip travel less than for tree-length skidding.

Road-Landing Layout and Cost

The cost per mile of road and landing construction was obtained previously. To facilitate comparison of the total costs per M bd.ft. under each logging system, the construction costs must be transferred from cost per mile to cost per M bd.ft. To find the construction cost to be borne per M bd.ft., a technique developed by Matthews[1/] was used. The calculations in this

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1/ D. M. Matthews, Cost Control in the Logging Industry, 119.

portion are not aimed at maximum economy through economical road location, but are the costs incurred under the present company policy of road location for ground skidding, and proposed company policy of road location for arch skidding. The economical locations of roads and landings will be developed under "Logging Layouts For The Management Plans", Pages No. 126 to No. 148.

Cost and Time Analyses No. 1 and No. 2 on the following pages calculate the cost per M bd.ft. for skidding, and construction of roads and landings under the two systems of logging.

COST AND TIME ANALYSIS NO. 1 - GROUND SKIDDING, ROAD, AND LANDING COSTS

(For clear cutting, using International TD-9 tractors)

	Winter Roads	Summer Roads
Road and landing construction cost/mile	$523.96	$1105.84
Less cost of landings/mile	45.06	45.06
	$478.20	$1060.78
Divided by 52.8 = cost per station	9.03	20.20

Cost of landings $45.06 ÷ 11 landings per mile = $4.10 per landing
Cost of skidding/100'/M bd.ft. = 15.8¢
Volume = 9.7 M bd.ft./acre

		Winter Roads (cents)	Summer Roads (cents)
Road construction cost/station	r	903	2020
Landing construction cost	L	410	410
Skidding cost/100'/M	C	15.8	15.8
Volume /acre	V	9.7 M	9.7 M

<u>Present plan for ground skidding</u>: Space roads 10 chains (660') apart and landings at 7-1/2 chains (495') apart.

Spacing or S = 6.6 hundred feet. $Z = \frac{495}{660} \times 100 = 75\%$. That is landings are spaced at 75% of road spacing.

<u>Costs under present plan</u>

		Cost/M (cents) Winter Roads	Summer Roads
Skidding: Fixed		236.0	236.0
Variable .PCS or 0.327 x 15.8 x 6.6		34.1	34.1
Roads	$\frac{4.356r}{VS} = \frac{4.356 \times 903}{9.7 \times 6.6}$	61.5	
	$\frac{4.356r}{VS} = \frac{4.356 \times 2020}{9.7 \times 6.6}$		137.5
Landings	$\frac{\frac{L}{2}}{0.161\ S\ V} = \frac{\frac{410}{2}}{0.161(6.6) \times 9.7}$	6.0	6.0
		337.6	413.6

COST AND TIME ANALYSIS NO. 2 - ARCH SKIDDING, ROAD, AND LANDING COSTS

(For straight liquidation, using International TD-14 tractors)

Road construction cost, same as ground skidding, $9.03 /station for winter roads and $20.20 /station for summer roads.

Cost of landings same as ground skidding $4.10 /landing
Cost of skidding/100'/M bd.ft. = 10.2 ¢
Volume = 9.7 M/acre

		Winter Roads (cents)	Summer Roads (cents)
Road construction cost/station	r	903	2020
Landing construction	L	410	410
Skidding cost/100'/M	C	10.2	10.2
Volume /acre	V	9.7 M	9.7 M

Present plan for arch skidding: Space roads 40 chains (2640') apart and landings at 5 chains (330') apart.

Spacing or S = 26.4 hundred feet. $Z = \frac{330}{2640} \times 100 = 12\text{-}1/2\%$

That is landings are spaced at 12-1/2% of road spacing.

Costs under present plan

Cost/M (cents)

	Winter Roads	Summer Roads
Skidding: Fixed	245.0	245.0
Variable .2CS or .2525 x 10.2 x 26.4	68.0	68.0
Roads $\frac{4.356r}{VS} = \frac{4.356 \times 903}{9.7 \times 26.4}$	15.4	
$\frac{4.356r}{VS} = \frac{4.356 \times 2020}{9.7 \times 26.4}$		34.4
Landings $\frac{L/2}{0.02873\,V} = \frac{410/2}{0.0287(26.4) \times 9.7}$	2.1	2.1
	330.5	349.5

From Cost and Time Analyses No. 1 and No. 2, it is obvious that tree-length system with arches would be less costly per M bd.ft. for skidding, and road and landing construction. On winter roads, tree-length skidding would save $3.38 - $3.31 = $0.07 per M bd.ft., and on summer roads $4.14 - $3.50 = $0.64 per M bd.ft. Tree-length skidding would save an average of $0.36 per M bd.ft. if there are equal amounts of winter and summer roads.

Total Logging Costs

While a great deal depends on the location of roads and the dependent skidding and construction costs, the final test of the most profitable system is the total of all logging costs. Of the two crews that will be compared, one employs ground skidding with an average production of 25 M bd.ft. per day, and the other arch skidding with a daily production of 22 M bd.ft. All costs are calculated on a per M bd.ft. basis for easy as well as equitable comparison, Tables XX and XXI, Pages No. 120, No. 121, No. 122 and No. 123.

The sums of the total logging costs show that ground skidding under the present practice amounts to $24.24 per M bd.ft., whereas the total logging cost if arches were used under the proposed plan amounts to $20.59, or a difference in favor of the tree-length system of $3.65 per M bd.ft. Assuming six million board feet are logged annually, the tree-length system would save the company $21,880.00 per year.

TABLE XX - TOTAL LOGGING COSTS - PRESENT SYSTEM OF GROUND SKIDDING

Clear-cutting, and producing 25 M board feet per day.

		Cost Per M	Total Cost Per M
Felling and bucking			
Sawing cost, $5.00 per M plus 17.2% for social taxes		$5.86	
Saw boss @ $1.10 per hour, plus 17.2% for social taxes, prorated over 25 M per day		.41	$6.27
Skidding (Direct)			
Fixed cost @ $2.36 per M		$2.36	
Variable cost .327 x 15.8 x 6.6		.34	$2.70
Road and Landing Construction			
Roads (average for summer and winter)			
winter = $\frac{4.356 \times 903}{9.7 \times 6.6}$ = 61.5¢			
summer = $\frac{4.356 \times 2020}{9.7 \times 6.6}$ = 137.5 / 199.0¢		$0.99	
Landings $\frac{410/2}{0.161(6.6) \times 9.7}$		.06	$1.05
Loading			
One mechanical loader @ $3.00/hr. for 8 hours =	$24.00		
One operator @ $1.15/hr. plus 17.2% for social taxes for 8 hours =	10.79		
Two hookers @ $1.00/hr. plus 17.2% for social taxes for 8 hours =	18.75		
	$43.54		
Prorated over 25 M, $43.54 ÷ 25			$1.75
Hauling (See Cost and Time Analysis D, Pages No. 49 and No. 50 in Appendix)			$9.00

TABLE XX continued

Scaling and Supervision			
One scaler @ $1.25 per hour plus 17.2% for social taxes prorated over 25 M per day	$0.47		
One foreman @ $1.50 per hour plus 17.2% for social taxes, prorated over 25 M per day	.56	$1.03	
Equipment Maintenance			
Already figured in (Machine rate)			
Office equipment, shop equipment and buildings			$0.50
			$22.30
10% allowed for inefficiency			2.23
Total average cost per M board feet			$24.53

TABLE XXI - TOTAL LOGGING COSTS - NEW SYSTEM OF ARCH SKIDDING

Clear cutting, and producing 22 M board feet per day.

		Cost Per M	Total Cost Per M
Felling only			
Two fellers at \$1.50 per hour, using their own chain saw, plus 17.2% for social taxes. Two 2-man crews producing 22 M per day			\$2.45
Skidding (tree length)			
Fixed cost @ \$2.45 per M		\$2.45	
Variable cost .2525 x 10.2 x 26.4		.68	\$3.13
Road and Landing Construction			
Roads (average for summer and winter)			
winter = $\frac{4.356 \times 903}{9.7 \times 26.4}$ = 15.4¢			
summer = $\frac{4.356 \times 2020}{9.7 \times 26.4}$ = $\frac{34.4}{49.8¢}$		\$0.25	
Landings $\frac{410}{0.0287(26.4)^2 \times 9.7}$		.02	\$0.27
Bucking and Loading (Done by same crew)			
Bucking: cost of chain saw and other equipment used per day	\$5.00		
Loading: One mechanical loader @ \$3.00 per hr. for 8 hours	24.00		
One operator @ \$1.15/hr. plus 17.2% for social taxes	10.79		
Two hookers @ \$1.00/hr. plus 17.2% for social taxes	18.75		
	\$48.54		
Prorated over 22 M, \$48.54 ÷ 22			\$2.20
Hauling (see Cost and Time Analysis D, Pages No. 49 and No. 50 in Appendix)			\$9.00

TABLE XXI continued

Scaling and Supervision		
One scaler @ $1.25 per hour plus 17.2% for social taxes prorated over 22 M per day	$0.53	
One foreman @ $1.50 per hour plus 17.2% for social taxes prorated over 22 M per day	0.64	$1.17
Equipment Maintenance		
Already figured in (Machine rate)		
Office equipment, shop equipment and buildings		$0.50
		$18.72
10% allowed for inefficiency		1.87
Total average cost per M board feet		$20.59

Personnel and Equipment

The number of personnel and amount of equipment required is materially reduced in tree-length skidding as compared with ground skidding by the substitution of low cost mechanization for high priced labor. The number of men required is reduced from 27 to 18, and the number of tractors is reduced from 3, TD-9's to 1, TD-14. Table XXII lists the crews in a more detailed manner.

TABLE XXII - PERSONNEL AND EQUIPMENT REQUIRED

Job Description	Ground Skidding Crew Producing 25 MBM per 8-hour day				Arch Skidding Crew Producing 22 MBM per 8-hour day			
	Trucks	Tractors	Loader	No. Men	Trucks	Tractors	Loader	No. Men
Gangs of sawyers			5 gangs or	10			2 gangs or	4
Saw bosses				1				1
Tractors		3 TD-9's				1 TD-14		
Tractor operator				3				1
Choker setters				2				1
Mechanical loaders			1				1	
Loader operators				1				1*
Hookers for loaders				2				2*
Trucks	3 K-7's				3 K-7's			
Truck Drivers				3				3
Scalers				1				1
Foremen				1				1
Blacksmith				1**				1**
Mechanics				1				1
Total	3	3	1	27 men	3	1	1	18 men

* - Hookers and operator also do the bucking in tree-length logging.

** - Blacksmith's time for one crew is only 25%. (50% for sawmill and 25% for another crew).

Logging Layouts For The Management Plans

In this portion, the logging plan for each type of forest management, straight liquidation, sustained yield and two-cut liquidation is formulated. Straight liquidation dictates a clear cutting policy, while sustained yield and two-cut liquidation demand a selective cutting policy. A replanned logging layout with the determination of the economic road and landing spacing by Matthews[1/] formulae for clear and selective cutting will give a more reasonable logging cost figure under each of the management plans. The blocks of timber to be cut over annually are listed under "Management Data" in the Appendix for each plan, Tables O, P, Q, Pages No. 51, No. 52 and No. 53 and appear on the Logging Plan Maps, No. 4, No. 5 and No. 6 in the pocket of the Appendix.

Straight Liquidation

If the company continues to operate as they have in the past (clear cutting), but with the new logging system (tree-length skidding), maximum economy of logging should be aimed for. Since it was shown previously that tree-length skidding is cheaper than ground skidding only a calculation of the replanned operation for tree-length skidding is necessary. However, to point out how the company's past location of roads and landings were not planned for maximum economy, a replanned ground skidding operation will also be presented.

1/ D. M. Matthews, Cost Control in the Logging Industry, 136.

The section on "Management Data" Table Q, Page No. 51 in the Appendix, is merely a compilation of the various cutting areas by tract and legal description, (see Map No. 4 in the Pocket of the Appendix).

Replanned Logging Layout: The first step in replanning the operation of clear cutting is the determination of the economic road and landing location (see Cost and Time Analyses No. 3 and No. 4). These locations are determined by Matthews' procedure as shown previously. The next step is the calculation of the new skidding, road construction, and landing construction costs per M bd.ft. These new costs added to the other, more or less constant logging costs, give the new total cost of logging under straight liquidation.

COST AND TIME ANALYSIS NO. 3 - REPLANNED LAYOUT - GROUND SKIDDING CLEAR-CUT

It is obvious that under the present plan for spacing the skidding and road construction costs are not equal, or nearly equal. This disparity means that the roads should be spaced further apart to bring road cost in line with skidding.

A trial calculation for landing spaced 12-1/2 per cent of road spacing will show what the economic spacing should be.

Road spacing $S = \sqrt{\frac{17.25r}{VC}}$

Winter $S = \sqrt{\frac{17.25 \times 903}{9.7 \times 15.8}} = \sqrt{101.5} = 10.1$ hundred ft.

Summer $S = \sqrt{\frac{17.25 \times 2020}{9.7 \times 15.8}} = \sqrt{227.3} = 15.1$ hundred ft.

Winter

Variable skidding cost plus cost of roads on this spacing equal

$2 \times 0.2525 \times 15.8 \times 10.1 = 80.7$¢ per M

Landing cost $\frac{410}{0.0287 \times 101.5 \times 9.7} = 14.5$¢ per M

Ratio of road and skidding costs to landing cost $\frac{80.7}{14.5} = 5.6$ to 1

Summer

Variable skidding cost plus cost of roads on this spacing equal

$2 \times 0.2525 \times 15.8 \times 15.1 = 120.4$¢ per M

Landing cost $\frac{410}{0.0287 \times 227.3 \times 9.7} = 6.5$¢ per M

Ratio of road and skidding costs to landing cost $\frac{120.4}{6.5} = 18.5$ to 1

Table 4, Pages No. 138, No. 139, Cost Control in the Logging Industry by D. M. Matthews shows the landings can be spaced at intervals of 30% of road spacing for winter roads, and 20% for summer roads.

COST AND TIME ANALYSIS NO. 3 Continued

The correct road spacing for winter roads at this 30% ratio is

$$S = \sqrt{\frac{16.4 \times 903}{9.7 \times 15.8}} = \sqrt{96.6} = 9.8$$

Therefore the most economical road and landing spacing for winter roads is roads spaced every 980 feet, and landings spaced every 980 x 30% = 294 feet.

Costs under replanning (winter roads)		Cost/M (cents)
Fixed skidding cost		236.0
Variable skidding cost .265 x 15.8 x 9.8	=	41.1
Road construction cost $\frac{4.356 \times 903}{9.7 \times 9.8}$	=	41.4
Landing cost $\frac{410}{0.0689 \times 96.6 \times 9.7}$	=	6.4
		324.9

The correct road spacing for summer roads at this 20% ratio is

$$S = \sqrt{\frac{16.95 \times 2020}{9.7 \times 15.8}} = \sqrt{223} = 14.9$$

Therefore the most economical road and landing spacing for summer roads is roads spaced every 1490 feet, and landings spaced every 1490 x 20% = 298 feet.

Costs under replanning (summer roads)		Cost/M (cents)
Fixed skidding cost		236.0
Variable skidding cost .257 x 15.8 x 14.9	=	60.6
Road construction cost $\frac{4.356 \times 2020}{9.7 \times 14.9}$	=	60.9
Landing cost $\frac{410}{0.0459 \times 223 \times 9.7}$	=	4.1
		360.6

COST AND TIME ANALYSIS NO. 4 - REPLANNED LAYOUT - ARCH SKIDDING CLEAR CUT

It is evident that under the present plan for spacing the skidding and road construction costs are not equal or nearly equal. This disparity means that the roads should not be spaced so far apart to bring skidding costs in line with road costs.

A trial calculation for landings spaced 12-1/2 per cent of road spacing will show what the economic spacing should be.

Road spacing $S = \sqrt{\frac{17.25r}{VC}}$

Winter $S = \sqrt{\frac{17.25 \times 903}{9.7 \times 10.2}} = \sqrt{157} = 12.5$ hundred feet

Summer $S = \sqrt{\frac{17.25 \times 2020}{9.7 \times 10.2}} = \sqrt{350.7} = 18.7$ hundred ft.

Winter

Variable skidding cost plus cost of roads on this spacing equal $2 \times 0.2525 \times 10.2 \times 12.5 = 64.6$

Landing cost $\frac{410}{0.0287 \times 157 \times 9.7} = 9.4$

Ratio of road and skidding costs to landing cost $\frac{64.6}{9.4} = 6.9$ to 1

Summer

Variable skidding cost plus cost of roads on this spacing equal $2 \times 0.2525 \times 10.2 \times 18.7 = 96.7$

Landing cost $\frac{410}{0.0287 \times 350.7 \times 9.7} = 4.2$

Ratio of road and skidding costs to landing cost $\frac{96.7}{4.2} = 23$ to 1

Table 4, Pages No. 138, No. 139, Cost Control in the Logging Industry by D. M. Matthews shows the landings can be spaced at intervals of 30% of road spacing for winter roads and 20% for summer roads.

The correct road spacing for winter roads at this 30% ratio is

$$S = \sqrt{\frac{16.4 \times 903}{9.7 \times 10.2}} = \sqrt{149.5} = 12.2$$

Therefore the most economical road and landing spacing for winter roads is roads spaced every 1220 feet and landings spaced every 1220 x 30% = 366 feet.

Costs under replanning (winter roads)		Cost/M (cents)
Fixed skidding cost		245.0
Variable skidding cost	$.265 \times 10.2 \times 12.2$	33.1
Road construction cost	$\frac{4.356 \times 903}{9.7 \times 12.2}$	33.3
Landing cost	$\frac{410}{0.0689 \times 149.5 \times 9.7}$	4.1
		315.5

The correct road spacing for summer road at this 20% ratio is

$$S = \sqrt{\frac{16.95 \times 2020}{9.7 \times 10.2}} = \sqrt{345.5} = 18.6$$

Therefore the most economical road and landing spacing for summer roads is roads spaced every 1860 feet and landings spaced every 1860 x 20% = 372 feet.

Costs under replanning (summer roads)		Cost/M (cents)
Fixed skidding cost		245.0
Variable skidding cost	$.257 \times 10.2 \times 18.6$	32.6
Road construction cost	$\frac{4.356 \times 2020}{9.7 \times 18.6}$	32.7
Landing cost	$\frac{410}{0.0459 \times 345.5 \times 9.7}$	2.7
		313.0

TABLE XXIII - SUMMARY OF ROAD SPACINGS AND COSTS - CLEAR CUTTING

METHOD	WINTER HAUL			SUMMER HAUL		
	Spacing of Roads (feet)	Spacing of Landings (feet)	Cost of Logging per MBM	Spacing of Roads (feet)	Spacing of Landings (feet)	Cost of Logging per MBM
Log-length logging with direct skidding						
Company's past practice	660	495	$3.38	660	495	$4.14
Replanned Operation	980	294	$3.25	1490	298	$3.61
Difference in Cost			$0.13			$0.53
Tree-length logging with arch skidding						
Company's proposal	2640	330	$4.31	2640	330	$3.50
Replanned operation	1220	366	$3.16	1860	372	$3.13
Difference in Cost			$0.15			$0.37

TABLE XXIV - TOTAL LOGGING COSTS* - STRAIGHT LIQUIDATION

(Tree-length skidding with arches; clear cutting; daily production of 22 M)

		Cost per M
Felling only		$2.45
Skidding		
Fixed cost @ $2.45 per M	$2.45	
Variable cost		
Winter roads = $.265 \times 10.2 \times 12.2 = 33.1¢$		
Summer roads = $.257 \times 10.2 \times 18.6 = 32.6¢$		
Average = ...	.33	$2.78
Road and Landing Construction		
Roads		
Winter = $\frac{4.356 \times 903}{9.7 \times 12.2} = 33.3¢$		
Summer = $\frac{4.356 \times 2020}{9.7 \times 18.6} = 32.6¢$		
Average	$ .32	
Landings		
Winter = $\frac{410}{0.0689 \times 149.5 \times 9.7} = 4.1¢$		
Summer = $\frac{410}{0.0459 \times 345.5 \times 9.7} = 2.7¢$		
Average	.03	$0.35
Bucking and Loading		$2.20
Hauling		9.00
Scaling and Supervision		1.17
Office equipment, shop equipment and buildings		.50
		$18.45
10% allowed for inefficiency		1.85
		$20.30

* - See Table XXI, Page No. 122 for a more detailed breakdown of cost items.

In the light of the costs developed in the previous calculations (Cost and Time Analysis No. 3, Pages No. 128 and No. 129) and summarized in Table XXIII, Page No. 132, past practices of road location by the company have not been the most economical. The company's spacing, both for winter and summer roads of 660 feet has been too close. Whereas, economical spacing for ground skidding, was calculated to be 980 feet for winter and 1490 feet for summer roads. Landings have been spaced too far apart, 495 feet. Whereas economical spacing is 294 feet on winter and 298 feet on summer roads. With this more economical location, an estimated 13¢ per M bd.ft. on winter and 53¢ per M bd.ft. on summer roads, or an average of 33¢ per M bd.ft. could have been saved.

The company's proposed location for tree-length skidding with arches is just the opposite of ground skidding. The roads are spaced too far apart, and the landings too close together (Cost and Time Analysis No. 4, Pages No. 130 and No. 131). They propose to space roads every 2640 feet, but the economical spacing was calculated to be 1220 feet for winter and 1860 feet for summer roads. They propose to space landings every 330 feet, but economic spacing was found to be every 366 feet on winter and 372 feet on summer roads. Table XXIII, Page No. 132, shows that an estimated savings of 15¢ per M bd.ft. on winter and 37¢ per M bd.ft. on summer roads could be obtained if economic location of roads and landings were adherred to. Upon the adoption of this economic spacing approximately 5 miles of winter roads with 70 landings and 2-3/4 miles of summer roads with 39 landings would be constructed on a typical section. The average skidding distance would be 323 feet for winter and 479 feet for summer roads.

Table XXIV, Page No. 133 shows the total logging costs under straight liquidation to be $20.30 per M bd.ft. This is 29¢ less per M bd.ft. than the total costs calculated for the company's proposed spacing (see Table XXI, Page No. 122).

The number of crews needed under this system is calculated as follows:

Daily production of crew	22 M bd.ft.
Average number of days worked per year	150
Yearly production of crew	3300 M bd.ft.
Annual allowable cut under this plan	6000 M bd.ft.

$$\text{Number of crews needed} = \frac{6000 \text{ M bd.ft.}}{3300 \text{ M bd.ft.}} = 1.8 \text{ or } 2 \text{ crews}$$

Two crews of 18 men, 1 TD-14 tractor, 3 K-7 trucks, and 1 mechanical loader will be needed. (See Table XXII, Page No.125, for detailed crew breakdown).

Management Data: The annual allowable cut is 6 million board feet, with an annual cutting area of 620 acres divided into winter and summer logging compartments. Because of nature of the ownership pattern, terrain and other factors, the cutting areas cannot always be divided into two equal parts for winter and summer logging. Table O, Page No. 51 in the Appendix lists the compartments as to block, acres, and legal description. Map No. 4 in the pocket of the Appendix indicates where these compartments are situated.

Under this plan of straight liquidation the Wakefield Township area was chosen to be logged first (summer logging), because of the excessively high tax rate in this township. Areas that were stocked heavily with hemlock have been divided into as many compartments as was practical to spread the annual cut of hemlock more evenly throughout the period of operation.

Sustained Yield

The sustained yield and two-cut liquidation plans involve selective cutting, which means a lower volume per acre is to be logged off. A new calculation of both log-length and tree-length skidding is necessary to see which is the most economical with this lower volume per acre.

Replanned Logging Layout: To find where maximum economy can be obtained for this selective cut, removing 49% of the merchantable volume, 4.7 M bd.ft. per acre, the same general procedure is followed as that used in replanning the layout under straight liquidation previously. Because the volume (a variable factor) has been changed it is necessary to calculate the economic road and landing spacing and costs for each system of logging (see Cost and Time Analyses No. 5 and No. 6). Company officials have stated that they would use the same road and landing location for selective cutting as for clear cutting.

In the calculation of the total logging costs, felling, bucking and loading, hauling, and office equipment etc. were assumed to be the same as under clear cutting. An additional charge of 40¢ per M bd.ft. was added to the scaling and supervision costs for timber marking, timber cruises, and establishment of growth plots necessary under selective cutting.

COST AND TIME ANALYSIS NO. 5 - REPLANNED LAYOUT - GROUND SKIDDING - SELECTIVE CUT

(For selective cutting taking 49% of the volume, using International TD-9 tractors, taking 49% of the merchantable volume.)

		Winter Roads (cents)	Summer Roads (cents)
Road construction cost/station	r	903	2020
Landing construction cost	L	410	410
Skidding cost/100'/M	C	15.8	15.8
Volume/acre	V	4.7 M	4.7 M

Present Plan: Same as clear cutting, see Cost and Time Analysis No. 4.

Costs under present plan

		Cost/M (cents) Winter Roads	Cost/M (cents) Summer Roads
Skidding:	Fixed	236.0	236.0
	Variable .PCS or 0.327 x 15.8 x 6.6	34.1	34.1
Roads	$\frac{4.356r}{VS} = \frac{4.356 \times 903}{4.7 \times 6.6}$	127.0	
	$\frac{4.356r}{VS} = \frac{4.356 \times 2020}{4.7 \times 6.6}$		284.0
Landings	$\frac{L}{0.161\ S^2\ V} = \frac{410}{0.161(6.6)^2\ 4.7}$	12.4	12.4
		409.5	566.5

It is obvious under the present plan that the road construction cost is way out of line with variable skidding costs and roads should be spaced further apart.

A trial calculation for landings spaced 12-1/2 per cent of road spacing will show what the economic spacing should be

Road spacing $S = \sqrt{\frac{17.25r}{VC}}$

Winter $S = \sqrt{\frac{17.25 \times 903}{4.7 \times 15.8}} = \sqrt{210} = 14.5$ hundred feet

Summer $S = \sqrt{\frac{17.25 \times 2020}{4.7 \times 15.8}} = \sqrt{470} = 21.7$ hundred feet

Winter

Variable skidding cost plus cost of roads on this spacing equal $2 \times 0.2525 \times 15.8 \times 14.5 = 115.6$

Landing cost $\frac{410}{0.0287 \times 210 \times 4.7} = 14.5$

Ratio of road and skidding costs to landing cost .... $\frac{115.6}{14.5} = 8.0$ to 1

Summer

Variable skidding cost plus cost of roads on this spacing equal $2 \times 0.2525 \times 15.8 \times 21.7 = 173.0$

Landing cost $\frac{410}{0.0287 \times 470 \times 4.7} = \frac{}{6.5} = 26.6$ to 1

Table 4, Pages No. 138 and No. 139 in <u>Cost Control in the Logging Industry</u> by D. M. Matthews shows the landings can be spaced at intervals of 30% of road spacing for winter roads, and 20% for summer roads.

Replanned Economic Road and Landing Spacing

The correct road spacing for winter roads at this 30% ratio is

$$S = \sqrt{\frac{16.4 \times 903}{4.7 \times 15.8}} = \sqrt{199.6} = 14.1$$

Therefore the most economical road and landing spacing for winter roads is roads spaced every 1410 feet and landings spaced every 1410 x 30% = 424 feet.

Costs under replanning (winter roads)

	Cost/M (cents)
Fixed skidding cost	236.0
Variable skidding cost .265 x 15.8 x 14.1	59.1
Road construction cost $\frac{4.356 \times 903}{4.7 \times 14.1}$	59.4
Landing cost $\frac{410}{0.0689 \times 199.6 \times 4.7}$	6.3
	360.8

The correct road spacing for summer roads at this 20% ratio is

$$S = \sqrt{\frac{16.95 \times 2020}{4.7 \times 15.8}} = \sqrt{462} = 21.5$$

Therefore the most economical road and landing spacing for summer roads is roads spaced every 2150 feet and landings spaced every 2150 x 20% = 430 feet.

Costs under replanning (summer roads)

	Cost/M (cents)
Fixed skidding cost	236.0
Variable skidding cost $.257 \times 15.8 \times 21.5$	87.3
Road construction cost $\frac{4.356 \times 2020}{4.7 \times 21.5}$	87.1
Landing cost $\frac{410}{0.0459 \times 462 \times 4.7}$	4.1
	414.5

COST AND TIME ANALYSIS NO. 6 - REPLANNED LAYOUT - ARCH SKIDDING SELECTIVE CUT

(For selective cutting, using International TD-14 tractors, taking 49% of the merchantable volume)

		Winter Roads (cents)	Summer Roads (cents)
Road construction cost/station	r	903	2020
Landing construction cost	L	410	410
Skidding cost/100'/M	C	10.2	10.2
Volume/acre	V	4.7 M	4.7 M

Present Plan: Same as clear cutting, see Cost and Time Analysis No. 4.

Costs under present plan

		Cost/M (cents) Winter Roads	Summer Roads
Skidding:	Fixed	245.0	245.0
	Variable .PCS or .2525 x 10.2 x 26.4	68.2	68.2
Roads	$\frac{4.356r}{VS} = \frac{4.356 \times 903}{4.7 \times 26.4}$	31.7	
	$\frac{4.356r}{VS} = \frac{4.356 \times 2020}{4.7 \times 26.4}$		71.0
Landings	$\frac{L}{0.0287\ S^2\ V} = \frac{410}{0.0287(26.4)^2\ 4.7}$	4.4	4.4
		349.3	388.6

It is evident that under the present plans that the skidding cost is way out of line with road costs, to remedy this, roads should be spaced closer together.

A trial calculation for landings spaced 12-1/2 percent of road spacing will show what the economic spacing should be.

$$\text{Road spacing } S = \sqrt{\frac{17.25r}{VC}}$$

$$\text{Winter } S = \sqrt{\frac{17.25 \times 903}{4.7 \times 10.2}} = \sqrt{324} = 18 \text{ hundred feet}$$

$$\text{Summer } S = \sqrt{\frac{17.25 \times 2020}{4.7 \times 10.2}} = \sqrt{725} = 26.9 \text{ hundred feet}$$

Winter

Variable skidding cost plus cost of roads on this spacing equal $2 \times .2525 \times 10.2 \times 18 = 93.0$

Landing cost $\frac{410}{0.0287 \times 324 \times 4.7} = 9.4$

Ratio of road and skidding costs to landing cost .... $\frac{93}{9.4} = 9.9$ to 1

Summer

Variable skidding cost plus cost of roads on this spacing equal $2 \times .2525 \times 10.2 \times 26.9 = 139.0$

Landing cost $\frac{410}{0.0287 \times 725 \times 4.7} = 4.2$

Ratio of road and skidding costs to landing cost .... $\frac{139}{4.2} = 33.3$ to 1

Table 4, Pages No. 138 and No. 139, in Cost Control in the Logging Industry by D. M. Matthews shows the landings can be spaced at intervals of 25% of road spacing for winter roads, and 20% for summer roads.

Replanned Economic Road and Landing Spacing

The correct road spacing for winter roads at this 25% ratio is

$$S = \sqrt{\frac{16.6 \times 903}{4.7 \times 10.2}} = \sqrt{311.5} = 17.6$$

Therefore the most economical road and landing spacing for winter roads is roads spaced every 1760 feet and landings spaced every 1760 x 25% = 440 feet.

Costs under replanning (winter roads)

	Cost/M (cents)
Fixed skidding cost	245.0
Variable skidding cost $.261 \times 10.2 \times 17.6$	47.0
Road construction cost $\frac{4.356 \times 903}{4.7 \times 17.6}$	47.6
Landing cost $\frac{410}{0.0573 \times 311.5 \times 4.7}$	4.9
	344.5

The correct road spacing for summer roads at this 20% ratio is

$$S = \sqrt{\frac{16.95 \times 2020}{4.7 \times 10.2}} = \sqrt{712} = 26.7$$

Therefore, the most economical road and landing spacing for summer roads is roads spaced every 2670 feet and landings spaced every 2670 x 20% = 534 feet.

Costs under replanning (summer roads)

	Cost/M (cents)
Fixed skidding cost	245.0
Variable skidding cost .251 x 10.2 x 26.7	70.3
Road construction cost $\frac{4.356 \times 2020}{4.7 \times 26.7}$	69.8
Landing cost $\frac{410}{0.0459 \times 712 \times 4.7}$	2.7
	387.8

TABLE XXV - SUMMARY OF ROAD SPACINGS AND COST - SELECTIVE CUTTING

METHOD	WINTER HAUL			SUMMER HAUL		
	Roads (feet)	Spacing of Landings (feet)	Cost of Logging (per MBM)	Roads (feet)	Spacing of Landings (feet)	Cost of Logging (per MBM)
Log-length with ground skidding						
Company's proposal	660	495	$4.10	660	495	$5.67
Replanned operation	1410	424	$3.61	2150	450	$4.15
Difference in cost			$0.49			$1.52
Tree-length with arches						
Company's proposal	2640	330	$3.49	2640	330	$3.89
Replanned operation	1760	440	$3.45	2670	534	$3.88
Difference in cost			$0.04			$0.01

TABLE XXVI - TOTAL LOGGING COSTS* - SUSTAINED YIELD AND TWO-CUT LIQUIDATION

(Tree-length skidding with arches; selective cut at 49%; daily production of 22 M)

	Cost/M	Total Cost per M
Felling only		$2.45
Skidding		
Fixed cost @ $2.45 per M	$2.45	
Variable cost		
Winter roads = .261 x 10.2 x 17.6 = 47.0 ¢		
Summer roads = .257 x 10.2 x 26.7 = 70.3 ¢		
Average	.59	$3.04
Road and Landing Construction		
Roads		
Winter = $\frac{4.356 \times 903}{4.7 \times 17.6}$ = 47.6 ¢		
Summer = $\frac{4.356 \times 2020}{4.7 \times 26.7}$ = 69.8 ¢		
Average	$ .59	
Landings		
Winter = $\frac{410}{0.0573 \times 311.5 \times 4.7}$ = 4.9 ¢		
Summer = $\frac{410}{0.0459 \times 712 \times 4.7}$ = 2.7 ¢		
Average	.04	$0.63
Bucking and Loading		$2.20
Hauling		9.00
Scaling and Supervision (includes marking, etc.)		1.57
Office equipment, shop equipment and buildings		.50
		$19.39
10% allowed for inefficiency		1.94
		$21.33

* - See Table XXI, Page No.122, for a more detailed breakdown of cost items.

From Cost and Time Analysis No. 5, Pages No. 138 through No. 140 summarized in Table XXVI, Page No. 145, it is evident that the company's past road and landing spacing were not the most economical for selective cutting if log-length skidding is used. A replanned location of roads and landings gave a difference of $0.49 per M bd.ft. for winter and $1.52 per M bd. ft. for summer roads.

However, the tree-length logging again proved to be the most economical to use (see Cost and Time Analysis No. 6, Pages No. 141 through No. 143, and in this case the company's proposed locations are much nearer maximum economy than in the log-length skidding discussed above. To obtain maximum economy in tree-length skidding, the winter roads should be spaced closer together and the landings of both summer and winter roads should be spaced farther apart than the company's proposed plan. The company's proposed plan for summer road location is just about right, 2640 feet. The replanned location was calculated to be 2670 feet and is only 1¢ cheaper per M bd.ft. The winter roads under replanning are only 4¢ cheaper per M bd.ft.

If the economic spacing of roads and landings were followed, approximately 2-3/4 miles of winter roads with 33 landings, and 2-1/4 miles of summer roads with 22 landings would be constructed on a typical acre, thus giving an average skidding distance of 459 feet for winter and 687 feet for summer roads.

Table XXVI, Page No. 145, shows the total logging costs under sustained yield and two-cut liquidation to be $21.33 per M bd.ft. This is $1.03 more per M bd.ft. than the total costs calculated for clear cutting under straight liquidation (see Table XXIV, Page No. 133).

The number of crews needed under selective logging for sustained yield is calculated as follows:

Daily production of crew	22 M bd.ft.
Average number of working days per year	150
Yearly production of crew	3300 M bd.ft.
Annual allowable cut under sustained yield	2400 M bd.ft.

$$\text{Number of crews} = \frac{2400 \text{ M bd.ft.}}{3300 \text{ M bd.ft.}} = .73 \text{ or } 1 \text{ crew}$$

One crew of 18 men, 1 TD-14 tractor, 3 K-7 trucks, and 1 mechanical loader will be needed. At the present estimated production rate it will take one crew only 110 working days to cut the annual allowable cut of 2400 M bd.ft. (Table XXII, Page No. 125, gives a more detailed list of the crew). After logging their own land the crew could be used to log other areas the company has bought or secured the cutting rights on to maintain a full year's employment.

Management Data: The annual allowable cut during the first cycle of sustained yield is 2.4 million bd.ft. with an annual cutting area of 514 acres divided into summer and winter logging compartments as explained under "Management Data" for straight liquidation, Page No. 135.

Table P, Page No. 52, in the Appendix, lists the compartments as to blocks, acres, and legal description, and Map No. 5 in the pocket of the Appendix helps to show how they are situated.

Two-cut Liquidation

The two-cut liquidation plan involves selective cutting as does sustained yield. Since the same amount of volume is to be removed in a selective cut for this plan as for sustained yield, 49% of the merchantable volume, the economic location of roads and landings of the replanned logging layout for the two-cut plan is the same as that calculated for sustained yield. The number of crews needed however, would be the same as straight liquidation (two crews) because the annual allowable cut is identical under both liquidation plans.

Management Data: The annual allowable cut under this plan is six million board feet, with an annual cutting area of 1285 acres the first cut, and 978 acres the second cut. These cutting areas are divided into winter and summer compartments as explained previously.

Table Q, Page No. 53 in the Appendix lists the compartments as to blocks, acres, and legal description, and Map No. 6 in the pocket of the Appendix helps to show how they are situated.

A resume of the logging problem shows that the Ahonen tracts are favorably situated for winter and summer logging, which tends toward more evenly distributed production throughout the year, and gives labor a full years work instead of only seasonal.

Of the two systems of logging presented, log-length with ground skidding, and tree-length with arch skidding, the latter proved to be the least costly in men and equipment. Calculations were made on the basis of the company's past road locations for ground skidding and proposed locations for arch skidding.

In the determination of the economic road location under each forest management plan, the costs of skidding, and construction of roads and landings were calculated for each system of logging and for both summer and winter roads. Tree-length skidding with arches was found to be the least expensive system of logging on summer and winter roads, and for both clear and selective cutting. With tree-length skidding, logging costs 1/ for clear cutting average $0.29 less per M bd.ft. than ground skidding and $0.22 less per M bd.ft. for selective cutting.

It is definitely established 2/ in these calculations that selective cutting using either system of logging is more costly than clear cutting. If the company were to change from its present policy of clear cutting to one of selective cutting, logging costs 1/

1/ Logging costs in this case involve only skidding, and construction of roads and landings.
2/ See Table R, Page No. 54 in the Appendix.

would be increased by 45¢ per M bd.ft. for ground skidding, and 52¢ per M bd.ft. for arch skidding if economic road and landing location were adopted by the company. Total logging costs differ by $1.03, clear cutting being the cheaper.

ANALYSIS OF PLANS

In the first portion of this section, the three management plans will be analyzed on an orthodox financial basis. This analysis will be followed by a pecuniary comparison of the plans, and writer's recommendation. The operator's point of view of the adoption of the management plans presented will be discussed in the last portion.

Financial Analysis

Since profit is the end of any business enterprise, the relative financial yields of the three management plans will be adduced. The anticipated costs and returns are only estimates and will probably change many times by the end of the various periods of operation of the different management plans.

There are four important factors to consider under each of the three management plans presented, taxation, depreciation, depletion, and valuation. Each will be discussed and a conclusion drawn as to which plan would be financially best for the company to adopt in relation to that particular factor.

Taxation

The taxation problem has been analyzed on the basis of total taxes to be paid during the periods of operation under each of the possible management plans. Under the two-cut liquidation or sustained yield plan, the company may register their selectively cut lands under the Commercial Forest Reserve Law (Pearson Act) to take advantage of possible tax reduction. This law provides for a tax of $0.05 per acre per year on selectively cut or unmerchantable timberlands, and a sliding scale yield tax, which begins at 2% of the value of the stumpage cut the first year after the lands are listed and increases 1% each year until the ninth and each subsequent year in which the 10% maximum must be paid.

In a comparison of the costs of land registered under general property tax and the Pearson Act, the Porcupine block has been disregarded because of the liquidation policy called for. The average general property tax has been computed by weighting the taxes of the various political townships of the Gogebic and Tula blocks (see Pages No. 55 through No. 57 in the Appendix). The weighted average tax on these blocks was calculated to be 40 cents per acre per year. This annual tax is low because (1) the rate of assessment is only 21.56 mills per dollar of valuation, and (2) the assessed value of the timber is less than 30% of the present market value. The weighted average of cut-over lands was calculated to be 14 cents per acre per year. These tax rates were compared with the rates that would exist, if the land were classified under the Pearson Act in schedules (Tables S through W, Pages No. 58 to No. 62 in the Appendix).

Summary of Tax Schedules

Management Plan	General Property Tax	Pearson Act	Period (years)
Straight Liquidation	$49,407.00	----	17
Two-cut Liquidation	50,675.00	$88,839.00	19
Sustained Yield	67,619.00	47,044.50	20(1st cycle
	61,680.00	38,680.00	20(2nd cycle
	71,960.00	42,080.00	20(3rd cycle

Under a straight liquidation plan there is no alternative and the company must leave its lands registered under the general property tax classification. Two-cut liquidation allows a choice between the general property tax and the Pearson Act. From the summary of the schedules, it is obvious that the lands as classified under the Pearson Act are much higher ($38,164.00) than the general property tax, because the general property tax rate of 21.56 mills is quite low, and the 10% yield tax is quite high. After the first cut, the tax rate is five cents per acre per year, and upon the second cut the yield tax of 10% of the stumpage value is charged. The second cut with its requirement of 10% of the stumpage value comes so soon after the first cut that there is no appreciable savings during the time the land is taxed at only five cents per acre per year. In order to justify a 10% yield tax, a longer period is needed at the tax rate of five cents per acre and a smaller stumpage volume should be removed, thus making the yield tax lower. Under present conditions this would be impractical to follow.

If a plan of sustained yield is adopted, classifying the lands under the Pearson Act would save the company an estimated $20,575.00 during the first cycle. Estimates of the second and third cycles were made but these periods are so far in the future that the figures cannot be relied on. However, these calculations further prove that it would be a profitable move to classify the lands under the Pearson Act in the event of a sustained yield program.

For reasons of comparison of the three plans, the average annual tax for the period of operation (first cycle only in sustained yield) is calculated.

AVERAGE TAX	PER ANNUM	PER M BD.FT.
Straight Liquidation (17 years) GPT	$2,900.00	$0.50
Two-cut Liquidation (19 years) GPT	2,668.00	0.46
Sustained Yield-first cycle (20 years) Pearson Act	2,350.00	0.98

In the event of straight or two-cut liquidation, the cutting budget should be set up, as far as possible, for liquidating first those townships of high tax rate. Wakefield township has an abnormally high tax rate of 96.8 cents per acre per year. Even if the land is not disposed of immediately after the second cut or after clear-cutting under straight liquidation, the timber which is the basis for assessment, will have been removed and the assessed value will fall, thus decreasing high carrying charges on 1,136 acres.

Depreciation

In the past, accountants have usually set up depreciation charges in the lumber industry on a liquidation basis. Matters of depreciation were handled in the straight line manner, by taking the whole investment of plant and equipment, less its residual value, and charging it to the volume of timber that existed. The residual value was usually figured at some low percentage of the original cost.

According to Paton,[1/] this straight line method of handling depreciation is not valid because the equipment performing the last year of operation is usually performing at only a slightly lower

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1/ W. A. Paton, Essentials of Accounting, 536.

efficiency than it was during the first year, hence its actual mechanical value is only slightly less than it was at the beginning. However, for the sake of simplicity, the straight line method will be used for comparison of the three plans of management here.

In straight line method of depreciation, a fixed charge per M board feet of timber will be set aside in an account labeled reserve for depreciation. This fixed charge is computed by dividing the total volume of timber into the total investment (less residual value) in plant and equipment. With this charge affixed per M board feet, the depreciation is geared to annual production which provides flexibility for periods of high and low demand of lumber.

Under a plan of liquidation, the fixed charges for depreciation are prorated against the total volume of timber, 99,491 M board feet. Since the company wishes to cut six million feet of timber from their own lands yearly, the depreciation charge would be the same each year for a period of seventeen years or about 5.9% per year.

In the case of two-cut liquidation, the same fixed charge per M would be charged against the volume taken out during the first cut. However, at the beginning of the second cut, when a more exact volume estimate can be made that includes growth, a new depreciation rate should be calculated based on the new volume and new period of operation. Hence, in the first cut the depreciation would be charged against 48,150 M board feet for a period of eight years; then, if the present estimates hold true, a depreciation charge may be prorated against 63,000 M board feet for a period of eleven years, or, in terms of straight line depreciation, 4.8% of the original investment will be written off yearly during the second cut. The total volume in two-cut case is 111,150 M board feet or 11,659 M board feet more than the straight liquidation plan. This 12.3% increase in volume is due to growth, which in turn, increases the period of operation 11.3% more (2 years) than the straight liquidation period. Thus the total investment will be prorated against a larger volume of timber over a longer period of time which results in a decreased charge per unit (M board feet).

The difficulty arising peculiar to this problem is how to charge for depreciation under a sustained yield plan. Under a sustained yield program, the equipment will not "wear out" or be salvaged in a prescribed period, but will be replaced from time to time as its efficiency drops below the level of economic desirability. In order to determine the rate of depreciation and use the straight line method, the writer has arbitrarily set the life of plant and equipment at forty years or the first two cycles. This procedure will be tantamount to depreciating the equipment at about half the annual percentage under the two-cut liquidation, or about 2-1/2% per year.

From the summary of the sustained yield plan, Page No. 83 the fixed depreciation charge would be spread over an annual volume of 2,400 M board feet for the first twenty years and 1,420 M board feet the second twenty years. A new estimate of the growth should be undertaken at the beginning of the second cycle to insure correctness of the new volume. The summary of the sustained yield plan shows that only 40% of the required volume would be cut during the first cycle. This decrease in volume will raise the charge per M board feet somewhat, even though the period of straight line depreciation has been extended to forty years.

Table XXVII, Page No. 158, shows the computation of the unit (M bd.ft.) depreciation charge for the three systems of management.

From the summaries of the straight and two-cut liquidation, and the sustained yield plans, it is evident that more capital is invested annually in road and landing construction under the two-cut plan (during the first cut) because of the larger cutting area (1,285 acres) covered under this plan per year. The cutting areas of the straight liquidation and sustained yield plans respectively, are 620 and 514 acres. The road and landing construction investment rate would be least for the sustained yield plan because it has the smallest annual cutting acreage.

In a stringent accounting theory, constructed roads are permanent and should be treated as a capital investment, written off yearly. Therefore, the road and landing investment under the two-cut plan can be written off more slowly[1] than under straight liquidation because of the longer operating period.

Theoretically, the writing off of the investment in road and landing construction under sustained yield would be spread over an indefinite period and an unlimited volume of timber. The practice of this company, however, is to carry road construction costs in the current operating expense account.

1/ C. H. Stoddard Jr., op. cit., 21.

TABLE XXVII - FIXED INVESTMENT AND DEPRECIATION SHEET FOR PLANT AND EQUIPMENT

INVESTMENT ITEM	ORIGINAL COST	UNDEPRECIATED BALANCE	AVERAGE ANNUAL DEPRECIATION RATE: STRAIGHT LIQUIDATION (17 yrs.) TOTAL	STRAIGHT LIQUIDATION (17 yrs.) PER M	TWO-CUT LIQUIDATION (19 yrs.) TOTAL	TWO-CUT LIQUIDATION (19 yrs.) PER M	SUSTAINED YIELD (40 yrs.) TOTAL	SUSTAINED YIELD (40 yrs.) PER M
Sawmill	$ 80,000	$ 66,400						
Planing Mill	50,000	48,000						
Grain Door Plant	8,000	320						
Flooring Plant	75,000	53,250						
Dry Kilns	100,000	82,000						
Yard Equipment	15,000	12,150						
Office, garages, etc.	15,000	8,250						
Miscellaneous equipment	10,000	4,000						
Total	$353,000	$255,470				First cut $1.97 8 yrs. Second cut $1.67 11 yrs. Weighted Average $1.76		First cycle $2.10 Second cycle $3.54 Third cycle $3.16 Weighted (volume) Average $2.63
Less 5% Salvage Value		17,650						
Net Total		$237,820	$13,989.41	$1.97*	$12,516.84	$1.76*	$5,945.50	$2.63*
Logging Equipment	$ 25,000	$ 15,250						
Less 5% Salvage Value		1,250						
Net Total		$ 14,000	$ 823.53	.14**	$ 736.84	.12**	$ 350.00	.18**
Per M Total				$2.11		$1.88		$2.81
Total Original Investment	$378,000	$270,720						

* - Charged to milling operation and therefore charged against 6000 M bd.ft. x 18.3% = 7098 M bd.ft. Mill Scale

** - Charged to logging operation and therefore charged against 6000 M bd.ft. Log Scale

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Initial road building costs would probably be charged against the volume of timber removed during the first cut. Maintenance and reconditioning costs incurred during the second cut would be borne by the volume of timber removed during the second cut. This same procedure would be followed in the successive cuts of the sustained yield plan.

From Table XXVII it is evident that the two-cut liquidation system presents the lowest charge for depreciation of the three proposed plans. Sustained yield does not show very favorably even though the period of straight line depreciation would be forty years in length with an average annual depreciation rate of only 2-1/2%. This high charge of depreciation is due to the small volume of timber cut under sustained yield, which is only 40% of the volume cut under the liquidation plans.

Depletion

Paton[1/] defines unit depletion in the sense of a wasting asset: "the total cost (of the timber) divided by the estimated number of the recoverable units (estimated total volume, board feet) represented by the available resource gives unit depletion". This quotation treats depletion, actually a cost of material, as an operating cost and is charged to present production as so much per M board feet.

Under the straight liquidation policy, the fixed charge per M would equal the total value of the timber, $722,700.00 divided by 99,491 M board feet, which equals $7.27 per M board feet or

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1/ W. A. Paton, op. cit., 514.

$43,600.00 annually (cutting six million feet per year). In this case the $722,700.00 is the book value of the Tula and Cogebic blocks of timber after four years depletion 1946 through 1949. The 99,491 M board feet is the total volume on these blocks.

Under two-cut liquidation, the total volume is increased by 12.3% over straight liquidation, thus the timber stumpage charge (depletion) is spread over a larger volume, hence the unit charge is reduced. This increased volume is not obtained cost free, but obtained at an expenditure of selective cutting.[1/]

The same rate of depletion is charged off during the selective cut of the two-cut plan as straight liquidation ($7.27 per M). At the end of the selective cut, a new estimate should be made to obtain an accurate account of the growth accrued. This new volume estimate is divided into the undepleted balance of the book value to find a new depletion charge per M. If the growth estimates contained in this paper are approximately accurate, the volume of the second cut (63,000 M board feet) is charged with a depletion of $5.94 per M board feet as calculated below.

	$43,600	annual depletion, first cut
x	8	years, time of selective cut (first cut)
	$348,800	total depletion, first cut
	$722,700	book value now
-	348,800	total depletion of first cut
	373,900	depletion for second cut (undepleted balance)
÷	63,000	M bd.ft. total volume of second cut (new volume)
=	$5.94	depletion charge per M bd.ft.

1/ For a further discussion, see Page No. 168.

At an annual drain of six million feet of timber[1] this lower charge amounts to a yearly savings of $7,980.00 as calculated below.

	$373,900	total depletion charge, second cut
÷	10.5	years, period of operation, second cut
=	$ 35,620	depletion charge, per year, second cut

$ 43,600	depletion charge per year, first cut
- 35,620	depletion charge per year, second cut
$ 7,980	reduction of the annual depletion charge under the two-cut plan

The average depletion charge per M board feet for the length of the operation under the two-cut plan is $6.52 per M as calculated below.

First cut	$7.27/M depletion charge x	8 years	= $58.16
Second cut	$5.94/M depletion charge x	10.5 years	= 62.40
		18.5	)$120.56
			$6.52 weighted average

Matthews[2] states that under sustained yield, the charge for depletion which is necessitated by destructive logging, is eliminated because the capital (growing stock) is kept intact by growth. Accordingly, there would be no charge for depletion under sustained yield and a savings of $43,600.00 a year in comparison with straight liquidation, or $35,620.00 a year in the two-cut plan.

Valuation

One of the best methods of comparing the merits of the three different management plans is the capitalization of future incomes to find the present value of the property. To find the

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1/ Annual quota of volume to be fulfilled from company lands.
2/ D. M. Matthews, Management of American Forests, 344.

present worth, the production costs, both logging and milling, must be calculated and values attached to the sawn lumber to find the profit per M board feet. When the profit per M board feet is known, the annual income is easily obtained and the present worth then calculated.

Lumber Values: Lumber values were calculated by using Broughton's Standard Price List of November 25, 1949. These prices were applied to the weighted lumber grades to obtain the average selling price per M board feet lumber tally of rough, air dry lumber. An adjustment was also made for the quality of timber as explained in the Appendix, Page No. 63.

Table XXVIII, Page No. 163, shows the Average Dry Lumber Values on a per acre basis. This table is the end result of the calculations in the Appendix. From this table, it is apparent that the low vigor trees are worth more than the high vigor trees. From past experience the first cut has usually been of lower value than the second and final cut because the defective and overmature trees are cut first, leaving the young and thrifty trees to grow for the second cut. Since the first cut of the two-cut plan in this case, takes only the low vigor trees, the first cut according to Table XXVIII is worth more. This discrepancy of a higher value per M on the first cut is due to the omission of grading the high vigor trees. The survey only recorded the grades of trees of the low vigor category. The trees left (high vigor) were graded on basis of the Trout Creek Mill Study, but this method of grading is probably not very accurate when applied to this problem, see

TABLE XXVIII - AVERAGE DRY LUMBER VALUE (Per Acre Basis)

Mill Scale Per Thousand, by Species
(Includes 5% Deduction for Loss in Drying)

SPECIES	LOW VIGOR						HIGH VIGOR						TOTAL	
	Net Volume* M bd.ft. (log scale)	Average** Overrun	Net Volume M bd.ft. (mill scale)	5% Shrinkage in volume allowed. Net Volume M bd.ft. dry lumber (mill scale)	Dry Lumber*** value per M bd.ft. (mill scale)	Dry Lumber value per acre	Net Volume* M bd.ft. (log scale)	Average** Overrun	Net Volume M bd.ft. (mill scale)	5% Shrinkage in volume allowed. Net Volume M bd.ft. dry lumber (mill scale)	Dry Lumber*** value per M bd.ft. (mill scale)	Dry Lumber value per acre	Total Net Volume Dry Lumber (M bd.ft.) mill scale	Total Dry Lumber Value per acre
Hard Maple	1.575	18.3	1.863	1.771	$ 76.40	$132.10	1.563	18.3	1.849	1.755	$ 74.20	$130.20	3.526	$262.30
Hemlock	1.409	18.3	1.666	1.584	71.00	112.50	1.586	18.3	1.876	1.780	74.00	131.50	3.364	244.00
Birch	1.307	18.3	1.546	1.469	110.80	162.50	0.706	18.3	0.834	0.791	97.00	76.70	2.260	239.20
Ash	0.250	18.3	0.296	0.281	67.60	19.00	0.220	18.3	0.260	0.247	69.00	17.10	0.528	36.10
Elm	0.289	18.3	0.342	0.325	73.40	23.80	0.141	18.3	0.167	0.158	59.00	9.30	0.483	33.10
Basswood	0.236	18.3	0.279	0.265	100.70	26.70	0.075	18.3	0.089	0.085	99.00	8.40	0.350	34.10
Soft Maple	0.152	18.3	0.180	0.171	80.00	13.70	0.123	18.3	0.145	0.137	86.70	11.90	0.308	25.60
Spruce		18.3					0.046	18.3	0.054	0.051	112.10	5.70	0.051	5.70
TOTAL	5.218			5.866		$490.30	4.460			5.004		$390.80	10.870	$881.10
Average Dry Lumber Value per MBM					Low Vigor -	$84.00					High Vigor	$79.40	Total	$81.00

* - See Per Acre Stand Table, Table VIII, Page No. 52.

** - Based on 4 year average 1946 through 1949.

*** - See Calculation of Adjusted Average Selling Price, Pages No.76 - No.77 in Appendix.

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Tables EE, FF, GG, Pages No. 72 through No. 75 in the Appendix. High vigor trees are also worth less because of the lower average diameter now, thus making the factors from the Quality Price Index, (Table FF, Page No. 73), lower. However, with the increase in diameter after the selective cut, these trees will increase considerably in value by the time of the second cut and will be of more than the present value in Table XXVIII. A discrepancy is inevitable in this procedure for obtaining dry lumber values, because there is no way to predict the increase in quality between first and second cuts.

<u>Production Costs</u>: Production costs, see Table XXIX, Page No. 165 were compiled largely from the company's records and from production costs estimated by Copper Range Company.

In Table XXIX, there appears to be an increase of $1.03 per M board feet (Log Scale) in logging costs of the initial cut under the two-cut plan over straight liquidation. This increase is due to the cost of marking timber for the selective first cut, and was incorporated into the charge for supervision and scaling. In the second and final cut the logging costs are 98 cents lower per M board feet (Log Scale) than the first cut. This decrease is attributed to (1) smaller charge for road construction, which actually is only a reconditioning and maintenance cost because the initial road construction costs were charged off on the first cut, and (2) the lower depletion charge, lower per M, because of the increased volume due to growth. The average weighted cost of logging under the two-cut plan is $30.00 or 15 cents per M board

TABLE XXIX - PRODUCTION COSTS

LOGGING COSTS

Logging Costs partially developed in Table XXIV, Page No. 133 and Table XXVI, Page No. 145. Other costs obtained from the Ahonen Lumber Company and Copper Range Company.

	Straight Liquidation* M bd.ft. Log Scale	Straight Liquidation* Overrun	Straight Liquidation* M bd.ft. Mill Scale	Two-Cut Liquidation* First Cut M bd.ft. Log Scale	Two-Cut Liquidation* Second Cut M bd.ft. Log Scale	Two-Cut Liquidation* Overrun	Two-Cut Liquidation* First Cut M bd.ft. Mill Scale	Two-Cut Liquidation* Second Cut M bd.ft. Mill Scale	Sustained Yield** First Cycle M bd.ft. Log Scale	Sustained Yield** Second Cycle M bd.ft. Log Scale	Sustained Yield** Third Cycle M bd.ft. Log Scale	Sustained Yield** Overrun	Sustained Yield** First Cycle M bd.ft. Mill Scale	Sustained Yield** Second Cycle M bd.ft. Mill Scale	Sustained Yield** Third Cycle M bd.ft. Mill Scale
Direct Costs: Felling	$2.45			$2.45	$2.45				$2.45	$2.45	$2.45				
Skidding	4.40			4.66	4.66				4.66	4.66	4.66				
Bucking and Loading	2.20			2.20	2.20				2.20	2.20	2.20				
Hauling	9.00			9.00	9.00				9.00	9.00	9.00				
Indirect Costs: Road and Landing Construction	0.35			0.63	.01				0.63	0.03	0.03				
Scaling and Supervision	1.17			1.57	1.57				1.57	1.57	1.57				
Office equipment, shop equipment & buildings	.50			.50	.50				.65	.65	.65				
Office Expense	.80			.80	.80				.90	.90	.90				
Inefficiency	2.01			2.10	2.04				2.10	2.04	2.04				
Depletion***	7.27			7.27	5.94										
TOTAL	$30.15	18.3%	$24.52	$31.18	$29.17	18.3%	$25.42	$23.80	$24.16	$23.50	$23.50	18.3%	$19.70	$19.17	$19.17

Note: Depreciation on Logging Equipment calculated on machine rates of equipment

MILLING COSTS

Milling Costs obtained from the Ahonen Lumber Company.

	Straight Liquidation M bd.ft. Mill Scale	Two-Cut First Cut M bd.ft. Mill Scale	Two-Cut Second Cut M bd.ft. Mill Scale	Sustained Yield First Cycle M bd.ft. Mill Scale	Sustained Yield Second Cycle M bd.ft. Mill Scale	Sustained Yield Third Cycle M bd.ft. Mill Scale
Sawing, Labor, Supplies and Repairs	$11.85	$11.85	$11.85	$11.85	$11.85	$11.85
Sorting and Piling	1.90	1.90	1.90	1.90	1.90	1.90
Shipping Expense	7.46	7.46	7.46	7.46	7.46	7.46
Selling Expense	1.27	1.27	1.27	1.27	1.27	1.27
Discounts and Allowances	2.13	2.13	2.13	2.13	2.13	2.13
Insurance	1.49	1.49	1.49	1.49	1.49	1.49
Taxes	0.55	0.55	0.55	0.55	0.55	0.55
Depreciation****	1.97	1.97	1.67	2.10	3.54	3.16
Overhead	6.00	6.00	6.00	6.00	6.00	6.00
TOTAL	$34.62	$34.62	$34.32	$34.76	$36.20	$35.72

* - Based on Logging 6 Million board feet and Sawing 10 Million board feet annually.

** - Based on Logging 2.4, 1.4, 1.6 Million board feet, First, Second and Third Cycles respectively.
It is assumed that the company will either (1) buy the balance of the economic requirement on the open market, thus sawing 10 Million board feet annually, or (2) revamp the mill to the expected cut under sustained yield to approximately keep present milling cost.

*** - Table XXXI, Page No. 170.

**** - Table XXVII, Page No. 158.

feet (Log Scale) less than the cost of logging under straight liquidation.

There is a marked difference in the logging costs of sustained yield than either of the liquidation plans. The reason for this marked difference is the policy of not having a depletion charge as a logging cost on the sustained yield plan. The depletion charge excluded, the cost of logging under the sustained yield plan is higher than that of the liquidation plans.

Milling costs under the sustained yield plan are larger than the liquidation plans because of the high charge for depreciation. This cost is higher because the depreciation charge, though spread out over a longer period of time than that of the liquidation plans, is prorated over a much smaller volume of timber. The amount of timber removed during the first cycle of the sustained yield plan is only 40% of the volume removed under either of the liquidation plans.

Profits: Table XXX, Page No. 167 shows the calculation of both annual and total incomes under the three plans. In comparing the sustained yield program with the liquidation plans, only the first cycle will be used, as this approximately covers the same period of time.

Of the three plans in question, the two-cut liquidation has the largest annual income and also the largest total income.

Total Income, excluding depletion

Two-cut	$2,963,000	Two-cut	$2,963,000
Straight	2,440,000	Sustained(First cycle	1,680,000
Difference	$ 523,000	Difference	$1,283,000

TABLE XXX - CALCULATION OF INCOMES

	Cost of Logging M bd.ft. (Mill Scale)	Cost of Milling M bd.ft. (Mill Scale)	Total Production Costs	Dry Lumber* Value M bd.ft. (Mill Scale)	Net Realization M bd.ft. (Mill Scale)	Volume Cut/Acre bd.ft. (Mill Scale)	Net Realization Per Acre (Mill Scale)	Annual Cutting Area (Acres)	Annual Income	Annual Income Including Depletion	Total Income for Period Excluding Depletion (Net Realization x 10,280 acres)	Total Income Including Depletion	Total Taxes for** Period	Total Income Excluding Depletion After Taxes
Straight Liquidation	$24.52	$34.62	$59.14	$81.00	$21.86	10.87 M	$237.25	620	$147,100	+ ($43,600) = $190,700	$2,440,000	+ ($722,700) = $3,162,700	$49,407	$2,390,593.00
Two-cut Liquidation														
First Cut	$25.42	$34.62	$60.04	$84.00	$23.96	5.53 M	$132.50	1286	$170,100	+ ($43,600) = $213,700	$1,362,000	+ ($348,800) = $1,710,800		
Second Cut	$23.80	$34.32	$58.12	$79.60	$21.48	7.25 M	$155.75	978	$152,840	+ ($35,620) = 188,100	$1,601,000	+ ($373,900) = $1,974,900		
											$2,963,000 for 19 yrs.Two-Cut Plan	$3,685,700	$50,675	$2,912,325.00
Sustained Yield														
First Cycle	$19.70	$34.76	$54.46	$84.00	$29.54	5.53	$163.50	514	$ 84,000	No depletion under sustained yield $ 84,000	$1,680,000	No depletion under sustained yield $1,680,000	$47,044.50	$1,632,955.50
Second Cycle	19.17	36.20	55.37	80.30	24.93	3.27	81.60	514	41,930	41,930	839,000	839,000		
Third Cycle	19.17	35.72	54.89	79.40	24.51	3.67	90.00	514	46,290	46,290	925,500	925,500		

* - Weighted Average in the Second Cuts of the Two-Cut and Sustained Yield Plans; weighted because both high and low vigor trees were cut.

** - From Summary of Tax Schedules, Page No. 152.

Total profits accumulated over a period of operation is not the best way to valuate the three proposals. In order to be fair and count all incomes, the incomes should be capitalized to find the present value of the property.

Present Worth of Plans: Under straight liquidation for a period of seventeen years, the present value of the property is equal to $2,152,000.00 as calculated below.

Annual Income	$147,100
+ Depletion	43,600
	$190,700

$$PW = \frac{\$190,700\ (1.05^{17} - 1)}{.05 \times 1.05^{17}}$$

$$PW = \$190,700 \times 11.2741$$

$$PW = \$2,152,000$$

The two-cut system for a period of nineteen years has a present value of $2,433,000 as calculated below.

	First Cut	Second Cut
Annual Income	$170,100	$152,480
+ Depletion	43,600	35,620
	$213,700	$188,100

$$+\ PW = \frac{\$213,700\ (1.05^{8} - 1)}{.05 \times 1.05^{8}} + \frac{\$188,100\ (1.05^{11} - 1)}{.05 \times 1.05^{19}}$$

$$PW = \$213,700 \times 6.4632 + \$188,100 \times 5.582$$

$$PW = \$1,383,000 + \$1,050,000$$

$$PW = \$2,433,000$$

The Sustained Yield plan with its twenty year cycles has a value of $1,374,300 as calculated below.

	First Cycle	Second Cycle	Third Cycle and all Subsequent Cycles
Annual Income	$84,000	$41,930	$46,290

$$PW = \frac{\$84{,}000(1.05^{20} - 1)}{.05 \times 1.05^{20}} + \frac{\$41{,}930(1.05^{20} - 1)}{.05 \times 1.05^{40}} + \frac{\$46{,}290}{.05 \times 1.05^{40}}$$

$$PW = \$84{,}000 \times 12.4622 + \$41{,}930 \times 4.68 + \frac{\$46{,}290}{.352}$$

$$PW = \$1{,}047{,}000 + \$196{,}000 + \$131{,}300$$

$$PW = \$1{,}374{,}300$$

The two-cut plan shows the highest value of the Present Worth calculations with $2,433,000. It has a margin of $281,000 over straight liquidation and $1,058,700 over sustained yield. Straight liquidation has the next highest present worth value, $2,224,000, and this has a margin of $777,700 over sustained yield.

Two-cut	$2,433,000	Two-cut	$2,433,000
Straight	2,152,000	Sustained	1,374,300
Difference	$ 281,000	Difference	$1,058,700
Straight	$2,152,000		
Sustained	1,374,300		
Difference	$ 777,700		

Comparison of Plans

In a pecuniary comparison of the three proposed plans, valuation is more important than taxation, depreciation, or depletion. Valuation is the end result of a consideration involving the previous three factors. It is most equitable because it is the test of profits, and shows the result of this test by capitalization of all future incomes (profits) thus obtaining the present worth (value) of the property under each plan.

Comparison of the Four Factors

In the calculation of profit, depreciation and depletion play an important part, because reduction in these charges enables the profit or net realization to increase or vice versa.

Table XXXI below summarizes these four factors for each plan.

TABLE XXXI - FINANCIAL FACTORS

	Taxation per M bd.ft. (log scale)	Depreciation per M bd.ft. (log scale)	Depletion per M bd.ft. (log scale)	Valuation (PW)
Straight Liquidation	$0.50	$2.11	$7.27	$2,453,000
Two-cut Liquidation	0.46	1.88	6.52	2,152,000
Sustained Yield	0.98	2.81	none	1,374,300

The general property tax was found to be the cheapest form of taxation for the liquidation plans, see Page No. 154 and the lands were assumed to be classified under the Pearson Act for the sustained yield plan. Even with this cheaper tax rate, the tax charge per M board feet under sustained yield was higher than that of liquidation, because the annual volume cut under sustained yield is only 2,400 M board feet or 40% of the six million feet obtainable under either of the liquidation plans. This same relatively small volume is also the cause for the high depreciation charge, even though the period of time in the straight line depreciation calculation was extended to forty years. No depletion charge is figured for the sustained yield plan, because the timber is not depleted and therefore no charge can be made for such. As Marquis[1/] states "The removal of the depletion charge, which is simply the accountant's method of expressing the productivity of the soil, is the saving that makes sustained yield forestry most attractive when other circumstances are favorable."

The valuations or present worth calculations serve as the best guide in the financial analysis of the three management plans. There is one point that should be remembered about these present worth values: in both liquidation plans, the annual depletions were added to the annual income figures, because the depletion is, theoretically at least, a capital return to the stockholders. In other words, that portion of the money the stockholders invested in the company that is used to purchase timber, is being returned at an annual rate called depletion charge and is added to the annual incomes. Under sustained yield, the timber is not being depleted, and therefore no money can be returned to the stockholders. However, it should be remembered that this timber is always there and has a definite market value. Even though the present worth of the sustained yield plan is the lowest of the three, this $1,374,300.00 present value has an additional timberland value of at least $722,700.00 (present book value of timber).

No income was calculated for the sale of cut-over land under the liquidation plans. The company's policy has been to sell the lands as soon as they have finished logging them. They are usually

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1/ R. W. Marquis, <u>Economics of Private Forestry</u>, 134-135.

sold to small pulpwood and mining timber operators for an average price of $10.00 per acre. If these lands had been considered in the calculations, the total taxes would have been less for the straight and two-cut liquidation, and also, an additional income would be received for the land.

Under straight liquidation, 620 acres of land would be sold annually, from the end of the first year through the seventeenth. Under the two-cut plan, no land would be sold until the ninth year, and from that year to the nineteenth year, 978 acres would be sold annually. This additional present worth value is calculated below.

<u>Straight Liquidation</u>

$$PW = \frac{\$6200\,(1.05^{17} - 1)}{.05 \times 1.05^{17}}$$

$$PW = \$6200 \times 11.2741$$

$$PW = \$69,800$$

<u>Two-Cut Liquidation</u>

$$PW = \frac{\$9780\,(1.05^{11} - 1)}{.05 \times 1.05^{19}}$$

$$PW = \$9780 \times 5.582$$

$$PW = \$54,600$$

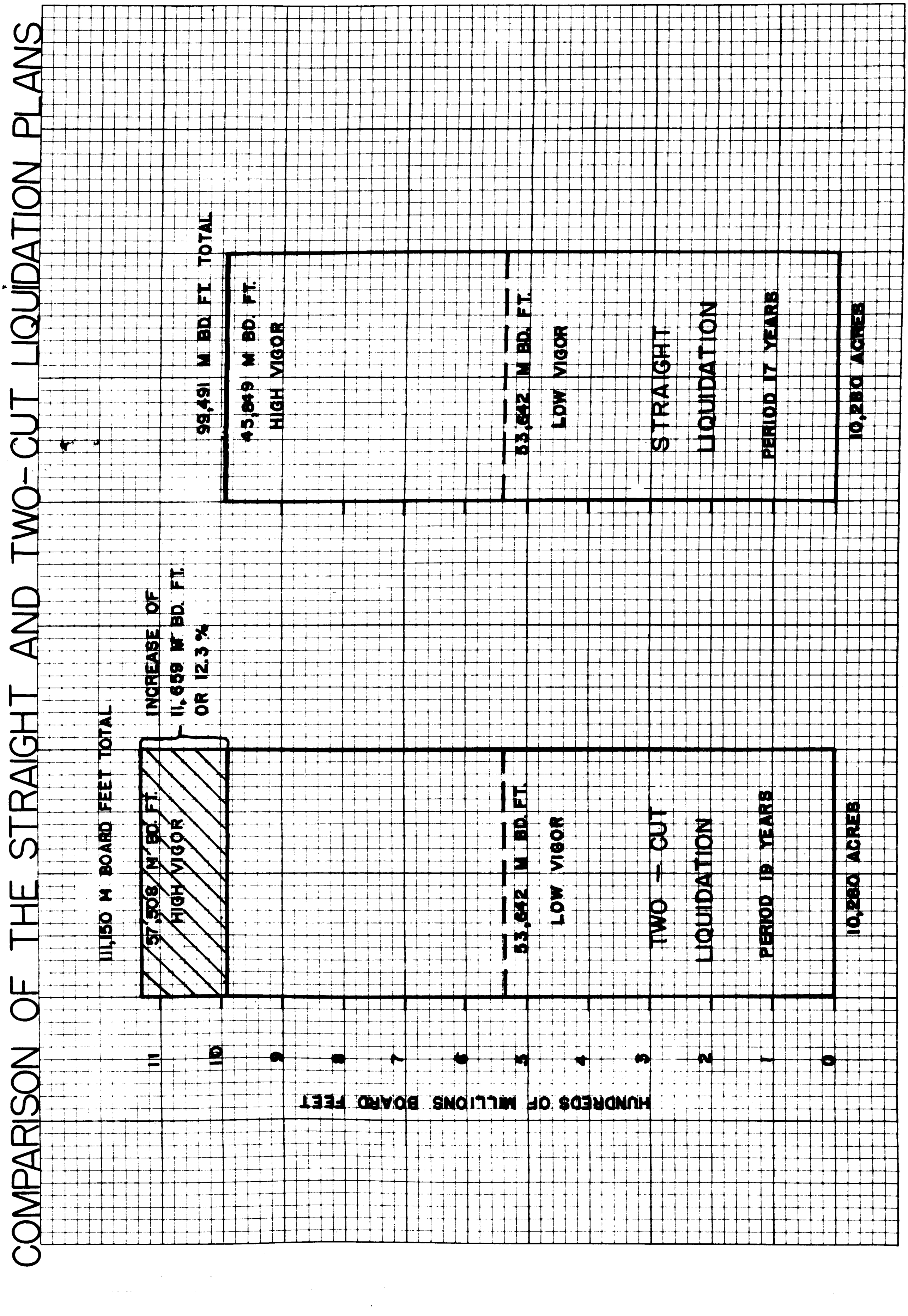
Here again, although no present worth can be calculated for the land under sustained yield, it must be remembered that this land can always be clear cut and sold, and therefore has a value.

<u>Straight versus Two-Cut Liquidation</u>

In Table XXXI, Page No. 170 either one of the liquidation plans appears to be more financially sound than the sustained yield plan. Sustained yield is the least profitable to the company and should not be undertaken because the immediate realization from liquidation is more than the long termed sustained income. The choice left for the company is between a continuance of their present policy of straight liquidation or changing to the two-cut plan. The two-cut plan is more profitable than the straight liquidation, because of the larger volume of timber cut - an increase of 12.3% over the straight liquidation plan - and the extended period of operation by two years. The increase in time and volume is derived from the first cut of the two-cut, being made selectively (see Chart XIV, Page No. 174). Selective cutting will probably raise the logging costs because of the more intensive cruises needed, marking of the timber, and the policy of charging initial road costs off during the first cut. These road costs would be quite high during the first cut because the company would cover all their holdings in eight years under the two-cut plan, whereas under straight liquidation the capital invested in similar road construction would be spread out over seventeen years. Also, the cost of milling may be increased during the first cut, should the quality of timber prove to be poorer than the mill run material under straight liquidation.

A favorable feature of selective cutting is that the residual volume of the first cut increases in value to a surprising amount. The two-cut plan leaves a residual investment of $237.25 - $132.50 = $104.75 per acre. In eight years this $104.75 will increase to $155.75 or an increment of $51.00, which means that in eight years time the per acre value has increased 38-1/2% in value. The value of the land after the second and final cut should be more because the condition in which the forest is left will be much better than it would be under straight liquidation.

In addition to a lower taxation, depreciation, and depletion charge per M board feet, there are other advantages in the two-cut plan that the straight liquidation plan does not possess. Because of the rapid extension of roads, for instance, a great deal of


COMPARISON OF THE STRAIGHT AND TWO-CUT LIQUIDATION PLANS
111,150 M BOARD FEET TOTAL
57,508 M BD. FT.
HIGH VIGOR
INCREASE OF
11,659 M BD. FT.
OR 12.3 %
53,642 M BD. FT.
LOW VIGOR
TWO - CUT
LIQUIDATION
PERIOD 19 YEARS
10,280 ACRES
99,491 M BD. FT. TOTAL
45,849 M BD. FT.
HIGH VIGOR
53,642 M BD. FT.
LOW VIGOR
STRAIGHT
LIQUIDATION
PERIOD 17 YEARS
10,280 ACRES
11
10
9
8
7
6
5
4
3
2
1
0
HUNDREDS OF MILLIONS BOARD FEET

material may be salvaged under the two-cut plan that otherwise might be lost. Since the first cut is selective, it not only enables the residual stand to put on thrifty growth, but stimulates reproduction and lessens the time required for the new forest to establish itself.

Should the two-cut liquidation plan be adopted, the company would gain firsthand information of the advantages and disadvantages of selective cutting, and would know exactly what the logging costs, and growth rates under sustained yield would be.

The growth of mature timber is static while that of selectively cut timber is dynamic. The faster timber is changed from static to dynamic the more profitable the cut. Under the two-cut plan, any selective cutting in mature timber such as that owned by the Ahonen Company would yield more dollar return per acre than clear cutting under straight liquidation or selective cutting under sustained yield, because more acreage (1285 acres) is put into production (for growth) annually than straight liquidation (620 acres) or sustained yield (514 acres).

Since the two-cut plan has proved itself financially sounder than straight liquidation, and has a present worth value of $281,000.00 more than the straight liquidation, it is recommended that two-cut liquidation be adopted by the company.

<u>Possibilities of Converting to Sustained Yield</u>

There are two possible alternatives by which the company may undertake a sustained yield program, (1) through revampment of their sawmill, and (2) through acquisition of additional timberland (or working agreements with other companies), or a combination of both.

The Ahonen Lumber Company has a present mill capacity of ten million board feet per year and wishes to maintain this capacity for the next eight years until the major portion of the sawmill and other equipment has been written off the books. Revampment of the mill for sustained yield program can best be achieved in a gradual manner in order to allow adjustment of all details concerned. The capacity after revampment should be based on the volume the company expects to obtain from the three possible sources of timber (1) their own lands, (2) maximum volume they could profitably purchase on the open marked, (3) timberland, or cutting agreements that can be made in the surrounding area. The company could continue to selectively cut six million board feet from their own lands for the next eight years, but then would either have to depend on the open market for logs or purchase additional stumpage for the following eleven years until their own growing stock has increased sufficiently to permit economic selective logging.

The maximum economic hauling distance under present conditions is a fifty mile radius of the mill. Exceptions to this practice may be made if the quality of timber is very good, volume large, logging easy, and hauling routes are in good condition.

Prices of most cut-over land are too high for the company to purchase and hold until the timber is mature. Prices are high on second growth timberlands because these timberlands have a market value for mining timbers, lagging, ties, pulpwood, and other products. The competitive bidding for these timberlands between lumber companies and small mining timber and pulpwood operators has caused the value to increase to $5.00 to $10.00 per acre.

Many of the mining, veneer, and lumber companies, now operating within the economic hauling distance of the Ahonen mill, will have cut-over land for sale when they get through in the area perhaps ten years or so from now.

Ahonen's timberlands, for the most part, are classified either as mature sawtimber or recently cut-over. To fill the requirements of a sustained yield program, land of the pole or small sawtimber size class must be acquired. If six million board feet is the maximum volume the company can annually cut from their own lands, selective cutting as proposed in this paper would last for approximately eight years (this selective cutting is the same as the initial cut of the two-cut liquidation program). Additional timberland sufficient to last from eight to ten years, with six million board feet cut annually, would have to be procured in order to fill the mill requirement. Any cut-over land that would have 3.5 M board feet per acre eight years hence would be worth buying. When the cutting of the acquired land is completed, the second cut of the presently owned land could be initiated.

Mr. Julian F. McGowin of the W. T. Smith Lumber Company, Chapman, Alabama,[1/] has discussed both of these alternatives, pessimistically, perhaps, but practically. The situation of

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1/ J. F. McGowin, "The Lumberman's Viewpoint on the Forestry Program for the South", Journal of Forestry, vol. 36, No. 5 (May 1938) 572-75.

conversion to sustained yield, "A concern with a large plant investment and small remaining supply of timber, cannot, obviously hope for a sustained yield operation". Regarding the acquisition of huge acreages of timberland, Mr. McGowin has pointed out its disadvantages stating 1/ that the proper administration of huge acreages is much harder to maintain, protective measures against fires and timber stealing must be expanded, taxation is higher, and there is the risk of losing a greater sum of money invested in stumpage, because of fire, disease or insect epidemics, blowdowns and other similar acts of nature.

Operator's Viewpoint

Since the Ahonen Lumber Company is now following a plan of straight liquidation, any change will involve the relinquishment of the present policy for the adoption of either two-cut liquidation or sustained yield plans. It is very easy for an outsider to suggest the company switch from one form of forest management to another, mere paper shuffling. But for the operator, in addition to the top level planning and reorganization necessitated by such a change, many of the practical, every day problems that will confront him, arise.

The writer had the fortunate opportunity to converse with company officials and learn their particular problems, and personnel objections to any such a policy change.

1/ J. F. McGowin, op. cit., 572-75.

<u>The Case of Sustained Yield</u>

Investment of money by an individual in a business venture is made primarily for the sake of a return on the investment during his lifetime. Investments in the lumber industry are no exception. The Ahonen Company, being family owned, and located in a rather small community has shown a sense of social responsibility, attested to by the large amounts of money and material donated to various community activities and groups. Marquis[1/] points out, "Many lumbermen are sincere in their belief that they owe a duty to society in the proper treatment of their forest holdings, but it is not conceived as a duty to provide social benefits at the cost of sacrificing profit to the individual". No one should expect the investor of a lumber company, or any other investor, to sacrifice his own investment for the sake of future national economy. A basic assumption of elementary economics is that, profits are returned for assuming risk, and these risks in the lumber industry are quite high. The owner or investor must expect risks from the destructive forces of fire, disease, insects and wildlife. The lumber company owner or investor must also face the risks of fluctuating costs and markets. Thus, profit is the return for risk the investor assumes, and a reasonable return (rent if you like) on his investment. Agriculture entails such risks, but does not entail waiting from 100 to 150 years to harvest a crop. Agrarian

---

1/ R. W. Marquis, <u>op</u>. <u>cit</u>., 146.

Production is based on risks that usually only last one year, and these products are now even subsidized by our government.

Various reasons for the company's skepticism in undertaking a sustained yield program are presented below. They are not listed in any particular order and no effort was made to select the most important ones.

Insufficient timber supply is the fundamental reason for the unfeasibility of sustained yield at present. It was brought out in the section on "Management Plans", that the highest possible yield under sustained yield will only produce 40% of the annual quota.

Increased technology in the manufacture of lumber substitutes, such as the process of making lumber from sawdust,1/ has created a fear that the future demand for natural lumber will decline. This fear has been expressed by other prominent lumber men of the Upper Peninsula.2/

The disparity in the demands for lumber during the fluctuations of the business cycle, induce cutting to capacity during the periods of large demand and high lumber prices, thus reducing the desire of such long-term investments. Also, loans for such long-term investments are difficult to secure at low interest rates.

The present high interest rates on money borrowed by the Ahonen Company, to procure their timberland, and other carrying charges are a heavy pressure in forcing quick retirement of the loan.

A large annual cut is needed to carry the heavy annual charges such as depreciation, depletion, interest and taxes. This need was shown in the prior discussion of the "Financial Analysis". Of the four factors, only depletion proved to be less for sustained yield than for liquidation.

1/ See "Timber Topics", Vol. 12, No. 4, August-September 1949, pages 6,7.

2/ Mr. Kurt Stoehr, Vice President of the Bay De Noquet Lumber Company, Bay De Noquet, Michigan.

The possibility that a fire, or insect or disease epidemic could wipe out the whole timber investment and bankrupt a sustained yield lumber company is a consideration.

Competition of other regions and unforeseen production cost increase may make lumber manufacture unprofitable in this particular area.

The interest the company would receive from the investment of money in the sustained yield program would not be as high as the interest on the investment received under straight liquidation.

Acquisition of additional land to facilitate a sustained yield plan is hampered by the fact that there is little land in the vicinity left for sale, and what is, is expensive because of the competitive purchasing of land by other companies and the United States Forest Service. Present stumpage prices prohibit buying stumpage for distant future harvest. Timber offered for sale on the Ottawa National Forest is too high to bid on.

There is always reason to believe that government cutting regulation may come into existence.

The decreased volume under sustained yield would mean reductions in the number of employees in both the woods and mill. The employees laid off would probably not understand such an argument as "We're laying you off to insure those left with employment twenty years hence". This action might create a serious labor problem, and would certainly create ill feeling towards the company by the job losers.

The fixed charges would increase in proportion to the income under sustained yield, and thus reduce profits, which would mean a reduction of income for the owner. This reduction of income, after working for many years to build up the industry, would be a bitter pill to swallow.

Additional reason for skepticism of sustained yield is selective logging, which is discussed in more detail under "The Case of Two-cut Liquidation", which follows.

<u>The Case of Two-Cut Liquidation</u>

From the operator's viewpoint, the problem of straight versus two-cut liquidation is simply a case of clear cutting versus selective cutting. Naturally, there is resistance to change, not only among the officials, but even among the woods crew. The latter will contend that selective cutting makes more work for them and therefore wages should be increased. Others are listed below.

> Dense reproduction coming in after the initial cut impedes logging of second cut, and presents both a labor and technical problem.
>
> There is also the question of relative costs between clear and selective cutting. In this paper selective cutting (see Pages No. 149 and No. 150) was calculated to be more per M board feet than clear cutting. However, costs were not computed on a diameter basis and may be erroneous.
>
> Selective cutting would open the stand up so that a large number of trees would either be killed by exposure or blown down by strong winds.

Of the three management plans presented, straight liquidation, sustained yield, and two-cut liquidation, the latter proved to be the most utile in the financial analysis of the plans.

Sustained yield would only provide 40% of the six million board feet annual quota from company lands and hence would not be feasible. Two-cut has many advantages over straight liquidation, the two most important being an increased volume of timber (11,659 M board feet), and an extended period of operation (2 years). The major charges against the timber, taxation, depreciation, and depletion are less for the two-cut plan than for straight liquidation, and the present worth calculation showed the two-cut plan was worth $281,000.00 more than straight liquidation. On the basis of the foregoing data, it is recommended that the company adopt the two-cut liquidation plan.

Two possible alternatives are still open to the company for the adoption of sustained yield. First, revampment of their mill to a lower capacity, second, acquisition of additional timberland to meet the present capacity. Conditions at present make either one of these alternatives rather remote now.

The operator's objections to the adoption of either the sustained yield plan or the two-cut liquidation plan are summarized below. Objectives to two-cut liquidation are primarily based on selective cutting and would apply equally to sustained yield.

Sustained Yield

1. Insufficient timber supply.
2. Fear of lumber substitutes causing a decline in lumber demand in the future.
3. Violent and frequent fluctuations of the business cycle produce an unstable lumber market.
4. Loans for long-term investments too difficult to secure at low interest rates.
5. Interest rates on borrowed money (used for purchasing stumpage) together with other carrying charges, force a quick retirement of the loan.
6. A large annual cut is needed to carry the heavy annual charges.
7. Possible decimation of timberland by fire, insects, or disease epidemics.
8. Competition of other regions may make future lumber manufacturing unprofitable in this area.
9. Interest on money invested is too low.
10. Acquisition of additional land not practical at present.
11. Fear of government control over cutting.
12. Reduction in the number of employees is necessary.
13. Reduction in profits.
14. Object to selective cutting (see two-cut liquidation).

Two-cut Liquidation

1. Dense reproduction following the initial selective cut impedes logging and causes discontent among labor on succeeding cuts.
2. Doubt about the supposedly cheaper logging and milling costs incurred under selective cutting.
3. Fear that selective cutting would open the stand up too much and cause excessive losses from exposure and wind throw.

APPENDIX

THE FIELD CREW

The field crew consisted of two key men and three tally men from the Ahonen Lumber Company, one forester from the School of Forestry and Conservation, University of Michigan, one forester from the Michigan Department of Conservation, and one forester from the United States Forest Service.

<u>Ahonen Lumber Company</u> - Roy Ahonen, forester
Charles Konnonberg, cruiser
J. Cvengros, tally man
G. Halverson, tally man
J. Erickson, tally man

<u>School of Forestry and Conservation, University of Michigan</u> - Walter (Ozzie) Bender, graduate student forester

<u>Michigan Department of Conservation</u> - James C. Lamy, forester

<u>United States Forest Service</u> - William W. Barton, forester

TABLE A - ACREAGES IN AHONEN TIMBER TRACTS

		Virgin Timber Acreage	Cut-over Acreage	Non-Productive Acreage	Total
Porcupine Block					
T51N, R42W,	Sec. 32	480.04	159.96	-	
	Sec. 33	200	440.00	-	
T50N, R43W,	Sec. 3	211.31	70.65	-	
	Sec. 4	300.17	299.73	-	
		1191.52	970.34		2161.86
Gogebic Block					
T48N, R42W,	Sec. 13	120	-	-	
	Sec. 14	360	160	-	
	Sec. 15	-	280	-	
	Sec. 20	-	371.35	-	
	Sec. 22	-	640	-	
	Sec. 23	400	240	-	
	Sec. 24	320	-	80	
	Sec. 25	182	-	58	
	Sec. 26	475	-	165	
	Sec. 27	80	20	-	
	Sec. 28	-	618.50	-	
	Sec. 35	233	-	7	
	Sec. 36	581	-	19	
		2751	2329.85	329	5449.85
Tula Block					
T48N, R44W,	Sec. 4	246	-	-	
T49N, R44W,	Sec. 4	619	-	-	
	Sec. 6	573	-	-	
	Sec. 7	601	-	-	
	Sec. 18	601	-	-	
	Sec. 20	80	-	-	
	Sec. 28	640	-	-	
	Sec. 29	640	-	-	
	Sec. 30	320	282.59	-	
	Sec. 31	80	522.55	-	
	Sec. 32	320	240.00	-	
	Sec. 33	640	-	-	
T49N, R45W,	Sec. 2	611	-	-	
	Sec. 12	40	-	-	
T50N, R44W,	Sec. 28	240	-	-	
	Sec. 29	640	-	-	
	Sec. 32	400	-	-	
T50N, R45W,	Sec. 34	240	-	-	
		7531	1045.14		8576.14
Total Gogebic and Tula Blocks only		10282	3374.99	329	13,985.99
TOTAL (ALL BLOCKS)		12,273.52	3345.33	329	16,183.85

TABLE B - MARKET VALUE OF TIMBER HOLDINGS

Porcupine Block (value of timber only)

Section 3	211.31 acres	@ 11 M/Acre =		2,323,000 bd.ft.
Section 4	300.17 acres	@ 8 M/Acre =		2,400,000 bd.ft.
Section 32	480.04 acres	@ 11 M/Acre =		5,280,000 bd.ft.
Section 33	200 acres	@ 12 M/Acre =		2,400,000 bd.ft.
	1191.52			12,403,000 bd.ft.

Tula and Gogebic Blocks

Productive Land - 10,282 acres	- Sawtimber		99,491,000 bd.ft.
		Total	111,894,000 bd.ft.
	- Pulpwood		7,226 cords
	- Cedar		10,414 cords

Sawtimber	111,894,000 bd.ft.	@ $24.25 per M =	$2,724,000.00
Pulpwood	7,226 cords	@ 10.00 per cord =	72,260.00
Cedar	10,414 cords	@ 10.00 per cord =	25,135.00
Cut-over land	2285 acres	@ 10.00 per acre =	22,850.00
Non-productive land (by forties)	120 acres	@ $ .50 per acre =	60.00
Non-productive land (muskeg in 10,282 acres)	169 acres	@ $ .50 per acre =	84.50
			$2,840,389.50

TABLE C - ACREAGE VALUATION DERIVED FROM PER ACRE STAND TABLE AND PRESENT (1949) MARKET STUMPAGE PRICES

	Species	Per Acre (Net Volume) (M bd.ft.)	Stumpage Price per (M)	Value per Average Acre
Sawtimber	Maple	3.138	$25	$78.60
	Hemlock	2.995	10	29.95
	Birch	2.013	47	94.80
	Ash	.470	16	7.52
	Elm	.430	16	6.88
	Basswood	.311	33	10.28
	Soft Maple	.275	20	5.50
	Spruce	.046	20	.92
	Total	9.678		$234.45

Average price per M $\frac{234.45}{9.678}$ = $24.25

	Species	(cords	(cords)	
Pulpwood	Balsam	.319	$10	$3.19
	Aspen	.294	6	1.77
	Spruce	.090	23	2.07
	Total	.703		$7.03

Average price per cord $\frac{\$7.03}{.703 \text{ cords}}$ = $10 per cord

Cedar	Cedar	1.013	$3.50	$3.96 per cord

Average price per cord $3.50

Grand Total .... $245.44 per Acre

TABLE D - SUMMARY OF TAXES

Tula Forest Products Company

		Forties	Average	Amount
1946 -	Tula Block	223		$3,433.30
	Gogebic Block	110		1,497.12
	Porcupine Block	62		742.29
	Cut-over Land	88		361.83
		483	12.49	$6,034.54
1947 -	Tula Block	223		$3,936.09
	Gogebic Block	94		1,184.43
		17 purchased (16 sold)		207.25
	Porcupine Block	56		779.47
	Cut-over Land	26 (62 sold)		205.54
		416	15.17	$6,312.78
1948 -	Tula Block	223		$3,904.83
	Gogebic Block	111		1,449.35
	Porcupine Block	56		828.86
	Cut-over Land	26		259.97
		416	15.48	$6,443.01

Appendix 6

TABLE E - TAX RATE PER $1,000 VALUATION

Township		Average % of Assessed Value	Average mills of Assessed Value	Total Valuation per Township as of 1948
Carp Lake	1946 - $18.00			
	1947 - 21.00			
	1948 - 23.63			
	3)62.63			
	Average $20.876	2.0876%	20.876 mills	$147,930
Matchwood	1946 - $18.00			
	1947 - 18.00			
	1948 - 20.00			
	3)56.00			
	Average 19.333	1.9333%	19.333 mills	$ 55,050
Bergland	1946 - $37.00			
	1947 - 37.00			
	1948 - 39.00			
	3)113.00			
	Average 37.666	3.7666%	37.666 mills	$ 6,600
Wakefield	1946 - $37.20			
	1947 - 38.70			
	1948 - 39.80			
	3)115.70			
	Average 38.573	3.8573%	38.573 mills	$ 29,100
				$298,680

RATE AS OF 1948

Total Tax / Assessed Value = %

$6443.01 / $298,680.00 = 2.156%

or

21.56 mills

DETERMINATION OF THE NUMBER OF 1/5 ACRE PLOTS

First, it was decided to combine the Tula and Gogebic blocks rather than figure them separately; together the amount of acreage of virgin timber amounted to 10,280 acres. The Porcupine block was not figured in because the cutting rights expire in 1955, and this block must be cut under a liquidation policy. Second, an accuracy of 15% plus or minus was regarded as adequate in determing the total volume inventory of all species. Third, the size class, density, and uniformity of the timber stand were determined from aerial photos of the area and Forest Service Acquisition Type Maps by the procedure set up by Barton and Stott.1/ The guides in determing the density, size class and uniformity appear below.

Size Class of Timber (After Barton and Stott)

The guide below indicates the size of the predominating d.b.h. class.

Large sawtimber	(16" and over d.b.h.)
Mixed sawtimber	
Small sawtimber	(10"-14" d.b.h.)
Mixed sawtimber-cordwood	
Cordwood	(6"-8" d.b.h.)

Density

The number of trees 6" d.b.h., and larger, per acre is a good guide to density. The table below shows the ranges considered to represent medium density in different timber size classes.

1/ W. W. Barton and C. B. Stott, loc. cit., 750-54

Timber Size Classes	No. trees per 1/5 acre plot	No. trees per acre
Large sawtimber	7-10	35-50
Mixed sawtimber	8-13	40-65
Small sawtimber	11-19	55-95
Mixed sawtimber-cordwood	16-28	80-140
Cordwood	26-45	130-225

Another method of judging density is the use of the hardwood percent-of-stocking formula. With 50-80% as medium density the results are almost identical with the table above, including trees 6" d.b.h. and larger.

$$\text{Percent of stocking} = \text{No. of trees/acre} \times \frac{\text{average d.b.h.} - 4}{10}$$

Uniformity

The appearance of the stand is the only guide to uniformity. Average uniformity allows 20-40% of the stand in patches of different size classes or density than that judged to represent the stand as a whole. Stands with less variation are considered uniform. Stands with many openings and those about half way between size class or density classifications are about the only ones that fall into the patchy group.

By reference to aerial photos and type maps, and the guides, the following was determined:

(1) Size Class of Timber - all was considered to be large sawtimber, 16" predominate d.b.h. class.

(2) Density - the Tula block was found to be of primarily good density. The Gogebic block had variation of poor to good density. All of the non-productive area was measured and discarded; on that basis the remaining

productive areas were thought to vary from high-medium to good density. For the over-all area, a good density classification was used.

(3) Uniformity - the Tula block was considered to vary from average to uniform and the Gogebic block was average to patchy in a few places. Average uniformity was considered the best choice for the area as a whole.

Later, the actual field data was checked against the three results obtained from Barton and Stott's guides to size class, density, and uniformity. The field data showed the following:

(1) Size Class of Timber - the predominating age class according to the stock table (see Table K in Appendix, Page No. 32) indicates that the 12" diameter class was the predominant one. However, the average size of the sawtimber (trees 12" d.b.h. and up) is 15.8". This average size of sawtimber compensates somewhat for the error in judgement of the predominate d.b.h. class.

(2) Density - From the stock table there are 81.4 trees 6" d.b.h. and up on the average acre. According to Barton and Stott's table this number is far above the <u>medium</u> density of large sawtimber, so the ocular estimate of <u>good</u> density was right. A further check may be had by using the hardwood percent-of-stocking formula.

Percent of stocking = No. of trees per acre x $\frac{\text{average d.b.h.} - 4}{10}$

Percent of stocking = 81.4 x $\frac{15.0" - 4}{10}$

Percent of stocking = 89.54

The stocking percent greatly exceeds the standard of <u>medium</u> stocking (50-80%), and therefore must be <u>good</u> stocking.

(3) Uniformity - the only check on uniformity in the field was ocular estimate. The conclusion of average uniformity was considered correct by the field parties. Therefore, all of the interpretations from the aerial photos and type maps were proved correct on later field checks. The most erroneous estimate was for size class of timber and this should not prove significant where the average sized merchantable tree is 15.8" in diameter.

Next, the number of plots needed to be examined to give 15% plus or minus accuracy in total volume was calculated by the method set up by Barton and Stott.

N = F x M Where N equals the number of plots,
F equals the stand factor,
M equls the statistical accuracy multiplier

According to Table F, the stand factor is 5. The statistical accuracy multiplier for 15% is 9.

TABLE F - TABLE OF STAND FACTORS*

SIZE CLASS OF TIMBER	Predominant dbh classes	GOOD DENSITY Uniform	GOOD DENSITY Average	MEDIUM DENSITY Uniform	MEDIUM DENSITY Average	MEDIUM DENSITY Patchy	POOR DENSITY Uniform	POOR DENSITY Average	POOR DENSITY Patchy
Large Sawtimber	16" +	3	5	7	10	20	15	20	40
Mixed Sawtimber		1	2	3	5	10	10	15	30
Mixed Sawtimber-cordwood		1	2	3	4	10	7	10	20
Small Sawtimber	10"-14"	1	1	2	4	10	7	10	20
Cordwood	6"-8"	1	1	2	3	7	7	10	20

LIST OF STATISTICAL ACCURACY MULTIPLIERS (M)

Degree of accuracy	Multiplier (M)
5%	80
10%	20
15%	9
20%	5
25%	3
31%	2

* - This method is based directly on statistical formulae. It is derived from original work done about 1938 at the Lake States Forest Experiment Station, St. Paul, Minnesota by silviculturists S. R. Gevorkiantz and William A. Duerr.

N F x M

N 5 x 9

N <u>45 plots</u>

This procedure checked with the formula set down by Professor Matthews

$$\text{No. of plots} = \frac{N t^2 c^2}{N(a)^2 \quad t^2 c^2}$$

Where N = total number of possible plots
t = probability
c = coefficient of variation
a = desired accuracy

On 10,280 acres, 10,280 x 5 (number of plots it takes to make 1 acre) 51,400 the total number of possible plots. t was assumed to be 2 (probability of 21 - 1), a 15%, and c^2 was .25.1/

$$\text{No. of plots} = \frac{51{,}400 \times (2)^2 \times .25}{51{,}400 \times (.15)^2 \quad (2)^2 \times .25}$$

No. of plots = 45

PLANNING RANDOM SAMPLE

Afer calculation of the number of plots the spacing of the plots was computed by the following procedure:

Change acres to square chains, multiplying by 10, 10,280 x 10 = 102,800
Divide by number of plots .... 102,800 ÷ 45 = 2284
Take square root of number to find approximate square spacing...... $\sqrt{2284}$ = 47.8

A grid made of squares 47.8 chains per side on a piece of transparent plastic, scale 80 chains to the mile was laid over the base map of 1" to the mile and plots or intersections were pin-pricked through, thus giving a random sample.

1/ James W. Girard and Suren R. Gevorkiantz, <u>Timber Cruising</u>, 129 (Table 36).

TABLE G - SCIENTIFIC NAMES OF SPECIES

Common Name	Scientific Name
Northern white pine	Pinus strobus
Red pine (Norway pine)	Pinus resinosa
Tamarack	Larix laricina
Black spruce	Picea mariana
White spruce	Picea glauca
Eastern hemlock	Tsuga canadensis
Balsam fir	Abies balsamea
Northern white cedar	Thuya occidentalis
Aspen	Populus tremuloide
Large tooth aspen	Populus grandidenta
Balsam popler	Populus balsamifera
Yellow birch	Betula lutea
Paper birch	Betula papyrifera
Red oak	Quercus borealis
American elm	Ulmus americana
Sugar maple (Hard maple)	Acer saccharum
Red maple (Soft maple)	Acer rubrum
Basswood	Tilia glabra
Black ash	Fraxinus nigra

FIELD METHODS AND PROCEDURES

Magnetic bearing

Reference is made to Map No. 2 in the pocket of the Appendix. Plot lines were run in cardinal directions. The magnetic bearing of a true North line in Ontonagon and Gogebic Counties in Michigan in 1949 was about North, 1° East. (The compass needle pointed 1° East of true North).

Species tallied

In all types of sawtimber and pulpwood all species were tallied on 1/5 acre plots. On Form 70-R-9, Scribner scale, trees of 10" and larger d.b.h. classes of the following species were tallied:

Basswood	Hemlock
Ash (Black and White)	Red (Soft) Maple
Yellow Birch	Sugar Maple
Elm (American and Slippery)	Red Oak
White Pine	Tamarack

On Form 65-R-9 Standard Cords, trees of 6" and larger d.b.h. classes of these species were tallied:

Aspen	Balsam Fir
White Cedar	Black Spruce

On Form 65-R-9 Standard Cords, trees 6" and 8" **only** were tallied: (above 8" they were tallied on sawlogs on Form 70-R-9).

White Pine	Tamarack
White Spruce	

Explanation of Localized Cumulative Volume Tally Sheet 1/

This explanation is taken from the publication shown in the footnote, and supplemented when necessary by facts peculiar to the Ahonen Survey. Quotations are indicated.

"BACKGROUND

Several years of designing and testing have resulted in the development of a series of Localized Cumulative Volume Tally Sheets. The tally sheets have given reliable information on volume and growth in trial and regular use throughout the North Central and Lake States. The sheets, 5" x 9" to fit a small tatum, are made in International 1/4 inch kerf, Scribner C and Doyle log rules, and in standard cords.

Advantages of this new sheet are that (1) trees are tallied by d.b.h. alone eliminating judgment of log height; (2) usable heights are obtained by careful measurement of random sample trees, reducing errors in judgment of height; (3) growth is obtained by stand projection, is quickly adjustable to any period, and includes all major factors affecting growth; and (4) regardless of the size of plot used the sheet may be computed very quickly by several different mathematical means.

USE

The Localized Cumulative Volume Tally Sheet is intended, principally, for making inventories of volume and growth on tracts of commercial sized timber where a relatively large number of plots (40 or more) will be used. Inventories may be readily made in which trees are grouped in various condition and quality classes. Simple grouping such as by good and poor growing stock or by cut and leave may be handled with symbols."

1/ United States Department of Agriculture, Forest Service, "The Localized Cumulative Volume Tally Sheet, 1-4.

"

BASIS

The Lake States Forest Experiment Station Composite volume tables (1942) and standard usable height curves developed by the Lake States Forest Experiment Station and the North Central Regional Office of the United States Forest Service are the basic data from which this sheet is developed. To adjust the volume for individual species to take into account such peculiarities as exceptionally thin or thick bark, average form class different from that of the basic table, etc., a species factor is used.

Adjustment of the stand volume developed from a single table to give reliable results for both taller and shorter timber stands depends upon two general rules which are not entirely without exception. Those rules are (1) that within practical limits usable height curves for timber stands are of similar form, and (2) that volumes of stands vary above and below the volumes developed from the basic table more or less directly with the difference between the basic usable height curve and the stand usable height for the d.b.h. class containing the greatest amount of volume.

DESIGN

By trial and error, the sheet layout has been worked over to make it easy to use both in the field and in the office. The tally sheets are made up in rubber-backed pads so that as many sheets as desired may be kept together in a book, one sheet being used for each species. The slant, cut-away overlap in the lower right hand corner facilitates sheet turning and allows quick identification of the proper species sheet. Alternate sheets are colored differently to help prevent listing errors.

METHOD

The method explained below is that of a volume and growth inventory. It is one of the ways in which the sheet is being used currently by its originators in the North Central Region of the United States Forest Service, by men of several State Forestry Divisions, and by several private companies."

Sample Form - Sheet 1

FORM 70 R-9
1-1-48

SCRIBNER
LOCALIZED CUMULATIVE VOLUME TALLY SHEET

FOR COMMERCIAL SAWLOG STANDS
Based on Composite Volume Tables by the
Lake States Forest Experiment Station — 1944

NAME Ahonen Lumber Co. SCRIBNER
COUNTY Ontonagon STATE Mich PLOT 21
PARTY C.K. + O.B. DATE Aug. 10, 1949 TYPE NHe'''
NENW, S 18, T 49N, R 44W, MER STRIP

dbh | SCRIBNER LOG RULE - FAIR SITE — VARIABLE TOP, MINIMUM 8 INCH DIB

dbh																				
12	3	3	3	3✓	3	13	15	17	19	22	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	47	49	[illegible]	[illegible]	56	58	60	62	64	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	80	[illegible]	[illegible]	[illegible]
	[illegible]	90	[illegible]	95	97	99	101	103	105	108	[illegible]	[illegible]	114	[illegible]	[illegible]	[illegible]	124	[illegible]	[illegible]	[illegible]
	[illegible]	133	135	138	140	142	144	146	148	150	154	[illegible]	[illegible]	159	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• 14	~~2~~	2	12	16	20	24	28	32	36	40	45	49	[illegible]	[illegible]	[illegible]	[illegible]	64	[illegible]	[illegible]	[illegible]
	[illegible]	89	93	97	101	105	109	113	117	122	126	130	134	[illegible]	142	146	150	154	[illegible]	162
	[illegible]	[illegible]	174	178	182	186	190	194	198	[illegible]	207	211	[illegible]	[illegible]	223	227	231	235	[illegible]	[illegible]
	[illegible]	251	255	259	263	267	271	275	279	284	288	292	296	[illegible]	304	308	312	[illegible]	[illegible]	[illegible]
• 16	3✓	13	19	25	32	38	44	51	57	64	70	76	83	[illegible]	[illegible]	102	108	114	[illegible]	[illegible]
	[illegible]	[illegible]	146	152	159	165	171	178	184	190	197	203	210	216	222	229	235	241	[illegible]	[illegible]
	[illegible]	267	273	279	286	292	298	305	311	318	324	330	337	343	349	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
• 18	[illegible]	18	27	36	45	54	63	72	81	90	100	109	118	127	136	145	154	163	172	[illegible]
	190	199	208	217	226	235	244	253	262	272	281	290	299	308	317	326	335	344	[illegible]	[illegible]
20	✗	24	36	49	61	73	85	97	109	122	134	146	158	170	182	194	207	219	231	243
	255	267	279	292	304	316	328	340	352	364	377	389	401	413	425	437	450	462	474	486
• 22	~~16~~✓	31	47	62	78	94	109	125	140	156	172	187	203	218	234	250	265	281	296	312
	328	343	359	374	390	406	421	437	452	468	484	499	515	530	546	562	577	593	608	624
24	19✓	39	58	78	97	117	136	156	175	194	214	233	253	272	292	311	331	350	370	389
26	3 (over 24)	47	71	94	118	141	165	188	212	236	259	283	306	330	353					
28	28	56	84	112	140	167	195	223	251	279	307	335	363	391	418					
30	32	65	98	130	162	195	228	260	292	325										
32	37	74	112	149	186	224	261	298	335	372										
34	42	84	126	169	211															
36	47	94	141	189	236															
38	52	104	157	209	261															
40	57	115	172	230	287															
42	63	126	188	251	314															
44	68	136	50	83	166															
46	73	146	52	88	176															
48	78	156	54	92	185															

FIGURES REPRESENT VOLUME IN HUNDREDS OF BOARD FEET PER ACRE

NEAR MERCHANTABLE TREES
•• / •• G
•• / • P

LEGEND

NO. PLOTS TALLIED

GROWTH RATE (R) — RINGS PER RADIAL INCH — TOT. — AVG. 14

SAMPLE USABLE HEIGHTS in feet

dbh in inches							
12	14	16	18	20	22	24	26
18			36				

SHEET TOTALS

61 (poor stock)

32 (good stock)

41 (good stock when 2 inches larger in dbh)

SPECIES Hard Maple

Sum of final figures marked represents 1/20 actual volume tallied. For per acre volume, multiply by 100 and divide by number of 1/5 acre plots.

"

Tree Classification (See Table G)

Trees are tallied separately as low vigor (poor growing stock) or as high vigor (good growing stock). The latter is used to calculate growth. From the former comes the first harvest cut.

Symbols

A circle is placed around the number in the block to indicate a low vigor conifer, and a log grade number for hardwoods. A diagonal line is used to indicate a high vigor tree (see sample form, Page No. 17). Each set of symbols begins at the extreme left in each d.b.h. block, the high and low vigor symbols being written on top of each other so that separate totals for low vigor and high vigor may be read directly from each d.b.h. block.

At the end of the cruise, the sum of the figures under the last low vigor symbol in each d.b.h. block is listed at the bottom of the sheet under sheet total, on the line labeled poor stock; likewise, the good stock figures are totaled and the total listed on the good stock line."

TABLE H - GUIDE TO VIGOR CHARACTERISTICS

(Roots, trunk, and crowns of all trees must be examined on all sides)

	ROOTS	TRUNK	CROWN
High Vigor /	Firm No extensive rot No serious mechanical injury	Moderate rot or frost cracks permitted in first 8' of bole A few limb swells or blind knots permitted May have a few large dead stubs on upper bole	Intermediate or better Medium size and density of foliage Permits a few large dead limbs Some branches may be dying back
Low Vigor 0, V, 2, 3	Trees not meeting the above specifications are low vigor. One or more of the characteristics listed below will definitely throw a tree into the low vigor class.		
	Sprung roots Serious rot or mechanical damage	Heavy rot in first 8' Moderate rot above 8' Large weak crotches Many large broken limbs	Small, suppressed or thin Many large dead limbs Many branches dying back

<u>Hardwood Log Grades</u>: Grading of the butt log in the low vigor hardwood trees was done by the forester in each crew. The rules for grading hardwood logs adopted and published by the Northern Hemlock and Hardwood Manufacturers' Association were used.

Veneer Grade - (Symbol V)

Logs 12" and larger, 10 feet and longer (11" surface clear, 12-foot and longer logs are acceptable).

Grain reasonable straight, spiral not over 1" in 10" of length.

Sweep not to be more than 1/6 of small end d.i.b.

Logs 16" and over in d.i.b. may have one straight, tight seam, not more than 4 inches divergent from a straight line from end to end. A seam is considered as one defect.

Defects allowed: In 10 foot logs - 1
In 12 foot logs - 2
In longer logs - 3

Outwardly visible standard defects are: Knots, worm holes, cat faces, dead and dozey spots, seams, pin holes and pin knots.

All defects in a single foot of length are considered as one defect. Defect in butt log not inside diameter represented by the small end of the log is not considered a defect (fluted bark, shallow scars, etc.)

No. 2 Log - (Symbol 2)

Lengths 8 feet or longer; diameters 10 inches or larger; logs under 10 feet long must be 12 inches or larger.

Logs 10 feet long, 10 inches or larger, must have not less than 2/3 of each of 3 faces clear in not over 2 cuttings 3 feet or longer.

Logs 12 feet or longer will admit not over 3 cuttings per face.

Logs under 10 feet long, 12 inches or over, must cut not less than 3/4 clear on 3 faces in not over 2 cuttings 3 feet or longer.

Sweep limited to 30 per cent deduction in gross scale.

No logs admitted with net scale less than 50 per cent of gross scale.

No. 3 Log - (Symbol 3)

Lengths 8 feet or longer; diameters 10 inches or larger. Logs must scale not less than 50% of their gross volume.

"

Near-Merchantable Trees

During the cruise 10" d.b.h. trees (6" d.b.h. on Cordwood Sheet 65-R-9) were tallied by dot-and-dash in the block labeled near-merchantable tree. Only high vigor trees in the near-merchantable block were tallied.

Sample Height Measurements

About fifteen sample usable height measurements are desired for each species. In this 45-plot cruise, for species which occur on nearly every plot, one sample usable height measurement was taken on every third plot; for those species which were expected to occur on a quarter to a half of the plots, a sample was taken on each plot on which the species occurred; and, for species which occurred on the tract very infrequently, the usable height of every tree of that species which was found on any of the plots was measured.

Where only one tree of each species is measured on a plot, the tree selected is the one of that particular species which is closest to the plot center. The height to which the tree will be utilized is ascertained to the nearest foot and is listed in the block provided for this purpose on the bottom of the tally sheet."

For each species, on the plots indicated below, (corresponds to the plot number on the plot map, see Map No. 2 in the pocket of the Appendix) the merchantable height was measured to the nearest foot with the Pocket Cruiser Stick, and an increment boring was taken.

Sugar Maple - the nearest merchantable tree to center of the plot on plots 1-4-7-10-13-16-19-22-25-28-31-34-37-40-43.

Yellow Birch and Hemlock - the nearest merchantable tree to center of plot on plots 2-4-6-8-10-12-14-16-18-20-22-24-26-28-30-32-34-36-38-40-42-44.

White Spruce, Balsam Fir, Black Spruce, Soft Maple, and White Cedar - the nearest merchantable tree or trees to the center of the plot on all plots (up to 3 trees on a single plot).

All other species (Basswood, black and white ash, American and slippery elm, red oak, aspen, tamarack, and white pine) sample heights were taken on all trees occurring on plots and occasional trees on lines between plots, up to a maximum number of fifteen trees of any one species.

The merchantable height was listed by 2" d.b.h. classes in the block provided for it at the bottom of the tally sheet.

Explanation of merchantable height: the height to a point when the inside bark diameter is 8" in sawlog species and 4" in pulpwood and Cedar, or to the point where the top of the last log or bolt would be cut because of appearance of large limbs, rot, crook, sweep, etc. All but serious rot in the upper bole was disregarded in making this measurement, since factors used in calculating volumes allowed for both woods and mill cull.

"

<u>Growth</u>

The number of years it will take trees of an individual species to increase an average of 2" in d.b.h. is the same as the average number of annual rings per radial inch. By projecting it one d.b.h. class ahead, we may readily determine the stand volume when the good growing stock, including the present near merchantable stock, has become 2" larger in d.b.h.

To obtain a volume index for the stand projected 2" in d.b.h., the number of high vigor near-merchantable trees is transposed into the first d.b.h. block on the sheet and the <u>good stock</u> in each d.b.h. block is shifted to the d.b.h. block next larger by placing a check mark in the square where the last tree falls in each d.b.h. block (see sample form, Page No. 17). The sum of these <u>end figures</u> is then listed at the bottom of the tally sheet under Sheet Totals on the line labeled <u>good stock when 2" larger d.b.h.</u>

<u>Growth Rate</u>

Rings per radial inch may be determined from stumps or from increment borings. In most cases involving inventories on which to base operational plans, the rate desired is that which will follow cutting in the stand (selective or thinning) and not the present average rate of crowded stems. Under good silvicultural practices, this rate may be greater than that shown by borings or stumps. If local experimental information on residual stand growth rates is not available, careful judgement must be used in order not to assume an excessively rapid rate.."

Borings taken during the survey showed only the average rate of growth of trees in the virgin timber stand. These figures were discarded as useless for determing growth following a selective cut, and figures from the Upper Peninsula Forest Experiment Station at Dukes, Michigan were used. A brief check of the rate of growth in stands selectively cut eight to ten years ago on Copper Range Lands (Houghton County) indicated that the rates from Dukes were not exaggerated. A similar check at the Menominee Indian Reservation, and at the Patten Lumber Company also gave support to these growth rates as very conservative.

"

Plot Record

When separate books are used for each plot (when statistical calculations are to be made), the plot numbers are shown on each book in the space provided in the sheet heading. The type, size, and density class (timber condition class) of the timber on the individual plot may be recorded in the space below the plot number."

TABLE I - STATISTICAL CHECK

x	f (No.)	$\bar{x}$ (deviate from mean)	$f\bar{x}$ (product)	$\bar{x}^2$	$f\bar{x}^2$
0	2	- 11	- 22	121	242
1	0				
2	2	- 9	- 18	81	162
3	1	- 8	- 8	64	64
4	1	- 7	- 7	49	49
5	3	- 6	- 18	36	108
6	2	- 5	- 10	25	50
7	2	- 4	- 8	16	32
8	0				
9	3	- 2	- 6	4	12
10	3	- 1	- 3	1	3
11	5	0		0	0
12	3	+ 1	+ 3	1	3
13	8	+ 2	+ 16	4	32
14	2	+ 3	+ 6	9	18
15	2	+ 4	+ 8	16	32
16	1	+ 5	+ 5	25	25
17	1	+ 6	+ 6	36	36
18	1	+ 7	+ 7	49	49
19	1	+ 8	+ 8	64	64
20	0				
21	0				
22	1	+ 11	+ 11	121	121
23	1	+ 12	+ 12	144	144

$\Sigma N = 45$ $\quad \Sigma f\bar{x} = -18$ $\quad \Sigma f\bar{x}^2 = 1246$

Assumed Average (x) 11.000

Correction $= \frac{\Sigma f\bar{x}}{\Sigma N} = \frac{-18}{40} =$ (d) .400

Arithmetic Average (M) 10.600

$$s^2 = \frac{\Sigma f\bar{x}^2}{\Sigma N-1} = \frac{1246}{44} = 28.31838$$

$$\sigma^2 = s^2 - d^2 \; (-d^2) \quad \sigma^2 = \begin{array}{l} -0.16000 \\ 28.15818 \end{array}$$

$$\sigma^2 M = \frac{\sigma^2}{\Sigma N} = \frac{28.15818}{45} = 0.62574$$

$$\sigma M = \sqrt{0.6254} = 0.79104$$

$$\text{Statistical Error} = \frac{\pm \sigma M \times 100}{M} = \frac{2(0.79104)}{10.6} \, 100$$

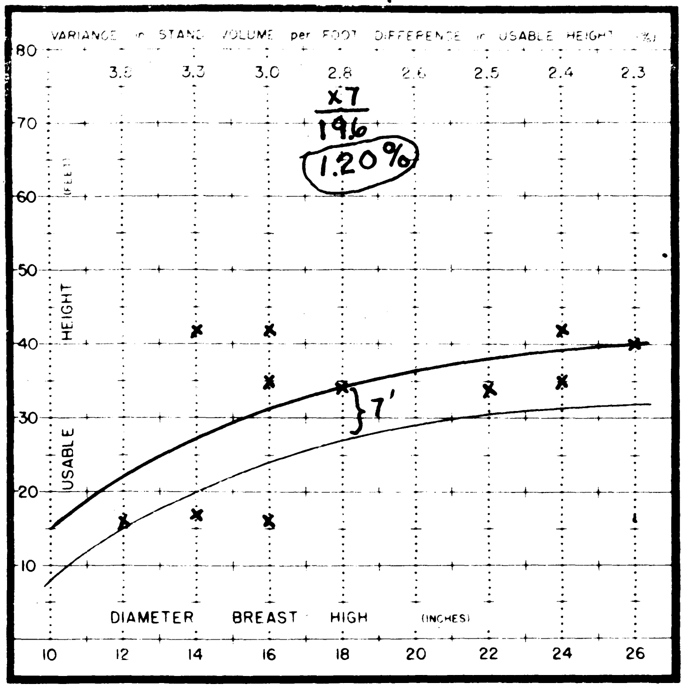
$$= \frac{158.20800}{10.6} = \pm 14.9\% \pm$$

x = Group number or x per acre.
f = Frequency of occurrence or No. of plots that have so much x per acre.
$\bar{x}$ = Deviation or difference from assumed average group number (11 in this case).
d = Correction.
s = Standard deviation measured from arithmetic average (M).
σ = Standard error of a single measurement.
σM = Standard error of the Arithmetic Average (M).

Sample Form - Sheet 2

SCRIBNER Hard Maple

Summary Sheet



TO DETERMINE HEIGHT FACTOR

1. Plot individual sample heights.
2. Fit a reasonably balanced curve.
3. Using d.b.h. class of greatest volume, find distance above (+) or below (-) standard curve.
4. Multiply this number of feet by % variance per foot shown at top of d.b.h. line.
5. Add or subtract this product to or from 100% to get height factor.
6. List as a decimal in line 5, column (a in calculation block below.

CALCULATION BLOCK (all percents listed as decimals)

	KIND OF FACTOR		PRESENT NET VOLUME				GROWTH	
			POOR STOCK		GOOD STOCK		GOOD STOCK 2" LARGER	
			FACTOR (a)	LOGARITHM (b)	FACTOR (c)	LOGARITHM (d)	FACTOR (e)	LOGARITHM (f)
1	CONSTANT		100	2.0000				
2	NO. of PLOTS	÷	45	( )				
3	CRUISE	=	2.22	.				
4	SPECIES	X	1.00	.				
5	HEIGHT	X	1.20	.				
6	VOLUME	=	2.66	.	2.66	.	2.66	.
7	SHEET TOTALS	X	846	.	653	.	954	.
8	GROSS VOLUME Per ACRE	=	2250	.	1737	.	2538	.
9	1.00 - CULL	X	0.70	(1).	0.90	(1).	0.90	(1).
10	NET VOLUME Per ACRE	=	1575	.	1563	.	2284	.

			FACTOR	LOGARITHM
11	1.00 - MORTALITY (R 14 YEARS X 0.005)	X	0.93	(1).
12	NET VOLUME Per ACRE in R YEARS	=	2124	.
13	NET VOLUME Per ACRE PRESENT GOOD STOCK	÷	1563	(.)
14	$(1.0p)^R$ (LINE 12 ÷ LINE 13)	=	1.359	.
15	1.0p (LOGARITHM LINE 14 ÷ R)	=	1.0222	.
16	$(1.0p)^N$ (LOGARITHM LINE 15 X N 10 YEARS)	=	1.245	.
17	NET VOLUME Per ACRE PRESENT GOOD STOCK	X	1563	.
18	NET VOLUME Per ACRE in N YEARS	=	1946	.
19	NET VOLUME Per ACRE GROWTH in N YEARS	=	383	← line 18 - line 17
20	NET VOLUME GROWTH / ACRE / YEAR (over N YEAR PERIOD)	=	38	← line 19 ÷ N

LOGARITHMS IN ( ) ARE SUBTRACTED, OTHERS ADDED, BETWEEN HEAVY LINES

Calculation of Volumes and Growth Rates

(from the Localized Cumulative Volume Tally Sheets) 1/

The following explanation is taken largely from the publication indicated in the footnote and supplemented when necessary by facts peculiar to the Ahonen survey.

"NET VOLUME CALCULATION (See sample form, Page No. 26)

The calculation block is designed to be worked by the method of your choice. This may be longhand, with a calculating machine, with a slide rule, with logarithms, or with a combination of these methods.

To calculate the growth, a set of compound interest tables, a log-log slide rule, or a four place logarithmic table is required. Logarithms or the slide rule are preferable because these are more flexible; interest tables seldom read to a fine enough division.

Summary Booklet

If, in the field, separate books of sheets were used to tally each plot, a summary booklet is now made up with a single sheet used for each species.

Decimal Places

As a general rule it is desirable to carry only two decimal places from step to step. Where more decimal places should be carried, it is indicated in the text thus -- (4 dec).

Calculation Procedure

1. Determine the height factor as described at the top of the calculation side of the tally sheet."

1/ "The Localized Cumulative Volume Tally Sheet", loc. cit., 5-8.

"

2. <u>List the factors in the calculation block</u> <u>as indicated below.</u>

Lines are numbered and columns are lettered.

List in 2 a	<u>Number of 1/5 acre plots.</u>
4 a	<u>Species factor</u>. (This factor is a composite adjuster for form class, bark thickness, and local utilization.* 1/
5 a	<u>Height factor</u> from top of sheet.
7 a, c & e	<u>Sheet totals</u> - poor stock, good stock and good stock when 1/2" larger in d.b.h.- from lower right on front of tally sheet. 1/*
9 a, c & e	1.00 minus cull-percent.

3. <u>To calculate present net volume per acre</u>

a. Divide 1a by 2a to get 3a (cordwood sheet 4 decimal places).
b. Multiply 3a by 4a and then this product by 5a. List answer in blocks 6a, c and e. (cordwood sheet 4 decimal places).
c. Multiply line 6 by line 7. List product in line 8. (board feet or thousandths of cords).
d. Multiply line 8 by line 9. List this product in line 10. (board feet in thousandths of cords). <u>THIS IS THE NET VOLUME PER ACRE</u>.

4. <u>To calculate the net growth volume per acre per year</u>

a. Down to line 10, growth calculation is similar to that for net volume.
b. Mortality is allowed at 1/2% per year over a period of years equal to the growth rate (R) in rings per radial inch."

1/ See Page No. 31, Table J in Appendix for factor used in volume calculation in this survey.
* See more detailed discussion on Page No. 29 of the Appendix.

"(1) Enter R in space provided in line 11
(2) Multiply R by .005
(3) Subtract this product from 1.00 and list in 11e
(4) Multiply block 10e by 11e. List in 12e (board feet or thousandths of cords)

c. List figure from 10c in 13e
d. Divide 12e by 13e to get $(1.0p)^R$. List in 14e to 4 decimal places.
e. Using compound interest tables, look up $(1.0p)^R$ under R years and find rate 1.0p. List this rate in 15e to 3 decimal places.
f. Using the compound interest table, determine $(1.0p)^N$, where N is any reasonable period over which you desire to know the growth. List $(1.0p)^N$ in 16e to 3 decimal places.
g. Enter figure from 10c (same as 13e) in 17e.
h. Multiply 16e by 17e to get 18e (board feet or thousandths of cords).
i. Subtract 17e from 18e to get 19e.
j. Divide line 19 by N to get line 20. THIS IS THE NET VOLUME GROWTH PER ACRE PER YEAR OVER THE N YEAR PERIOD.

(A note about this growth figure)

The growth figure developed here includes diameter growth, height growth, in-growth of near merchantable trees, mortality, tree form class, and local species utilization. It is adjustable to any period. All species may be compared quickly over any specified period of time regardless of the species radical rates of diameter growth.

SPECIES FACTOR

Eventually this factor should be based on local cruise-cut out check. Until such local information is acquired, factors from experiment station data shown on Page No. 23 of the Wood Lot Foresters Tool Kit may be used, or an adjustment may be made for Girard Form Class.

The basic table from which this sheet is made has an average form class of 78. For all practical purposes you may allow 3% change in volume for each unit above or below form class 78. For example: for timber you judge to have an average form class of 82, use a species factor of 1.12; for form class 76, use 0.94."

<u>CULL ALLOWANCE</u>: The amount to be allowed for woods and mill cull was discussed with company men and personnel of the Ottawa National Forest. The figures used have been reviewed by Messrs. Arvey and Roy Ahonen and have been certified as being reasonably correct for this timber.

TABLE J - FACTORS USED IN AHONEN LUMBER COMPANY VIRGIN-TIMBER INVENTORY CALCULATIONS - August 1949.

(Applied to Localized Cumulative Volume Tally Sheets)

Species	Volume Adjustment factors: Species 1/	Volume Adjustment factors: Height 2/	Net Volume Factors 3/ 1.00 - cull %: Low Vigor Trees	Net Volume Factors 3/ 1.00 - cull %: High Vigor Trees	Growth Rings per Radial inch 4/
Sawtimber					
Sugar Maple	1.00	1.20	.70	.90	14
Hemlock	.92	1.25	.65	.90	10
Yellow Birch	1.00	1.00	.75	.90	14
Ash	.95	1.30	.80	.90	12
Elm	1.05	1.10	.65	.85	12
Basswood	.98	1.40	.65	.85	10
Soft Maple	1.05	1.20	.75	.90	10
Spruce	.96	1.50	.90	.95	14
Pulpwood					
Balsam	.96	.80	.80	.95	10
Aspen	1.07	.90	.80	.90	8
Spruce	.96	1.00	.90	.95	14
Cedar	.90	.70	.75	.85	20

1/ Woodlot Foresters Tool Kit, 23.
2/ Developed from Sample Tree Measurements on tally sheets.
3/ See Page 30 of Appendix Cull Allowances.
4/ See Page 23 of Appendix Growth Rate.

TABLE K - PER ACRE STOCK TABLE BY SPECIES AND DBH

HIGH AND LOW VIGOR TREES

Average Number of Trees and Basal Area Per Acre

All Trees DBH	SUGAR MAPLE Low Vigor No.	SUGAR MAPLE Low Vigor BA.	SUGAR MAPLE High Vigor No.	SUGAR MAPLE High Vigor BA.	HEMLOCK Low Vigor No.	HEMLOCK Low Vigor BA.	HEMLOCK High Vigor No.	HEMLOCK High Vigor BA.	YELLOW BIRCH Low Vigor No.	YELLOW BIRCH Low Vigor BA.	YELLOW BIRCH High Vigor No.	YELLOW BIRCH High Vigor BA.	ASH Low Vigor No.	ASH Low Vigor BA.	ASH High Vigor No.	ASH High Vigor BA.
4																
6																
8																
10			3.3	1.8			0.1	0.1			0.8	0.4			0.8	0.5
12	2.8	2.2	2.1	1.7	1.2	1.0	1.7	1.3	0.3	0.3	1.0	0.8	0.6	0.4	0.6	0.4
14	0.9	1.0	2.0	2.1	2.0	2.1	1.8	1.9	0.6	0.7	0.7	0.7	0.2	0.2	0.1	0.2
16	1.3	1.8	1.8	2.5	1.0	1.4	1.2	1.7	0.4	0.6	0.9	1.2	0.4	0.6	0.4	0.6
18	1.8	3.2	1.7	2.9	0.4	0.8	0.8	1.4	0.4	0.8	0.8	1.4	0.2	0.4	0.1	0.2
20	0.3	0.7	0.8	1.7	1.2	2.7	1.3	2.9	0.6	1.5	0.2	0.5	0.3	0.7	0.2	0.5
22	0.4	1.2	0.9	2.3	0.2	0.6	0.6	1.5	0.6	1.8	0.4	1.2	0.1	0.3	0.1	0.3
24	1.2	3.8	0.2	0.7	0.7	2.1	0.4	1.4	0.3	1.0						
26	0.8	2.9	0.1	0.4	0.3	1.2	0.3	1.2	0.4	1.6	0.4	1.6				
28	0.2	1.0	0.1	0.5	0.3	1.4	0.2	1.0	0.3	1.4						
30					0.4	2.2			0.4	2.2						
32					0.2	1.2										
34									0.1	0.7						
36									0.1	0.8						
38																
40									0.1	1.0						
	9.7	17.7	13.0	16.7	8.1	16.7	8.4	14.3	5.1	14.3	5.2	7.8	1.9	2.7	2.4	2.6

All Trees DBH	ELM Low Vigor No.	ELM Low Vigor BA.	ELM High Vigor No.	ELM High Vigor BA.	BASSWOOD Low Vigor No.	BASSWOOD Low Vigor BA.	BASSWOOD High Vigor No.	BASSWOOD High Vigor BA.	SOFT MAPLE Low Vigor No.	SOFT MAPLE Low Vigor BA.	SOFT MAPLE High Vigor No.	SOFT MAPLE High Vigor BA.	CEDAR Low Vigor No.	CEDAR Low Vigor BA.	CEDAR High Vigor No.	CEDAR High Vigor BA.
4															0.3	0.0
6													1.4	0.3	0.9	0.2
8													0.8	0.3	1.1	0.4
10			0.5	0.3			0.1	0.1			0.6	0.3	0.6	0.3	0.3	0.2
12	0.2	0.2			0.1	0.1	0.1	0.1	0.4	0.3	0.5	0.4	1.0	0.8	0.4	0.3
14			0.2	0.2	0.1	0.1			0.4	0.5	0.9	1.0	0.8	0.8	0.6	0.6
16	0.1	0.2			0.2	0.3					0.1	0.2	0.6	0.8	0.3	0.5
18			0.2	0.4	0.2	0.4	0.3	0.6					0.4	0.8	0.1	0.2
20	0.1	0.2							0.1	0.2						
22					0.2	0.6			0.1	0.3						
24			0.2	0.7	0.1	0.3			0.1	0.3			0.1	0.3		
26																
28																
30					0.1	0.5										
32	0.1	0.6														
34																
36																
38																
40	0.2	1.9														
	0.8	3.1	1.2	1.6	1.1	2.3	0.6	0.7	1.2	1.6	2.1	1.9	5.7	4.4	4.0	2.4

All Trees DBH	BALSAM FIR Low Vigor No.	BALSAM FIR Low Vigor BA.	BALSAM FIR High Vigor No.	BALSAM FIR High Vigor BA.	SPRUCE Low Vigor No.	SPRUCE Low Vigor BA.	SPRUCE High Vigor No.	SPRUCE High Vigor BA.	ASPEN Low Vigor No.	ASPEN Low Vigor BA.	ASPEN High Vigor No.	ASPEN High Vigor BA.	TOTAL B.A. BY DIAMETER CLASS Low Vigor No.	TOTAL Low Vigor BA.	TOTAL High Vigor No.	TOTAL High Vigor BA.	DBH
4			1.7	0.1			0.1	0.0			0.1	0.0			0.2	0.2	4
6	0.3	0.1	1.0	0.2	0.3	0.1	0.4	0.1	0.2	0.0	0.7	0.1	2.3	0.5	3.0	0.6	6
8	0.4	0.2	1.0	0.3	0.1	0.0	0.2	0.1	0.6	0.2	1.1	0.4	1.9	0.7	3.4	1.2	8
10	0.4	0.2	0.4	0.2	0.3	0.2	0.9	0.5	0.3	0.2	0.3	0.2	1.7	1.1	8.3	4.5	10
12	0.1	0.1	0.3	0.3			0.3	0.3	0.3	0.3			7.1	5.6	7.1	5.6	12
14			0.1	0.2									5.1	5.0	6.3	6.2	14
16													4.1	5.7	4.8	6.7	16
18							0.1	0.2					3.6	6.3	4.1	7.3	18
20													1.8	6.1	2.6	5.6	20
22													1.2	4.7	2.0	5.3	22
24													2.6	8.4	0.8	2.5	24
26													1.6	5.7	0.9	3.3	26
28													0.8	3.8	0.3	1.4	28
30													1.0	4.9			30
32													0.3	1.9			32
34													0.1	0.7			34
36													0.1	0.8			36
38																	38
40													0.3	2.9			40
	1.3	0.6	4.6	1.3	0.8	0.3	2.1	1.1	1.4	0.7	2.2	0.7	37.3	64.8	46.1	50.3	

TABLE 1 - MARKING GUIDE FOR CUT & LEAVE - NET VOLUME

(By species)
Based on Per Acre Stand Table (Trees 12" d.b.h. and over only)

SPECIES	LEAVE						CUT	
	High Vigor		Low Vigor		Total Leave		Low Vigor	
	Net Volume	% Total Net Volume	Net Volume	% Total Net Volume	Net Volume	% Total Net Volume	Net Volume	% Total Net Volume
Hard Maple	1,563	16.2	161	1.7	1,724	17.9	1,414	14.6
Hemlock	1,586	16.5	145	1.5	1,731	18.0	1,214	13.0
Yellow Birch	706	7.3	134	1.4	840	8.7	1,173	12.1
Ash	220	2.3	26	0.3	246	2.6	224	2.3
Elm	141	1.4	32	0.3	172	1.7	257	2.7
Basswood	75	0.8	26	0.3	91	1.1	210	2.1
Soft Maple	123	1.2	16	0.2	139	1.4	136	1.4
Spruce	46	0.4			46	0.4		
Total (All species)	4,460	46.1	540	4.9	5,000	51.0	4,678	49.0

TABLE N - MARKING GUIDE FOR CUT & LEAVE - NUMBER OF TREES

(By Species)
Based on Per Acre Stand Table (Trees 12" d.b.h. and over only)

SPECIES	LEAVE						CUT	
	High Vigor		Low Vigor		Total Leave		Low Vigor	
	No.of Trees	% Total No.of Trees	No.of Trees	% Total No.of Trees	No.of Trees	% Total No.of Trees	No.of Trees	% Total No.of Trees
Hard Maple	13.0	20.9	1.0	1.6	14.0	22.5	8.8	14.1
Hemlock	9.7	15.6	0.8	1.4	10.5	17.0	7.3	11.6
Yellow Birch	5.2	8.4	0.5	0.9	5.7	9.3	4.6	7.3
Ash	2.4	3.9	0.3	0.5	2.7	4.2	1.6	2.8
Elm	1.2	1.9	0.1	0.1	1.3	2.0	0.7	1.2
Basswood	.6	1.0	0.1	0.2	0.7	1.2	1.0	1.6
Soft Maple	2.1	3.4	0.1	0.2	2.2	3.6	1.1	1.7
Spruce	1.3	2.1			1.3	2.1		
Total (All Species)	34.2	55.0	2.9	4.7	37.1	59.7	25.1	40.3

Appendix 34

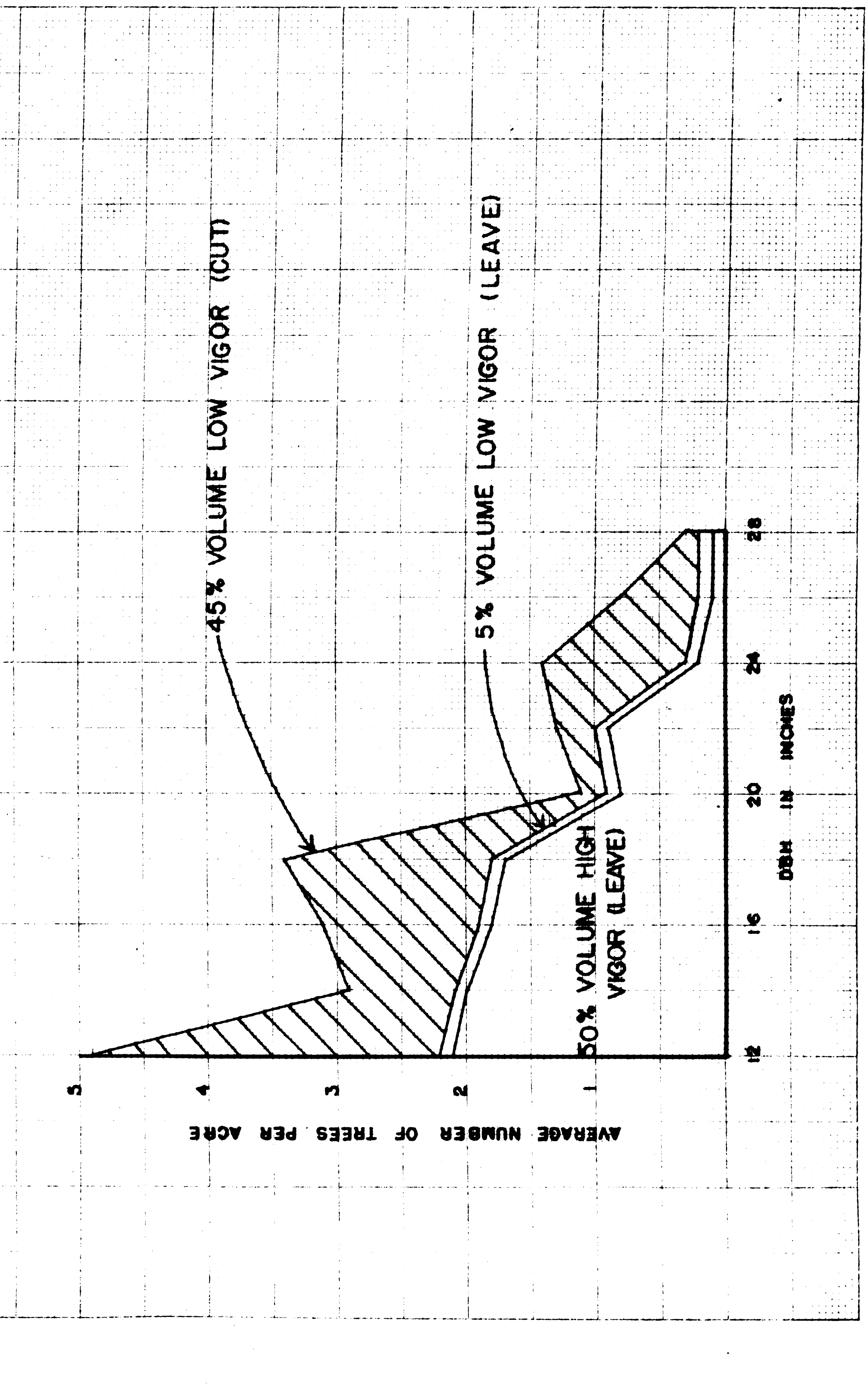
TABLE N - MARKING GUIDE FOR CUT & LEAVE - BASAL AREA

(By Species)
Based on Per Acre Stand Table (Trees 12" d.b.h. and over only)

SPECIES	LEAVE						CUT	
	High Vigor		Low Vigor		Total Leave		Low Vigor	
	Basal Area	% Total Basal Area	Basal Area	% Total Basal Area	Basal Area	% Total Basal Area	Basal Area	% Total Basal Area
Hard Maple	16.7	15.7	1.8	1.7	18.5	17.4	15.9	15.1
Hemlock	14.3	13.5	1.7	1.6	16.0	15.1	15.0	14.2
Yellow Birch	7.8	7.4	1.5	1.4	9.3	8.8	12.9	12.2
Ash	2.7	2.5	0.3	0.3	3.0	2.8	2.5	2.3
Elm	1.7	1.5	0.3	0.3	2.0	1.8	3.0	2.8
Basswood	0.8	0.8	0.2	0.2	1.0	1.0	2.1	2.0
Soft Maple	1.9	1.9	0.2	0.2	2.1	2.1	1.5	1.4
Spruce	1.0	1.0			1.0	1.0		
Total (All Species)	46.9	44.3	6.0	5.7	52.9	50.0	52.9	50.0

PER ACRE STOCK TABLE DIAGRAM-HARD MAPLE FOR MARKING CUT & L.V.

SHOWING RELATION OF THE DIFFERENT DBH CLASSES REMOVED IN A 49% CUT



PER ACRE STOCK TABLE DIAGRAM—YELLOW BIRCH FOR MARKING CUT & LV.

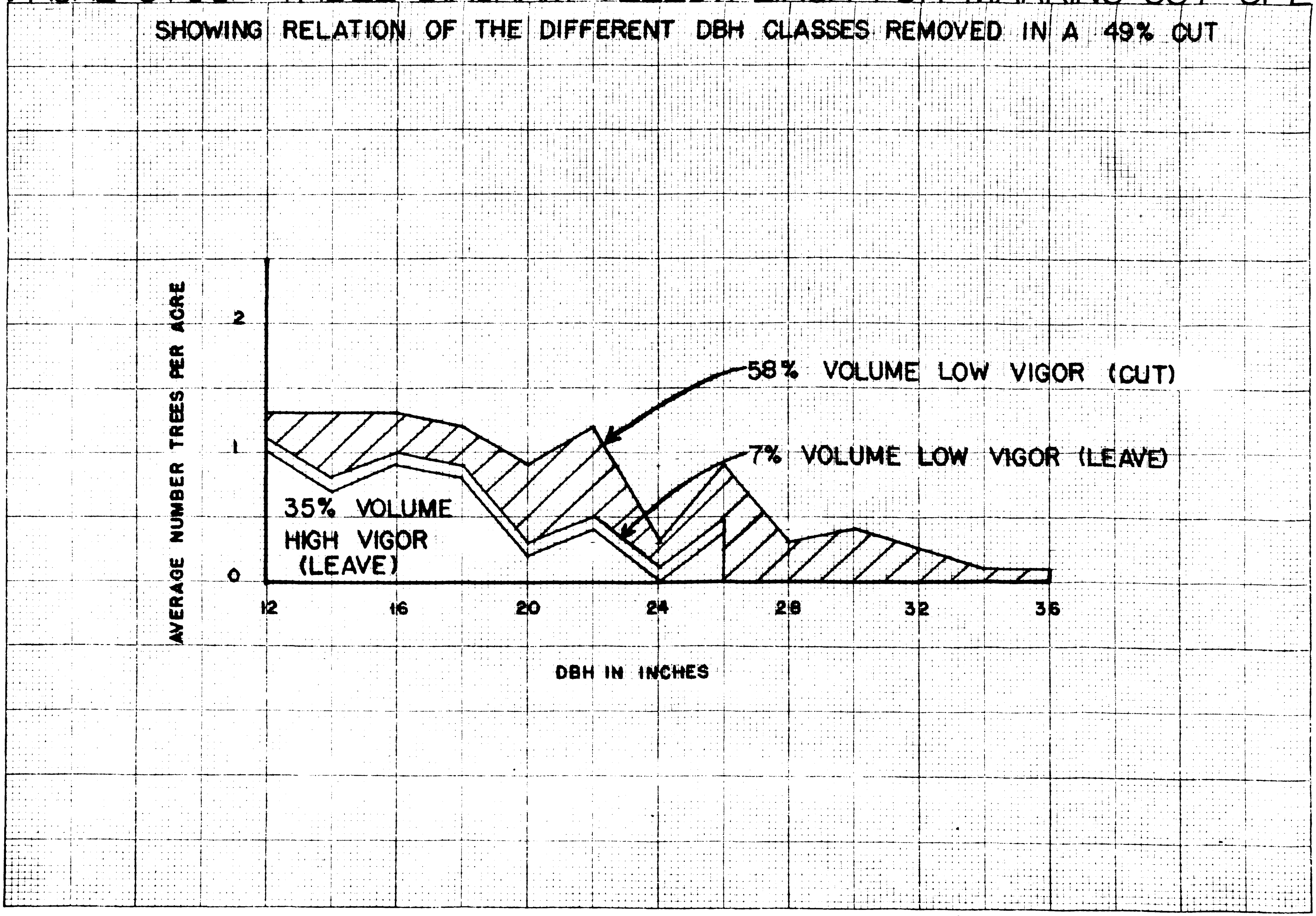
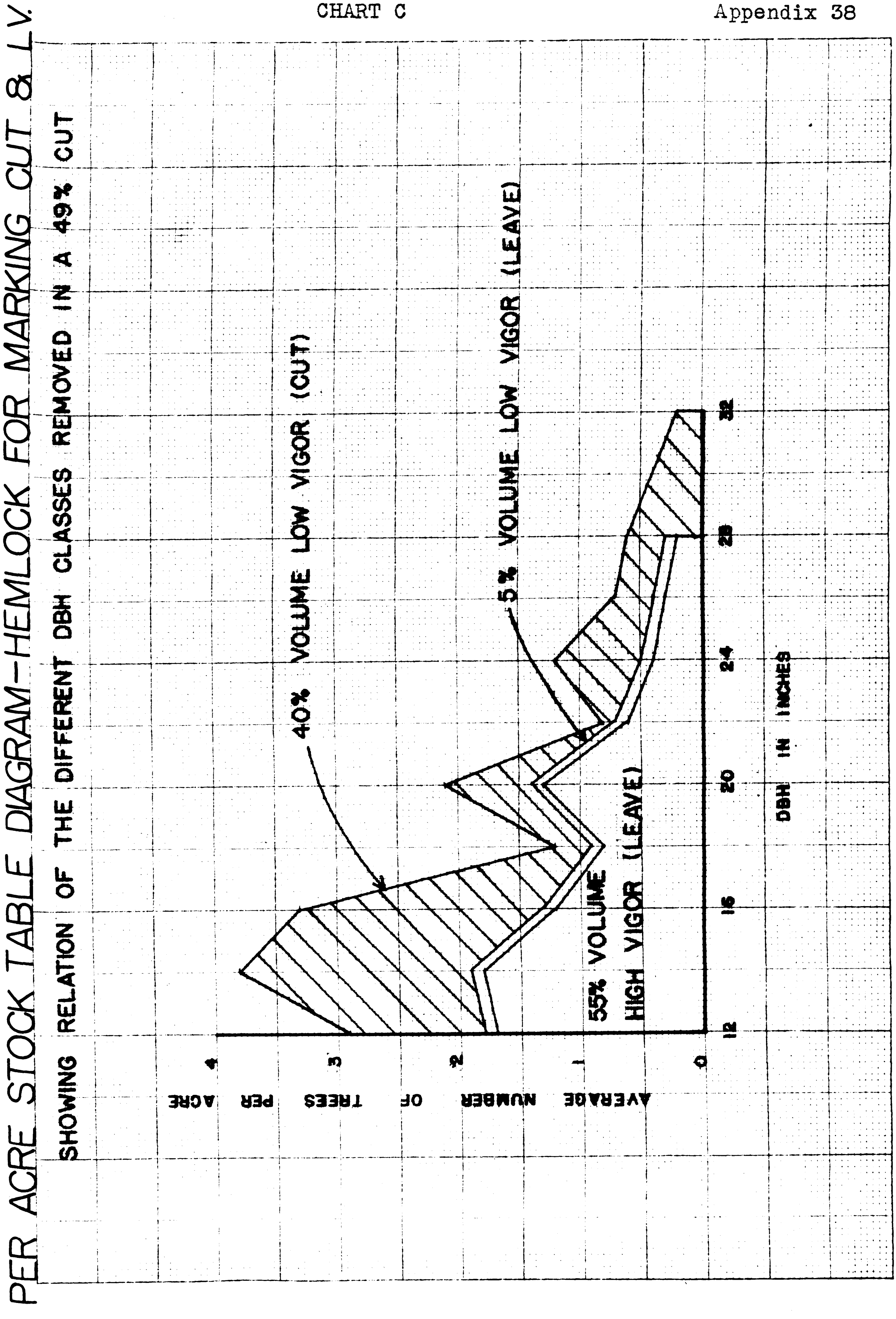


CHART C


PER ACRE STOCK TABLE DIAGRAM-HEMLOCK FOR MARKING CUT & LV.
SHOWING RELATION OF THE DIFFERENT DBH CLASSES REMOVED IN A 49% CUT
40% VOLUME LOW VIGOR (CUT)
5% VOLUME LOW VIGOR (LEAVE)
55% VOLUME
HIGH VIGOR (LEAVE)
AVERAGE NUMBER OF TREES PER ACRE
4
3
2
1
0
12
16
20
24
28
32
DBH IN INCHES

COST AND TIME ANALYSIS A - LOGGING ROAD CONSTRUCTION

Machine Rate

(For International TD-14 Bulldozer) — Cost per Day

I Labor

		Cost per Day
*A.	Operator @ $1.25 per hour for 9-hour day plus 17.2% for social taxes. Operator does greasing and general maintenance (1 hour), operates tractor 8 hours per day	$14.04
B.	Two mechanic's labor @ $1.35 each per hour for 9-hour day plus 9.9% for social taxes. Mechanics time is prorated over 7 logging trucks and 16 other units (tractor included in these units) - however, 75% of labor is charged to trucks as they spend that percentage of time on them	.41
		$14.45

II Operation

		Cost per Day
A.	Fuel, 3 gallons per hour @ 14.7¢ for 8-hour day	$3.53
B.	Gasoline (for starting), 1/2 gallon for 8-hour day @ 22¢ per gallon	.11
C.	Oil, 1 gallon for 8-hour day @ 71¢ per gallon	.71
D.	Grease, 3 lbs. for 8-hour day @ 12-1/2¢ per pound	.38
	Total, based on 8-hour day	$4.73

* - Labor based on 40 hour - 5 day week and overtime prorated over 40 hours.

Example: 9 hrs./day x 5 days = 45 hours or

47-1/2 hours x $1.25 = $59.40 ÷ 5 days = $11.87 x 1.172 ST = $14.04

COST AND TIME ANALYSIS A - LOGGING ROAD CONSTRUCTION Continued

Cost per day

III Depreciation & Other Recurrent Costs

A. Initial cost of TD-14 tractor, including bulldozer frame and blade (total initial cost) $10,575

Salvage value (33-1/3%) 3,500
Amount to be depreciated .... $ 7,075
Estimated period of use .... 5 years

B. Average annual depreciation $7075 ÷ 5 = $1415.00

C. Average annual interest-bearing investment

$$\frac{\$10,575 + 3,500}{2} + \frac{1,415}{2} = \$7745$$

Average interest charge @ 6% on this investment $7745 x .06 = $ 464.70

D. Taxes, 2% of average annual investment... 141.58
Insurance, .9% on average annual investment 67.00

Total annual burden $2088.28

Daily cost on basis of 100 days per year $20.88
Repair parts at $500 per year 5.00
$45.06

Total charge per day $45.06
Total charge per hour 5.63
Total charge per minute 9.4¢

COST AND TIME ANALYSIS A - LOGGING ROAD CONSTRUCTION Continued

Work Performance and Unit Cost of Production
(in well stocked sawtimber, on heavy clay soil hilly topography)

	Cost per mile	
	Winter Roads	Summer Roads
I Location		
Two men locating 1 mile per day @ $10.00 per day per man plus 17.2% for social taxes. Blazing skidways also included in above..........	$23.44	$23.44
II Clearing		
A. Saw Gang, 2 men @ $10.00 per day plus 17.2% for social taxes doing 1/2 mile per day	46.88	46.88
B. Two men dynamiting stumps @ $8.00 per day plus 17.2% for social taxes doing 1/2 mile per day	37.52	37.52
III Bulldozing		
A. Six days with TD-14 @ $45.06 per day for 1 mile of road	270.36	270.36
B. One day making landings and "turn arounds" or connecting spurs. Actually this work would be done as he went along, i.e., 1/7 of his time would be spent pushing skidways and "turn-arounds"	45.06	45.06

COST AND TIME ANALYSIS A - LOGGING ROAD CONSTRUCTION Continued

	Cost per mile Winter Roads	Cost per mile Summer Roads
IV Other Costs and Maintenance		
A. Gravelling	---	$600.00
B. Ditching, drainage, culverts, filling up holes, etc. 2 men @ $8.00 per day plus 17.2% for social taxes doing 1 mile per day about twice a year	---	37.52
C. Grading, bulldozing etc., 1 bulldozer day per mile (average road)	---	45.06
D. Snow removal, dragging and sanding for winter	$100.00	---
Total Cost per mile	$523.26	$1105.84
Cost per 100 feet $\frac{\text{total cost per mile}}{52.8}$ =	$9.90	$20.98

Total Cost per mile if road is used summer and winter (Class V) $1205.84

Cost per 100 feet 22.85

COST AND TIME ANALYSIS B - GROUND SKIDDING WITH INTERNATIONAL TD-9

Machine Rate

		Per Day	Per Hour
I	**Labor**		
A.	Operator @ $1.15 per hour for 8-1/2 hour day plus 17.2% for social taxes. Operator does his own greasing and general maintenance (1/2 hour) operates tractor 8 hours...	$11.79	
B.	Hooker @ 95¢ per hour for 8 hour day plus 17.2% for social taxes	8.91	
C.	Two mechanics @ $1.35 each per hour for 9-hour day plus 9.9% for social taxes. Mechanics time prorated over 7 logging trucks and 16 other units (tractors included in these 16 units)- however, 75% of labor is charged to logging trucks as they spend that percentage of time on them	.41	
D.	Blacksmith @ $1.15 per hour for 8-1/2 hour day prorated over 7 logging trucks and 16 other units (tractors included in these units) - however, 50% of labor is charged to sawmill maintenance	.27	
	Total, based on 8 hours actual working time of tractor	$21.38	$2.672
II	**Operation**		
A.	Diesel fuel oil, 20 gallons per 8-hour day @ 14.7¢ per gallon	$ 2.94	
B.	Gasoline (for starting), 1/2 gallon per 8-hour day @ 22¢ per gallon	.11	
C.	Lubricating oil, 1 gallon per 8-hour day @ 71¢ per gallon	.71	
D.	Grease, 2 lbs. per 8-hour day @ 12.5¢ per lb.	.25	
	Total based on 8-hours per day	$ 4.01	.501

COST AND TIME ANALYSIS B - GROUND SKIDDING WITH INTERNATIONAL TD-9 Continued

		Per Day	Per Hour
III Depreciation & Miscellaneous Recurrent Costs			
A. Initial Cost of TD-9 Tractor...	$7590.00		
Tong Rack	50.00		
Chokers - 15 per tractor @ $14.50 per choker	217.50		
Two tongs & chains	50.00		
Total initial cost	$7957.50		
Estimated trade in value after 5 years (31-1/2%)............	2500.00		
Amount to be depreciated	$5457.50		
B. Average annual depreciation $\frac{\$5457.50}{5}$ =	$1091.50		
C. Average annual interest-bearing investment $\frac{\$7957.50 + 2500}{2} + \frac{\$1091.50}{2} = \$5774.50$			
Average interest charge @ 6% on this investment $5774.50 x .06 =	$346.47		
D. Taxes, 2% of average annual investment	$141.58		
Insurance, .8% of average annual investment	46.00		
E. Average annual repair parts	250.00		
Total annual fixed charges	$1849.46		
Average charge per day based on 150 work days per year @ 8-hours per day		$12.50	
Grand totals		$37.89	$4.736

Total cost per minute 7.89¢

COST AND TIME ANALYSIS B - GROUND SKIDDING WITH INTERNATIONAL TD-9
Continued

Work Performance and Unit Cost of Production
(For average load of 300 bd.ft. gross scale, Scribner log rule)

	Time per turn (minutes)	Time per MBM (minutes)	Cost per MBM
Average fixed time for hooking, unhooking, and all delays	9	30	$2.36
Average variable time to cover 100 feet round trip (in with load and return empty)	.6	2.0	15.8¢

COST AND TIME ANALYSIS C - ARCH SKIDDING WITH INTERNATIONAL TD-14

Machine Rate

	Per Day	Per Hour
I Labor		
A. Operator @ $1.25 per hour for 8-1/2-hour day plus 17.2% for social taxes. Operator does his own greasing and general maintenance (1/2 hour) operates tractor 8 hours..	$12.82	
B. Hooker (Bulldozer Swamper) @ 95¢ per hour for 8-hour day plus 17.2% for social taxes.	8.91	
C. Two mechanics labor @ $1.35 each per hour for 9-hour day plus 9.9% for social taxes. Mechanics time prorated over 7 logging trucks and 16 other units (tractors included in these 16 units) however, 75% of labor is charged to logging trucks as they spend that percentage of time on them......	.41	
D. Blacksmith @ $1.15 per hour for 8-1/2 hour day prorated over 7 logging trucks and 16 other units (tractors included in these units) - however, 50% of labor is charged to sawmill maintenance	.27	
Total, based on 8 hours actual working time of tractor	$22.41	$2.801
II Operation		
A. Diesel fuel, 3 gallons per hour @ 14.7¢ for 8-hour day	$ 3.53	
B. Gasoline (for starting), 1/2 gallon for 8-hour day @ 22¢ per gallon	.11	
C. Oil, 1 gallon for 8-hour day @ 71¢ per gallon	.71	
D. Grease, 3 lbs. for 8-hour day @ 12-1/2¢ per lb.	.38	
Total based on 8-hour day	$ 4.73	.591

COST AND TIME ANALYSIS C - ARCH SKIDDING WITH INTERNATIONAL TD-14
Continued

		Per Day	Per Hour
III Depreciation & Miscellaneous Recurrent Costs			

A. Initial cost of TD-14 including bulldozer frame and blade................$10,575.00
Hyster Winch 1,500.00
Caterpiller Logging Arch. 1,800.00
Chokers, 15 per tractor @ $14.50 per choker 217.50
$14,092.50
Salvage value (33-1/3%) 4,680.00

Amount to be depreciated $ 9,412.50
Estimated period of use 5 years

B. Average annual depreciation
$9,412.50 ÷ 5 = $1,882.50

C. Average annual interest-bearing investment

$$\frac{\$14,092.50 + 4,680}{2} + \frac{\$1,882.50}{2} = \$10,327.50$$

Average interest charge @ 6% on this investment
$10,327.50 x .06 = $ 620.00

D. Taxes, 2% of average annual investment 206.50

Insurance .9% on average annual investment 93.00

E. Average annual repair parts $500... 500.00

Total annual fixed charges $3,302.00

	Per Day	Per Hour
Average charge per day based on 150 work days per year @ 8-hours per day	$22.02	
Grand totals	$49.16	$6.145

Total cost per minute 10.2¢

COST AND TIME ANALYSIS C - ARCH SKIDDING WITH INTERNATIONAL TD-14
Continued

Work Performance and Unit Cost of Production
(For average load of 1000 bd.ft. gross scale, Scribner log rule, tree-length)

	Time per turn (minutes)	Time per MBM (minutes)	Cost per MBM
Average fixed time for hooking, unhooking, and all delays	24	24	$2.45
Average variable time to cover 100 feet round trip (in with load and return empty)	1.0	1.0	10.2¢

COST AND TIME ANALYSIS D - HAULING COSTS

Machine Rate

(for K-7 International Trucks
1941-1944 Models - 2-3 ton
2000 hr. operating year - 4 year life

			Cost per Hour
I Fixed Cost per Hour			
A. License and Insurance			
Registration (Truck $74 / (Trailer $36	$110.00		
Public Liability	58.19		
Property Damage	59.25		
Collision	30.00		
Fire and Theft	12.25		
	$269.69	÷ 2000 hrs.=	$0.135
B. Depreciation			
Original Cost	$2100.00		
Less tires	800.00		
	$1300.00		
Less wrecking value	100.00		
	$1200.00	÷ 8000 hrs.=	0.150
C. Labor			
Driver's Wages			1.100
Social Security, Workmen's Compensation, Unemployment Compensation, Group Insurance			.190
Total Fixed Cost per Hour			$1.575
(Total Fixed Cost per Hour excluding Depreciation			$1.425)

COST AND TIME ANALYSIS D - HAULING COSTS Continued

	Cost per Hour
II Operating Cost per Hour	
Oil at $0.20 per qt. (1 qt. every 10 hrs.)	$ .020
Repairs - including labor (average of $1000 per year)	.500
Fuel (average 4 gals./hr. @ $0.24 per gal.)	.960
Tires ($800 ÷ 1000 hrs.)	.800
Total Variable Cost per Hour	$2.280
Total Fixed Cost per Hour	$1.575
Total Hauling Cost per Hour	$3.855

(Total Hauling Cost per Hour excluding Depreciation $3.705)

Work Performance and Unit Cost

Average load .... 2.1 M bd.ft.

Average round trip time........ 5.2 hours
Less delay time .... .5 hours

Hauling time .... 4.7 hours

Operating Cost 4.7 hours x $3.86 = $18.14

Delay Cost .5 hours x $1.58 = .79

$18.93 ÷ 2.1 M bd.ft. = $9.00/M bd.ft.

TABLE O - CUTTING COMPARTMENTS - STRAIGHT LIQUIDATION

No. of Cutting Area	Total Acres	Winter Logging Compartment No.	Block	Acres	Location	Summer Logging Compartment No.	Block	Acres	Location
1	647	W-1	Gogebic	280	T48N,R42W: W 1/2 NE 1/4, SENE, SE 1/4, Sec. 36	S-1	Tula	367	T49N,R45W: NE 1/2 of Sec. 2 divided by main-haul road, everything north of road NWNW, Sec. 12
2	604	W-2	Gogebic	320	T48N,R42W: W 1/2, Sec. 36	S-2	Tula	284	T49N,R45W: SW 1/2 of Sec. 2 divided by main-haul road, everything south of road
3	574	W-3	Gogebic	334	T48N,R42W: W 1/2, SW 1/4, SESW, SWSE, Sec. 26 W 1/2, NE 1/4, SENW, N 1/2 SW 1/4, SWSW, Sec. 35	S-3	Tula	240	T40N,R45W: NE 1/4, E 1/2 SE 1/4, Sec. 34
4	618	W-4	Gogebic	360	T48N,R42W: SW 1/4, Sec. 24 E 1/2 W 1/4, SWSE, Sec. 25	S-4	Tula	258	T49N,R44W: W 1/2 NENE, W 1/2 NE 1/4, 1/3 SENE, NW 1/4, northern portions of NESW, NWSE, 3/4 NWSW, Sec. 6
5	618	W-5	Gogebic	320	T48N,R42W: SESW, Sec. 23 S 1/2 SE 1/4, N 1/2 NE 1/4, SENE, NENW, E 1/2 SW 1/4, Sec. 26	S-5	Tula	298	T49N,R44W: E 1/2 NENE, everything east of the South Branch Little Carp River, Sec. 6 and Sec. 7 Everything west of Canyon Creek Sec. 7 Portion NWNE Sec. 18
6	622	W-6	Gogebic	316	T48N,R42W: SWSW, Sec. 23 SWNE, W 1/2 NW 1/4, SENW, NESW, NWSE, Sec. 26 NENW, NESW, SWSW, Sec. 27	S-6	Tula	306	T49N,R44W: SW portion Sec. 6 west of South Branch Little Carp River Northern portions of NWNE, N 1/2 NW 1/4, Sec. 7
7	626	W-7	Gogebic	280	T48N,R42W: E 1/2 SW 1/4, SWSE, Sec. 13 NW 1/4, Sec. 24	S-7	Tula	346	T49N,R44W: Western portion Sec. 7, everything west of South Branch Little Carp River Northern portion N 1/2 NW 1/4, Sec. 18
8	619	W-8	Gogebic	320	T48N,R42W: S 1/2 SE 1/4, Sec. 14 NE 1/4, N 1/2 SE 1/4, Sec. 23	S-8	Tula	299	T49N,R44W: SE portion E 1/2 SE 1/4, Sec. 7 N 1/2 Sec. 18 except where other compartments extend in northern portions
9	581	W-9	Gogebic	280	T48N,R42W: E 1/2 NE 1/4, W 1/2 NW 1/4, SENW, N 1/2 SE 1/4, Sec. 14	S-9	Tula	301	T49N,R44W: S 1/2, Sec. 18
10	628	W-10	Tula	320	T49N,R44W: E 1/2, Sec. 30	S-10	Tula	308	T49N,R44W: N 1/2 and portions of S 1/2; north of creek NE 1/4, NW 1/4, portions of N 1/2 SW 1/4 north of Creek, Sec. 4
11	631	W-11	Tula	320	T49N,R44W: W 1/2, Sec. 29	S-11	Tula	311	T49N,R44W: Southern portion S 1/2 NE 1/4, southern portion N 1/2 S 1/2 SW 1/4, SE 1/4, Sec. 4
12	640	W-12	Tula	320	T49N,R44W: E 1/2, Sec. 29	S-12	Tula	320	T50N,R44W: NE 1/4, E 1/2 SE 1/4, Sec. 28 E 1/2 SE 1/4, Sec. 32
13	640	W-13	Tula	320	T49N,R44W: E 1/2 NE 1/4, Sec. 31 NE 1/4, E 1/2 NW 1/4, Sec. 32	S-13	Tula	320	T50N,R44W: NE 1/4, E 1/2 NW 1/4, W 1/2 SE 1/4, Sec. 32
14	642	W-14	Tula	320	T49N,R44W: N 1/2, Sec. 33	S-14	Tula	322	T50N,R44W: Everything east of South Branch Little Carp River, Sec. 29
15	641	W-15	Tula	323	T48N,R44W: N 1/2 NW 1/4, Sec. 4 T49N,R44W: S 1/2 SE 1/4, Sec. 32 SW 1/4, Sec. 33	S-15	Tula	318	T50N,R44W: Everything west of South Branch Little Carp River, Sec. 29
16	615	W-16	Tula	323	T48N,R44W: N 1/2 NE 1/4, SWNE, SENW, Section 4 T49N,R44W: SE 1/4, Sec. 33	S-16	Tula	292	T49N,R44W: S 1/2 NE 1/4, eastern portion E 1/2 SW 1/4 -everything east of Main Tula Road, SE 1/4, Sec. 28
17	429	W-17	Tula	192	T49N,R44W: W 1/2 W 1/2, plus 32 acres in E 1/2 W 1/2, Sec. 28	S-17	Tula	237	T49N,R44W: S 1/2 SE 1/4, Sec. 20 N 1/2 NE 1/4, E 1/2 NW 1/4 -everything east of Main Tula Road, Sec. 28

TABLE P - CUTTING COMPARTMENTS - SUSTAINED YIELD

No. of Cutting Area	Total Acres	Winter Logging Compartment No.	Block	Acres	Location	Summer Logging Compartment No.	Block	Acres	Location
1	498	W-1	Gogebic	280	T48N,R42W: W 1/2 NE 1/4, SENE, SW 1/4, Sec. 36	S-1	Tula	218	T49W,R45W: NE portion - everything north of Tiebel Creek, Sec. 2
2	485	W-2	Gogebic	240	T48N,R42W: S 1/2 NW 1/4, SW 1/4, Sec. 36	S-2	Tula	245	T49N,R45W: Central portion, between main-haul road and Tiebel Creek, Sec. 2 NWNW, Sec. 12
3	516	W-3	Gogebic	232	T48N,R42W: E 1/2 NE 1/4, SENW, N 1/2 SE 1/4, SWSW, Sec. 35	S-3	Tula	284	T49N,R45W: SW portion - everything south of main-haul road, Sec. 2
4	520	W-4	Gogebic	280	T48N,R42W: E 1/2 NW 1/4, E 1/2 SW 1/4, SESW, Sec. 25 N 1/2 NE 1/4, Sec. 36	S-4	Tula	240	T50N,R45W: NE 1/4, E 1/2 SE 1/4, Sec. 34
5	510	W-5	Gogebic	244	T48N,R42W: NE 1/4, SENW, NESW, N 1/2 SW 1/4, SESW, Sec. 26	S-5	Tula	266	T49N,R44W: S 1/2, Sec. 6 - west of South Branch Little Carp River Western portion of W 1/2 E 1/2 Sec. 7
6	515	W-6	Gogebic	254	T48N,R42W: SWNE, E 1/2 SW 1/4, SESW, SWSE, Sec. 26 NENW, NESE, SWSE, Sec. 27	S-6	Tula	261	T49N,R44W: Everything east of South Branch Little Carp River, Sec. 6 E 1/2 NE 1/4, and portions of W 1/2 NE 1/4, Sec. 7
7	516	W-7	Gogebic	240	T48N,R42W: N 1/2 SE 1/4, Sec. 24 SW 1/4, Sec. 25	S-7	Tula	266	T49N,R44W: W 1/2, Sec. 7, except for 14 acres in SESW
8	517	W-8	Gogebic	240	T48N,R42W: S 1/2 S 1/2, Sec. 23 N 1/2, NW 1/4, Sec. 26	S-8	Tula	267	T49N,R44W: Everything in S 1/2, Sec. 7 - south of South Branch Little Carp River Everything north of Canyon Creek in Sec. 7 and Sec. 18
9	508	W-9	Gogebic	280	T48N,R42W: E 1/2 SW 1/4, SWSE, Sec. 13 NW 1/4, Sec. 24	S-9	Tula	228	T49N,R44W: N 1/2 Sec. 6 - everything west of South Branch Little Carp River
10	524	W-10	Gogebic	240	T48N,R42W: S 1/2 SE 1/4, Sec. 14 NE 1/4, Sec. 23	S-10	Tula	284	T49N,R44W: SE portion E 1/2 SE 1/4 Sec. 7 E 1/2 NE 1/4, SWNE, portions of SWNW, SENW, NWSW, N 1/2 SE 1/4, Sec. 18
11	542	W-11	Gogebic	280	T48N,R42W: E 1/2 NE 1/4, W 1/2 NW 1/4, SENW, N 1/2 SE 1/4, Sec. 14	S-11	Tula	262	T49N,R44W: SW 1/4, S 1/2 SE 1/4, Sec. 18
12	536	W-12	Tula	280	T49N,R44W: W 1/2 NE 1/4, SENE, SE 1/4, Sec. 30	S-12	Tula	256	T50N,R44W: Portion of S 1/2 NE 1/4, E 1/2 NW 1/4, SE 1/4, Sec. 32
13	514	W-13	Tula	280	T49N,R44W: W 1/2 NW 1/4, SW 1/4, Sec. 29 NENE, Sec. 30	S-13	Tula	234	T50N,R44W: S 1/2 SE 1/4, Sec. 29 NE 1/4, Sec. 32
14	522	W-14	Tula	280	T49N,R44W: NE 1/4, E 1/2 NW 1/4, NWSE, Sec. 29	S-14	Tula	242	T50N,R44W: Everything east of South Branch Little Carp River except S 1/2 SE 1/4, Sec. 29
15	598	W-15	Tula	280	T49N,R44W: E 1/2 NE 1/4, Sec. 31 W 1/2 NE 1/4, SENE, E 1/2 NW 1/4, Sec. 32	S-15	Tula	318	T50N,R44W: Everything west of South Branch Little Carp River, Sec. 29
16	588	W-16	Tula	280	T49N,R44W: NESE, S 1/2 SE 1/4, Sec. 29 NENE, Sec. 32 N 1/2 NW 1/4, SWNW, Sec. 33	S-16	Tula	308	T49N,R44W: N 1/2 NE 1/4, north portion S 1/2 NE 1/4, NW 1/4, north portion N 1/2, SW 1/4, Sec. 4
17	591	W-17	Tula	280	T49N,R44W: NE 1/4, SENW, NESW, NWSE, Sec. 33	S-17	Tula	311	T49N,R44W: South portion, S 1/2 NE 1/4 and N 1/2 SW 1/4, S 1/2 SW 1/4, SE 1/4, Sec. 4
18	523	W-18	Tula	283	T48N,R44W: N 1/2 NW 1/4, Sec. 4 T49N,R44W: S 1/2 SE 1/4, Sec. 32 W 1/2 SW 1/4, SESW, Sec. 33	S-18	Tula	240	T50N,R44W: NE 1/4, E 1/2 SE 1/4, Sec. 28
19	568	W-19	Tula	283	T48N,R44W: N 1/2 NE 1/4, SWNE, SENW, Sec. 4 T49N,R44W: NESE, S 1/2 SE 1/4, Sec. 33	S-19	Tula	285	T49N,R44W: East of Main Tula Road in SENW and E 1/2 SW 1/4, SE 1/4, Sec. 28
20	475	W-20	Tula	192	T49N,R44W: W 1/2 W 1/2 plus 32 acres in E 1/2 W 1/2 Sec. 28	S-20	Tula	283	T49N,R44W: S 1/2 SE 1/4, Sec. 20 NE 1/4, NENW, Sec. 28

TABLE Q - CUTTING COMPARTMENTS - TWO-CUT LIQUIDATION

No. of Cutting Area	No. of Cut	Total Acres	Winter Logging Compartment No.	Block	Acres	Location	Summer Logging Compartment No.	Block	Acres	Location
1	First	1291	IW-1	Gogebic	640	T48N,R42W: W 1/2 NE 1/4, SENE, NW 1/4, S 1/2, Sec. 36	IS-1	Tula	651	T49N,R45W: Sec. 2 NWNW, Sec. 12
2	First	1322	IW-2	Gogebic	634	T48N,R42W: S 1/2 N 1/2, S 1/2 Sec. 26 NENW, NESE, SWSE, Sec. 27 W 1/2 NE 1/4, SENW, N 1/2 SW 1/4, SWSW, Sec. 35	IS-2	Tula	688	T49N,R44W: Everything east of Main Tula Road, Sec. 28 T50N,R45W: NE 1/4, E 1/2 SW 1/4 Sec. 34
3	First	1321	IW-3	Gogebic	640	T48N,R42W: E 1/2 SW 1/4, SWSE, Sec. 13 W 1/2, Sec. 24 E 1/2 W 1/2, SWSE, Sec. 25	IS-3	Tula	681	T49N,R44W: Sec. 18 S 1/2 SE 1/4, Sec. 20
4	First	1241	IW-4	Gogebic	640	T48N,R42W: S 1/2 SE 1/4, Sec. 14 E 1/2, S 1/2 SW 1/4, Sec. 23 N 1/2 N 1/2, Sec. 26	IS-4	Tula	601	T49N,R44W: Sec. 7
5	First	1285	IW-5	Gogebic Tula	280 432 712	T48N,R42W: E 1/2 NE 1/4, W 1/2 NW 1/4, SWNW, N 1/2 SE 1/4, Sec. 14 T49N,R44W: Everything west of Main Tula Road, Sec. 28 N 1/2 NE 1/4, SENE, E 1/2 SE 1/4, Sec. 29	IS-5	Tula	573	T49N,R44W: Sec. 6
6	First	1299	IW-6	Tula	680	T49N,R44W: SWNE, NW 1/4, N 1/2 SW 1/4, SWSW, NWSE, Sec. 29 E 1/2, Sec. 30	IS-6	Tula	619	T49N,R44W: Sec. 4
7	First	1320	IW-7	Tula	680	T49N,R44W: SESW, SWSE, Sec. 29 E 1/2 NE 1/4, Sec. 31 NE 1/4, E 1/2 NW 1/4, Sec. 32 N 1/2 NE 1/4, SWNE, NW 1/4, Sec. 33	IS-7	Tula	640	T50N,R44W: NE 1/4, E 1/2 SE 1/4, Sec. 28 NE 1/4, E 1/2 NW 1/4, SE 1/4, Sec. 32
8	First	1326	IW-8	Tula	686	T48N,R44W: N 1/2 NE 1/4, SWNE, N 1/2 NW 1/4, SENW, Sec. 4 T49N,R44W: S 1/2 SE 1/4, Sec. 32 SENE, S 1/2, Sec. 33	IS-8	Tula	640	T50N,R44W: Sec. 29
9	Second	1009	IIW-1	Gogebic	480	T48N,R42W: S 1/2 N 1/2, S 1/2 Sec. 36	IIS-1	Tula	529	T49N,R45W: Everything west of Tiebel Creek, Sec. 2 NWNW, Sec. 12
10	Second	936	IIW-2	Gogebic	478	T48N,R42W: W 1/2 SW 1/4, SESW, SWSE, Sec. 26 NENW, NESE, SWSE, Sec. 27 W 1/2 NE 1/4, SENW, N 1/2 SW 1/4, SWSW, Sec. 35	IIS-2	Tula	458	T49N,R45W: Everything east of Tiebel Creek, Sec. 2 T50N,R45W: NE 1/4, E 1/2 SE 1/4, Sec. 34
11	Second	824	IIW-3	Gogebic	480	T48N,R42W: SW 1/4, Sec. 24 E 1/2 W 1/2, SWSE, Sec. 25 NWNE, N 1/2 NW 1/4, Sec. 36	IIS-3	Tula	344	T49N,R44W: Everything west of South Branch Little Carp River, Sec. 7
12	Second	907	IIW-4	Gogebic	468	T48N,R42W: S 1/2 SW 1/4, SWSE, Sec. 23 N 1/2, NESW, N 1/2 SE 1/4, SWSE, Sec. 26	IIS-4	Tula	439	T49N,R44W: Everything west of South Branch Little Carp River, Sec. 6
13	Second	994	IIW-5	Gogebic	480	T48N,R42W: E 1/2 SW 1/4, SWSE, Sec. 13 NE 1/4, Sec. 24 S 1/2 NE 1/4, N 1/2 SE 1/4, SESE, Sec. 23	IIS-5	Tula	514	T49N,R44W: E 1/2 NENE, Sec. 6 Everything east of South Branch Little Carp River, Sec. 6 and Sec. 7 Everything north of Canyon Creek, Sec. 18
14	Second	885	IIW-6	Gogebic	440	T48N,R42W: E 1/2 NE 1/4, W 1/2 NW 1/4, SENW, SE 1/4, Sec. 14 N 1/2 NE 1/4, Sec. 23	IIS-6	Tula	445	T49N,R44W: NE 1/4, NE portion, NENW, southern portion N 1/2 SW 1/4, S 1/2 SW 1/4, SE 1/4, Sec. 4
15	Second	981	IIW-7	Tula	486	T48N,R44W: N 1/2 NE 1/4, SWNE, N 1/2 NW 1/4, SENW, Sec. 4 T49N,R44W: S 1/2 SE 1/4, Sec. 32 S 1/2 S 1/2, Sec. 33	IIS-7	Tula	495	T49N,R44W: NW 1/4 except NE portion NENW, northern portion N 1/2 SW 1/4, Sec. 4 T50N,R44W: NE 1/4, E 1/2 SE 1/4, Sec. 28 S 1/2 SE 1/4, Sec. 32
16	Second	955	IIW-8	Tula	480	T49N,R44W: N 1/2, N 1/2 S 1/2, Sec. 33	IIS-8	Tula	475	T50N,R44W: East of South Branch Little Carp River, NE 1/4, SE 1/4, Sec. 29 NE 1/4, NESE Sec. 32
17	Second	965	IIW-9	Tula	480	T49N,R44W: E 1/2 SW 1/4, W 1/2 SE 1/4, Sec. 29 E 1/2 NE 1/4, Sec. 31	IIS-9	Tula	485	T50N,R44W: West of South Branch Little Carp River, W 1/2 NE 1/4, NW 1/4, SW 1/4, Sec. 29 E 1/2 NW 1/4, NWSE, Sec. 32
18	Second	946	IIW-10	Tula	480	T49N,R44W: W 1/2 W 1/2, Sec. 29 E 1/2, Sec. 30	IIS-10	Tula	466	T49N,R44W: SW portion E 1/2 SE 1/4, Sec. 7 Everything south of Canyon Creek, Sec. 18
19	Second	1040	IIW-11	Tula	512	T49N,R44W: Everything west of Main Tula Road, Sec. 28 NE 1/4, E 1/2 NW 1/4, E 1/2 SE 1/4, Sec. 29	IIS-11	Tula	528	T49N,R44W: S 1/2 SE 1/4, Sec. 20 Everything east of Main Tula Road, Sec. 28

TABLE R - LOGGING COST* COMPARISON OF CLEAR AND SELECTIVE CUTTING

Method	Winter Haul: Spacing of Roads (feet)	Winter Haul: Spacing of Landings (feet)	Winter Haul: Cost of Logging (per MBM)	Summer Haul: Spacing of Roads (feet)	Summer Haul: Spacing of Landings (feet)	Summer Haul: Cost of Logging (per MBM)
Log length with ground skidding						
Company's past practice						
CLEAR-CUTTING	660	495	$3.38	660	495	$4.14
SELECTIVE CUTTING	660	495	$4.10	660	495	$5.67
Difference			$0.72			$1.53
Average** cost per MBM more for selective cutting			$1.12			
Replanned operation						
CLEAR-CUTTING	980	294	$3.25	1490	298	$3.61
SELECTIVE CUTTING	1410	424	$3.61	2150	430	$4.15
Difference			$0.36			$0.54
Average** cost per MBM more for selective cutting			$0.45			
Tree-length with arch skidding						
Company's proposal						
CLEAR-CUTTING	2640	330	$3.31	2640	330	$3.50
SELECTIVE CUTTING	2640	330	$3.49	2640	330	$3.89
Difference			$0.18			$0.39
Average ** cost per MBM more for selective cutting			$0.29			
Replanned operation						
CLEAR-CUTTING	1220	366	$3.16	1860	372	$3.13
SELECTIVE CUTTING	1760	440	$3.45	2670	534	$3.88
Difference			$0.29			$0.75
Average** cost per MBM more for selective cutting			$0.52			

* - Costs involve only skidding, and road and landing construction, based on economic location of roads and landings.

** - It is assumed that there are equal amounts of summer and winter roads.

TIMBERLAND TAXES*

(General Property Tax)

Porcupine Block

Carp Lake Tw.	Section 32	T51N	R42W	640A	$ 8,700
	Section 33	T51N	R42W	640	10,880
	Section 3	T50N	R43W	281.96	4,140
	Section 4	T50N	R43W	640	10,010
				2801.96A	$33,730 = $12.05 value/A @ 2.0876% per $1 = $.251 or 25.1¢/A

Gogebic Block

Matchwood Tw.	Section 13	T48N	R42W	120A	$ 1,200	
	Section 14	T48N	R42W	480	13,000	
	Section 15	T48N	R42W	280	1,500	(cut-over)
	Section 22	T48N	R42W	640	4,000	(cut-over)
	Section 23	T48N	R42W	640	10,100	
	Section 24	T48N	R42W	320	5,000	
				80	500	(non-value)
	Section 25	T48N	R42W	160	4,400	
				80	500	(non-value)
	Section 26	T48N	R42W	640	10,000	
	Section 27	T48N	R42W	120	2,250	
	Section 35	T48N	R42W	240	5,500	
	Section 36	T48N	R42W	600	13,800	
				3320A	$55,050	= $16.59/A @ 1.9333% per $1 = 32.1¢/A
Bergland Tw.	Section 20	N48N	R42W	371.35A	$ 3,000	(cut-over)
	Section 28	N48N	R42W	618.50	3,600	(cut-over)

	Acres	Value
Cut-over	1280	5400 = $4.22 value/A @ 1.9333% per $1 = $.0816 or 8.2¢/A
Non-value	160	1000 = $6.25 value/A @ 1.9333% per $1 = $.1207 or 12.1¢/A
Bergland (Cut-over)	1280	$6,600 = $5.16 value/A @ 3.7666% per $1 = $.1942 or 19.4¢/A

* Refer to Table E, page 6 in Appendix for Tax Rate per $1000 Valuation.

TIMBERLAND TAXES Continued

Tula Block

Carp Lake Tw.	Section 28	T50N	R44W	240A	$ 4,080	
	Section 29	T50N	R44W	640	10,200	
	Section 32	T50N	R44W	400	7,600	
	Section 4	T49N	R44W	618.67	10,440	
	Section 6	T49N	R44W	573.43	10,150	
	Section 7	T49N	R44W	600.88	10,200	
	Section 18	T49N	R44W	600.96	10,200	
	Section 20	T49N	R44W	80	1,760	
				80	400	(cut-over, 80 acres valued at $400 = $5/A @ 2.0876% per $1 or 11.4¢/A
	Section 28	T49N	R44W	640	8,480	
	Section 29	T49N	R44W	640	14,080	
	Section 30	T49N	R44W	602.59	5,000	
	Section 31	T49N	R44W	602.55	4,250	
	Section 32	T49N	R44W	640	6,880	
	Section 33	T49N	R44W	640	10,880	
				7519.08A	$114,200	= $15.19 value/A @ 2.0876% per $1 = $.317 or 31.7¢/A
Wakefield Tw.	Section 4	T48N	R44W	245.74	6,400	
	Section 2	T49N	R45W	610.56	14,600	
	Section 12	T49N	R45W	40	900	
	Section 34	T50N	R45W	240	7,200	
				1136.30	29,100	= $25.62 value/A @ 3.8573% = $.988 or 98.8¢/A

TIMBERLAND TAXES Continued

Weighted Average Merchantable Timber

Porcupine Block (not included because of liquidation policy)
2801.96A @ 25.1¢/A = 7,050

Gogebic Block
Matchwood Tw. 3320.00A @ 32.1¢/A = 106,600

Tula Block
Carp Lake Tw. 7519.08A @ 31.7¢/A = 238,100

Wakefield Tw. 1136.30A @ 98.8¢/A = 112,300

Weighted Average excluding Porcupine Block 11,655.38....11,655.38)457,000
59.2¢ aver. per A

Weighted Average including Porcupine Block 14,457.34....14,457.34)464,050
32.0¢ aver. per A

Weighted Average Cut-over Timberland

Gogebic Block
Matchwood Tw. 1280A @ 8.2¢/A = 10,490
Bergland Tw. 1280A @ 19.4¢/A = 24,820

Tula Block
Carp Lake Tw. 80 A @ 11.4¢ = 912
Weighted Average 2640 2640)36,212
13.7¢ aver. per A

Average No-Value Timberland

Gogebic only
Matchwood Tw. 160A @ 12.1¢/A

TABLE 3 - TAX SCHEDULE - STRAIGHT LIQUIDATION, GENERAL PROPERTY TAX

Tax Period		Merchantable Timber (Acres)	Total Tax @ 40¢ per Acre	Cutover Land (Acres)	Total Tax @ 14¢ per Acre	Total All Land Taxes
1	1951*	10,280	$4,112.00			$4,112.00
2	1952	9,660	3,864.00	620	$ 87.00	3,951.00
3	1953	9,040	3,616.00	1240	173.00	3,789.00
4	1954	8,420	3,368.00	1860	260.00	3,628.00
5	1955	7,800	3,120.00	2480	347.00	3,467.00
6	1956	7,180	2,872.00	3100	434.00	3,306.00
7	1957	6,560	2,624.00	3720	520.00	3,144.00
8	1958	5,940	2,376.00	4340	607.00	2,983.00
9	1959	5,320	2,128.00	4960	694.00	2,822.00
10	1960	4,700	1,880.00	5580	780.00	2,660.00
11	1961	4,080	1,632.00	6200	868.00	2,500.00
12	1962	3,460	1,384.00	6820	954.00	2,338.00
13	1963	2,840	1,136.00	7440	1,041.00	2,177.00
14	1964	2,220	888.00	8060	1,127.00	2,015.00
15	1965	1,600	640.00	8680	1,215.00	1,855.00
16	1966	980	392.00	9300	1,300.00	1,692.00
17	1967 (6 mo.)	360	144.00	19920	1,387.00	1,531.00
				10280	1,438.00	1,438.00
17			$36,176.00		$13,231.00	$49,407.00

* Estimated year that company will start cutting on the Gogebic and Tula blocks.

TABLE T - TAX SCHEDULE TWO-CUT LIQUIDATION, GENERAL PROPERTY TAX

Tax Period		Merchantable Timber (Acres)	Total Tax @ 40¢ per Acre	Selectively Cut Land (Acres)	Tax After* First Cut @ 25¢ per Acre	Cut-over Land (Acres)	Total Tax @ 14¢ per Acre	Total All Land Taxes
1	1951	10,280	$4,112.00					$4,112.00
2	1952	8,995	3,592.00	1,285	$ 321.00			3,913.00
3	1953	7,710	3,081.00	2,570	642.00			3,723.00
4	1954	6,425	2,568.00	3,855	963.00			3,531.00
5	1955	5,140	2,053.00	5,140	1,285.00			3,338.00
6	1956	3,855	1,540.00	6,425	1,605.00			3,145.00
7	1957	2,570	1,028.00	7,710	1,925.00			2,953.00
8	1958	1,285	513.00	8,995	2,248.00			2,761.00
9	1959			10,280	2,565.00			2,464.00
10	1960			9,302	2,327.00	978	$ 137.00	2,565.00
11	1961			8,324	2,081.00	1956	274.00	2,355.00
12	1962			7,346	1,836.00	2934	411.00	2,247.00
13	1963			6,368	1,592.00	3912	548.00	2,140.00
14	1964			5,390	1,347.00	4890	684.00	1,031.00
15	1965			4,412	1,104.00	5868	822.00	1,926.00
16	1966			3,434	858.00	6846	958.00	1,816.00
17	1967			2,456	614.00	7824	1,095.00	1,709.00
18	1968			1,478	370.00	8802	1,232.00	1,602.00
19	1969 (6 mo.)			500	125.00	9780	1,369.00	1,494.00
19			$18,387.00		$23,758.00		$7,530.00	$50,675.00

* Reassessment value with estimate of 25¢ tax rate on 6130 board feet per acre.

TABLE U - TAX SCHEDULE - TWO-CUT LIQUIDATION, COMMERCIAL FOREST PRESERVE ACT

Tax Period		Merchantable Timber (Acres)	Total Tax @ 40¢ Per Acre	Selectively Cut Land (Acres)	Total Tax @ 5¢ per Acre	Percent Yield Tax	Total Yield Tax 10% @ $10 per M	Total All Taxes
1	1951	10,280	$4,112.00			2		$4,112.00
2	1952	8,995	3,592.00	1,285	$ 64.25	3		3,656.25
3	1953	7,710	3,081.00	2,570	128.50	4		3,309.50
4	1954	6,425	2,568.00	3,855	192.75	5		2,760.75
5	1955	5,140	2,053.00	5,140	256.00	6		2,309.00
6	1956	3,855	1,540.00	6,425	321.25	7		1,861.25
7	1957	2,570	1,028.00	7,710	385.50	8		1,413.50
8	1958	1,285	513.00	8,995	449.75	9		962.75
9	1959			10,280	514.00	10	$6,000	6,514.00
10	1960			10,280	514.00	10	6,000	6,514.00
11	1961			10,280	514.00	10	6,000	6,514.00
12	1962			10,280	514.00	10	6,000	6,514.00
13	1963			10,280	514.00	10	6,000	6,514.00
14	1964			10,280	514.00	10	6,000	6,514.00
15	1965			10,280	514.00	10	6,000	6,514.00
16	1966			10,280	514.00	10	6,000	6,514.00
17	1967			10,280	514.00	10	6,000	6,514.00
18	1968			10,280	514.00	10	6,000	6,514.00
19	1969 (6 mo.)			10,280	514.00	10	3,000	3,514.00
19			$18,387.00		$7452.00		$63,000	$88,839.00

TABLE V - TAX SCHEDULE - SUSTAINED YIELD, GENERAL PROPERTY TAX

Tax Period		Merchantable Timber (Acres)	Total Tax @ 40¢ per Acre	Selectively Cut Land (Acres)	Tax After* First Cut @ 25¢ per Acre	Total All Taxes
1	1951	10,280	$4,112.00			$4,112.00
2	1952	9,766	3,908.00	514	$ 128.00	4,036.00
3	1953	9,252	3,700.00	1028	257.00	3,957.00
4	1954	8,738	3,491.00	1542	386.00	3,877.00
5	1955	8,224	3,290.00	2056	514.00	3,804.00
6	1956	7,710	3,082.00	2570	668.00	3,750.00
7	1957	7,196	2,875.00	3084	772.00	3,647.00
8	1958	6,682	2,672.00	3598	900.00	3,572.00
9	1959	6,168	2,469.00	4112	1,028.00	3,497.00
10	1960	5,654	2,259.00	4626	1,156.00	3,415.00
11	1961	5,140	2,054.00	5140	1,285.00	3,339.00
12	1962	4,626	1,848.00	5654	1,412.00	3,260.00
13	1963	4,112	1,648.00	6168	1,542.00	3,190.00
14	1964	3,598	1,437.00	6682	1,673.00	3,110.00
15	1965	3,084	1,234.00	7196	1,800.00	3,034.00
16	1966	2,570	1,028.00	7710	1,928.00	2,956.00
17	1967	2,056	822.00	8224	2,058.00	2,880.00
18	1968	1,542	617.00	8738	2,185.00	2,802.00
19	1969	1,028	411.00	9252	2,312.00	2,723.00
20	1970	514	206.00	9766	2,442.00	2,648.00
TOTAL TAXES FIRST CUTTING CYCLE			$43,163.00		$24,456.00	$67,619.00
					Tax Average** during Second Cut @ 30¢ per Acre	
1 thru 20	1971-1990			10,280	$3084.00	$3084.00
TOTAL TAXES SECOND CUTTING CYCLE						$61,680.00
					Tax Average*** during Third Cut @ 35¢ per Acre	
1 thru 20	1991-2010			10,280	$3598.00	$3598.00
TOTAL TAXES THIRD CUTTING CYCLE						$71,960.00

* Reassessment value with estimate of 25¢ tax rate on 5000 board feet per acre.
** Reassessment value with estimate of 30¢ tax rate on 7261 board feet per acre.
*** Reassessment value with estimate of 35¢ tax rate on 8100 board feet per acre.

TABLE W - TAX SCHEDULE - SUSTAINED YIELD, COMMERCIAL FOREST PRESERVE ACT

Tax Period		Merchantable Timber (Acres)	Total Tax @ 40¢ per Acre	Selectively Cut Land (Acres)	Total Tax @ 5¢ per Acre	Total Yield Tax 10% @ $10 per M	Total All Taxes
1	1951	10,280	$4,112.00				$4,112.00
2	1952	9,766	3,908.00	514	$ 25.70		3,933.70
3	1953	9,252	3,700.00	1028	51.40		3,751.40
4	1954	8,738	3,491.00	1542	77.10		3,568.10
5	1955	8,224	3,290.00	2056	102.80		3,392.80
6	1956	7,710	3,082.00	2570	128.50		3,210.50
7	1957	7,196	2,875.00	3084	154.00		3,029.00
8	1958	6,682	2,672.00	3598	179.80		2,851.80
9	1959	6,168	2,469.00	4112	205.50		2,674.50
10	1960	5,654	2,259.00	4626	231.00		2,490.00
11	1961	5,140	2,054.00	5140	257.00		2,311.00
12	1962	4,626	1,848.00	5654	282.20		2,130.20
13	1963	4,112	1,648.00	6168	308.50		1,956.50
14	1964	3,598	1,437.00	6682	334.00		1,771.00
15	1965	3,084	1,234.00	7196	359.50		1,593.50
16	1966	2,570	1,028.00	7710	385.50		1,413.50
17	1967	2,056	822.00	8224	411.50		1,233.50
18	1968	1,542	617.00	8738	436.50		1,053.50
19	1969	1,028	411.00	9252	462.50		875.50
20	1970	514	206.00	9766	488.50		694.50
TOTAL TAXES FIRST CUTTING CYCLE			$42,163.00		$4881.50		$47,044.50
1 thru 20	1971-1990			10,280	$514.00	$1,420	$1,934.00
TOTAL TAXES THIRD CUTTING CYCLE					10,280.00	28,400.00	$38,680.00
1 thru 20	1991-2010			10,280	$514.00	$1,590.00	$2,104.00
TOTAL TAXES THIRD CUTTING CYCLE					10,280.00	31,800.00	$42,080.00

LUMBER VALUES

Calculation of the average selling price of lumber (rough, air-dried) was performed as follows:

1. Broughton's Standard Price List, dated November 25, 1949, of current average selling prices was applied to the INDEX figures for the Trout Creek Mill Study in Tables X through DD, pages 64 to 71, and gives the current average selling price per MBM lumber tally for the Ahonen timber, on the assumption that it is the same quality as that analyzed in the Trout Creek Mill Scale Study.

2. The next step is an adjustment to allow for the difference in quality in the Ahonen stands. For the low vigor portion of the stand the tree quality by butt log grades were taken from the survey figures. For the high vigor stand, the grades assumed were based on the relative percents by d.b.h. classes found in the Trout Creek Study only for sugar maple and yellow birch. These figures, curved and rounded to the nearest 5% are shown in Table EE, page 72.

3. QUALITY PRICE INDEX was calculated next. Only the sugar maple and yellow birch log grades were taken into account. All other species were calculated in high and low vigor classification only. See Table FF, pages 73, 74. From the PRICE INDEX an AVERAGE QUALITY FACTOR was obtained.

4. The AVERAGE QUALITY FACTOR was applied to the average selling price obtained in step 1, to get the average price per MBM mill tally of this particular stand. See Table GG, pages 75, 76 and 77.

TABLES X Thru DD

AVERAGE VALUE CALCULATION SHEETS

BY

SPECIES, LUMBER GRADE AND THICKNESS

Computed Prices

Broughton's Standard Price List
November 25, 1949.

(Published by The Broughton Printing Co.
of Minneapolis, Minnesota)

U.S.F.S. R-9 Milwaukee, Wisconsin, Jan. 1950
59 (Revised)

TABLE X - AVERAGE VALUE CALCULATION SHEET FOR SUGAR MAPLE

Price List Broughton's Standard
Date November 1949.
F.O.B. Mill (Air Dry Rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (6.1)	4	(21.9)	.013359	$186	
	5	(51.8)	.031598	191	
	8	(24.8)	.015128	201	
	16	(1.5)	.000915	290	
Selects (5.7)	4	(35.8)	.020406	166	
	5	(44.8)	.025536	171	
	8	(17.8)	.010146	181	
	16	(1.6)	.000912	260	
No. 1 (18.3)	3	(.4)	.000732	115	
	4	(51.2)	.093696	115	
	5	(43.5)	.079605	120	
	6	(0.1)	.000183	125	
	8	(4.8)	.008784	135	
No. 2 (12.8)	3	(0.1)	.000128	73	
	4	(71.7)	.091776	73	
	5	(26.3)	.033664	75	
	8	(1.8)	.002304	78	
	12	(0.1)	.000128	93	
No. 3A (6.7)	4	(80.8)	.054136	37	
	5	(17.1)	.011457	38	
	8	(0.8)	.000536	40	
	16	(1.3)	.000871	48	
No. 3B (28.1)	4	(16.8)	.047208	37	
	5	(1.5)	.004215	38	
	8	(0.2)	.000562	40	
	12	(34.7)	.097507	44	
	16	(46.8)	.131508	48	
Ties to 3A (22.3)	4	(100.0)	.223000	37	
			1.000000		75.81

Average Value per MBM above date $75.81.

* Trout Creek Mill Scale Study Total Stand Data.
** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

NOTE: Negligible quantity of 6-4 No. 2 Com. lumber.

TABLE Y - AVERAGE VALUE CALCULATION SHEET FOR YELLOW BIRCH

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (14.7)	4	(10.4)	.015288	$211	
	5	(89.6)	.131712	216	
Selects (9.2)	4	(22.6)	.020792	191	
	5	(76.7)	.070564	196	
	6	(0.5)	.000460	201	
	8	(0.2)	.000184	206	
No. 1C (17.9)	3	(0.3)	.000537	130	
	4	(35.0)	.062650	130	
	5	(63.1)	.112949	135	
	6	(1.5)	.002685	145	
	8	(0.1)	.000179	161	
No. 2C (15.4)	3	(0.1)	.000154	74	
	4	(49.0)	.075460	74	
	5	(47.4)	.072996	79	
	6	(2.8)	.004312	84	
	8	(0.7)	.001078	89	
No. 3 (5.2)	3	(0.1)	.000052	39	
	4	(57.3)	.029796	39	
	5	(25.0)	.013000	40	
	6	(5.7)	.002964	41	
	8	(10.1)	.005252	45	
	16	(1.8)	.000936	34	
No. 3 (30.7) BC	4	(12.4)	.038068	39	
	5	(9.7)	.029779	40	
	6	(12.8)	.039296	41	
	8	(48.8)	.149816	45	
	12	(11.8)	.036226	42	
	16	(-4.5)	.013815	45	
Ties Conv. to 3 AC (6.9)	4	(100.0)	.069000	39	
			1.000000		103.25

Average Value per MBM above date $103.25.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

TABLE Z - AVERAGE VALUE CALCULATION SHEET FOR BASSWOOD

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (19.4)	3	(0.1)	.000194	$140	
	4	(98.3)	.190702	160	
	5	(0.8)	.001552	165	
	12	(0.8)	.001552	200	
Selects (7.7)	4	(95.1)	.073227	145	
	5	(3.1)	.002387	150	
	12	(1.8)	.001386	185	
No. 1C (16.7)	3	(0.6)	.001002	100	
	4	(96.0)	.160320	115	
	8	(2.5)	.004175	135	
	12	(0.9)	.001503	155	
No. 2C (19.2)	3	(0.1)	.000192	65	
	4	(90.1)	.172992	71	
	8	(7.7)	.014784	89	
	12	(2.1)	.004032	98	
No. 3AC (19.1)	4	(25.2)	.048132	40	
	8	(74.8)	.142868	50	
No. 3BC (17.9)	4	(14.3)	.025597	40	
	8	(85.7)	.153403	50	
			1.000000		93.44

Average Value per MBM above date $93.44.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

NOTE: Negligible quantity of 9-4 FAS, Sels., No. 1 Common, No. 2C, given same price as 8-4.

TABLE AA - AVERAGE VALUE CALCULATION SHEET FOR RED MAPLE

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (6.9)	4	(55.5)	.038295	$135	
	5	(3.4)	.002346	140	
	8	(41.1)	.028359	160	
Selects (6.0)	4	(83.7)	.050220	115	
	5	(16.3)	.009780	120	
No. 1C (16.5)	3	(1.2)	.001980	90	
	4	(79.5)	.131175	100	
	5	(2.6)	.004290	105	
	8	(16.7)	.027555	115	
No. 2C (16.7)	4	(86.9)	.145123	62	
	5	(4.2)	.007014	67	
	8	(8.9)	.014863	77	
No. 3AC (1.4)	4	(100.0)	.014000	39	
No. 3BC (52.5)	4	(14.5)	.076125	39	
	8	(018)	.004200	42	
	12	(48.0)	.252000	40	
	16	(36.7)	.192675	41	
			1.000000		66.19

Average Value per MBM above date $66.19.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

TABLE BB - AVERAGE VALUE CALCULATION SHEET FOR ELM

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air Dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (29.9)	4	(15.1)	.045149	$100	
	6	(1.3)	.003887	110	
	8	(83.6)	.249964	115	
Selects (13.9)	4	(34.3)	.047677	90	
	8	(65.7)	.091323	105	
No. 1C (12.4)	3	(1.8)	.002232	75	
	4	(46.4)	.057536	80	
	8	(51.8)	.064232	95	
No. 2C (15.2)	4	(56.5)	.085880	60	
	8	(43.5)	.066120	66	
No. 3AC (7.2)	4	(14.9)	.010728	38	
	8	(85.1)	.061272	42	
No. 3BC (21.4)	4	(19.8)	.042372	38	
	8	(80.2)	.171628	42	
			1.000000		79.75

Average value per MBM above date $79.75.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

TABLE CC - AVERAGE VALUE CALCULATION SHEET FOR BLACK ASH

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air Dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
FAS (17.1)	4	(76.9)	.131499	$135	
	6	(23.1)	.039501	145	
Selects (5.9)	4	(75.7)	.044663	130	
	6	(24.3)	.014337	130	
No. 1C (17.4)	4	(81.3)	.141462	90	
	6	(10.6)	.018444	100	
	8	(8.1)	.014094	105	
No. 2C (16.5)	4	(80.0)	.132000	68	
	8	(20.0)	.033000	78	
No. 3AC (5.7)	4	(41.7)	.023769	38	
	8	(58.3)	.033231	41	
No. 3BC (37.4)	4	(25.1)	.093874	38	
	6	(1.1)	.004114	39	
	8	(73.8)	.276012	41	
			1.000000		74.96

Average value per MBM above date $74.96.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

TABLE DD - AVERAGE VALUE CALCULATION SHEET FOR HEMLOCK

Price List	Broughton's Standard
Date	November 1949
F.O.B.	Mill (Air Dry-rough)

LUMBER*

GRADE (%)	Thickness (%) in quarters		INDEX**	Price per MBM	Accumulated Figure
No. 1C (46.3)	4	(3.4)	.013742	$69.50	
	8	(90.8)	.420404	67.50	
	16	(5.8)	.026854	69.50	
No. 2C (14.6)	4	(4.2)	.006132	68.50	
	6	(.3)	.000438	66.00	
	8	(95.5)	.139430	66.50	
No. 3C (6.8)	4	(29.0)	.019720	64.50	
	8	(71.0)	.048280	61.50	
No. 4C (26.6)	4	(1.0)	.002660	47.50	
	8	(99.0)	.263340	44.00	
No. 5C (5.7)	4	(5.9)	.003363	22.00	
	8	(94.1)	.053637	22.00	
			1.000000		66.19

Average Value per MBM above date, $66.19.

* Trout Creek Mill Scale Study Total Stand Data.

** Index - The proportion of lumber volume in each thickness and lumber grade in the average old growth northern hardwood stand for average milling conditions.

TABLE EE - TROUT CREEK MILL SCALE STUDY 1940

Percent of the number of trees within each dbh class containing butt logs of the various quality grades after removal of 35% of the volume in a businessman's selective cut.

Sugar Maple

dbh inches	Percent of trees with butt log grading #1	#2	#3	Basis-- No. of Trees
12	0	25	75	61
14	5	65	30	77
16	30	45	25	77
18	40	35	25	64
20	45	35	20	36
22	50	35	15	25
24	50	35	15	12
26	50	35	15	4
28	50	35	15	1
30	50	35	15	1
Basis	93	149	116	358
% of Total	26	42	32	100

Yellow Birch

dbh inches	Percent of trees with butt log grading #1	#2	#3	Basis-- No. of Trees
12	0	50	50	11
14	0	70	30	55
16	35	45	20	44
18	50	35	15	43
20	60	25	15	29
22	65	20	15	21
24	65	20	15	9
26	70	15	15	4
28	70	15	15	2
30	70	15	15	1
Basis	87	89	43	219
% of Total	39	41	20	100

TABLE FF - QUALITY PRICE INDEX (Lake States timber)

(factors to be weighted by log scale volume found by applying average d.b.h. (underlined), against adjusted price calculated from Broughton's Price Index to secure estimated lumber tally price of timber.

SUGAR MAPLE*

dbh	Tree Quality Grade (grade of butt log		
	#1	#2	#3
	price index		
12	.00	.87	.84
14	.97	.91	.84
16	1.14	.97	.86
18	1.19	1.04	.88
20	1.24	1.09	.91
22	1.29	1.14	.97
24	1.36	1.19	.97
26	1.44	1.23	.99
28	1.55	1.28	1.03
30	1.66	1.31	1.06
32	1.79	1.35	1.09
34	1.92	1.40	1.13
36	2.02	1.43	1.15

YELLOW BIRCH

dbh	Tree Quality Grade (grade of butt log		
	#1	#2	#3
	price index		
12	.00	.73	.64
14	1.02	.80	.69
16	1.09	.89	.75
18	1.16	.96	.81
20	1.22	1.01	.86
22	1.29	1.08	.90
24	1.35	1.12	.94
26	1.39	1.16	.96
28	1.43	1.20	.99
30	1.46	1.23	1.00
32	1.49	1.25	1.02
34	1.52	1.26	1.02
36	1.53	1.26	1.01

* Use Maple also for Black Ash and Beech.

TABLE FF - QUALITY PRICE INDEX (Lake States timber) Continued

BASSWOOD

dbh	Tree Quality Grade (grade of butt log) #1	#2 & #3
	price index	
12	.00	.96
14	1.18	.94
16	1.17	.96
18	1.18	.97
20	1.18	.98
22	1.19	.99
24	1.21	1.01
26	1.22	1.02
28	1.24	1.03
30	1.25	1.03
32	1.27	1.04
34	1.29	1.05
36	1.29	1.04

OTHER SPECIES**

dbh	(variations by size only, no data available for variation by grade) R.Maple	Elm	Hemlock	W. Spruce
		Price index		
12	1.31	.63	1.35	1.09
14	1.21	.69	1.26	1.13
16	1.16	.74	1.21	1.19
18	1.12	.82	1.16	1.25
20	1.07	.87	1.11	1.32
22	1.04	.92	1.08	1.39
24	1.00	.98	1.04	1.46
26	.97	1.04	1.02	1.52
28	.95	1.10	1.01	1.60
30	.91	1.14	.99	1.65
32	.90	1.19	.98	1.71
34	.87	1.23	.97	1.77
36	.84	1.27	.96	1.80
38		1.31	.95	1.85
40			.94	1.89
42			.92	1.90
44			.91	1.94
46			.90	1.97
48			.89	1.97
50			.88	1.99

** Use Hemlock for Cedar and White Spruce for White Pine.

TABLE GG - QUALITY PRICE INDEX AND LUMBER TALLY* CALCULATION SHEET
(Scribner Dec. C Lumber Tally Price)

Species	Tree Quality Grade of Butt Log: V or #1 — Average d.b.h.	V or #1 — Net Volume/ Average Acre	V or #1 — Price** Index	V or #1 — Volume x Index	#2 — Net Volume/ Average Acre	#2 — Price** Index	#2 — Volume x Index	#3 — Net Volume/ Average Acre	#3 — Price** Index	#3 — Volume x Index	Total Net Volume/ Average Acre
Hard Maple											
Low Vigor	18	394	1.19	469	504	1.04	524	677	.88	596	1575
	Quality Factor = Total Volume x Price Index = 1589 ÷ Net Volume = 1.0089										
High Vigor	16	406	1.14	465	656	.97	636	501	.86	431	1563
	Quality Factor = Total Volume x Price Index = 1530 ÷ Net Volume = 0.979										
Yellow Birch											
Low Vigor	20	614	1.22	749	379	1.01	383	314	.86	270	1307
	Quality Factor = Total Volume x Price Index = 1402 ÷ Net Volume = 1.074										
High Vigor	16	275	1.09	300	290	.89	258	141	.75	106	706
	Quality Factor = Total Volume x Price Index = 664 ÷ Net Volume = 0.940										
Hemlock											
Low Vigor	18	1409	1.16	1632	Quality factor = 1.16						1409
High Vigor	16	1586	1.21	1920	Quality factor = 1.21						1586
Ash											
Low Vigor	14	250	.90	225	Quality factor = 0.90						250
High Vigor	14	220	.92	202	Quality factor = 0.92						220
Elm											
Low Vigor	22	289	.92	266	Quality factor = 0.92						289
High Vigor	16	141	.74	104	Quality factor = 0.74						141
Basswood											
Low Vigor	18	236	1.08	255	Quality factor = 1.08						236
High Vigor	14	75	1.06	80	Quality factor = 1.06						75
Soft Maple											
Low Vigor	14	152	1.21	184	Quality factor = 1.21						152
High Vigor	12	123	1.31	161	Quality factor = 1.31						123
Spruce											
High Vigor	12	46	1.35	62	Quality factor = 1.35						46

* - Based on method of stumpage appraisal worked out by Copper Range Company, Houghton, Michigan and the U.S. Forest Service.

** - Price Index from U.S. Forest Service Mill Study at Trout Creek, 1940.

CALCULATION OF ADJUSTED AVERAGE SELLING PRICE (VALUE)

Sugar Maple

Average Value per MBM (November 1949) $75.81

	Low Vigor	High Vigor	
Weighted Value MBM	$75.81	$75.81	
Quality factor	x 1.008	x 0.979	
Adjusted Average Value	$76.40	$74.20	per MBM mill tally (Air dry-rough)

Yellow Birch

Average Value per MBM (November 1949) $103.25

	Low Vigor	High Vigor	
Weighted Value MBM	$103.25	$103.25	
Quality factor	x 1.074	x 0.940	
Adjusted Average Value	$110.80	$ 97.00	per MBM mill tally (Air dry-rough)

Hemlock

Average Value per MBM (November 1949) $61.20

	Low Vigor	High Vigor	
Weighted Value MBM	$61.20	$61.20	
Quality factor	x 1.16	x 1.21	
Adjusted Average Value	$71.00	$74.00	per MBM mill tally (Air dry-rough)

Ash

Average Value per MBM (November 1949) $74.96

	Low Vigor	High Vigor	
Weighted Value MBM	$74.96	$74.96	
Quality factor	x 0.90	x 0.92	
Adjusted Average Value	$67.60	$69.00	per MBM mill tally (Air dry-rough)

Elm

Average Value per MBM (November 1949) $79.75

	Low Vigor	High Vigor	
Weighted Value MBM	$79.75	$79.75	
Quality factor	x 0.92	x 0.74	
Adjusted Average Value	$73.40	$59.00	per MBM mill tally (Air dry-rough)

CALCULATION OF ADJUSTED AVERAGE SELLING PRICE (VALUE) Continued

Basswood

Average Value per MBM (November 1949) $93.44

	Low Vigor	High Vigor	
Weighted Value MBM	$93.44	$93.44	
Quality factor	x 1.08	x 1.06	
Adjusted Average Value	$100.70	$99.00	per MBM mill tally (Air dry-rough)

Soft Maple

Average Value per MBM (November 1949) $66.19

	Low Vigor	High Vigor	
Weighted Value MBM	$66.19	$66.19	
Quality factor	x 1.21	x 1.31	
Adjusted Average Value	$80.00	$86.70	per MBM mill tally (Air dry-rough)

Spruce

Average Value per MBM (November 1949) $83.08

	High Vigor Only	
Weighted Value MBM	$83.08	
Quality factor	x 1.35	
Adjusted Average Value	$112.10	per MBM mill tally (Air dry-rough)

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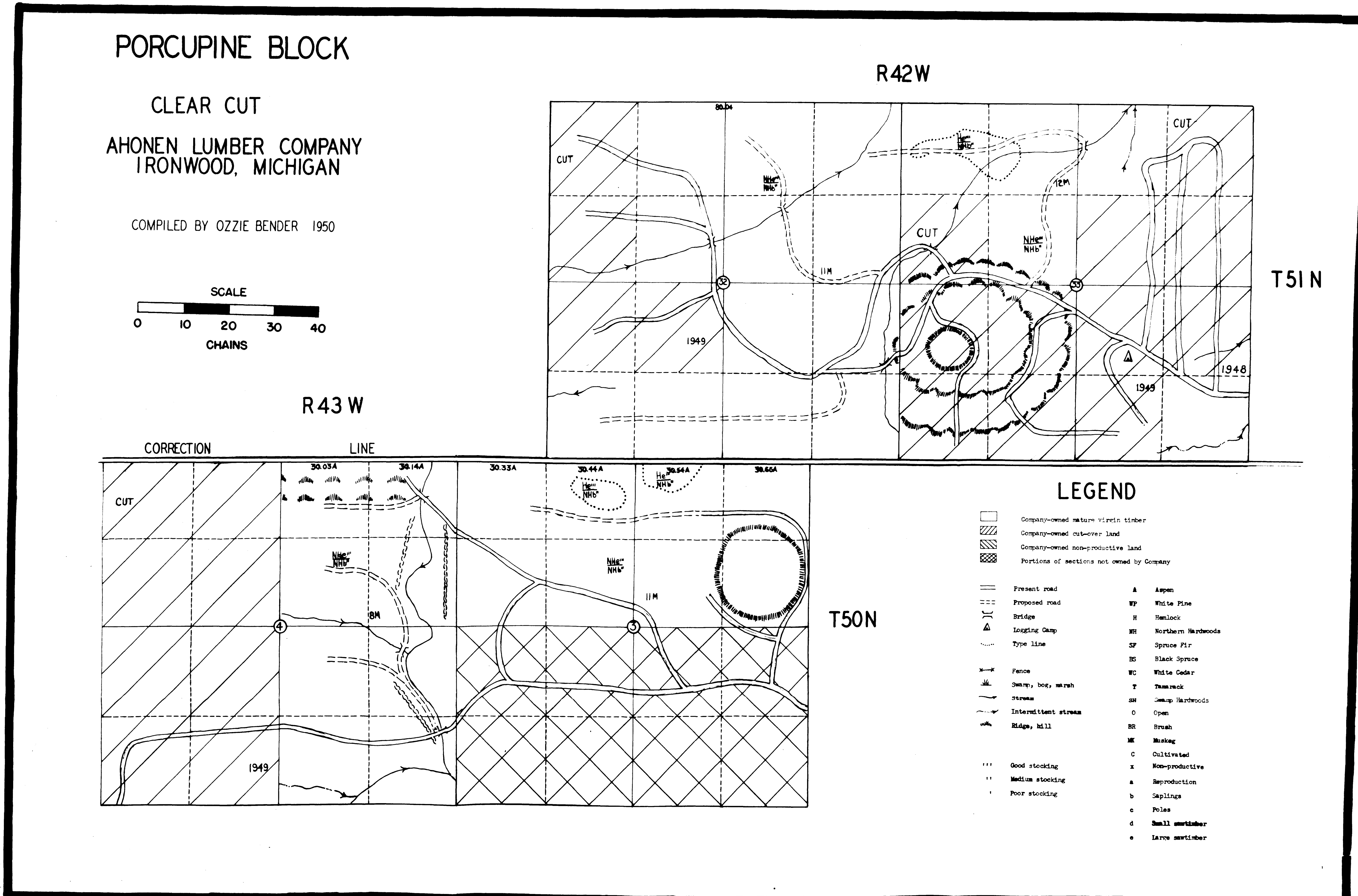
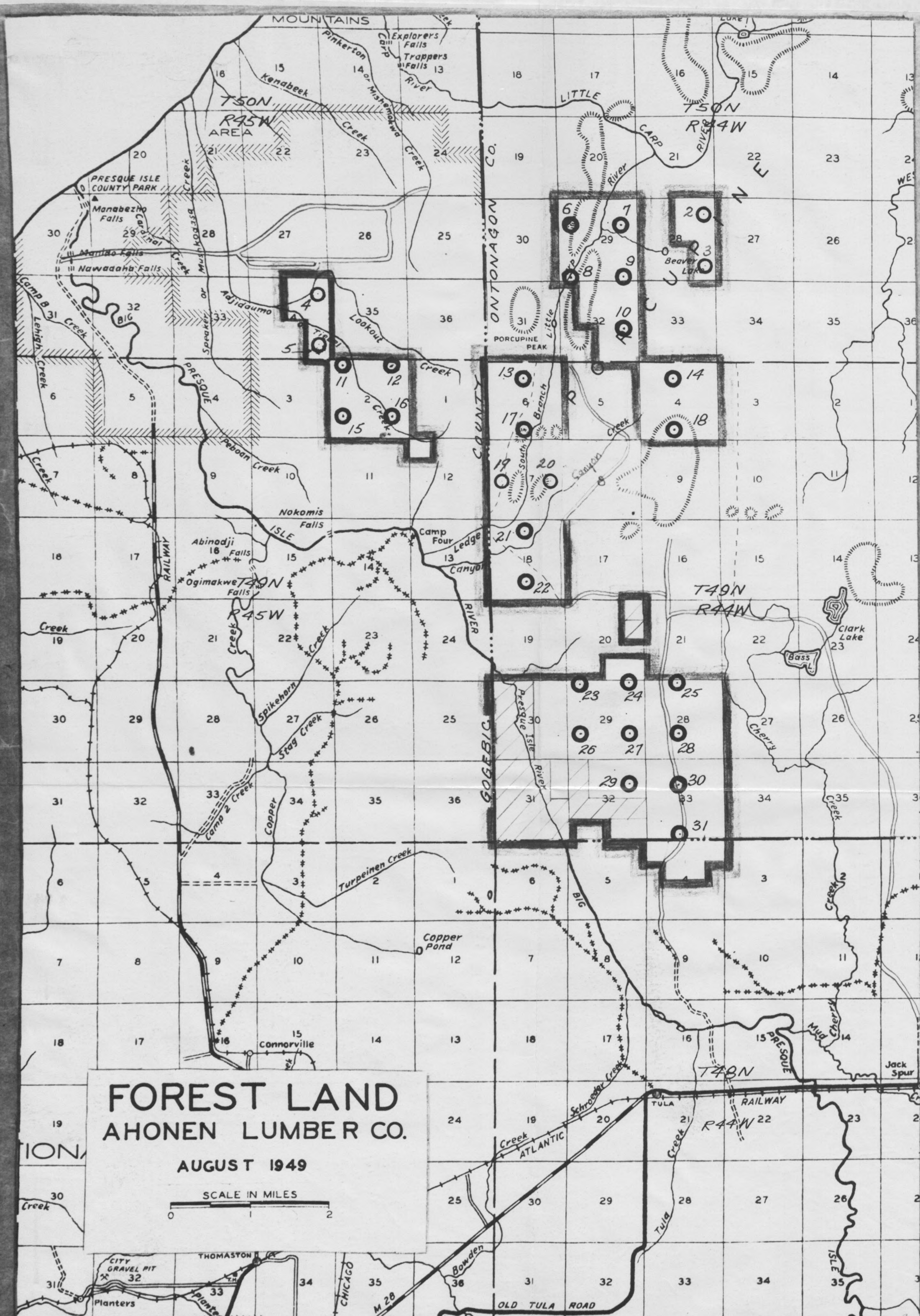
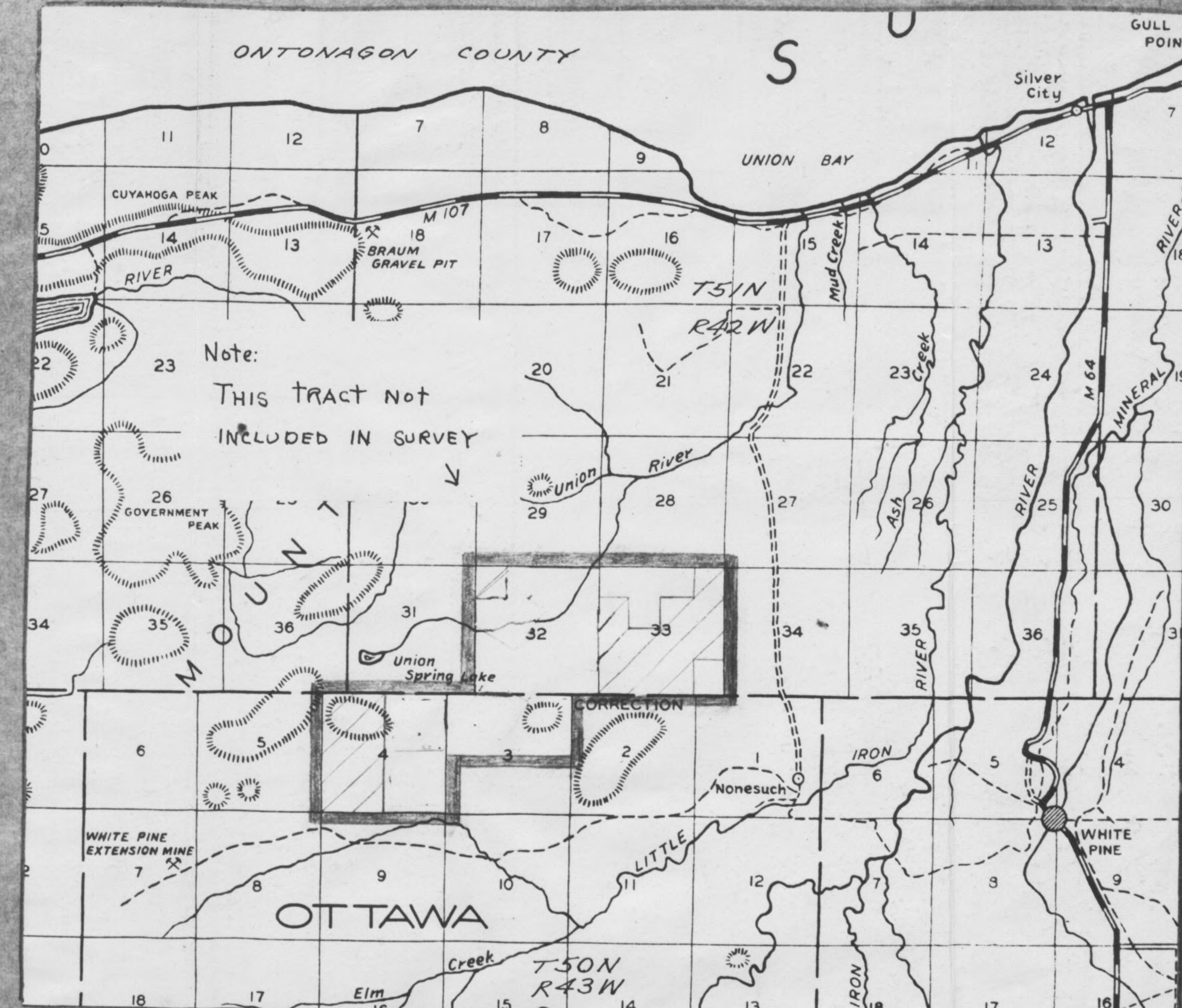
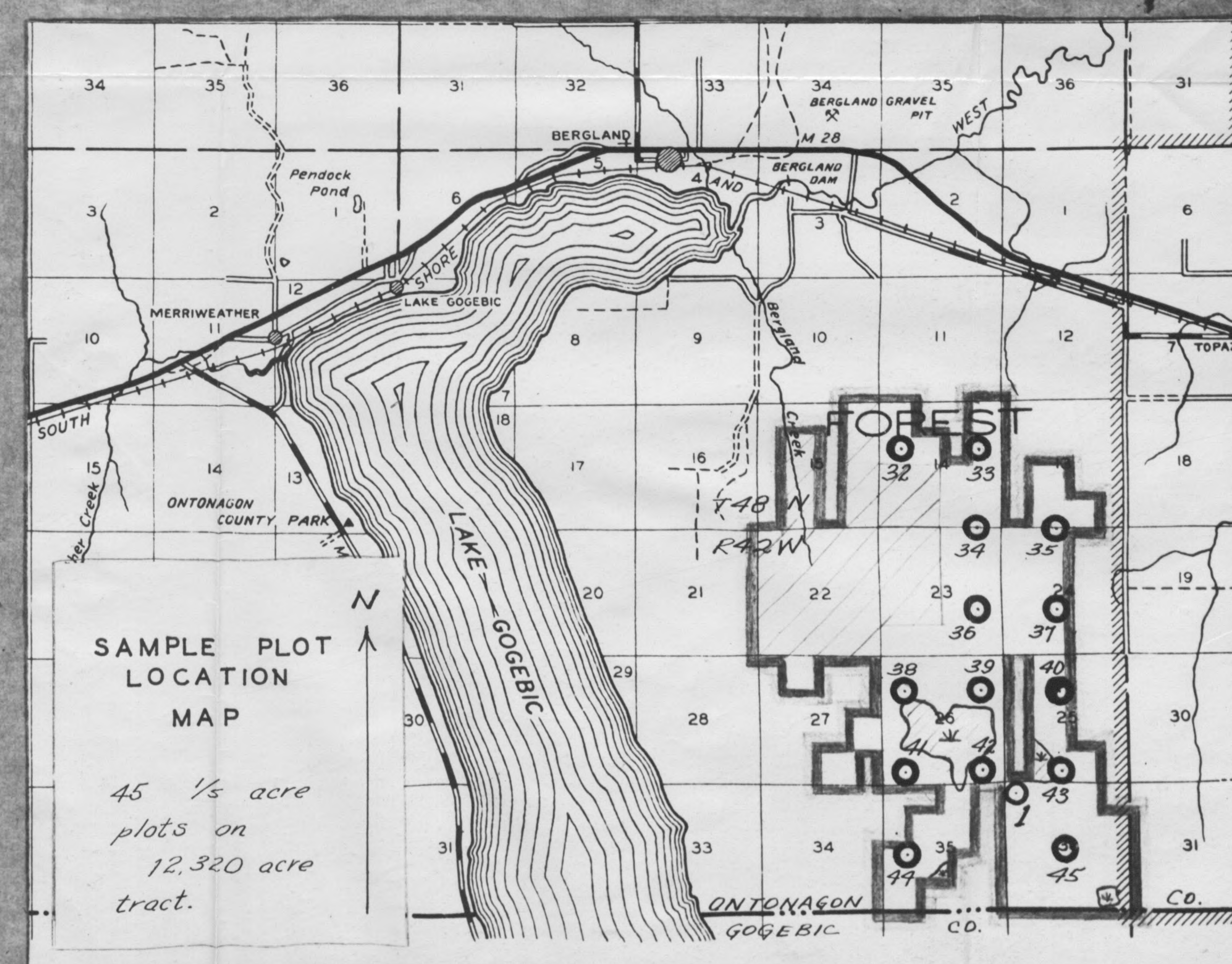


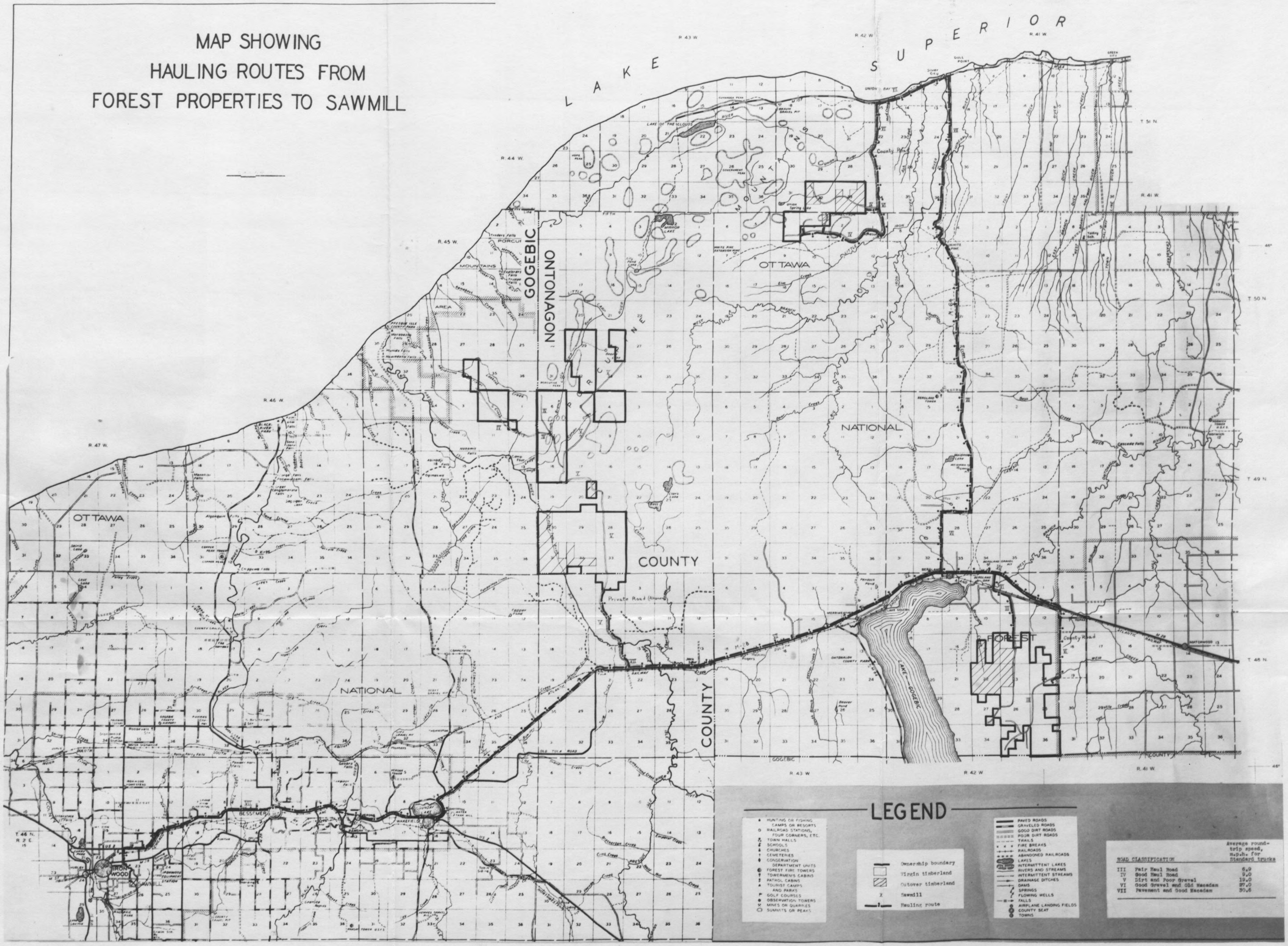
PORCUPINE BLOCK
CLEAR CUT
AHONEN LUMBER COMPANY
IRONWOOD, MICHIGAN
COMPILED BY OZZIE BENDER 1950
SCALE
0 10 20 30 40
CHAINS
R42W
R43W
T51N
T50N
CORRECTION LINE
CUT
1949
1948
11M
12M
8M
32
33
4
3
LEGEND
Company-owned mature virgin timber
Company-owned cut-over land
Company-owned non-productive land
Portions of sections not owned by Company
Present road
Proposed road
Bridge
Logging Camp
Type line
Fence
Swamp, bog, marsh
Stream
Intermittent stream
Ridge, hill
Good stocking
Medium stocking
Poor stocking
A Aspen
WP White Pine
H Hemlock
NH Northern Hardwoods
SF Spruce Fir
BS Black Spruce
WC White Cedar
T Tamarack
SH Swamp Hardwoods
O Open
BR Brush
MK Muskeg
C Cultivated
x Non-productive
a Reproduction
b Saplings
c Poles
d Small sawtimber
e Large sawtimber

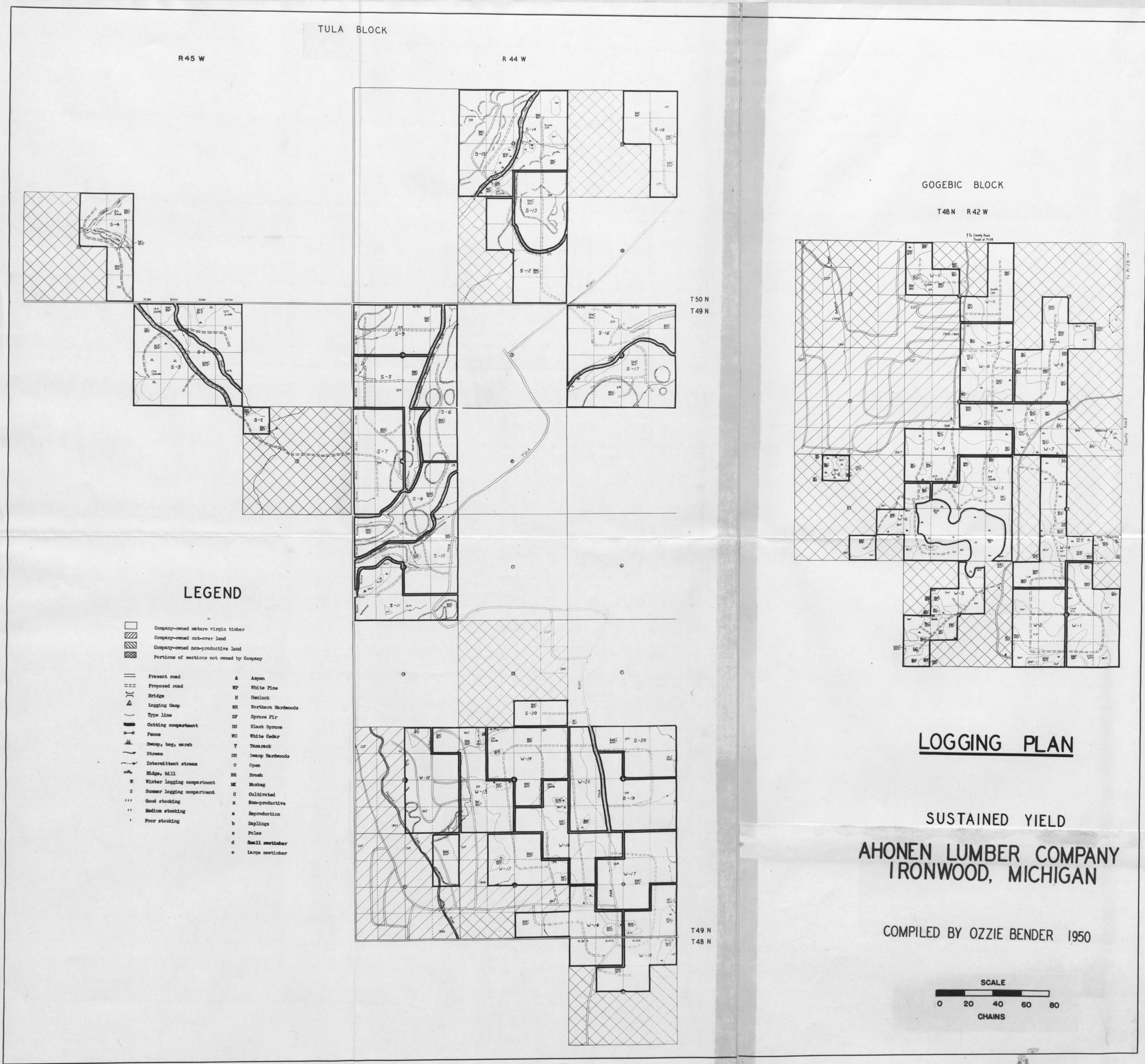

FOREST LAND
AHONEN LUMBER CO.
AUGUST 1949
SCALE IN MILES
0
1
2
T50N
R45W
T50N
R44W
T49N
R45W
T49N
R44W
T48N
R44W
ONTONAGON CO.
GOGEBIC
PRESQUE ISLE COUNTY PARK
PORCUPINE PEAK
Presque Isle River
Explorers Falls
Trappers Falls
Manabezho Falls
Nawadaha Falls
Nokomis Falls
Camp Four
Clark Lake
Bass L.
Copper Pond
Connorville
Jack Spur
TULA
RAILWAY
ATLANTIC
OLD TULA ROAD
THOMASTON
CITY GRAVEL PIT
Planters
M 28
CHICAGO

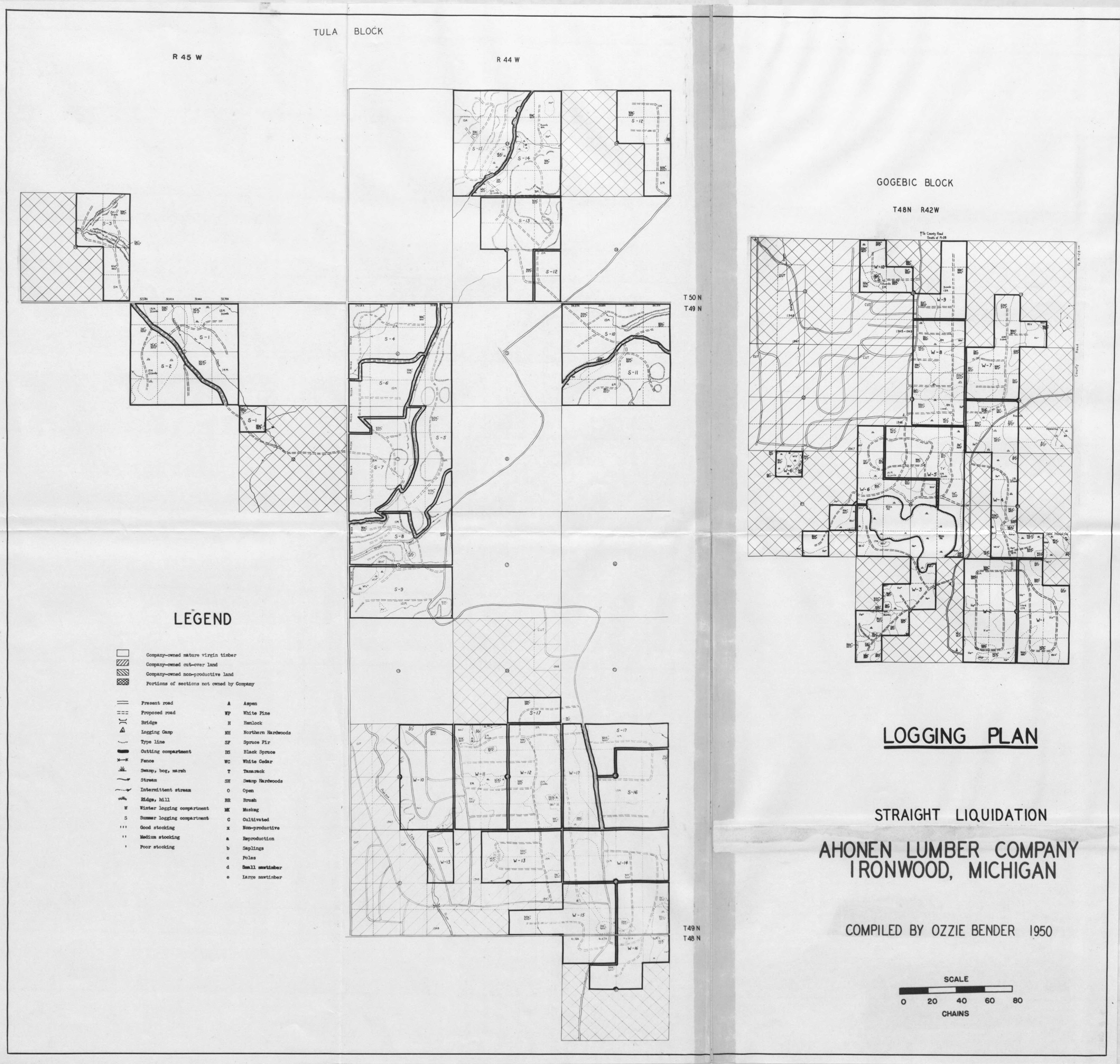

ONTONAGON COUNTY
GULL POINT
Silver City
UNION BAY
CUYAHOGA PEAK
M 107
BRAUM GRAVEL PIT
T51N
R42W
Note:
This tract not
included in survey
GOVERNMENT PEAK
Union Spring Lake
CORRECTION
Nonesuch
WHITE PINE EXTENSION MINE
OTTAWA
WHITE PINE
M 64
T50N
R43W
Union River
Mineral River

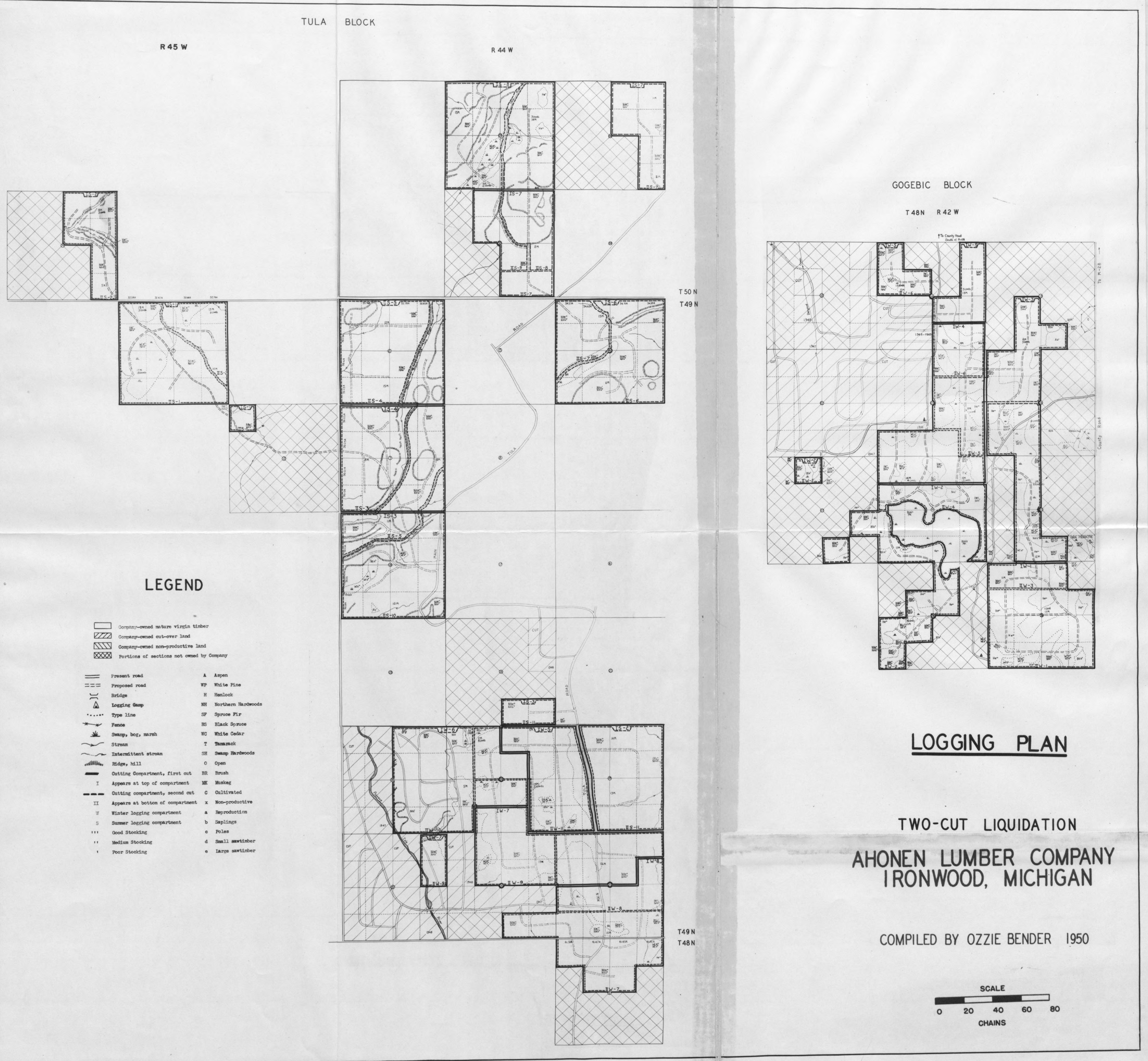

BERGLAND
BERGLAND GRAVEL PIT
BERGLAND DAM
M 28
Pendock Pond
MERRIWEATHER
LAKE GOGEBIC
SHORE
SOUTH
TOPAZ
ONTONAGON COUNTY PARK
FOREST
T48N
R42W
SAMPLE PLOT
LOCATION
MAP
N
45 1/5 acre
plots on
12,320 acre
tract.
ONTONAGON
GOGEBIC
CO.

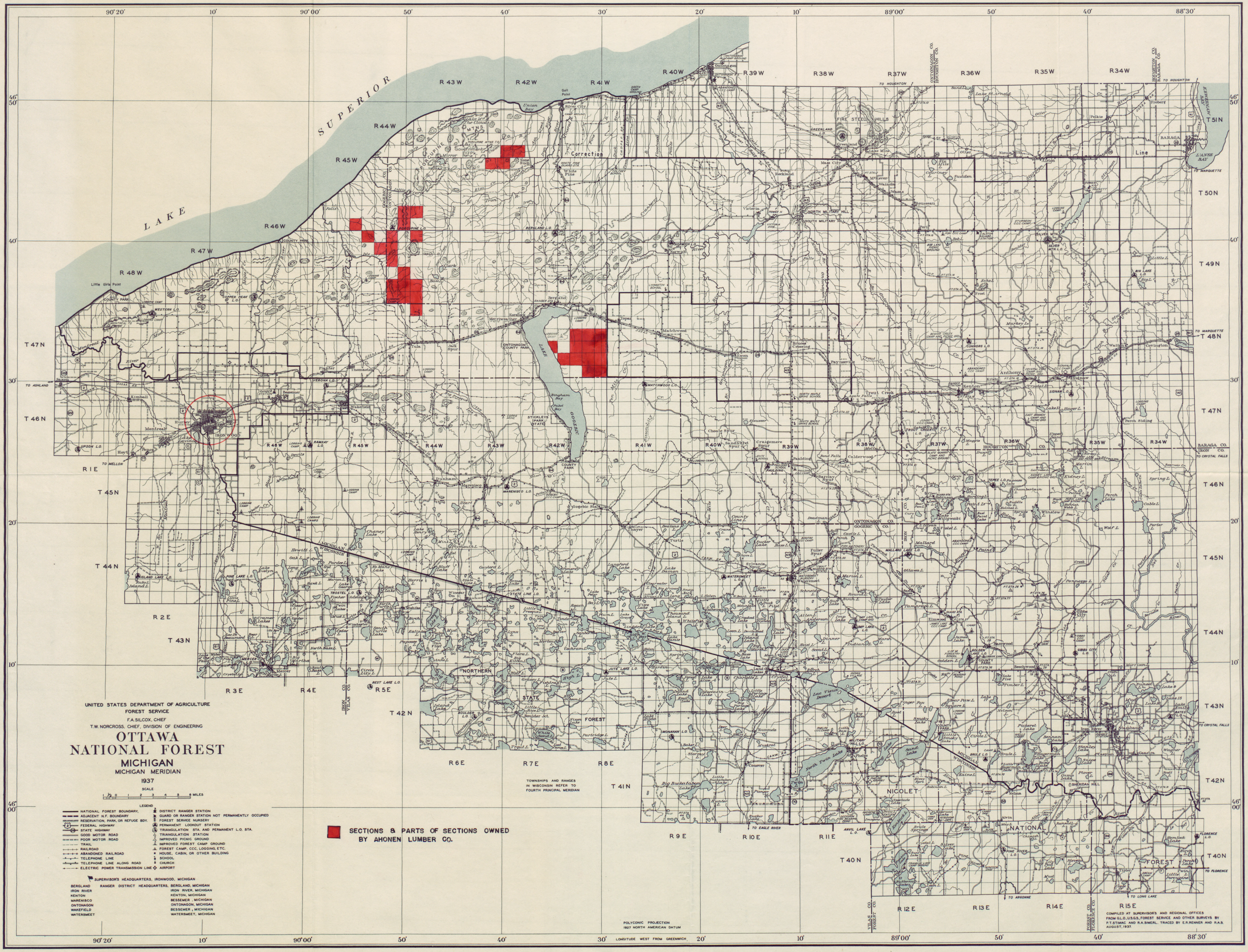
MAP SHOWING HAULING ROUTES FROM FOREST PROPERTIES TO SAWMILL




TULA BLOCK
R45 W
R 44 W
T50 N
T49 N
T49 N
T48 N
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-9
S-10
S-11
S-12
S-13
S-14
S-15
S-16
S-17
S-18
S-19
S-20
W-12
W-13
W-14
W-15
W-16
W-17
W-18
W-19
W-20
TULA
GOGEBIC BLOCK
T48N R42 W
W-1
W-2
W-3
W-4
W-5
W-6
W-7
W-8
W-9
W-10
W-11
LEGEND
Company-owned mature virgin timber
Company-owned cut-over land
Company-owned non-productive land
Portions of sections not owned by Company
Present road
Proposed road
Bridge
Logging Camp
Type line
Cutting compartment
Fence
Swamp, bog, marsh
Stream
Intermittent stream
Ridge, hill
W Winter logging compartment
S Summer logging compartment
Good stocking
Medium stocking
Poor stocking
A Aspen
WP White Pine
H Hemlock
NH Northern Hardwoods
SF Spruce Fir
BS Black Spruce
WC White Cedar
T Tamarack
SH Swamp Hardwoods
O Open
BR Brush
MK Muskeg
C Cultivated
x Non-productive
a Reproduction
b Saplings
c Poles
d Small sawtimber
e Large sawtimber
LOGGING PLAN
SUSTAINED YIELD
AHONEN LUMBER COMPANY
IRONWOOD, MICHIGAN
COMPILED BY OZZIE BENDER 1950
SCALE
0 20 40 60 80
CHAINS


TULA BLOCK
R 45 W
R 44 W
T 50 N
T 49 N
T49 N
T48 N
S-1
S-2
S-3
S-4
S-5
S-6
S-7
S-8
S-9
S-10
S-11
S-12
S-13
S-14
S-15
S-16
S-17
W-10
W-11
W-12
W-13
W-14
W-15
W-16
W-17
GOGEBIC BLOCK
T48N R42W
W-1
W-2
W-3
W-4
W-5
W-6
W-7
W-8
W-9
W-10
CUT
LEGEND
Company-owned mature virgin timber
Company-owned cut-over land
Company-owned non-productive land
Portions of sections not owned by Company
Present road
Proposed road
Bridge
Logging Camp
Type line
Cutting compartment
Fence
Swamp, bog, marsh
Stream
Intermittent stream
Ridge, hill
W Winter logging compartment
S Summer logging compartment
Good stocking
Medium stocking
Poor stocking
A Aspen
WP White Pine
H Hemlock
NH Northern Hardwoods
SF Spruce Fir
BS Black Spruce
WC White Cedar
T Tamarack
SH Swamp Hardwoods
O Open
BR Brush
MK Muskeg
C Cultivated
x Non-productive
a Reproduction
b Saplings
c Poles
d Small sawtimber
e Large sawtimber
LOGGING PLAN
STRAIGHT LIQUIDATION
AHONEN LUMBER COMPANY
IRONWOOD, MICHIGAN
COMPILED BY OZZIE BENDER 1950
SCALE
0 20 40 60 80
CHAINS


TULA BLOCK
R 45 W
R 44 W
T 50 N
T 49 N
T 49 N
T 48 N
GOGEBIC BLOCK
T 48 N R 42 W
LEGEND
Company-owned mature virgin timber
Company-owned cut-over land
Company-owned non-productive land
Portions of sections not owned by Company
Present road
Proposed road
Bridge
Logging Camp
Type line
Fence
Swamp, bog, marsh
Stream
Intermittent stream
Ridge, hill
Cutting Compartment, first cut
I Appears at top of compartment
Cutting compartment, second cut
II Appears at bottom of compartment
W Winter logging compartment
S Summer logging compartment
Good Stocking
Medium Stocking
Poor Stocking
A Aspen
WP White Pine
H Hemlock
NH Northern Hardwoods
SF Spruce Fir
BS Black Spruce
WC White Cedar
T Tamarack
SH Swamp Hardwoods
O Open
BR Brush
MK Muskeg
C Cultivated
x Non-productive
a Reproduction
b Saplings
c Poles
d Small sawtimber
e Large sawtimber
LOGGING PLAN
TWO-CUT LIQUIDATION
AHONEN LUMBER COMPANY
IRONWOOD, MICHIGAN
COMPILED BY OZZIE BENDER 1950
SCALE
0 20 40 60 80
CHAINS



UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
F.A. SILCOX, CHIEF
T.W. NORCROSS, CHIEF, DIVISION OF ENGINEERING
OTTAWA
NATIONAL FOREST
MICHIGAN
MICHIGAN MERIDIAN
1937
SCALE
1 ½ 0 1 2 3 4 5 6 MILES
LEGEND
NATIONAL FOREST BOUNDARY.
ADJACENT N.F. BOUNDARY
RESERVATION, PARK, OR REFUGE BDY.
FEDERAL HIGHWAY
STATE HIGHWAY
GOOD MOTOR ROAD
POOR MOTOR ROAD
TRAIL
RAILROAD
ABANDONED RAILROAD
TELEPHONE LINE
TELEPHONE LINE ALONG ROAD
ELECTRIC POWER TRANSMISSION LINE
DISTRICT RANGER STATION
GUARD OR RANGER STATION NOT PERMANENTLY OCCUPIED
FOREST SERVICE NURSERY
PERMANENT LOOKOUT STATION
TRIANGULATION STA. AND PERMANENT L.O. STA.
TRIANGULATION STATION
IMPROVED PICNIC GROUND
IMPROVED FOREST CAMP GROUND
FOREST CAMP, CCC, LOGGING, ETC.
HOUSE, CABIN, OR OTHER BUILDING
SCHOOL
CHURCH
AIRPORT
SUPERVISOR'S HEADQUARTERS, IRONWOOD, MICHIGAN
BERGLAND RANGER DISTRICT HEADQUARTERS, BERGLAND, MICHIGAN
IRON RIVER IRON RIVER, MICHIGAN
KENTON KENTON, MICHIGAN
MARENISCO BESSEMER, MICHIGAN
ONTONAGON ONTONAGON, MICHIGAN
WAKEFIELD BESSEMER, MICHIGAN
WATERSMEET WATERSMEET, MICHIGAN
SECTIONS & PARTS OF SECTIONS OWNED BY AHONEN LUMBER CO.
TOWNSHIPS AND RANGES IN WISCONSIN REFER TO FOURTH PRINCIPAL MERIDIAN
POLYCONIC PROJECTION
1927 NORTH AMERICAN DATUM
LONGITUDE WEST FROM GREENWICH
COMPILED AT SUPERVISOR'S AND REGIONAL OFFICES FROM G.L.O., U.S.G.S., FOREST SERVICE AND OTHER SURVEYS BY P.T. STIMAC AND R.A. SIMERL. TRACED BY E.R. RENNER AND R.A.S. AUGUST, 1937.
LAKE SUPERIOR