Reconciling Forest Conservation with Forest Liquidation in the United States Region

by

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RECONCILING FOREST CONSERVATION WITH FOREST LIQUIDATION IN THE LAKE STATES REGION

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SYNOPSIS

1. The timber belt of northern Wisconsin and the Upper Peninsula of Michigan still contains about 23 billion board feet of merchantable, old growth hardwood and hemlock timber on an area of approximately 2 million acres.

2. There are a large number of wood-using industries drawing on this timber for raw material; the most important single division, which controls the largest part of the resource, is composed of 48 large lumber companies. The average life remaining to most of these concerns is only 10 or 15 years.

3. The present operating policy of all but four or five of these organizations involves straight clear-cutting of the forest. A number of serious problems follow in the wake of this cutting method. The economic and social results are unemployment, loss of tax base, and community disintegration; the silvicultural results are poorly restocked lands, a serious fire hazard, and postponement of the next forest crop for a very long period.

4. Due to burdensome economic factors, the short life remaining to most units of the industry, and the nature of its capital structure, the pressure for liquidation is so strong that it forces some form of liquidation of timber resources.

5. Previous attempts to substitute better forest management have resulted in only a very small amount of concrete accomplishment. These efforts have centered around the sustained yield principle, which is applicable in only a few cases and which

would involve too costly a readjustment for the majority of these short-lived concerns.

6. Since it is impossible to hope for a complete reversal of current policy in order to maintain many of these forest industries on a permanent basis in the face of these powerful forces working toward liquidation, the most that may be expected is a modified method of liquidation which will stretch out the timber cut of the shorter-lived concerns and leave the lands well restocked with young timber. There is need for a compromise system between destructive liquidation and sustained yield.

7. This can be accomplished by a "Two-Cut" method of liquidation, which involves making an initial partial cutting over a whole tract to be followed after a period by a second final heavy cutting. No change in normal annual cut is necessary, the only change being that liquidation is made in two cuttings instead of one.

8. The principal advantages to be expected from this system are:

a. The operator may grow an additional volume of timber during the liquidating process.

b. Lower depreciation, depletion, and logging costs will result because of a greater volume of larger timber.

c. An increase in quality of the stand due to proper cutting methods will yield timber of high average value.

d. Taxes may be reduced by taking advantage of the Forest Tax laws in both Wisconsin and Michigan.

e. The residual lands after the final heavy cutting will be left in much better condition, containing vigorous reproduction and sound, unmerchantable, small trees capable of producing a crop at a much earlier period than under clear-cutting.

f. Very little fire hazard is left; and no added public expense will be necessary to restore these lands to productivity.

g. This method of operating may be handled with very little readjustment in present business procedure, the only important change, as indicated above, being in woods cutting practices.

9. A case illustration, presented in Part Three and based on an actual operating concern, compares the financial results of straight clear-cutting with that of the "Two-Cut" method of liquidation. The financial advantages claimed for the "Two-Cut" system are developed in some detail.

10. Additional suggestions are set forth in Part Four for putting the "Two-Cut" system into operation for any tract of timber. These are presented as a guide to the operator and his technical man in drawing up a plan of management and putting this system into practical application.

11. Partial cutting as a method of liquidation of forest resources provides a means of leaving well-stocked cutover lands in a thrifty condition. Since a large part of the lumber industry, not only in this region but in others as well, is faced with the necessity of liquidation, partial cutting leading to gradual liquidation appears to offer a practical solution to a previously unsolved problem. The transition from an industry based on old growth forests to one based on young forests will be definitely provided for and the more serious social and economic consequences greatly alleviated.

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THE NATURE AND SCOPE OF THE PROBLEM

The forest problems of the northern Lake States region center around two separate focal points. The first of these is the large area of cutover land, the "New Public Domain," in need of protection and an opportunity to become adequately restocked. A second and equally important problem is that of the proper management of the remaining bodies of old growth timber upon which a large part of the economy of this section still rests. With the recent rapid development of public forest land acquisition, fire protection and program of reforestation, the problem of adequate care of the cutover lands is well started on the road toward solution. However, sound forest management still lags in the remaining bodies of old growth timber which are essential to the maintenance of existing forest industries. Further addition of waste lands to the already too large area will only intensify the present very difficult situation.

During the early days of logging in the Lake States, when white pine was dominant, lumbermen passed by the northern hardwood and hemlock forests, considering them valueless at the time. Today these forests support a large lumber manufacturing industry

which supplies the nation with about one-fourth of its hardwoods. In fact, northern hardwood forests are now even more valuable than the remaining scattered tracts of pine. Consequently, a large part of the existing lumber industry in the Lake States, which was founded in the era of pine exploitation, has been carried over to the present by the northern hardwood and hemlock timber. Minnesota is not considered for it never had very large bodies of high quality northern hardwood timber. The industry is now centered in northern Wisconsin and the Upper Peninsula of Michigan.

These present day lumber and wood-using concerns constitute a large part of the tax base; give a large amount of direct employment and part-time work; and, through wages and company purchases, supply a marked for a considerable volume of produce raised on local farms. Furthermore, an interdependence has been built up around these forest industries, the loss of which will mean further damage to an already shaky economic structure. Since these marginal communities are largely dependent upon their forest resources for existence, their future depends upon the wisdom exercised in handling these natural assets. There is a definite need for a realistic, practical program which will appeal to the timber owners and operators as financially sound and, at the same time, prevent the wholesale destruction of forest resources. It may not be possible to prevent the eventual loss of the present industries, but it is entirely possible to manage the cutting of the remaining bodies of standing timber in such a way as to pro-

long the life of the industry and encourage an early regrowth of valuable forest cover. This study places particular emphasis on this phase of the problem.

PART ONE

THE PRESENT SITUATION IN THE REGION

THE STATUS OF THE FOREST INDUSTRIES AND FOREST RESOURCES

In order to gain a perspective of the situation in the northern Wisconsin and Michigan areas, it is necessary to examine the present condition of this key industry and its raw material supply. The history of the business of lumber manufacture reveals that speculation in increasing stumpage and lumber values has been the impelling motive from the beginning. Few lumber manufacturing concerns were founded solely upon the idea of making a profit through processing raw forest products. The actual production of lumber was more particularly a tool for liquidating stumpage acquired at low cost into money capital. Cheap, abundant timber supplies, adequate water transportation, and a ready market in the developing agricultural Middle West provided a natural setting for an early thriving business.

THE FOREST INDUSTRIES

The manufacture of forest products in the Lake States region has become a somewhat more diversified procedure than it was in its earlier period. Though lumber still constitutes the largest single item of manufacture, many other finished products are turned out which are of great value. Veneers, flooring, railroad ties and woodenware from hardwoods; pulp from hemlock, spruce, balsam fir and other woods; wood alcohol and chemicals from the distillation of hardwood waste; and numerous other minor products are manufactured by the various industries. Although

there are fairly large quantities of jack pine, coniferous swamp timber and aspen in the region, the northern hardwood and hemlock forests are by far the most important to the lumber and miscellaneous wood-using industries.

Recent data compiled by the Forest Service and other agencies[1] reveal that the lumber industry uses about 80% of the total annual sawtimber production from this latter type of forest. Only 12% of this total is used by the paper industry, most of which is hemlock, while the balance of the sawtimber goes into the various miscellaneous industries mentioned previously. Consumption of the different sawtimber species from these northern forests by industries for the year 1936 is shown in Table 1. Pulpwood and Miscellaneous data are only approximations.

TABLE 1. Consumption by Species for 1936 - MBF.

SPECIES	LUMBER*		PULPWOOD		MISCELLANEOUS**		TOTAL		
	Wis.	Mich.	Wis.	Mich.	Wis.	Mich.	Wis.	Mich.	Total
Sugar Maple									
Yellow Birch									
Basswood									
White Pine									
Hemlock									
All Others									
Total									

*Scribner Net Volume **Veneer, Woodenware, etc.

About 90 per cent of the lumber produced in the region is cut by 50 large mills, each cutting between 5 and 50 million feet annually. The potential capacity of these mills is nearly a billion board feet per year, but actual production varies between 400 and 800 million feet, the amount depending upon business conditions. These manufacturing plants are usually located near their source of raw material, whereas the paper mills are often located at some distance, generally with reference to water power facilities. The veneer mills, woodenware plants and others are scattered in location, though usually within reasonable distance of the raw material supply.

THE FOREST RESOURCES

The Forest Survey data on timber areas and volumes[2] reveal several significant facts. Of a total volume of about 19½ billion feet found in the species and forest types in the Upper Peninsula of Michigan, 15½ billion feet are of northern hardwood and hemlock sawtimber. This 15½ billion feet of timber is found in old growth and second growth sawtimber stands on 1,478,000 acres. This area, which carries most of the merchantable timber in the Upper Peninsula, is only one-fourth of the land bearing forest cover. Although the data for Wisconsin have not been made available, much the same trend is apparent. The total merchantable volume in sawtimber stands for northern Wisconsin is estimated at somewhere about 7 billion feet. The greatest part of this volume is hardwood and hemlock, found on a small proportion of the total area

of forest land, in fact on less than one million acres. The accompanying map (Figure 1) shows the location of the larger remaining blocks of old growth timber in the region in 1932. Cutting since then has not changed this situation significantly.

The ownership situation as revealed by preliminary estimates of the Forest Survey shows that the large proportion of merchantable timber is held by relatively few large owners, who control a thousand or more acres each. The ownership of all forest lands, especially cutover lands, is distributed very unevenly among both large and small holdings. Most of the merchantable timber in contiguous blocks is owned by operating lumber companies, although a fairly large share is still controlled by mining concerns and land-holding companies. It is reasonable to expect that most of this timber held by these non-operating concerns will fall into the hands of operating companies as time goes along and these tracts are exploited. Since lumber companies control the very large share of timberland, the forest management problem rests largely upon this industry.

THE FUTURE OF THE LUMBER INDUSTRY

It is usually a risky procedure to forecast for a period as long as twenty years. However, the future of the Lake States lumber mills can be anticipated with a reasonable degree of accuracy. In connection with this study the tributary timber resources by ownerships and the average rate of cutting have been determined for each large mill for a period of 10 years (including the highs and lows of the business cycle), with which infor-

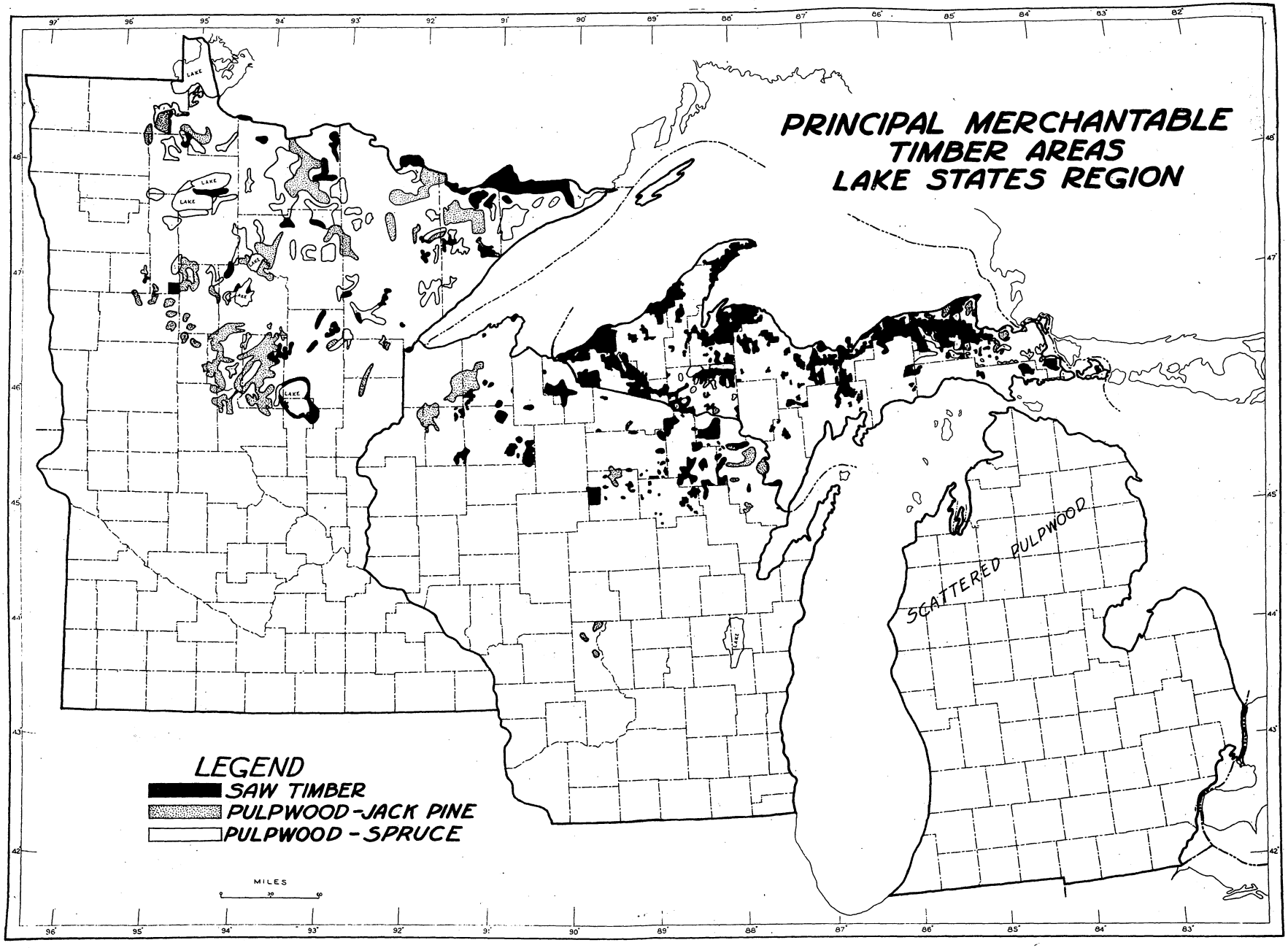

PRINCIPAL MERCHANTABLE
TIMBER AREAS
LAKE STATES REGION
SCATTERED PULPWOOD
LEGEND
SAW TIMBER
PULPWOOD-JACK PINE
PULPWOOD - SPRUCE
MILES
LAKE

FIGURE 1

mation reasonably close predictions of general future trends can be made. Any prolonged period of prosperity or depression would shorten or lengthen the life expectation accordingly. Figure 2 has been developed to present the estimated future of Lake States mills by plotting the average annual production and the total number of operations making up that production for the next twenty years. The gradual exhaustion of timber supplies is shown in the declining annual production and smaller number of mills. This decline is clearly based upon the liquidation of the present forest resources by the clear-cutting process, which is the general practice in the region and leads to ultimate closing of the mills as soon as the resources are exhausted. The decline is modified slightly by second growth stands and scattered patches.

THE CAUSES AND CONSEQUENCES OF THE FOREST POLICY FOLLOWED BY THE INDUSTRY

THE PRESENT FOREST POLICY

Except for a few notable cases, the general practice of the industry in this region is to liquidate standing timber in one clear-cutting. Lumbermen as well as foresters and conservationists have long recognized the great losses created by destructive timber exploitation. Unfortunately, there are so many economic factors which seem to force this method of operation, that many people have become resigned to the ultimate loss of this fine supply of forest growing stock.

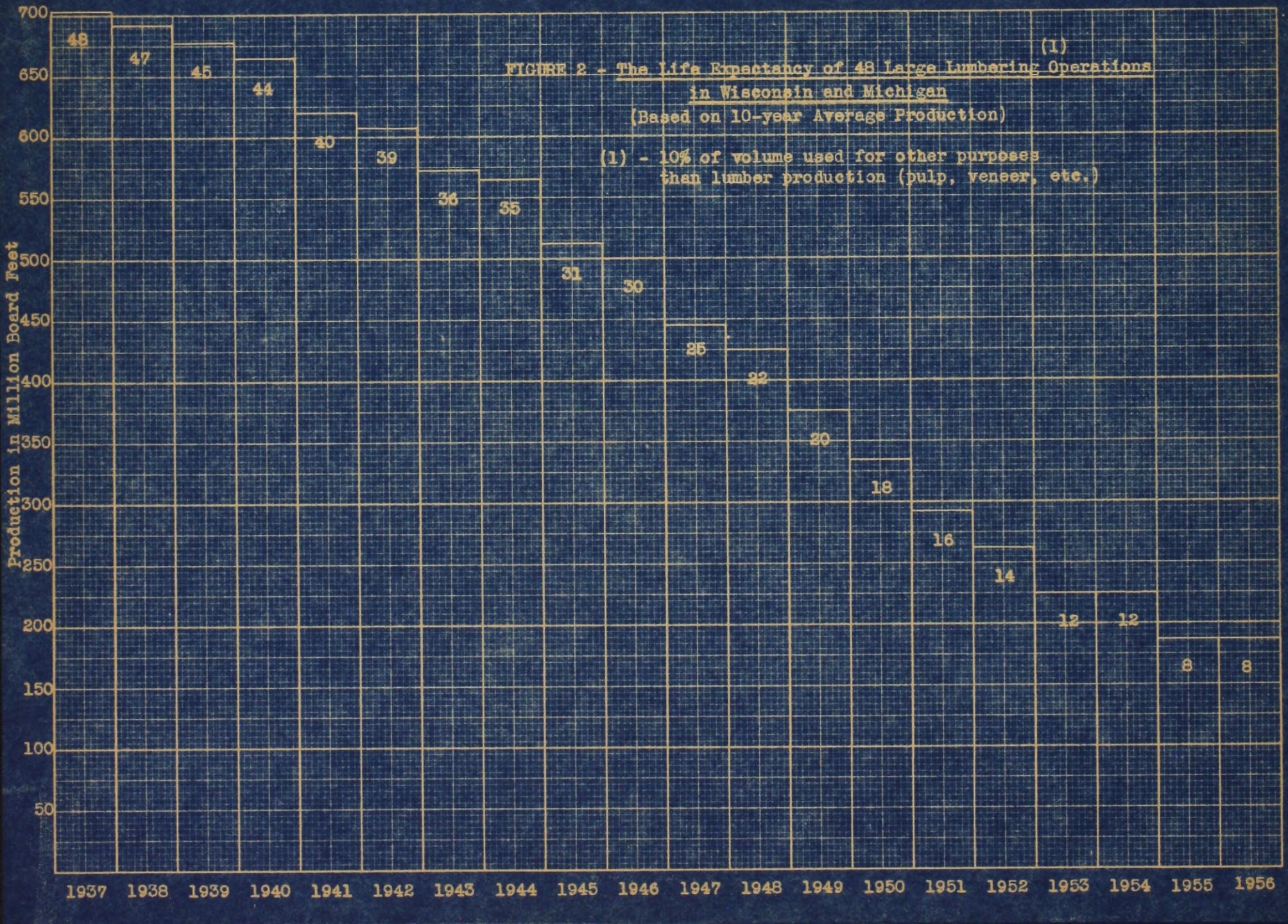


FIGURE 2 - The Life Expectancy of 48 Large Lumbering Operations in Wisconsin and Michigan
(Based on 10-year Average Production)
(1)
(1) - 10% of volume used for other purposes than lumber production (pulp, veneer, etc.)
Production in Million Board Feet
700
650
600
550
500
450
400
350
300
250
200
150
100
50
48
47
45
44
40
39
36
35
31
30
26
22
20
18
16
14
12
12
8
8
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956

It is desirable to focus attention at this point on the disadvantages of the policy of clear-cutting. There are two major types of losses involved in the immediate liquidation of forest values by clear-cutting: silvicultural and economic. The first involves the destruction of forest conditions which have been brought to a delicate balance during generations of natural development. As a result of the sudden removal of all the large trees from the stand, the site conditions, such as ground moisture, exposure to the sun and wind, humidity, transpiration of the young growth, and many others, are radically disturbed. This change occurs so rapidly that most of the small trees and reproduction left after logging are unable to become adapted to the new environment and so gradually die out. Deterioration of the site proceeds rapidly and as a result, in most cases, the ground is soon covered with valueless shrubs and weeds, such as raspberries, elderberry, hazel and fireweed. The area, thus rendered non-productive, constitutes a serious fire hazard for a long period until the slash has rotted down. Since new forest growth in the area is often long delayed, several decades may pass before the establishment of any valuable growth, and even centuries before another merchantable crop may be obtained. Many operators and some foresters believe upon specific evidence that if these clear-cut areas are protected from fire they will come back to good hardwood growth. This is probably true in a few cases, but investigations in connection with this study show that

(1) The period required for re-establishment of young growth is about 15 years.

(2) The resulting stand is very inferior both in quality of trees and species.

(3) Unless there is a heavy growth of advanced reproduction prior to cutting, the resulting stand will be worthless for generations to come.

The point is that clear-cutting, while it has resulted in good second growth in some instances, cannot be depended upon to give favorable results in general.

The losses in economic values are equally serious. As the timber is cut out and the mills cease activity, the communities in which they are located are seriously affected, the supporting prop is pulled and the economic structure comes tumbling down. Cutover lands hold such little promise for future returns that the owners usually cease payment of taxes. The local government thus suffers a loss of revenue as the tax base shrinks. Opportunities for permanent future employment are reduced as clear-cutting proceeds. Relief costs to care for the people left stranded in these communities can only be met through increased taxation. If fire starts on the area, the cost of suppression must be borne by the public, even though the hazard has been created by private action. Usually any attempts to restore the land to productivity must be carried out at public expense, which in turn will result in further tax burdens on private enterprise. Thus the transformation of a great public and private asset into a greater public liability is completed.

FACTORS INFLUENCING FOREST LIQUIDATION

Organizational Aspects of the Lumber Business:

Since the future management of the remaining timber stands rests largely with the lumber industry, an examination of the organizations and their background will provide an understanding of the policy now followed. Most of the larger lumbering concerns in the region are medium-sized corporations with outstanding capital varying from a half million to two or more million dollars. As a general rule, they are incorporated in the states where they are located, though there is a fair sprinkling of "Delaware" corporations. In common with the lumber industry in general, these companies are usually closed corporations. The stock is held by a relatively few individuals or within one family, and there is little or no trading of the common stock through ordinary securities channels.

These lumber organizations have one or more sawmills cutting between 5 and 50 million board feet annually. The plants are reasonably well equipped for manufacturing a good product, although most of the mills are over 10 years old and fairly well depreciated. Only a minority of companies make any attempt to manufacture by-products, such as small dimension and veneer, although some mills have dry kilns and flooring plants. The timber supplies still held are sufficient to last from five to fifteen years in the ordinary operation, and a few larger companies have considerably more, as indicated in Figure 2. Railroad logging still predominates, although trucks are proving to be much cheaper in many

cases. A certain traditional way of doing things still keeps many of the lumbermen from changing to trucks or adopting newer ideas and equipment.

In regard to the question of policy making and control it is significant to note the closeness of ownership and management in this industry in contrast to the set-up of most modern businesses. In many cases the chief stockholders are also executives. Berle and Means(3) in their exhaustive study of modern corporations have shown that, whereas the ownership of large corporations has become widespread, control usually gravitates to a minority without a corresponding increase of social responsibility. Many of the corporate abuses prevalent in larger concerns, where ownership and management are widely separated, are not serious problems with these lumber companies. At the same time, it may be noted that where the executives do not have to answer to a large group of stockholders for results, there is apt to be a lack of progress in some lines. Therefore, these small closed corporations have certain disadvantages as well as advantages. The principal advantage is that the executives are relatively free to act without the "red tape" present in larger corporations, and they represent a healthy type of home ownership, which carries with it a much greater feeling of social responsibility.

Forty-four of the larger concerns in the region have been analyzed and divided into three types of ownership as follows:

Group I	Individual or Family Corporations	17
Group II	Small Groups of Owners	19
Group III	Large Corporations (or their subsidiaries)	8

Although timberland ownership is fairly evenly distributed among these groups, some of the larger corporations control a somewhat greater than proportional share of the remaining timber stands.

This analysis, on the basis of control of ownership, was made specifically to determine which types of companies were following the most progressive forest policies. Strangely enough, almost all the progress toward better forest management has been made by those concerns principally controlled by one individual or family. Although these concerns are apt to be slower in adopting new methods of manufacturing or selling, their timber and business have given them a certain amount of pride and social responsibility. The widely held corporations, which control large areas of timber, have been slower to improve forest management methods. This latter phase may possibly be attributed to the fact that lesser officials, who are responsible for showing good financial results in order to maintain their position, do not want to jeopardize themselves by making any drastic changes which might possibly involve temporary losses or greater costs. On the other hand, the higher executives, who are located away from the scene of operations, have an impersonal viewpoint, with the result that an inertia is built up which is difficult to break down.

Major Factors Causing Clear-Cutting

In recent years it has generally been assumed that the various forms of external pressure force the lumbermen to realize on their timber investment as rapidly as possible. Both the lumbermen and the foresters are in general agreement that the following items constitute strong pressure for clear-cutting.

1. Heavy taxes and carrying charges[4] on large timber assets have in many cases built up a greater money investment than the merchantable value of the timber. Therefore, in order to prevent further losses, it is necessary to cut as rapidly as conditions will permit.

2. Fixed annual charges, such as depreciation, taxes, and interest, require a large volume of business in order to carry them.

3. Pressure from stockholders for dividends force the adoption of policies which will bring in the greatest immediate return.

4. Difficulty of obtaining long-term credit at low interest rates forces short-term commitments with consequent higher charges.

5. Companies in receivership are forced by the desires of the creditors and bondholders to liquidate all the assets held by the company.

6. Present day inheritance taxes are so high as to require large amounts of cash for settlement, a factor which may force liquidation of timber to obtain money for settlement, especially in closely held concerns where stock cannot be easily sold.

These points, being self-explanatory, need little further discussion. It is clear that any company operating under one or a combination of these handicaps is at a disadvantage in any attempt to consider the long-term viewpoint. As a result, the easiest way out has been through the clear-cutting system of

liquidation in the absence of any other alternative.

Other Underlying Causes

In the course of this study an attempt was made to find some of the less obvious reasons for forest liquidation which may be tied up with nature and workings of the economic system. Due to the limitations of time it has been possible to give only minor consideration to these factors, however. In recent years the lumber business has had a reputation among investors of not being very profitable. This industry is forced to make heavy investments in raw material sufficient for many years, which is subject to wide price changes and heavy carrying charges during the holding period. In addition, because of the long drying period for the product, large sums are tied up in inventories which turn over more slowly than in most other businesses. These items affect such operating ratios as the relation of liquid to fixed assets, annual sales to total capital, and annual sales to inventories, so adversely as to put the lumber business in a sluggish position when compared with many other industries. Bankers, investors, and others scan these ratios in an effort to find what industries are making the most money on capital used. Since the lumber industry necessarily ties up large amounts of capital and has not showed very favorable returns in many cases recently, investors have shunned its stocks and bonds, and bankers have been reluctant to make loans. The feeling has been that the large sums invested in timber for long periods are practically frozen.

Modern American business enterprise is essentially based upon a short-term viewpoint in which a high degree of liquidity is paramount. Evidence for this is found in the regard which bankers and businessmen have for "quick" propositions, in the rapid turnover of capital in the "best" businesses, and in the large daily volume turnover in the stock exchange. Next to profitability, liquidity is held at a premium. With the passing of the ownership of industry from many small businesses with individual owners to a few large aggregations of both, liquidity holds an especially favored position. Berle and Means(3) have noted that this tendency has become increasingly pronounced in recent years with the growth in size of business units and their widespread ownership. In fact, they find that liquid equities now represent 40% of American invested capital, whereas in 1912 they were only 20%. The ownership of a share in a business does not carry with it the sense of social responsibility that it once did. Investors speculate with industry ownership and put their money in stocks for purposes of profit only, very much as they would in a horse race. When the earnings of a particular concern slump, stockholders sell out and shift their capital into more profitable channels.

Obviously those interested in the lumber industry are put to a serious disadvantage in this "age of liquidity." Since most lumbering concerns are still comparatively closely held, very few of their stocks are quoted on stock exchanges. Furthermore, no

commodity exchange quotes futures on the product. Lumber investors seeing their money tied up in a less profitable venture than others are faced with the desire to shift their capital in the same manner as other investors but are unable to. The cumulative effect on the stability of forest ownership is clear enough. Liquidity is attained in the only method available: by clear-cutting forest assets. Not only does the desire for liquidity actually encourage instability of ownership, but it is accompanied by a corresponding lack of social responsibility as well. Sound forest management requires stable, long term ownership to be successful, but where the present owners wish to get their money out of timber and invest it in more liquid assets, it does not stand a chance.

RESULTS OF PREVIOUS EFFORTS TO IMPROVE FOREST MANAGEMENT METHODS

REVIEW OF SUGGESTED PROPOSALS

In order to solve this vexing problem of industrial self-destruction and the economic suicide facing so many communities, those most concerned have worked out several proposals centered around the general principle of sustained yield. These proposals have been based very largely on two separate approaches which, if they succeeded, would result in a continuous supply of timber from the same forests and the maintenance of the existing industrial organization.

The first of these proposals was based upon the assumption

that if the external pressure for liquidation were moderated or removed, improved forest practices would automatically follow. This first group of proposals centered around the removal of the inherently unsound features of the tax burden, and aiding those companies by long-term loans which would remove the short-term debts and enable them to plan for a long period ahead. Much progress has been made in both Wisconsin and Michigan in the former phase. Both states have changed their tax laws on certain forest lands to the extent of setting a fixed annual rate per acre plus a yield or income tax on the value of the stumpage whenever it is cut. Unfortunately, it has only been comparatively recently that Wisconsin has allowed the registry of mature timber under a special section of the law. Michigan still does not permit this class of forest land to be entered, although it does allow selectively logged lands to be classified. The results from these tax law changes have not been too successful, especially with respect to the timber owning and operating companies. In regard to the extension of long-term credit to forest industries, so little has been done that it is difficult to judge what effect this might have. Several proposals have been developed for refinancing the forest industries to enable them to adjust their debt structures. Although these might bring some changes, it is questionable whether even so strong an incentive would generally entice the liquidating companies into a better system of forest operation.

The other means by which foresters have sought to bring about proper forest management have been through propounding the financial attractiveness of selective logging methods, leading to the adoption of the sustained yield principle. Logging and milling cost data, developed by the U. S. Forest Service,(5) has shown that direct unit costs are lower under selective logging than under clear-cutting because of the larger average sizes of timber removed. In addition, many other advantages are claimed, such as lower depletion charges due to growth, low depreciation charges, and finally an elimination of road and railroad construction costs after the first cutting cycle had been completed. These numerous plans are built around the assumption that the industry must be geared to the productive capacity of the forests. In other terms, excess mill capacity over and above that needed to manufacture the annual cut from sustained yield forests under selective logging must be retired from production. To do this requires drastic changes in the present scheme of management. The plans for reorganization which have been most generally proposed to bring about improved forest management in the industry are briefly reviewed as follows:

Plan 1 - "Manage each individual operation as a sustained yield unit by restricting the annual cut to the growth of the forests owned at present."

Only a few of the larger outfits could consider

this plan because of the large area of forest property needed. Companies with smaller holdings would be unable to meet fixed charges on the small volume obtained through selective cuttings under sustained yield.

Plan 2 - "Merge two or more companies and retire excessive mill capacity in order to provide an adequate annual cut for one mill under a selective cutting system of sustained yield."

A reasonably possible procedure, but the only incentive would be improved forestry, which has proved to be insufficiently attractive so far. Would require writing off undepreciated plants and involve some loss to the companies. Has been rejected because of the difficulty of getting individual companies to agree on procedure or cooperate in making changes.

Plan 3 - "Continue operations on present volume basis, cutting selectively, and either rearrange operations by reducing cut to growth at the end or sell the residual timber to the government or other operators."

This contains too much of the element of risk in the disposal of the residual timber lands to be attractive to timber owners. Some companies have embarked on this program, but are becoming more uncertain regarding the ultimate disposal of their

selectively cut lands so as to break even at least.

Plan 4 - "Plan for a sustained annual cut at the present volume by buying up additional timber to supply any deficiency."

Requires too great an additional outlay of capital for the average company and is, therefore, financially impractical in most cases. Lack of any concrete examples showing ultimate profitability of this procedure eliminates further consideration. Available timber for acquisition is limited in most cases and insufficient to supply the deficiency.

PROGRESS ACHIEVED TO THE PRESENT

The success in practical application of these proposals has been very limited within the region. Two companies with well balanced holdings have followed the first plan, none the second, three or four have worked sporadically under the third, and none on the fourth. The remaining operators have continued to resist any changes based on the above plans. Although the sustained yield idea when carried out does result in a very low ratio of investment in timber as compared to the industry as it is now organized, it also involves a period of readjustment during which there is apt to be some loss or a need for an additional

financial investment. The following explanations, in addition to those given for liquidation, have been indicated by lumbermen at various times for non-acceptance of the sustained yield principle or even selective logging:

1. Inability of business concerns to obtain long-term credit.
2. Fluctuations in the business cycle tending to discourage very long-term investments.
3. Smallness of timber supply of average company, insufficient to sustain an adequate yield.
4. General belief that logging costs are higher under selective logging in spite of evidence to the contrary.
5. Lack of concrete examples to prove practicability of this method.
6. Resistance to change and fear of trying anything new.

Economists and psychologists who have interested themselves in this problem have developed what is called a "concept of time preference" as a means of explaining short-sighted exploitation of forests without provision for replenishment. As needs are pushed farther and farther into the future, they are appreciated and realized with diminished intensity. It is an attribute of human nature to be impatient for the satisfaction of immediate and near future wants without particular regard for the somewhat distant future. This theory explains to some extent the human equation which has to be reckoned with in the problem. The lack of enthusiasm by many private owners for any really improved

forest management methods is thus explained from this point of view. Apparently where the time element for realizing a profit is pushed farther and farther into the future there is less chance for investment being risked.

Sustained yield proposals have failed principally because of their lack of immediate financial appeal. They have not been sufficiently strong to offset the many unfavorable factors which are the basis of the present liquidation policy. The possible adoption of any of the sustained yield plans practically demands public participation either through loans, purchase of residual timber, or in other ways. The U. S. Forest Service has not been equipped to enter in any but a minor role. Nor have the states been able to assume their full responsibility in this respect, though they have revised tax laws to some extent in favor of forest lands.

All through these proposals, cooperation is necessary with other private owners and public agencies. The very poor accomplishment to date gives very little promise of future progress along the old lines of attack. It is very doubtful whether any new approach to the sustained yield principle can be devised which will appear attractive enough to bring about the desired results. Unfortunately, the time is past for any consideration of sustained yield by the majority of operators because of diminished timber supplies. Furthermore, an inertia has developed which is extremely difficult to overcome. Many people

have concluded that the only answer to the problem is through public regulatory control such as has been followed in Europe, particularly Sweden. In view of the very important social and economic values at stake, it would appear that some such action would be reasonably justified. The recent attempt at regulation of the forest cutting practices during the Lumber Code under the N.R.A. did not accomplish any substantial results. Preliminary to the adoption of a definite set of forest practice rules under Article X of the Code for this region, the Lumber Code Committee on Conservation concluded that cutting had gone on so far as to preclude the general advocacy of sustained yield as a recommended forest management policy of the industry.(6) Although designed to bring about restocking of the cutover lands by leaving a certain number of trees per acre, the Rules of Forest Practice were insufficient either silviculturally or from an economic standpoint. Since the passing of the Code, even these have largely been dropped. In drawing up these rules to begin with, those who formed them were faced with the problem of what requirements would be adequate silviculturally and economically for an industry with about a dozen years of life. The final result was a compromise of silvicultural and economic objectives, neither of which was satisfactory.

The problem still presses for a solution. These remaining forest districts face insolvency unless some action is taken to prevent further loss of tax bases, more unemployment and a long

period of unproductivity between the end of the present industry and the rise of another. Even if public regulation of timber cutting were re-established, it is questionable whether there would be much of an improvement over past experiences unless some better form of forest practice rules were developed.

PART TWO

THE SUGGESTED SOLUTION TO THE PROBLEM

LIQUIDATION THROUGH PARTIAL CUTTING - AN ALTERNATIVE TO CLEAR-CUTTING

BASIC CONSIDERATIONS IN A NEW APPROACH

The situation appears to be at a standstill. The lumbermen and foresters realize the consequences of the present policy, but are on opposite sides of the fence on the vital issue of perpetuating old growth forests. The former group says that sustained yield won't work, and point to their financial problems as evidence. The latter group, pointing to the unquestionably dire economic and social consequences of the present system, says that in some form it must work. An impasse has resulted which demands a compromise, but the unfruitful results of the recent attempt during the N.R.A. are still clear in the minds of many. The Forest Code compromise lacked a really workable plan. Another approach must be developed which is backed up with a well thought through program.

Before attempting to work out a new line of approach, it might be well briefly to call attention to the favorable factors which the private forest owner has in the northern Lake States.

Economic:

1. Comparatively low logging costs because of the absence of steep grades and of high-cost logging equipment.
2. Proximity to large Middle Western agricultural and industrial markets with resulting low freight rates.
3. Forest tax laws providing substantial reductions from general property taxes, especially in Wisconsin.

4. Good outlets for waste and by-products.

5. Opportunity for developing recreational lands for additional income.

Silvicultural:

1. Wide choice of species.

2. Adaptability of stands to known management methods.

3. Improved fire protection system.

4. Favorable growth rate.

5. Large area of land of low value.

6. Comparative freedom from serious insect and disease infestations.

These advantages are real factors in the future of forestry in the region. Just how strong an influence they have on the timber owners in bringing better forest management depends upon how these factors are shaped into a practical program which holds definite financial possibilities.

A re-examination of Figures 1 and 2 reveals some interesting information which will help in understanding just what material there remains to work with. The map on page 8a (Figure 1) shows that there are some very good bodies of timber remaining which are certainly susceptible to some form of management. The chart (Figure 2) indicates three definite groups of companies left in the region on the basis of timber supply and operating life. Of the 48 companies shown on the chart, 18 will be cut out during the next ten-year period, 22 during the period from ten to twenty years, and only 8 will remain beyond the twenty-year period.

The first group of short-lived companies offers very little opportunity for any action short of actual government or state purchase of their timberlands under a cooperative agreement. The eight companies having over twenty years' supply of timber give promise of making progress. Four have started on selective logging programs which may possibly develop into real sustained yield. Several more are contemplating such action, and only two can be considered still uninterested. The middle class of operations is the one of greatest concern. These industries in the aggregate provide the most employment, pay the most taxes, and control the majority of operating timber ownerships. It is this class of companies for which a solution is most needed, but for which little else than government acquisition has been suggested. Certainly there exists a large enough supply of timber to warrant some action even during the liquidating process.

THE "TWO-CUT" SYSTEM OF SELECTIVE LIQUIDATION

A different method of forest management, based upon the principles and limitations set forth in preceding chapters, has been developed to fit the particular conditions which confront so many Lake States operators. Briefly, the plan is for operators with eight to ten (or more) years' supply of timber to change present cutting practice in favor of a "Two-Cut" system. Instead of clear-cutting the timber as the operation progresses, in the "Two-Cut" system the operator would make a fairly heavy

selective cutting over the whole area, removing the normal annual requirements without any restriction of the total annual cut. Growth would accumulate on these partially cut stands during the interval before a final cutting, which would then remove all merchantable timber. The complete process involves two separate logging operations on the same area at intervals determined by the volumes available in the particular instance.

This method of liquidation gives appreciably better results, not only in increased yields of timber, but also in larger average sizes as well. The quality is improved, due to the elimination of the less promising trees in the first cut, so that the growth is concentrated on the thriftier trees. In addition, the small 4, 6, 8 and 10 inch trees not cut in logging would be enabled to adapt themselves to the opening up by expanding their crowns and root systems. A gradual adaptation in two successive cuttings, which removes the overstory, will enable these small trees to survive and take up a large part of the space left by the removal of the merchantable timber. These trees will grow well and produce some merchantable material sometime during the next score or so of years. A last advantage is the stimulation which reproduction will receive under the "Two-Cut" system. Small seedlings on the ground at the time of the first cutting will be given a controlled stimulation, prepared for release, and well able to grow rapidly after the final cut. They will not be as subject to drying out of the soil and intense heat,

nor competition from weeds and shrubs until they have reached a vigorous, thrifty stage of development.

The method is actually based on an old system of forest management used extensively in Europe and modified to fit the Lake States forest conditions. This system, known in forestry terminology as the "Shelterwood", involves two or more cuttings which gradually reduce the forest growing stock during the time necessary for a new forest cover to become well established. Where this has been applied in this country, it has almost entirely been confined to even-aged coniferous forests. However, it has been crudely used, more by chance than by previous planning, in the Lake States northern hardwood and hemlock forests. Several operators,(7 and 8) who dabbled in selective logging eight or more years ago, have recently returned for a second final, heavy cutting. In every one of these cases a thrifty growth of hardwood reproduction of valuable species was found, slash was reduced to a minimum, and the small residual trees left in good condition. The growth on the residual stands after the first cutting had gone forward at a rapidly accelerated pace in volume and quality, and was of sufficient value to cover the carrying charges and leave a reasonable return on the money invested. The silvicultural results to be expected are similar to those shown in diagrammatic form on the following page.

Numerous stands were visited in connection with this study in order to determine the degree of selective cutting which would give the best silvicultural results under the "Two-Cut"

CHANGES IN THE STAND UNDER THE "TWO-CUT" SYSTEM

1. Northern hardwood - hemlock forest marked for first 60% selective cutting under the "Two-Cut" system.

2. Same forest 7 years after first partial cutting and marked for second and final heavy cutting. (Note expanded crowns of small trees and progress of reproduction.)

3. Residual stand 10 years after second heavy cutting. (Note the thrifty condition of the remaining small trees and the rapid advance of the reproduction in the understory.)

system. In order to take care of normal trade requirements, the operator needs a varied assortment of sizes and species similar to those which are obtained from clear-cutting. He must also obtain a sufficient volume from each acre to provide economic operation. The silvicultural requirements demand that enough material be removed to accelerate the growth in the original stand and stimulate reproduction, but that not too much be cut to overexpose the site so that the residual stand will be subject to windthrow and sunscald. Since the basis for the recommended cut is developed in Part Four, it will suffice here to say that a selective cutting which removes approximately 60 per cent of the stand by volume satisfies these requirements reasonably well.

Before considering a change of liquidating methods, the operating concern will be interested to know what economic advantages are held out to them if they undertake this plan. There are numerous financial advantages certain to accrue to any operator who follows this process of liquidating his timber in two operations. The first of these is a definite lowering of taxes on timber as a result of the special forest tax laws in both Wisconsin and Michigan. The next is the obtaining of a greater volume and higher quality of timber than is now available, due to the growth which will accrue in the residual stand. In addition, the life of the operation will be increased in proportion to the volume of growth. This will have the one impor-

tant result that depreciation, depletion, and other fixed charges will be reduced by being spread out over a larger volume for a longer period. Another advantage lies in the higher average of timber quality which will be produced, due to the quality growth in the residual stand following the first cutting. Finally, experience shows that the remaining stand, after the final harvest, would be composed of small trees and hardwood reproduction left in a thrifty condition, well able to become adapted to the final heavy opening. Several other factors which work in favor of this procedure are brought out in subsequent discussion.

A company operating under the "Two-Cut" system would necessarily adopt several minor but important changes. In proceeding under the selective cutting, the normal total annual cut would require logging a larger area because of the reduced acre yield. For example, instead of taking 15 years to clear-cut the particular area discussed in the test case in Part Three, only $7\frac{1}{2}$ years would be spent if the operators were on the selective basis. At the end of this first cutting period the whole area would be cut again, and all the merchantable trees taken in this last cut until the operation was completed.

The advantage of this system to the company from a purely operating standpoint is that it is able to institute this new plan entirely within the present organization with very little additional outside aid or internal disturbance. No change in

production schedules is necessary, nor are any changes needed in capital structure. Only a minimum of technical supervision is required, since no long-range planning is contemplated. The operator is enabled to maintain his regular bookkeeping methods with only minor revisions. Only in actual woods cutting practice is there a major difference. The positive advantages that will result from this modified liquidation system should easily offset any inconveniences arising.

At this point a summary of the advantages under a "Two-Cut" system is necessary to bring together all the points in favor of it. They are listed and classified as follows:

Financial Advantages to Operators -

1. A greater total volume of timber may be obtained over the life of the operation from the same area of forest land.

2. A higher average quality of timber with greater volume will be produced.

3. Direct logging and milling costs will be decreased because of the larger average size of logs cut.

4. Depreciation charges will be reduced because of the longer operating period and higher value over which they are spread.

5. Depletion charges per M will be substantially reduced.

6. Taxes on timberland may be reduced if advantage is taken of the forest tax laws.

7. A more rapid coverage of the area will enable the operator to salvage much material which has died in the past few years (especially hemlock) or which may die or be windthrown.

8. A greater selectivity of material to be cut will result from the rapid extension of roads; therefore better advantage may be taken of special markets.

9. A larger total income will be received and the stockholders receive their dividends over a longer period.

10. Company officers will be employed for longer period.

11. Timber investment will increase in value and offset carrying charges against it.

Silvicultural Advantages -

1. The first selective cutting will enable the residual stand to put on thrifty growth and be better prepared to adapt itself to the final heavy cutting.

2. This first cutting will also stimulate reproduction to take over the site, as well as encourage new reproduction.

3. There will be less chance for breakage of the small trees because of two lighter cuttings instead of one heavy cut.

4. The fire hazard will be reduced because the slash from the first cut will have almost completely rotted down by the time the second cut will be made. A thrifty growth of young hardwoods covering the area will also lessen the chances for fire.

5. The hiatus or waiting period for the establishment of a new forest will be reduced or eliminated.

6. Trees dying between first and second cuts can be salvaged because of the short period between cuttings.

7. Residual trees after first cutting tend to become more windfirm, so that the next opening up will find them less subject to windthrow.

General Social and Economic Advantages -

1. The average life of the industry will be increased several years and the severity of the decline reduced with a corresponding lengthening out of employment.

2. The thrifty residual growth present on the ground after a "Two-Cut" liquidation should produce a small marketable crop of timber in twenty years, and thus contribute an economic value much earlier than would be possible on destructively cut-over lands.

3. The way will be opened for federal or state acquisition of these selectively logged lands before the second cut; an important factor which may be the strongest argument for adopting this policy.

4. Even if these lands become tax delinquent, they will continue to be a definite asset and able to contribute something of economic value in a short time.

5. No expense will be necessary to rehabilitate these lands.

In order that a complete illustration may be presented, clarification, as well as development, of some of these points is needed. This is best done by the practical example which is developed in the test case in Part Three, to which the reader is referred for more detailed information.

In connection with the "Two-Cut" system, several objections have been raised which it might be well to meet at this point. It has been contended that the regrowth coming in after the first cutting will prohibit economic logging. Experience shows, however, that not until a decade or more has passed will this be serious and even then not serious enough to prove an obstacle to a tractor. Another aspect of the problem of partial cutting is the contention of Watson(8) that water sprouts will reduce quality of residual yellow birch after a partial cutting. This may be true to some extent on areas which have been heavily cut,

but is not serious under the "Two-Cut" method. Since these sprouts generally occur at the top of the tree they affect only the top log, which is generally of low grade anyway. Furthermore, 5 or 10 years' growth of sprouts will only affect the outer portion of the log which will be slabbed off. Some lumbermen have also raised the objection that windfall and mortality in selectively cut stands is a serious obstacle. Experience in this method of cutting, however, indicates that the losses in mortality are less than in virgin stands.(9) Even where these partially cut stands contain a large proportion of hemlock, losses in the serious drouth years have been noticeably reduced.

PART THREE

COMPARATIVE CASE ANALYSIS
OF TWO METHODS OF FOREST LIQUIDATION

Clear-Cutting vs. "Two-Cut" System

SUMMARY OF OPERATING RESULTS UNDER THE TWO METHODS

In order to demonstrate the financial practicability of the "Two-Cut" system of liquidation as opposed to the straight clear-cutting method, a typical lumber company in the region has been singled out for a test case. Part Three deals in considerable detail with the changes in operating methods which this concern would make if it should undertake the liquidation process in two cuttings instead of one. The company chosen here is located in the middle group of operations whose timber is sufficient for ten to twenty years' cut. Financial data are based primarily on this concern's financial setup, but have been modified so as not to disclose confidential material. Some changes also were made where these data were out of line with regional averages in certain items. At the outset it may be well to state that this is a case analysis of a concern in relatively good financial condition with about average production costs and a good grade of timber. Recognition must be made of the fact that many concerns are not as well situated and would show very different results. Nevertheless, the basic relationships and comparisons brought out in this case will hold true for every concern in the region. If anyone wishes to make comparisons with specific companies, it will be well for him to keep in mind that the whole issue is not one of comparative costs of this company with that company, but rather what basic advantages

are gained if any company adopts the "Two-Cut" system.

The results of the detailed case analysis have been summarized for rapid inspection in the following presentation. Timberland owners who do not have sawmills in connection with their operations will find many of these conclusions applicable to their situations, while some will not be at all applicable. If this fact is kept in mind a fair comparison may still be made.

PRELIMINARY INFORMATION ON CASE OPERATION

Description of Operation

Merchantable Timberlands - 21,320 acres

Total Volume of Timber Owned and Controlled - 193,800 M board feet.

Volume of Timber per Acre - 9,083 board feet (net) Scribner rule.

Proportion of Species (by volume) -

Hemlock	40%
Sugar Maple	34%
Yellow Birch	14%
Basswood	8%
Others (Beech, Red Maple, etc.)	4%
	100%

Expected Average Annual Cut - 15 million board feet (log scale) or 17,750 million (mill scale) in a double band mill with a full capacity of about 25 million.

Proposed Method of Operation

Straight Clear-Cutting - If this procedure is followed, the company will continue to cut all merchantable timber over 10 inches in diameter, taking ties out of the small trees. One thousand six hundred and fifty acres would have to be cut each year to yield the needed volume. Railroad logging is generally used except on scattered parcels where trucks or sleighs are employed. The operation would be discontinued in 13 years.

Two-Cut System - Under this plan of operation, the same annual cut would be obtained (15,000 MBF), but a selective cutting of 60 per cent of the volume or an average of 5,450 board feet per acre would be taken. The period necessary to cover this whole area selectively would be only 7.8 years at the rate of 2,650 acres per year. An average residual volume of 3,633 board feet per acre would be left on the ground, which would increase through growth to 4,853 board feet. The second cutting would then yield about 4,900 board feet per acre because an estimated 50 board feet of dead material could be salvaged. This would be enough to maintain the operation for 7 more years and would necessitate the cutting of 3,060 acres annually. No change in logging methods or equipment other than that mentioned is involved in making these calculations.

COMPARISON OF FINANCIAL AND OPERATING RESULTS - CASE OPERATION

ITEM OF COMPARISON	METHOD OF CUTTING: Straight Clear-Cutting	METHOD OF CUTTING: Two-Cut Selective Liquidation
Total Volume Available	193,600 MBF	193,600 MBF - Orig.Vol. 27,100 MBF - Growth 7 yrs. 220,700 MBF - Total
Number of Years of Operating Life	12.9 Yrs.	7.8 Yrs.-1st Cycle 7.0 Yrs.-2nd Cycle 14.8 Yrs.-Total
Total Volume per Acre (Net, Scribner Scale)	9,083 BF	5,450 BF - 1st Cycle 4,853 BF - 2nd Cycle 10,303 BF - Total
Net Realization(1) per Acre	$ 83.79	$ 65.63 - 1st Cycle 35.24 - 2nd Cycle $100.87 - Total
Dry Lumber Value per Acre	$313.29	$190.16 - 1st Cycle 164.61 - 2nd Cycle $354.77 - Total
Cost of Production per MBF	$ 21.30	$ 20.78 - Aver.Both Cycles
Average Depletion Charge per MBF	$ 4.40	$ 3.86
Total Taxes Paid on Timberlands for Life of Operation -		
Wisconsin at 70¢ / A.	$ 121,777.00	$ 101,063.50
Michigan at 60¢ / A.	$ 106,994.00	$ 98,728.00
Predicted Future Annual Incomes(2) (excluding depletion)	$ 138,250.00	$ 180,000.00 - 1st Cycle $ 107,000.00 - 2nd Cycle
Total Net Incomes for Life of Operation(2) (excluding depletion)	$ 1,786,400.00	$ 2,150,550.00
Present Worth of Operation at 5%(2) (including depletion)	$ 1,918.757.38	$ 2,189,608.48

(1) Before taxes on timberlands have been deducted.

(2) Before timber taxes and income taxes, ranging around $30,000 per year, have been deducted.

DETAILED CASE ANALYSIS OF THE TWO SYSTEMS

GENERAL INTRODUCTORY DATA

The summary has presented the salient features of the comparative analysis. However, some of the preliminary information needs expansion before the detailed study will be understandable. The company chosen for the case study is one which has been in business for over 20 years and is representative of the group of companies mentioned in previous discussion, both in type of ownership and investment. As it happens, this concern has an investment in a town, although it is no longer a purely "company" town. This concern is the principal supplier of employment and local revenue, over 200 men being dependent upon it for woods and mill employment. Annual company pay rolls of about $200,000 are paid out. A struggling agricultural settlement has been built up in the vicinity which is maintained principally by selling hay, potatoes, etc., to the company camps, milk to a small cheese factory, and garden stuffs to the recently developing tourist and resort trade.

The company itself has been a reasonably successful venture for its owners. It has paid out in dividends an amount equivalent to the original capital investment of $1,200,000, or about a 5 per cent return during the 20 odd years of operation. Although this concern has been in debt to some extent during the past, it is now in good financial condition and has a fair surplus. Since 1933 it has been able to pay up some timber mort-

gages and make up most of its depression losses.

During the past ten years which have included both extremes in the business cycle the company has produced an average yearly cut of about 18,000 million feet of lumber mill scale or 15 million feet log scale. The mill is a double band, capable of producing from 25 to 30 million feet annually. It is generally run about 10 months in the year and shut down during bad logging weather when repairs are made.

The timber owned by the company, except for some small parcels close by, is in a fairly solid block about 16 miles from the mill by rail. This timber, the last of several large bodies which the company blocked up during an earlier period of expansion, is now the only stand of consequence in the vicinity. The present plans are to clear-cut this timber by railroad logging and wind up the operation on the small block near the mill. The owners are all businessmen who, in various capacities, have been connected with timber for many years.

Pertinent information needed to provide a basis for a complete management plan is discussed in Part Four. The information necessary for this case analysis is presented in tabular form as follows:

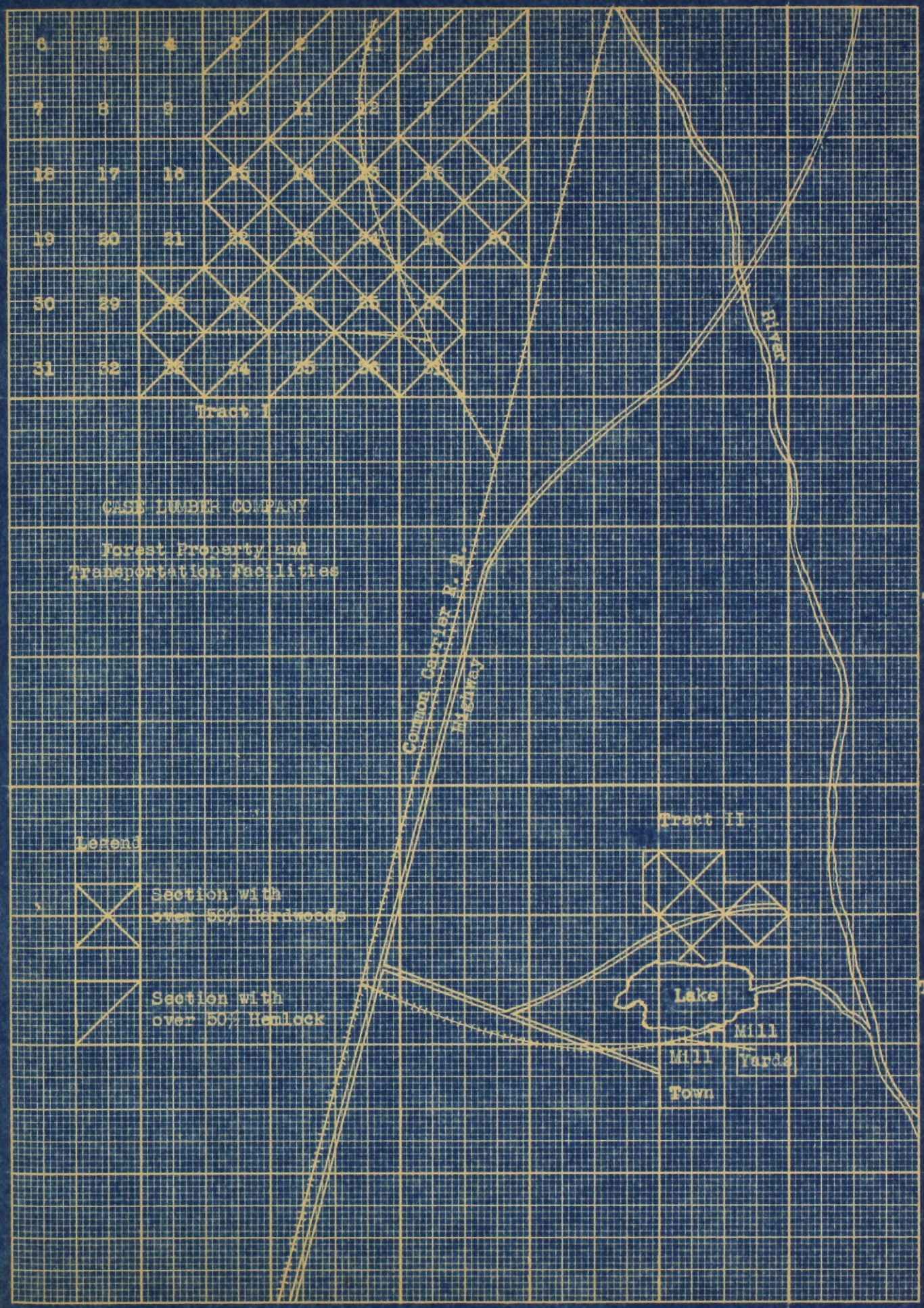
Table II - Volumes and Areas of Timber Owned.
(See also Table A, page 98 in Appendix)

Figure 3 - Map Showing Physical Layout of Company Property.

Table III - Consolidated Balance Sheet of Company as of Latest Year of Operation.

TABLE II - Volumes and Areas of Timber Owned

TRACT	ACREAGE	VOLUME
I	19,200	172,800 M Bd. Ft.
II	2,120	21,000 M Bd. Ft.
Total	21,320	193,800 M Bd. Ft.


R11W
R10W
T42 N
T41N
T40N
Tract I
CASE LUMBER COMPANY
Forest Property and
Transportation Facilities
Copper Carrier R. R.
Railway
River
Tract II
Legend
Section with
over 50% Hardwoods
Section with
over 50% Hemlock
Lake
Mill
Mill
Yards
Town

- Figure 5 -

TABLE III

Balance Sheet for "X" Lumber Company

December 31, 1937

ASSETS			
Fixed			
Plant, Machinery, Town and Logging Investments -	$ 600,000		
Less: 5% Salvage -	30,000		
Net before Depreciation -	$ 570,000		
Less: Reserves for Depreciation -	305,000		
Net after Depreciation -		$ 265,000	
Land and Timber, 193,600 M B.F. - (Net of Depletion)		851,840	
Total Fixed Assets -		$1,116,840	
Current			
Cash -	$ 50,000		
Securities -	3,000		
Receivables -	125,000		
Inventories -	300,000		
Total Current Assets -		$ 478,000	
Total Assets -			$1,594,840
LIABILITIES			
Fixed			
Capital Stock (1,200 shares at $100) -	$1,200,000		
Profit and Loss Surplus -	254,840		
Total Fixed Liabilities -		$1,454,840	
Current			
Notes Payable -	$ 60,000		
Accounts Unpaid -	80,000		
Total Current Liabilities -		$ 140,000	
Total Liabilities -			$1,594,840

DESCRIPTION OF OPERATING METHODS

The brief description of the two operating procedures included in the Summary is complete enough so that little further discussion is necessary. The straight clear-cutting plan, with annual cut of 15 million feet log scale, results in completing the operation in 12.9 years. The "Two-Cut" plan provides the same volume each year and prolongs the operation to 14.8 years, divided into two approximately even cutting cycles. Planning the operation for two cuts, seven years apart, requires some revision of procedure in the layout of transportation lines, planning of cutting areas, control over cutting methods, and other comparatively minor but necessary items. Much of this is taken up in Part Four with reference to general application to any operation. In order that the comparison between the present clear-cutting methods and the proposed method of operation may be made as close as possible, none of the changes designed primarily for greater efficiency have been included in these calculations. Part Four, however, presents for consideration the potentialities of some of the possible operating improvements.

TIMBER YIELDS IN VOLUME

The first question likely to arise concerns the difference in total yields obtained over the life of the operation under each cutting system. If it is assumed that the stand table shown in Table IV following and Table A in the Appendix represents the average volume available per acre, it is reasonable to expect that the company will obtain the full volume under clear-cutting if it should cut everything 10 inches and over. Under the "Two-Cut" system a 60 per cent cut by volume is recommended, which, during the first cutting cycle, would yield 5,450 board feet per acre secured from 20 of the 61 trees. In the following section under "Regulation of the Cut" it is determined that 7.8 years would be necessary to complete this first partial cutting period or cutting cycle over the whole 21,320 acres. After this has been completed, 7 more years would be required to finish the operation. The residual stand of 3,630 board feet left on the average acre after the first cut would be composed of 41 small trees, and would grow to 4,850 board feet in the 7-year interval, adding on 1,220 board feet at the rate of 175 board feet per year. By the addition of 10 small trees in the merchantable 10-inch class, the total number is raised to 51. Figures 3 and 4, which show this data in graphic form, are derived from Tables B, C and D in the Appendix (pages 99, 100, 101) The per acre volume available over 10 inches during the second cut would be 4,850 board feet, a figure derived from net growth

TABLE IV - Average Acre of Northern Hardwood - Hemlock Timber
Showing Volume to be Removed in First Partial Cutting under the "Two-Cut" System.

D.B.H. (2-in. classes)	No. of Trees	Basal Area in sq. ft.	Net Volume in bd. ft. (Scribner)	Volume to Cut(1)		Volume to Leave	
				Per cent	Board feet	Per cent	Board feet
2 - 8							
10	13.00	7.08	220.1	11.0	25.0	89.0	195.1
12	11.32	8.90	558.8	13.5	75.0	86.5	483.8
14	9.80	9.86	831.8	18.0	150.0	82.0	681.8
16	7.51	10.50	1,004.0	23.0	240.0	77.0	764.0
18	6.41	11.32	1,212.9	41.0	500.0	59.0	712.9
20	4.71	9.58	1,210.4	58.0	700.0	42.0	510.4
22	3.16	8.35	1,085.1	73.0	800.0	27.0	285.1
24	2.27	7.14	988.3	100.0	988.3	0.0	0.0
26	1.21	4.45	670.0	100.0	670.0	0.0	0.0
28	0.76	3.24	493.9	100.0	493.9	0.0	0.0
30+	0.98	4.80	807.9	100.0	807.9	0.0	0.0
Total (over 10")	61.13	85.22	9,083.2	60.0	5,450.1	40.0	3,633.1

(1) Summarized from Tables A, B, and C in the Appendix.

calculations with mortality allowed for. It is reasonable to expect that some of the trees which have died in the short interval between cuttings will be sound and in condition to be salvaged. A conservative estimate would be that at least 50 board feet per acre could be salvaged and the total volume available increased to 4,900 board feet.

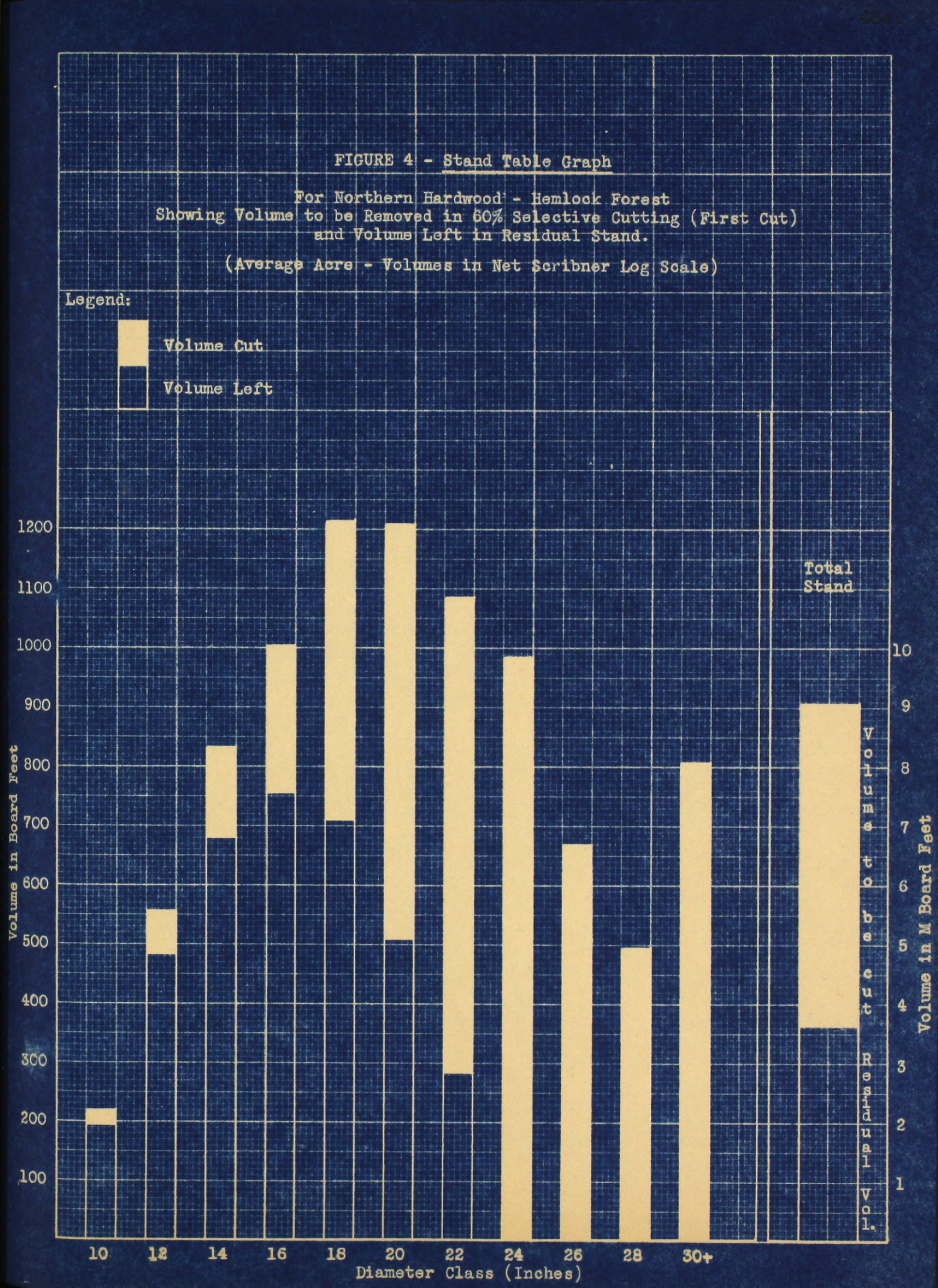
The volume available over the whole life of the operation if clear-cutting is followed will be 193,600 board feet, since no growth can be assumed in the virgin stand. Under the "Two-Cut" plan, 220,700 board feet will be available; an additional 27,100 M board feet, or enough to continue the operation almost two years longer at the rate of 15,000 M per year. Many lumbermen and others who have doubted the ability of these northern species to grow rapidly may be sceptical. The determining factor in this case is the acceleration which takes place in the residual stand after partial cutting. This is the factor which is responsible for the remarkable growth rate of 175 board feet per year net volume.

Examination of Figure 4 reveals the way in which the stand is marked for the first selective cutting. All trees over 22 inches in diameter are removed, together with those trees below 22 inches which give the least promise of rapid future growth. A fairly large volume is left in the 18, 20 and 22-inch classes of good thrifty timber, not only to put on high quality growth, but also to provide wide boards from the second cutting. In 7

FIGURE 4 - Stand Table Graph

For Northern Hardwood - Hemlock Forest
Showing Volume to be Removed in 60% Selective Cutting (First Cut)
and Volume Left in Residual Stand.

(Average Acre - Volumes in Net Scribner Log Scale)



years the volume would be distributed by diameter classes in the order shown in Figure 5, page 49a. Presumably, all this material would be harvested unless the operator should plan to leave some of the smaller trees. The progress of reproduction may be noted in Tables B and C in the Appendix on pages

The methods followed to obtain these growth figures were based upon previous very intensive studies(7), (9), (10) in the region.* Growth data from stands of about the same degree of cutting for each species were applied to the trees in the residual stand and then corrected for mortality. This new figure coincides almost exactly with recent results published by Eyre from stands in the Northern Peninsula of Michigan, where the same type of cutting was followed.

REGULATION OF THE CUT BY AREA

The problem of accurately determining in advance the future annual cut of any particular operation is an impossibility because of the ever-changing course of business cycles. It is reasonable to assume, however, that an operation with a mill of definite capacity will attempt to utilize the maximum of this capacity which can be economically operated. In this case, company officials estimate that they will be able to cut an average of about 15 million feet log scale or 17,750 feet mill scale (18.5% overrun) during the remainder of its operating life. If

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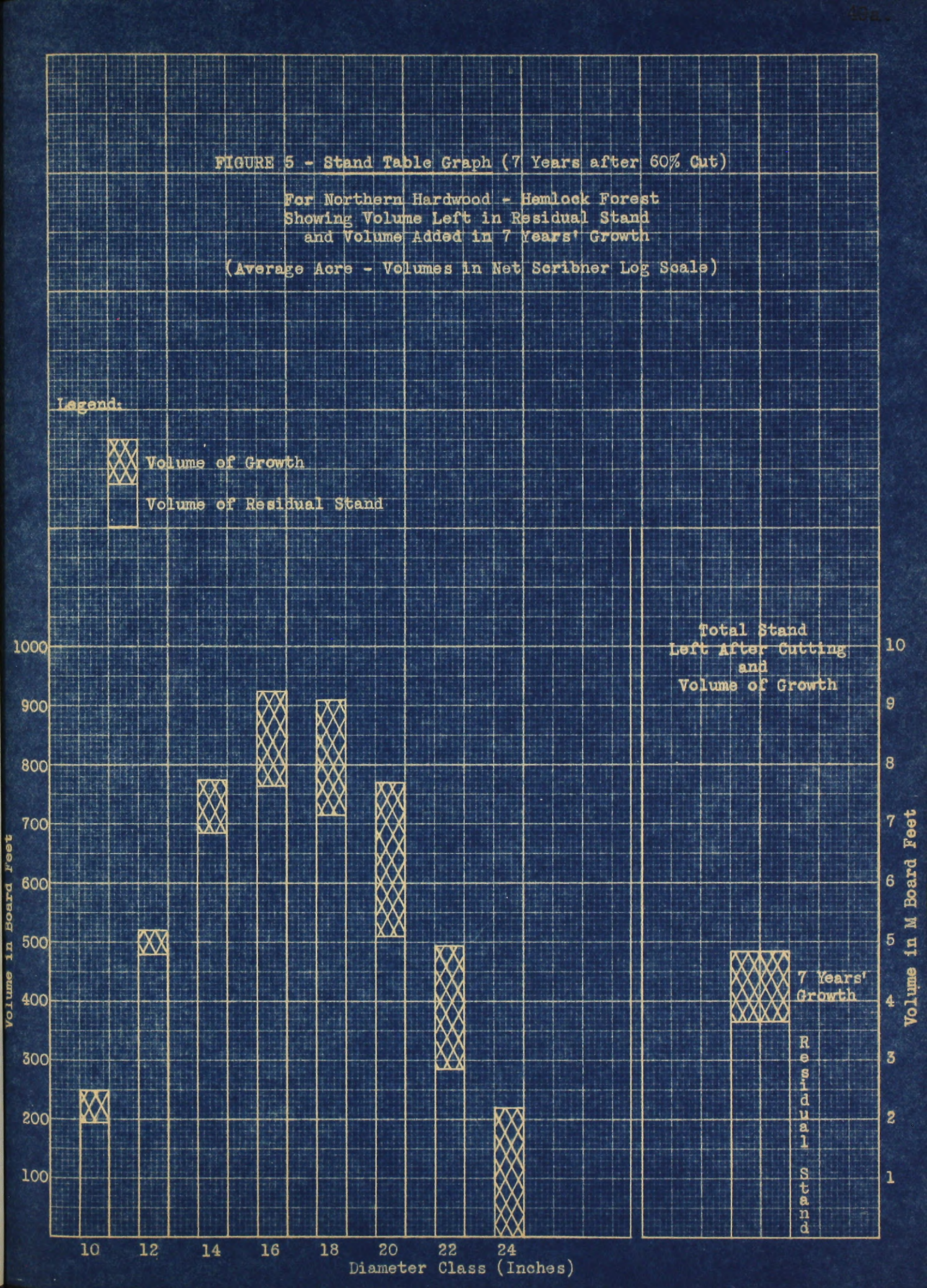
*Much of the credit for the work in developing these growth data is due to William E. Duerr of the Lake States Forest Experiment Station.

FIGURE 5 - Stand Table Graph (7 Years after 60% Cut)

For Northern Hardwood - Hemlock Forest
Showing Volume Left in Residual Stand
and Volume Added in 7 Years' Growth

(Average Acre - Volumes in Net Scribner Log Scale)



straight clear-cutting is followed, Table V, page 50a, shows that an area of 1,650 acres will be cut each year. Under a "Two-Cut" liquidating plan, 2,750 acres would be cut each year for the first cutting cycle of 7.8 years, and in the final cycle an area of 3,060 acres would have to be cut annually to yield 15 million feet. These cutting schedules are developed in detail in Table V.

Several things must be borne in mind when a cutting schedule under the "Two-Cut" system is drawn up. Under practical business conditions it must be flexible enough so that it can be revised from time to time. Fluctuations in the rate of cutting caused by changes in production, due to the business cycle, would have either one of two effects. If business were particularly good for a period of a few years at the beginning of the first cut, the area would be covered more rapidly. A decline during the second cut would cause the operation to be stretched out. The opposite set of conditions would have an opposite effect. Inasmuch as these changes cannot be predicted with any degree of reliability, the best alternative is to set the production rate high enough to take care of these possibilities. Under actual conditions there will be considerable variation in the volumes of different timber stands which will affect operating plans. For example, an operator should plan his operation in such a way as to cut over the older mature stands first and reserve the young stands until the latter part of the cycle. The heavier

TABLE V - Tentative Cutting Budgets
under Two Methods of Liquidation on Case Operation
Assuming an Annual Cut of 15MM per Year(1)

"TWO-CUT" METHOD					STRAIGHT CLEAR-CUTTING			
Year	Area to be Cut Annually		Volume Cut/A. Bd.Ft.	Total Vol. Removed Annually Log Sc. M Bd.Ft.	Year	Acreage to be Cut Annually	Volume Cut/A. Bd.Ft.	Total Vol. Removed Annually Log Sc. M Bd.Ft.
	First Cycle	Second Cycle						
1939	2,750		5,450	15,000	1939	1,650	9,083	15,000
1940	2,750		5,450	15,000	1940	1,650	9,083	15,000
1941	2,750		5,450	15,000	1941	1,650	9,083	15,000
1942	2,750		5,450	15,000	1942	1,650	9,083	15,000
1943	2,750		5,450	15,000	1943	1,650	9,083	15,000
1944	2,750		5,450	15,000	1944	1,650	9,083	15,000
1945	2,750		5,450	15,000	1945	1,650	9,083	15,000
1946	2,070	5,450	5,450	11,200	1946	1,650	9,083	15,000
1946		775	4,900(2)	3,800	--	-	-	-
1947		3,060	4,900	15,000	1947	1,650	9,083	15,000
1948		3,060	4,900	15,000	1948	1,650	9,083	15,000
1949		3,060	4,900	15,000	1949	1,650	9,083	15,000
1950		3,060	4,900	15,000	1950	1,650	9,083	15,000
1951		3,060	4,900	15,000	1951	1,520	9,083	13,800
1952		3,060	4,900	15,000	1952	-	-	-
1953		2,185	4,900	10,700	1953	-	-	-
Total	21,320	21,320		220,700		21,320		193,800

SUMMARY

Item	"Two-Cut" Method	Straight Clear-Cutting
Total Volume Cut	220,700 M Bd.Ft.	193,800 M Bd.Ft.
Life of Operation	14.7 Years	12.9 Years

(1) All figures have been rounded off to the nearest 5 to simplify presentation.

(2) Actual net volume is only 4,853 board feet, but it is assumed that 47 board feet of material which has been discounted as mortality can be salvaged.

volumes in the former will reduce the number of acres needed to make up the annual cut and will affect cutting schedules proportionately.

Overrun:

Since the size of average trees is larger in the first 60 per cent selective cutting than in the final cutting, the amount of overrun mill scale will be different, even though the log scale volume remains the same. The amount of overrun is apt to be reduced in the first cutting and increased in the second for this reason. This will be offset by the fact that the lumber values in the first cut will be somewhat higher than in the second. In this case, the overrun under clear-cutting is 18.5 per cent. Under the first cut of the "Two-Cut" system it is reduced to 13 per cent, and in the final cut increased to 25 per cent. This is of comparatively little significance if understood, but may be the cause of some concern if not kept clearly in mind.

SCHEDULES OF MAJOR FIXED CHARGES

Probably the most significant item in revised liquidation practice under the "Two-Cut" system is the ultimate effect which this change will have upon the financial returns of the company. In order to adjust for these changes, a study of logging and milling costs, depreciation, depletion, and forest taxation is necessary. Since the production costs are dependent to a large

extent upon the charges for depreciation and depletion, it will be well to handle this phase first.

Depreciation: Mill, Equipment and Logging Railroad:

Depreciation is determined by accountants by different methods. The one most commonly used in the lumber industry is to assume that the mill will last for the life of the timber, and therefore a fixed charge per M board feet of timber will be set aside. This is arrived at by dividing the total volume of merchantable timber owned into the total dollar investment of the plant and equipment. As the timber is cut, this charge is built up in the depreciation reserve and the plant depreciated at the rate at which production proceeds. This method allows considerable flexibility in handling fixed charges during depression years because they are not a constant annual cost but vary with the rate of production.

Each of the two methods of liquidation may be handled under this method of accounting. In the case of clear-cutting, the method may be followed as described. Under the "Two-Cut" system some changes should be made to adjust for the added volume of timber and the extra period of operation. The normal rate of depreciation per M feet of cut will continue to be followed during the first selective cutting period. For instance, this operation cutting 15 million feet (log scale) annually expects to continue operating for 13 years by clear-cutting, but would be able to continue for 15 years under the "Two-Cut" plan. Depre-

ciation would be carried for the first period of cutting, approximately 7½ years, at the normal rate based on the present timber volume. At the end of this period a revised estimate of the timber holdings should be made to include expected growth and the new depreciation rate per thousand be based on the new life expectancy.

Depreciation charges in this case operation have been divided into two categories: fixed permanent investment in mills, town, and heavy logging equipment; and changing investments in road and railroad construction. Table VI has been developed to present these data. Since these permanent investments were made some years ago, there only remains an undepreciated balance still to be written off. In order to handle a comparative depreciation schedule under the two liquidating methods as simply as possible the average rates have been determined, assuming that the total volume under the "Two-Cut" method is now accurately known. If clear-cutting is followed, the average depreciation charge for mill, town, and machinery is $1.00 per thousand feet, whereas it drops to $0.88 under the "Two-Cut" system. The charge for logging equipment and railroad rolling stock drops from 18 cents to 16 cents. The total difference in one year's operation amounts to a saving of almost $2,700 per year or about $30,000 in the life of the operation under the "Two-Cut" method.

The company under discussion has been following a policy of placing spurs at half-mile intervals. Therefore, the maximum

TABLE VI - Investment and Depreciation Sheet[1]
(Under Two Systems of Liquidation)

Sheet I

INVESTMENT ITEM	ORIGINAL COST	UNDEPRECIATED BALANCE	AVERAGE ANNUAL DEPRECIATION RATE Straight Liquidation 12.9 Years Total	Per M	Two-Cut Liquidation 14.8 Years Total	Per M
Plant and Equipment						
Sawmill (80 M)	$225,000					
Planing Mill	40,000					
Dry Kiln	50,000					
Flooring Plant	30,000					
Shingle Mill and Misc. Mfg. Equipment	55,000					
Total	$400,000					
Less 5% Scrap Value	20,000					
Net Total	$380,000	$180,000	$14,000	0.78[2]	$12,175	0.69[2]
Town, Office and Stores	$100,000					
Less 5% Scrap Value	5,000					
Net Total	$ 95,000	50,000	3,880	0.22[2]	3,380	0.19[2]
Mill and Town - Net Total		$230,000	$17,880	1.00[2]	$15,555	0.88[2]
Logging and Railroad Equipment						
R.R. Rolling Stock	$ 45,890					
Logging Equipment	30,000					
Total	$ 75,890					
Less 5% Scrap Value	3,890					
Net Total	$ 72,000	35,000	2,700	0.18[3]	2,360	0.16[3]
Total Original Investment	$575,890	$265,000	$20,580	-	$17,915	-

(1) Does not include Railroad and Road Construction.

(2) Charged to milling operation and therefore charged against 17,750 M bd. ft. mill scale.

(3) Charged to logging operation and therefore charged against 15,000 M bd. ft. log scale.

skidding distance is one-fourth mile and the average is one-eighth mile. This would necessitate the building of 13 miles of main-line railroad and 65 miles of spur line for the whole tract of 21,000 acres. The initial cost of construction of the former is estimated at $5,600 per mile and for the latter $1,667 per mile, including steel and ties.*

The depreciation charges for roads and railroads on the case operation under the two liquidating methods have been developed in Table VII. It was necessary to include an additional sum of $100 per mile for relaying the ties and steel on spurs in the second cut of the "Two-Cut" plan. It follows that more capital will be tied up under the "Two-Cut" system in roads and railroads because they are extended rapidly and written off more slowly. The average annual investment under clear-cutting amounts to slightly more than $35,000, which under the "Two-Cut" method jumps to almost double, or about $70,000. This is merely a matter of having a larger sum tied up for a slightly longer period, for in the end they are both retired. In spite of this fact, the per thousand depreciation charge drops from 93 cents in the former to 84 cents in the latter case. If interest charges were included on the additional money tied up, the favorable margin would be reduced somewhat, but still not enough to put the "Two-Cut" method to a disadvantage. It is doubtful whether additional borrowing would have to be resorted to, for the reduced tax burden

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* See Part IV for additional discussion on this subject.

TABLE VII - Fixed Investment and Depreciation Sheet
for Railroads and Logging Roads
(Under Two Systems of Liquidation)

Sheet II

CONSTRUCTION ITEM	INITIAL COST	APPROX. YEARS IN USE	PER CENT OF DEPRE-CIATION	AVERAGE ANNUAL DEPRECIATION(1) Total	Per M	AVERAGE FIXED INVESTMENT
Straight Clear-Cut Liquidation - 15,000 M per year for 13 (12.9) years.						
Railroad Main Line (Grade, ties and steel, 13 miles at $5,600/mi.)						
1st Year - 4 miles	$ 22,400	13	7.7	$ 1,730		$ 12,065
3rd Year - 2 miles	11,200	10	10.0	860		4,730
5th Year - 2 miles	11,200	8	12.5	860		3,870
7th Year - 2 miles	11,200	6	16.7	860		3,010
9th Year - 2 miles	11,200	4	25.00	860		2,060
11th Year - 1 mile	5,600	2	50.0	430		1,200
Total Main Line	$ 72,800	12.9		$ 5,600	$0.37	$ 26,935
Railroad Spurs(2) (Grade, ties and steel, 65 miles at $1,667/mi.)						
5 miles per year	$ 8,335	1	100.0			
Total Spurs - 12 yrs.	$108,350	13		$ 8,335	$0.56	$ 8,335
TOTAL FOR RAILROAD(2)	$181,150			$13,950	$0.93	$ 35,270
"Two-Cut" Selective Liquidation - 15,000 M per year for 15 (14.7) years.						
Railroad Main Line (Grade, ties and steel, 13 miles at $5,600/mi.)						
1st Year - 4 miles	$ 22,400	15		$ 1,510		$ 11,955
2nd Year - 2 miles	11,200	14		755		5,600
3rd Year - 2 miles	11,200	13		755		5,230
4th Year - 2 miles	11,200	12		755		4,860
5th Year - 1 mile	5,600	11		375		2,440
6th Year - 1 mile	5,600	10		375		2,050
7th Year - 1 mile	5,600	9		375		1,870
Total Main Line	$ 72,800			$ 4,900	$0.33	$ 33,905
Railroad Spurs(2) (Grade, ties and steel, 65 miles at $1,667/mi.)						
9 miles per year	$ 15,000	2				
Total Spurs - 7.2 yrs.	$108,350	15		$ 7,225	$0.48	$ 32,412
Additional Cost for Relaying Spur tracks	6,500	8		440	0.03	3,450
TOTAL FOR RAILROAD(2)	$187,650	15		$12,565	$0.84	$ 69,767

(1) Chargeable directly to logging operation of 15,000 M per year (log scale).
(2) Includes cost of truck roads where used in place of spurs.

and depletion charges would release a large part of the money needed for this temporary expense. This phase is developed in the next few paragraphs.

Timber Depletion:

Due to the added volume of timber available under the "Two-Cut" liquidating system, the timber stumpage charge per thousand is greatly lowered. Since this increased volume is obtained at no measurable increase in cost, the total money investment in timber remains unchanged. This has the effect of reducing the total annual stumpage charge, although the annual volume of timber cut remains unchanged. This is shown in Table VIII on the following page, where the timber depletion schedules under both cutting systems are revealed. It should be noted that the average annual stumpage cost under clear-cutting is $66,000 for a cut of 15,000 M board feet, or $4.40 per M, whereas under the "Two-Cut" plan this charge drops to $57,900, or $3.86 per M, a total drop of $8,100 on the same volume. This is of utmost significance, for the saving in depletion charges is the biggest single item of savings under the "Two-Cut" plan. During the course of the operation this annual saving of $8,100 adds up to a total of almost $100,000.

Timberland Taxes:

Previous mention has been made of substantial reductions in taxes paid on timber property made possible by the advantage

TABLE VIII - Depletion Schedule
(Two Methods of Liquidation)

STRAIGHT LIQUIDATION				TWO-CUT LIQUIDATION			
Year	Volume Cut M Bd. Ft.	Charge per M Bd.Ft.	Annual Charge	Year	Volume Cut M Bd.Ft.	Charge per M Bd.Ft.	Annual Charge
1939	15,000	$ 4.40	$ 66,000	1939	15,000	$ 3.86	$ 57,900
1940	15,000	4.40	66,000	1940	15,000	3.86	57,900
1941	15,000	4.40	66,000	1941	15,000	3.86	57,900
1942	15,000	4.40	66,000	1942	15,000	3.86	57,900
1943	15,000	4.40	66,000	1943	15,000	3.86	57,900
1944	15,000	4.40	66,000	1944	15,000	3.86	57,900
1945	15,000	4.40	66,000	1945	15,000	3.86	57,900
1946	15,000	4.40	66,000	1946	15,000	3.86	57,900
1947	15,000	4.40	66,000	1947	15,000	3.86	57,900
1948	15,000	4.40	66,000	1948	15,000	3.86	57,900
1949	15,000	4.40	66,000	1949	15,000	3.86	57,900
1950	15,000	4.40	66,000	1950	15,000	3.86	57,900
1951	13,600	4.40	59,840*	1951	15,000	3.86	57,900
1952	--	--	--	1952	15,000	3.86	57,900
1953	--	--	--	1953	10,700	3.86	41,240
Total	193,600		$851,840		220,700		$851,840

*Rounded off to come out even.

resulting from the state forest tax laws. Due to the difference in the laws of the two states, a somewhat different procedure is necessary for companies located in either one or the other state. If a timberland owner is paying fairly high taxes on his lands under the general property tax, substantial savings will result.

The Wisconsin Forest Crop Tax law provides for registry of lands either with mature standing timber or with only second growth. Merchantable timber comes under a special classification until 50 per cent or more of the volume has been removed, and requires a higher tax payment than selectively cut or second growth lands. If an owner registers all of his standing timber under this special classification, it is subject to the following per acre tax rates and severance (or yield) taxes on any timber cut in that year.

TABLE IX

Forest Crop Tax Law Rates (Wisconsin)

Year	Acre Tax	Yield	Year	Acre Tax	Yield
1st	40¢	2%	6th	20¢	7%
2nd	35	3	7th	20	8
3rd	30	4	8th	15	9
4th	28	5	9th	10	10
5th	28	6	10th	10	10

Lands which are already cut over bear a straight annual tax of 10 cents per acre and a yield tax of 10 per cent on any timber removed.

The Michigan Commercial Forest Reserve Law (the Pearson Act) has been amended so that rates are now lower than in Wisconsin, although no provision has yet been made to include merchantable timber. For lands bearing unmerchantable or selectively logged timber the tax is only five cents per acre annually with a yield tax at 10 per cent. The law has been interpreted to allow classification of selectively logged lands after cutting. In 1932 Michigan amended her state constitution, limiting the tax rate on real property to 15 mills per dollar of assessed value, with certain exceptions. In most townships this provided some relief, but where the local government was in debt or the voters approved increasing the rate to the maximum of 50 mills the burden is still heavy.

In dealing with the specific property used in this case, two sets of data have been prepared. Unpublished investigations made by the Lumber Code and Forest Service reveal that the average property tax on sawtimber stands in Michigan was about 60 cents per acre per year, while in Wisconsin it amounted to around 70 cents. If the company in this case should liquidate its timber by clear-cutting, the total tax on the whole tract of 21,320 acres would be reduced as fast as the land was cut over. Under the "Two-Cut" system in Wisconsin the schedule of rates shown in Table IX would apply, while in Michigan the real property taxes would hold until the timber was selectively cut and placed under the Pearson Act. These tax schedules are developed in detail in

Tables Ka, Kb, La, and Lb in the Appendix. Table X, included here, summarizes these scheduled taxes under both cutting systems. A total saving of $20,713.50 in Wisconsin is possible under the "Two-Cut" plan and of $8,266 in Michigan. Any difference from the assumed taxes in the present property taxes on a specific operation would increase or decrease the possible savings proportionately. An average rate of 12 cents per acre has been assumed for cutover lands under the clear-cutting operation.

Debt Servicing:

Because of the wide variations in the debt structure of the Lake States industry it has been thought advisable to leave this factor out of these calculations. Each operator may draw his own conclusions regarding the effect which interest and amortization charges would have in this case. It is reasonable to believe that under either method of operation there would be very little difference in the ultimate effect. If there were any difference, it would be in favor of the "Two-Cut" system because of the added period over which this expense might be spread.

COSTS OF PRODUCTION, LUMBER VALUES, AND NET REALIZATION

The final and most important financial comparison of the two methods is that of net profits. In order to determine the net profits it was necessary to find the total costs of logging and milling and subtract them from the dry lumber values. The

TABLE X - Comparison of Timberland Taxes
Under Two Methods of Liquidation

WISCONSIN			MICHIGAN		
Year	Total Taxes Paid		Year	Total Taxes Paid	
	Clear-cutting(1)	Two-Cut(2)		Clear-cutting(3)	Two-Cut(4)
1939	$ 14,924.00	$ 9,428.00	1939	$ 12,792.00	$ 12,722.00
1940	13,846.00	8,124.50	1940	12,000.00	11,279.50
1941	12,968.00	7,096.00	1941	11,408.00	9,767.00
1942	12,053.00	6,342.50	1942	10,416.00	8,254.50
1943	11,096.00	6,380.00	1943	9,624.00	6,742.00
1944	10,139.00	6,039.00	1944	8,832.00	5,229.50
1945	9,182.00	6,214.00	1945	7,840.00	3,717.00
1946	8,225.00	6,305.50	1946	7,248.00	3,344.50
1947	7,268.00	6,632.00	1947	6,456.00	5,566.00
1948	6,311.00	6,632.00	1948	5,664.00	5,566.00
1949	5,354.00	6,632.00	1949	4,872.00	5,566.00
1950	4,397.00	6,632.00	1950	4,080.00	5,566.00
1951	3,440.00	6,632.00	1951	3,188.00	5,566.00
1952	2,574.00	6,632.00	1952	2,574.00	5,566.00
1953	---	5,342.00	1953	---	4,276.00
Total	$121,777.00	$101,063.50		$106,994.00	$ 98,728.00
	Net Difference			Net Difference	
	$20,713.50			$ 8,266.00	

(1) From Table Ka in the Appendix.

(2) From Table Kb in the Appendix.

(3) From Table La in the Appendix.

(4) From Table Lb in the Appendix.

cost and lumber price data used in this case are based upon the average costs of the particular company and the lumber market values of the first half of 1936. This period was chosen as being reasonably normal, that is, costs and prices and the spread between them were relatively stable. Prediction of future values based on early 1936 figures was thought to be fairly conservative. It is reasonable to expect, however, that there will be many changes during the next 15-year period which cannot be predicted with accuracy.

Production Costs:*

The cost data used here are for a clear-cutting operation of 15 million feet a year. These data, set forth below, provided the basis for the detailed cost analysis developed in the following pages. The following were the costs per M used:

Logging (Log Scale)		Milling (Mill Scale)	
Log Making (felling and bucking	- $1.60	Sawing (labor and supplies)	- $2.31
Skidding	- 2.30	Sorting and Piling	- 1.00
Loading and Unloading	- 1.00	Planing	- 1.13
Railroad Transportation	- 1.75	Shipping	- 1.50
Camps	- 0.25	Selling	- 1.18
Supervision and Scaling	- 0.50	Insurance	- 0.42
		General Overhead	- 0.87
		Taxes on Mill, etc.	- 0.74

The first step in putting these data to use was to determine which of the items varied according to the size of the tree cut,

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* The total of these costs may be somewhat lower than those in many other operations though the direct costs and depreciation, etc., are in line. The discrepancy occurs in the lower overhead costs due to the fact that this concern maintains no office in a large city, and only a small office and small sales staff.

the total annual volume, and the area necessary to obtain the cut. Logging and milling cost studies in the past have found that the first four items in the logging column and at least the first item in the milling column will vary with the diameter of the tree. The camp item will vary according to the area cut over (i.e., volume cut per acre), and the remaining items will either change as the annual volume of production changes or remain constant. In this case the annual volume will remain unchanged under either cutting method.

The most difficult problem remaining is the translation of these woods and mill run costs into the costs by tree diameter classes. A method for doing this has been worked out for other stands by Matthews,(11) whereby cost data by diameter classes may be used. The Forest Service has made several studies applicable in this case, one of which has been particularly thorough.(5) The cost data are based on a clear-cutting job and therefore have to be revised to some extent for application in the "Two-Cut" system. The camp cost and general supervision costs were increased because of the added expense in logging a larger area. Camps were increased from 25 cents to 30 cents per M and general supervision from 50 cents to 60 cents. It was necessary to reduce all costs to mill scale in order to put them on the same basis with lumber values. Milling costs were already on mill scale, but logging costs had to be adjusted to overrun, as shown

in Tables E and F in the Appendix. The final results of all the cost determination are presented in Tables E, F, G, and H in the Appendix and summarized in Tables XI and XII following. The per M costs then had to be applied directly to the stand table data as shown in Table IV in order to determine the cost of producing lumber from trees of different sizes on the average acre under the two different cutting methods. It is of interest to note that the cost of production including depletion under clear-cutting amounted to $21.30 per M before taxes on timber, whereas in the first cycle of the "Two-Cut" method these costs dropped to $20.10 and rose again in the second cycle to $21.38. However, the weighted average of both cycles was only $20.74, or 56 cents less per M than under clear-cutting.

Lumber Values:

The lumber prices for the first 6 months of 1936 were obtained and applied to the stand volumes revised to mill tally. It was necessary to break down the different tree sizes and species by lumber grades, as shown by Zon and Garver[5] and then apply these values. In the small diameter classes tie values have been used wherever they were greater. Previous studies have shown that the lumber grades from different-sized hemlock trees vary so little that it is unnecessary to make any allowance for this species. Hardwoods, on the other hand, show wide differences, as Table I in the Appendix indicates. These data

TABLE XI - Production Costs
Per M Bd. Ft. (Mill Scale) for Trees of Different Diameters
Under Two Methods of Liquidation
(Operating Cutting 15,000 M Bd. Ft. per Year)

STRAIGHT CLEAR-CUTTING				TWO-CUT LIQUIDATION			
D.B.H.	Adjusted Logging Cost	Milling Cost	Total Production Cost	D.B.H.	Adjusted Logging Cost	Milling Cost	Total Production Cost
10	$13.00	$10.96	$23.96	10	$12.72	$10.84	$23.56
12	12.32	10.76	23.08	12	11.95	10.64	22.59
14	11.82	10.56	22.38	14	11.45	10.44	21.89
16	11.48	10.39	21.85	16	11.06	10.25	21.31
18	11.15	10.22	21.37	18	10.70	10.10	20.80
20	10.90	10.12	21.02	20	10.45	10.00	20.45
22	10 72	10.02	20.74	22	10.25	9.90	20.15
24	10.60	9.94	20.54	24	10.17	9.82	19.99
26	10.50	9.81	20.31	26	10.02	9.69	19.71
28	10.38	9.78	20.16	28	9.90	9.66	19.56
30+	10.70	9.74	20.44	30+	10.20	9.62	19.82

TABLE XII - Total Production Costs, Lumber Values and Net Realizations Per Acre

Under Two Methods of Forest Liquidation
By Diameter Classes

D.B.H. in Inches	STRAIGHT LIQUIDATION				
	Volume Per DBH Class (Mill Scale)	Total Production Cost Per M	Production Cost Per DBH Class	Dry Lumber Value Per DBH Class	Net Realization Per DBH Class(1)
10	330	$23.96	$ 7.91	$ 7.74	$ -0.17
12	786	23.08	18.15	18.58	0.43
14	1,097	22.38	24.55	27.59	3.04
16	1,250	21.85	27.31	33.68	6.37
18	1,460	21.37	31.20	40.79	9.59
20	1,408	21.02	29.62	41.41	11.79
22	1,230	20.74	25.55	37.45	11.90
24	1,094	20.54	22.47	34.80	12.33
26	730	20.31	14.83	23.07	8.24
28	533	20.16	10.74	18.03	7.29
30	840	20.44	17.17	30.15	12.98
Total	10,758		$229.50	$313.29	$83.79

Woods Run Per M - $21.30

DBH in In.	TWO-CUT SYSTEM OF SELECTIVE LIQUIDATION									
	FIRST CYCLE					FINAL CYCLE				
	Volume Per DBH Class (Mill Scale)	Total Production Cost Per M	Production Cost Per DBH Class	Dry Lumber Value Per DBH Class	Net Realization Per DBH Class(1)	Volume Per DBH Class (Mill Scale)	Total Production Cost Per M	Production Cost Per DBH Class	Dry Lumber Value Per DBH Class	Net Realization Per DBH Class(1)
10	37	$23.56	$ 0.87	$ 0.89	$ 0.02	376	$23.56	$ 8.83	$ 8.79	$ 0.04
12	105	22.59	2.36	2.37	0.01	732	22.59	16.50	17.50	1.00
14	197	21.89	4.29	4.93	0.64	1,022	21.89	22.40	25.87	3.47
16	295	21.31	6.30	7.82	1.52	1,153	21.31	24.60	30.98	6.38
18	601	20.80	12.44	16.74	4.30	1,093	20.80	22.77	30.66	7.89
20	817	20.45	16.70	23.68	6.98	896	20.45	18.37	26.25	7.88
22	907	20.15	18.30	27.68	9.38	549	20.15	11.08	17.05	5.97
24	1,094	19.99	21.88	34.80	12.92	241	19.99	4.82	7.51	2.69
26	730	19.71	14.39	23.07	8.68	-				
28	530	19.56	10.35	18.03	7.68	-				
30	840	19.82	16.65	30.15	13.50					
Total	6,156		$124.53	$190.16	$65.63	6,062		$129.37	$164.61	$35.24
	Woods Run Per M - $20.10					Woods Run Per M - $21.38				

(1) Before deduction for taxes on timber.

have all been reduced 5 per cent to account for loss in shrinkage from the green mill-run tally during seasoning.

The lumber values obtained from the average acre when clear-cut amounted to $313.29, whereas the total lumber values under the "Two-Cut" system rose to $354.17. A net value of $190.16 was obtained in the first cut, leaving a residual lumber value of $113.13 in the stand, which increased in 7 years to $164.61, or 45.5 per cent.

Net Realization:

If straight liquidation is followed on this operation, Table XII on page 61b shows that a net realization of $83.79 per acre will be obtained before taxes for timber are deducted. The "Two-Cut" system of liquidation will yield $65.63 per acre in the first cut and $35.24 in the second, or a total per acre yield for the whole operation of $100.87 before taxes on timberlands are deducted. In other words, the average yield per acre is increased $17.08 under the "Two-Cut" system. The net difference will be even larger when taxes are deducted, since the latter method will have the advantage of a lower annual rate than the former.

Under the "Two-Cut" plan a residual stand investment of $18.13 is left after the first cut $83.79 - $65.63), which will be worth $35.24 in 7 years, or a difference of $17.11. The total increase in the value of the residual stand is 100 per cent.

This increase is due to the added volume and higher values, as well as the lower direct costs in cutting larger timber and lower fixed charges.

The expected annual incomes under the two methods of liquidation vary not only with the net revenues per acre, but also with the area cut over each year. If clear-cutting is followed, the area cut over each year would be 1,650 acres, and would yield $83.79 per acre before timberland taxes were deducted. This is equivalent to an annual return of $138,254.50 per year, or $204,253.50 including depletion. For the first 7.8 years the "Two-Cut" method will yield $65.63 per acre from 2,750 acres, or $180,482.50 per year, or $238,382.50 if depletion is included. In the following 7 years the cut will be taken from 3,060 acres and yield $107,834.40 per year. If depletion is added, this amounts to $165,734.40. The average annual return for the whole operation under the "Two-Cut" system will be about $145,500. The rather severe drop in total incomes from the first to the second cut is largely a matter of bookkeeping. These would be more nearly equal if depreciation and depletion were charged off at the heavier rate in the first cut and at a lighter rate in the second. This procedure has been suggested as being more logical under actual conditions than the method followed here.

The total net returns, excluding depletion of $851,840, for the whole period of operation before deducting timberland taxes and after including taxes are shown below:

Clear-cutting: 21,320 acres x $83.79 = $1,786,402.80

"Two-Cut" Method:

First cut -	21,320 x $65.63 =	$1,399,231.60
Second cut -	21,320 x $35.24 =	751,316.80
	Total	$2,150,548.40

Net difference in favor of the "Two-Cut" plan = $364,145.60

When taxes are deducted, an even greater difference is shown:

	Wisconsin	Michigan
Clear-cutting	$1,786,402.80	$1,786,402.80
Total taxes	121,777.00	106,994.00
Net	$1,664,625.80	$1,679,408.80
"Two-Cut" system	$2,150,548.40	$2,150,548.40
Total taxes	101,063.50	98,728.00
Net	$2,049,484.90	$2,051,820.40
Net difference in favor of "Two-Cut"	$ 384,859.10	$ 372,411.60

Capitalization of these future incomes to obtain the present worth of the property under the two liquidating methods presents some additional information. In order to show a conservative figure for present worth, 5 per cent interest has been used in the following calculations. The figures are based on the net stumpage income before deducting for taxes. This income figure differs from the net income given in the previous paragraph in that depletion has been included.

COMPARISON OF PRESENT WORTH

Present Worth of the Operation under Clear-Cutting - 13[1] Years.

Annual Income - including depletion
but before timber taxes - $138,253.50 + $66,000.00 =
$204,253.50

Total Present Worth -

$$\frac{\$204,253.50}{.05 + \frac{.05}{1.05^{13} - 1}} \quad \text{or} \quad \frac{\$204,253.50}{.10646} = \$1,918,757.38$$

Present Worth of the Operation under "Two-Cut" System - 15[1] Years.

Annual Income -

First 7.8 year period, including depletion - $238,382.50
Second 7 year period, including depletion - $165,734.40

Present Worth of First-period Income -

$$\frac{\$238,382.50}{.05 + \frac{.05}{1.05^{8} - 1}} = \frac{\$238,382.50}{.15472} = \$1,540,666.10$$

Present Worth of Second-period Income -

$$\frac{\$165,743.40\ (1.05^{7} - 1)}{.05 \times 1.05^{15}} = \frac{\$165,734.40 \times 8.142}{2.0789} = \$648,942.38$$

Total Present Worth - $1,540,666.10 + $648,942.38 = $2,189,608.48

Difference in favor of "Two-Cut" System = $270,851.10.

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(1) All periods have been rounded off to the nearest even year.

FINAL RESIDUAL STAND VALUES

The calculations in the case analysis have not included any value for the lands left after the final heavy cutting. This factor has been purposely omitted in order to have the calculations stand on their own merits. However, these cut-over lands do have a real value in the thrifty, young growing stock left on the ground. Due to the variations in methods of valuation, the volumes which individual operators intend to leave, and the value that possible purchasers may place on these lands, no average figure has been developed to use in this case. That these lands are worth more than straight clear-cut areas cannot be doubted, for the Forest Service has recently made a practice of paying more for lands with good second growth than for waste lands. Operators contemplating the adoption of the "Two-Cut" system should give consideration to the resulting higher residual value of the cutover land.

PART FOUR

PRACTICAL CONSIDERATIONS IN THE APPLICATION OF THE "TWO-CUT" SYSTEM TO ANY OPERATION

SUGGESTIONS FOR CHANGES IN MANAGEMENT

NECESSARY PRELIMINARY DATA

It has been previously mentioned that there are no drastic changes other than in forest cutting methods involved in the process of supplanting the clear-cut system by the "Two-Cut" system of liquidation. Any company, having weighed the merits of this method of management and having decided to follow it, will have to assemble certain basic data for drawing up an operating plan. Most of this material is available in the records of the company and needs only a minimum of supplementary field work. The information necessary to drawing up the plan is as follows:

Volume and Areas of Timber: This should include estimates by forties of all timberland either owned or held under timber rights which the company plans to cut during its remaining existence. If the estimates are old, they should be brought up to date and the stands divided into the several subtypes as outlined on page 70. Stand and stock tables should be built up for each subtype to facilitate management. Total volumes for all areas by species should also be obtained. Areas of each important forest cover type and subtype should also be worked up and indicated on the base map, which ought to include topographical, natural, and man-made features, such as hills, valleys, watercourses, roads, railroads, and principal log transport routes.

Investment in Plant, Equipment, Timber, and Miscellaneous Property: Information on these items is of direct concern in revising depreciation and depletion schedules later on and is, of course, available on all company records. Timberland and other taxes should be included here.

Data on Logging and Milling Production Costs: The company has this information worked up on its profit and

loss statements, but should supplement it with some detailed analyses.

Data on Lumber Values: These should include a breakdown by species and grades of the net mill realization

The following preliminary data should be assembled before any further steps are taken:

Acreage and volume of timber available.
Stand table of average acre.
Maps of operations.
Balance sheet as of latest year.

These data should then be organized in such a way as to enable the operator and his forester to determine just what the possibilities are under the "Two-Cut" system for the particular company. A financial forecast should be developed in a somewhat similar manner to that shown in Part III. In this way the various limiting factors may be ascertained, the changes and revisions determined and the management plan set up.

FOREST MANAGEMENT

Analysis of the Principal Forest Type:

Management of a tract of timber requires an understanding of the basic composition and condition of the stand, including such factors as the distribution of different tree sizes, proportion of different species, the quality of the stand, and the reaction of the stand to different methods of treatment. This information, of course, can only be obtained by means of an accurate cruise and general acquaintance with the forest type through experience. The northern hardwood and hemlock forest

type in the Lake States varies greatly in composition from one area to another. The principal species are sugar maple, yellow birch, beech, basswood, and eastern hemlock. Miscellaneous species also found are red maple, white ash, red oak, balsam fir, white spruce, and white pine, as well as several others of lesser importance. The variations in the mixture of these species and the stage of development of the stand are the principal factors affecting management practice. Most of the common variations within the type are presented below. This classification only approximates the actual conditions, but serves as a rough guide to management policy. Typical variations in compositions of the northern hardwood and hemlock forest type in the Lake States are as follows:

Subtype I — Hemlock - In which 70 per cent or more of the stand is of eastern hemlock; yellow birch and sugar maple follow in order of importance.

Subtype IIa — Hemlock-Hardwood - In which 50 to 70 per cent of the stand is of hemlock and the remainder hardwood, usually sugar maple and yellow birch.

Subtype IIb — Hardwood-Hemlock - In which 50 to 70 per cent of the stand is of hardwoods and the balance of hemlock.

Subtype III — Hardwood - In which over 70 per cent of the stand is composed of sugar maple, yellow birch, and other northern hardwoods.

Within these subtypes a variety of conditions may be found which influence management technique to some extent. Such factors as proportion of cull volume per acre, and distribution of

tree size classes are the principal items. The latter is particularly important in selective cutting plans because the conditions of residual stand are naturally dependent upon the variety of sizes in the original stand. Each of these subtypes may be roughly divided into three different conditions in regard to the stage of development, which is in turn a reflection of this distribution. This division is as follows:

Class A Overmature - Largest proportion of basal area and volume concentrated in bigger trees (over 20 inches). Reproduction is very scanty and found only in the openings made by the loss of large trees. Volume in this class is usually in excess of 12 M board feet per acre net. Quality: medium to decadent. This class of timber puts on very little or no growth, mortality and cull being high.

Class B Mature - Volumes well distributed by sizes of trees throughout the stand, with a fairly abundant reproduction. Volume in this class usually varies between 6 and 11 M per acre net. Quality: difficult to generalize. Usually putting on some growth, but not enough to be of consequence.

Class C Young Merchantable - Large proportion of small and medium-sized trees with only a scattering of trees over 20 inches in diameter. This stand is growing rapidly and is in a thrifty condition. Abundant reproduction is usually present. The volume varies from 3 to 7 M per acre net. A good volume of net growth is being accumulated. Quality: generally good.

These broad classifications are fairly accurate for any specific tract or part of a tract. However, with each of these there may be variations. For instance, in Class B stands there

may be a heavy proportion of trees 6, 8 and 10 inches, which is just below the merchantable size. In the Overmature Class there might be found a heavy proportion of small reproduction on the ground, due to the type of canopy which allowed enough sunlight to come in to encourage germination. Generally speaking, these classifications will serve very well for the purposes of management. Since each acre of forest varies from every other, no standard can be set on paper which will be any more than a rough guide. Considerable judgment must therefore be used by technical and practical men on the ground.

General Silvicultural Aspects of Clear-Cutting and Partial Cutting:

Judgment of any silvicultural methods involves a comparison with other methods and the results produced under other types of stand treatment. The primary aim of the "Two-Cut" system is to bring about an improvement over the clear-cutting practice followed generally in the northern hardwood and hemlock forests. The silvicultural advantages of the "Two-Cut" method over clear-cutting have been enumerated, but some further explanation of how this method of liquidation will be better than the old will be helpful. Destructive liquidation in the northern hardwood-hemlock forests results in several major losses, of which the loss of forest conditions built up for several hundred years is probably the most serious. The change wrought by clear-cutting

causes such a serious disturbance to this balance that the remaining trees have great difficulty in becoming adapted to the radically new conditions. These trees in the residual stand are subject to sun scald, top dying, and deterioration of the root system. After several years, these changes are very noticeable, especially in yellow birch and hemlock. Stagheadedness in the former and quick death to the latter are generally the result. Windfall reaps some of the remaining trees which are exposed to sweeping winds. The injuries which the small remaining trees have suffered in logging, encourage the entrance of various fungi whose work completes the havoc.

Hall[12] has studied post-logging decadence over a wide area and has concluded that the losses to the residual stand usually result from the drastic change in ecological conditions. Such different factors as the physical, physiographic, and biotic combine to cause degradation to the residual stand. He concludes that the amount of post-logging decadence varies with the intensity of the cut. Thus, it can be reasonably concluded that the heavier the cutting the less chance there is for survival of the remaining trees. Consequently, the time when another crop of timber may be taken from the same area is greatly deferred.

The question of reproduction after clear-cutting is one which has caused considerable discussion, but very little actual work has been done to solve the problem. Numerous unburned cut-

over tracts in Wisconsin and Michigan which have been logged within the past decade were visited in connection with this study. Burned-over areas were not included, since it is well understood that fire will kill off reproduction. The results of those observations on 14 separate tracts showed definitely that reproduction following clear-cutting was either poor or non-existent. Three of the 14 tracts were well stocked with valuable species, two were stocked fairly well, but had a large number of weed species present, such as soft maple, popple, and white birch; and eight were either poorly stocked or had so little valuable young growth as to be considered unstocked. This variation in reproduction may be accounted for by the following factors:

1. Time of year of logging.
2. Condition of reproduction at time of logging.
3. Precipitation in years following logging.
4. Density of overstory in original stand.
5. Productivity of site.
6. Presence of nearby old growth or second growth stands.
7. Volume left per acre.

The time of year of logging undoubtedly has an influence on reproduction. Three of the four tracts which had a good stocking were winter logged. It is probable that logging during this period of dormancy causes less disturbance to the site and enables the young trees to adapt themselves more readily to the change than does summer logging when growth is in full swing and the residual forest is more subject to high temperatures and fluctuations in humidity. Another well sustained conclusion relates to the abundance and condition of the reproduction at the

time of logging. Stands composed of old growth hemlock, under which the ground was densely shaded, had very little reproduction present. Logging on these areas opened up the site in such a manner as to encourage such worthless vegetation as fireweed, elderberry, hazel, fire cherry, red maple, and even timothy grass. All these plants have choked out what little reproduction there was present and have delayed the establishment of new growth indefinitely. In those areas which were better stocked with seedlings at the time of logging and which had a fair start, some loss may have occurred during the recent drouth years.

Some observers who have studied the situation have noticed that the survival of reproduction and small trees is often very marked after heavy commercial cutting. This is particularly true at the Upper Peninsula Branch Station experimental plots at Dukes, Michigan. In the large majority of instances these areas have been small and protected by large timber on several sides. Forest conditions have been maintained much better than in large open tracts of clear-cut timber.

Final judgment of the "Two-Cut" system of liquidation on the silvicultural basis rests upon the improvement over clear-cutting practices. The two major difficulties from clear-cutting are the loss of a large part of the residual stand and the uncertainty of obtaining reproduction. Experience in selective logging in virgin timber over the past decade points to the fact that reproduction is greatly stimulated after cutting and soon

takes up all the available space. This is generally true, even in stands which had a very dense canopy shading the ground prior to cutting. As little reproduction was present at the time of logging, a short period is needed before the ground becomes well covered with young growth. The effect of the partial canopy of the residual stand is to let just enough light through to encourage the young seedlings to grow rapidly, but not enough to give the light-loving weeds and shrubs an opportunity to become established.

Hall and others[12], [8] have noted that the successful survival of larger residual trees in selectively cut stands varies to some extent with the proportion of the stand cut. This is noticeably the case with regard to windfall and to a slightly lesser extent with respect to ecological changes leading to decadence. Stands which have less than 30 per cent of the original volume, or less than 2,500 board feet contained in numerous small and medium sized trees after cutting are apt to suffer rather heavily from one or the other of these losses. Therefore, if in the first of the two cuttings a fairly well stocked residual stand is left, mortality will be held to a minimum and reproduction will either have a chance to become established or will be well stimulated if it is already on the ground.

Specific Measures for Cutting under the "Two-Cut" System:

The application of specific cutting methods to these varying forest conditions involves definite technical skill. There are

several important objectives which are desired under a "Two-Cut" liquidating system. The first cutting must be handled in such a way as to result in accelerated growth in the residual stand and to stimulate reproduction. Thus, a preparatory opening up of the stand is made to give the small trees from 2 to 11 or 12 inches an opportunity to expand their crowns and become generally adapted to more open forest conditions. During the intervening period after this first cut, these smaller trees will grow in thrift and vigor, and be able to survive when the second and final cutting takes place. Consequently, the first cut requires considerably more technical judgment than does the final cut.

Before the procedure followed in the first removal cutting is described, some of the points of difference between the objectives in this case and those of a selective cutting based on sustained yield should be mentioned. A decided effort must be made to produce timber of almost the same average size in the second cut as in the first. Unless this is done, the manufacturer will be placed in a difficult position regarding the widths of lumber produced. Judicious marking will avoid a large part of this discrepancy. Another practical aspect is to obtain the largest possible growth in quality on the best trees. The trees which are taken in the first cut should be those which hold the least promise for future rapid growth. The other thrifty trees, both

small and large, should be reserved to obtain the maximum value from their growth. An extra inch in diameter on a large tree is well worth the sacrifice of holding it for 6 or 7 years.

First Partial Cutting

The silvicultural and financial success of this "Two-Cut" liquidation method is dependent upon the way in which the first cutting is handled. The technique followed must be flexible in application to the different conditions of stands and consistent in its objectives. In order to make these principles understood, broad rules of marking practice will be first discussed for the field as a whole and later modified according to the variations of each subtype and condition.

Volume to be Removed: The average per acre removal should not exceed nor be much less than 60 per cent of the volume. Previous experience has shown this to be a very satisfactory proportion. Enough timber is left on the ground to maintain forest conditions, yet a large enough volume is removed to make operation economical.

It has been found that a 60 per cent cut in old growth stands is satisfactory silviculturally for the following reasons:

1. Reproduction is encouraged and stimulated, but not choked out or allowed to come in so heavily as to cause trouble at the time of the second cut.

2. Windfall and mortality are held to a minimum because all trees likely to die or blow down are removed.

3. Quality growth in the residual stand is at a maximum.

4. Small trees are given rapid stimulation through release.

5. Slash and debris are sufficiently scattered and will rot down before the next cut.

6. Logging damage is less than on selectively cut tracts where more of the large trees are removed.

Size, Condition, and Species of Tree to Cut: The kind of trees making up this volume of cut must be chosen from two standpoints. Condition and species are the two determining factors. The term "condition," as used here, means the general health, quality, and position of the tree in the stand. Trees which have reached their physical maturity are the first candidates for the axe. Large, overmature trees, medium-sized, mature trees which are slowly ebbing, and smaller, suppressed trees with little promise of future growth are in this classification. Others may appear thrifty, but actually contain so much defect that they should be cut. Rough diameter limits for different species are reasonably accurate in most situations. The flexible limit allows certain large, thrifty trees to be retained.

Species	Flexible Limit (D.B.H. in Inches)
Sugar Maple	22
Yellow Birch	22
Basswood	20
Beech	18
Eastern Hemlock	22
Miscellaneous Valuable	22
Miscellaneous Inferior	18

Although the bulk of this cut will be taken from larger timber, there will still be a good scattering of thrifty big trees for the next cut. The aim should be to remove more of the smaller, less promising trees and to leave the better-sized ones. This will yield a final cut of both small, medium, and large trees, but no overmature timber.

With other conditions equal, a choice in marking must often be made between two or more trees of different species. This question must be answered by estimating whether the future value of one species in 6 or 8 years will be greater or less than the other. Elimination of the less desirable trees in the first cut would not only make growth possible on the more valuable portion of the stand, but also would insure a more abundant reproduction of valuable species. The actual handling of this situation will depend upon the operator himself. Reserving the thrifty, fast-growing species in most cases will accomplish both the economic and silvicultural objectives.

Species to Favor	Intermediate (Depending on Position and Thrift	Species to Eliminate
Basswood	Beech	Balsam
Yellow Birch	White Elm	Red Maple
Sugar Maple	Hemlock	Paper Birch
Red Oak		Black Ash
White Ash		Miscellaneous Inferior
White Pine		
Rock Elm		
Miscellaneous Valuable		

Other Marking Considerations: Proper marking with good utilization should attempt in general to eliminate as much of the cull material from the stand as possible. Cull trees which can be made to yield only one good saw log can sometimes be taken at a profit. Use of these trees can be made for such material as truck-road planking on the operation, temporary camp buildings, fuel, and other temporary requirements. Railroad car stakes can be cut from small, suppressed trees, inferior species, or from small thickets of poles in need of thinning.

The aim of this cutting should be to retain as uniform a canopy of sound trees as possible. This may be done by leaving the larger gaps filled with big trees over the flexible limit or even cull trees. In some places larger gaps are certain to result by the removal of several very large, old trees which must be logged in the first cutting. Such a loss is not severe enough to harm the residual stand if there are sufficient trees surrounding these holes. A cutting of this sort follows the Group Selection principle and if well handled will encourage yellow birch over more tolerant species.

The Silvicultural Technique Applicable to the Various Subtypes and Stands:

In order that the best results from management of the northern hardwood and hemlock forests may be attained, some suggestions for applying these rules under various circumstances are

in order. The different stages of development require the widest flexibility in management practice, while the composition of the stand is the next factor which influences cutting methods.

Old, Overmature Stands: Stands composed of both hemlock and hardwoods must be treated with considerable care, for too heavy a selection cutting will cause almost as many complications as clear-cutting. Due to the heavy concentration of volume in large trees, adherence to the prescribed diameter limits might result in very large openings. Therefore, the proportion of volume marked must be carefully controlled, more by using the position and condition of the tree than size as a basis for marking. It may be necessary to make the first cutting a means of liquidating the most overmature timber only. The removal of somewhat less than 60 per cent of the volume may be advisable in heavy, old growth stands.

Mature Timber: This kind of timber, with normal distribution through the different size and age classes is ideal for silvicultural treatment. Reasonable adherence to the diameter limits should leave a good residual stand if used with discretion. Under normal conditions, there are enough small, unmerchantable trees and abundant reproduction (except where there have been ground fires previously). A 60 per cent volume removal will accomplish the needed stimulation and put the stand in healthy shape.

Young Merchantable Class: In this class a well handled commercial cutting of all the large trees might still leave a good forest of young trees on the ground. Some stands contain fairly large numbers of young sapling and pole sizes which will become merchantable and increase greatly in value if given a light cutting and a few years to grow. The proportion of volume to be removed may be less or greater than 60 per cent, depending on the number of large trees present. The removal of these large trees, plus the poorer intermediate sizes, will stimulate the growth of the smaller trees beyond expectation, chiefly because of their coming into the merchantable class. Marking in this sort of stand is simple.

A few suggestions in the handling of the different subtypes may be of value to the practicing forester. There are several questions concerning the response of different species to the opening up of the stand. For example, large, old hemlock is very sensitive to changed conditions brought about by logging. These trees often die out quickly, whereas small but old hemlocks, which have been almost standing still in the understory, suddenly come to life and make remarkable diameter growth.(13) Consequently, any partial cutting in stands with a large amount of hemlock must not expose the large trees too much, but still give the smaller ones a good deal of release.

The Second or Final Harvest Cutting

Although there is only a limited amount of experience in making the second cut, all evidence points to the fact that it is practical economically as well as found from the silvicultural point of view. The procedure in this case involves a final harvest cutting of all merchantable timber, which would mean all trees about 10 or 12 inches and over in diameter at breast height (D.B.H.). Consequently, a residual stand after this cut would be composed of scattered thrifty trees up to 12 inches with well formed crowns and a fairly dense understory of reproduction. The all-aged condition of the original stand would then change, temporarily at least, to a more or less two-story. The chances of survival and resistance to factors causing decadence are greatly improved. The final heavy cutting is certain to open up the stand to such a degree that there may be some windfall loss to the remaining trees, but even this should not be as great as in areas which were clear-cut.

This final cut requires little skill other than that required in caring for small trees in logging. Care must be used by fallers to drop the trees in openings in order to avoid loss of the 6, 8, and 10 inch trees remaining on the ground. If the Rules of Forest Practice set up during the Lumber Code are followed during the second cut very satisfactory results should be obtained. The question of slash disposal is not serious, since the slash cut in the first cycle will have rotted down fairly

well. If serious slash hazards develop in the course of the final cutting, it may be well to break these up by clearing the slash back from logging roads and railroad grades. The Code rules regarding the felling of large cull trees will handle this problem of fire hazard satisfactorily.

UTILIZATION PRACTICE

Along with a revision of forest cutting methods, under the "Two-Cut" system there exists an opportunity to improve the efficiency and technique of methods for both woods and mill utilization, a term used here to include all phases of woods cutting, transportation, and processing of forest products. The problem can, therefore, be separated into the woods and mill divisions. In the former the question of more efficient logging methods is the important issue, for under ordinary clear-cutting practice, the average Lake States logging operation is carried on in none too scientific a manner. There is a need for a greater knowledge of costs, for greater efficiency in utilizing the trees cut, and for a more scientific determination of proper transportation facilities. Most destructive logging operations are carried on with considerable wastage all along the line and a lack of definite control over costs. A well trained technical forester who is handling the forestry problems on such an operation can also exercise control over these engineering problems.

One of the most important questions is that of better cost

control. A properly trained technical man is able to analyze the ordinary company cost records in such a way as to determine what sizes, grades, and species of timber are producing a profit and what ones are not; what is the correct spacing for logging roads and railroad spurs; the most economical equipment that can be used to transport logs from various timber blocks; where camps should be located to serve the maximum area with the least outlay of cost, and many other problems of similar nature. A greater attention to costs, coupled with an accurate knowledge of the use to which this information may be put will yield considerably better results than are now obtained.(14)

Another field which needs attention is that of reducing woods' waste and thereby increasing the recoverable volume of material harvested. These losses result chiefly from high stumps, long butts, ignorance in making the most out of the merchantable stem, top material, broken trees, logs lost in the woods, and other similar wastes. Adequate woods supervision, including instruction of the loggers in better methods, will yield large values. The Forest Service has made studies of the logging wastes on a large number of Upper Peninsula operations, the results of which show that an average of 8.3 per cent of the net volume of merchantable material cut goes to waste. This figure includes some unavoidable waste material which is intermingled with cull material, but at least half is lost through ordinary negligence. The proportion of different kinds of waste shown

in this study is as follows:

High stumps	- 0.8% usually avoidable
Body waste	- 0.2% usually avoidable
Long butts	- 0.8% usually avoidable
Logs left in the woods	- 1.0% avoidable
Merchantable material in tops (such as ties, bolts, etc.)	- 5.0% partially avoidable
Other causes	- 0.5% unavoidable

Carelessness in long butting and in cutting high stumps causes a loss of much valuable material and is responsible for a large part of the top waste, some of which could be used for small dimension material, ties, or pulpwood. Even with the limitations mentioned, it is a conservative estimate that half of these wastes are avoidable and can be corrected by better supervision. Cutting of low stumps, picking up logs which might ordinarily be left in the woods, and obtaining more top volume can be easily accomplished on a selective logging job where there is less slash and logging debris to interfere with operations. If an estimated 4 per cent of the total waste were utilized, this would amount to 40 board feet per M board feet of standing volume cut. On an operation in which 15,000 M board feet is cut annually, better woods control would yield 600 M feet or a total of 15,600 M. The economic justification for increased woods control is evident in this one item alone, which, if well handled, would tend to be self-liquidating in itself. All this added material may require some expense for extra effort and supervision, but will be repaid once the change to more

efficient logging methods has been accomplished. If these 600 M of logs and tie cuts were worth $14.00 per M, they would bring in $8,400 of additional revenue, or more than enough to hire a well trained forester.

In addition to better utilization of cut material, the possibility of developing special markets for certain types of products such as hemlock tanbark, hardwood waste for chemical wood, special timbers and veneer logs, is worth investigating. For example, in a few operations it has been found that it pays to peel hemlock logs for tanbark, send them to the mill for lumber and sell the waste from the milling process for pulp chips. Fuelwood produced by efficient processes on some operations might be shipped to the large city markets instead of going to waste.

ENGINEERING AND TRANSPORTATION

One of the engineering problems certain to be encountered is the rapid extension of railroad, spur, and road facilities necessary when the area will be covered more rapidly under the "Two-Cut" plan. For example, attention should be given to the proper spacing of roads and spurs when lighter cuts are taken. Use may be made of the "break-even" calculations to determine the spacing.(14) This engineering problem must be handled in such a way as to keep costs to a minimum. For example, in the case operation cited in Part III the general practice has been

to space spurs at half-mile intervals. Accurate minimum cost analysis shows that a spacing at approximately 1800 feet for the clear-cutting operation and 1700 feet for the "Two-Cut" system will reduce the high skidding costs and offset the extra expense in laying more mileage of spur lines. More detailed analysis may show that the use of trucks to haul over the spur lines in the second cut of the "Two-Cut" plan would be cheaper than re-laying the railroad track. If other similar cost studies are carried out in advance of construction, worthwhile savings will be made and unnecessary expense eliminated.

Changes in milling operation under the "Two-Cut" system are optional. No change of normal procedure is necessary. On the other hand, if opportunities for expanding markets for special products present themselves, some changes might be desirable. For example, the manufacture of small dimension stock from bolts and slabs may warrant the installation of equipment to handle this material. Or if a chipper were installed, hemlock slabs and edgings might be chipped up and sold to a paper mill. These and many other possibilities present themselves which will have to be determined on the ground in each case.

COST ACCOUNTING PROCEDURE

In order to make the "Two-Cut" system as effective as possible in saving money to the operator, accurate records should be kept of costs in each stage of the operation. The problem

of distributing fixed costs over two cutting periods demands some attention. It has been suggested in Part III that during the first cutting period the same per M depreciation and depletion rates be charged off as under clear-cutting. The undepreciated balance will then be chargeable to the new volume as the second cut proceeds. This new volume is based upon growth determinations made and the new per M rate set for each item. For instance, under the "Two-Cut" plan railroads and roads necessary to cut over the whole area will have to be constructed during the first cutting period. Part of these construction costs should be charged against the first cut and the undepreciated balance held over to the final cut. If a road costing $40 were built through a 40-acre tract with 400,000 board feet, the write-off charge would be 10 cents per M under clear-cutting. Following the procedure of the "Two-Cut" plan, in which only 60 per cent of the volume is removed in the first cycle, 240,000 board feet would be cut, bearing a $24 cost at the 10 cent rate. The remaining $16 investment in this road would thus be set up as a capital expense to be written off in the next cut. Meanwhile, as a result of the fact that the remaining 160,000 board feet will add 40,000 feet in the growth interval and will amount to 200,000 feet in the second cut, the average depreciation charge will drop to 8 cents per M. The total volume removed would be 440,000 board feet, and the road write-off cost would average around 9.1 cents

per M as against 10 cents under the clear-cutting system. The heavier charge of 10 cents per M in the first cut is not unreasonable, since the timber is of larger size and more able to absorb it. Interest charges on the investment may reduce the difference slightly, but not enough to offset the advantages under the "Two-Cut" system.

Other cost questions such as those concerning the charges due to logging larger timber, better utilization of cut material, more intensive woods supervision, all need detailed attention if the operator makes the most of this intensive method of management. It has often been said that lumbermen seldom know their costs until the logs start through the mill. Since lumber must compete with substitutes manufactured with less hand labor and more machine labor, the problem of woods costs and their proper handling cannot be emphasized too strongly.

TECHNICAL DIRECTION

It is already apparent that the carrying out of this "Two-Cut" system of liquidation practically requires that a competent technical forester be employed on the operation. A man with proper training and experience who is realistic in his approach to the business problems involved is an asset to any organization embarking on this program. Instead of simply adding another item of overhead, the forester's job should be a self-liquidating one. In addition to his supervising the timber marking, his

work in timber cruising, bettering utilization standards, and handling production cost control will make this man extremely valuable to the company. These other duties can be made to fit in with the regular course of work after the revised woods' program is under way. It is not intended here to make the job of the forester any harder, but in a liquidating organization his work must be justified in a short period of time. This is in contrast with a sustained yield operation where a part of the forestry work represents an investment in future returns.

SOCIAL AND ECONOMIC ASPECTS OF THE "TWO-CUT" METHOD

It is rather difficult to forecast the social and economic results of this new method of liquidation in any more than a speculative manner. In Part II an attempt was made to outline briefly what advantages are likely to accrue to the public if private concerns should apply the "Two-Cut" system. It is altogether likely that these cutover lands will hold so much promise for an early return that private owners will continue to pay taxes on them. Even if this does not take place, these areas are certain to produce another crop of timber in considerably shorter time than might otherwise be expected. A definite asset is left, instead of a liability, which will provide a nucleus for a future industry on a smaller scale. This new forest cover will also be a recreational asset far superior to open slashings.

In return for allowing these lands to enjoy lower tax privileges, the public will receive several specific benefits. The first, and the one of most immediate concern, is the lengthening of the expected life of the mill, thereby proportionally increasing employment prospects. An added period of tax revenue from the mill properties will help to ease the financial strain to the communities. These are two very tangible items of consideration. In addition, the taxes paid by the companies on their forest lands will be continued for the additional period. No estimates can be made of the dollars and cents advantages because these will vary with each operation.

An opportunity is opened for greater participation by public agencies during the course of time in which this "Two-Cut" method is used, since a large part of the remaining merchantable forests in the region lie within the boundaries of National, State or County forests. If, for the purpose of acquisition, the Federal Forest Service, the States, or Counties are able to obtain sufficient funds during the next ten years under the various legislative acts, it would enable them to purchase these selectively cut tracts prior to the second cutting, thus making it possible to manage them on a sustained yield basis of light, frequent cuts and to dispose of the products through the industry. In any event, the various public agencies will be given ample opportunity to purchase as much of this partially cut land

as possible. These agencies therefore would undoubtedly be willing to lend considerable support in the promotion of this development not only through land purchases but by direct assistance in formulating plans of management.

CLOSING SUGGESTIONS

FOR INCREASING THE OPERATING LIFE

It must be clearly recognized that the final closing of these mills will be staved off only temporarily by the application of the "Two-Cut" system. However, the longer these industries can be maintained, the better off the region will be and the less painful the final readjustment. It is here that a practical cooperative program of land and resource-use planning, in which both the public agencies and the operating concerns take part, will be of inestimable value. For example, the Forest Service could make available to the industry all merchantable material which could be cut from its own lands under proper woods practices. Small scattered patches of merchantable timber which would not pay for the industry to operate could be cut selectively by Forest Service crews and the logs sold to the local mills. The products cut from timber stand improvement work and fire hazard reduction, and from road building, could be pooled where such a procedure would be economically feasible. In addition, the concerns themselves could encourage

farmers and small jobbers to bring in small quantities of logs. If this were done during the time in which the firm was logging its own timber, the period between the first and second cuts could be lengthened and additional growth would accrue. The Counties and States could enter in this program with their own lands. Wisconsin has much scattered merchantable timber which would be extremely valuable. It is entirely possible that relief labor projects which are working in these areas could be made partially self-liquidating under such an arrangement.

This whole program would involve a high degree of cooperative action between the public agencies and the industry. It is probable that the Division of State and Private Forestry of the Forest Service would be in the best position to act as a coordinator of public agencies, while the Northern Hemlock and Hardwood Manufacturers Association would represent the industry. The problem is one of local land-use planning and would need considerable groundwork on each operation.

APPLICATION OF THE "TWO-CUT" IDEA IN OTHER REGIONS

Much of the lumber industry throughout the country is faced with the necessity for liquidating its timber because of heavy indebtedness and for many other reasons. The present destructive forest practices are entirely unsatisfactory in that they make no attempt to leave the land in productive condition. It would seem reasonable that in those cases where sustained yield

is impracticable some adaptation of the Shelterwood Principle would provide a silviculturally sound method of forest liquidation. Several of the lumber trade associations have continued the old Code Rules of Article X and deserve much credit for this voluntary effort. Nevertheless, these rules do not go far enough in solving the fundamental problem of leaving productive forest lands. There is a great need for a clearly defined silvicultural approach to the liquidation problem, which will be satisfactory and practical and will reconcile immediate economic demands with long-run silvicultural and social needs. If the purely liquidating section of the industry will examine the possibilities of the "Two-Cut" system in an impartial manner, it should find some hope for reconciling its need for liquidation with the need of the public for future forests.

APPENDIX

TABLES A - L

TABLE A

Stand and Stock Table for Northern Hardwood and Hemlock Forest Type(1)

(Northeastern Wisconsin)

Average Acre - Merchantable Timber - Volumes in Net Scribner

Immediately Before Cutting:

DBH in In.	NUMBER OF TREES						NET SCRIBNER VOLUME - Board Feet						Basal Area Sq.Ft.
	Hemlock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	Hemlock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	
R	15.13	101.74	83.50	3.21	38.21	244.29							
2	14.09	64.36	15.75	11.88	9.39	115.47							
4	9.61	16.49	8.97	3.54	6.31	44.92							
6	8.14	8.11	4.51	1.80	3.49	26.05	--- Negligible ---						
8	6.48	5.78	3.04	2.13	2.06	19.49							
Total	38.32	93.74	32.27	18.35	23.25	205.93							
10	6.08	3.96	1.33	0.88	0.75	13.00	130.9	52.5	16.5	11.7	8.5	220.1	7.08
12	4.90	3.77	1.28	0.54	0.83	11.32	242.6	187.2	59.6	32.0	37.4	558.8	8.90
14	3.90	3.29	1.44	0.59	0.58	9.80	327.4	298.0	116.8	44.6	45.0	831.8	9.86
16	2.86	2.32	1.33	0.50	0.50	7.51	383.7	306.1	168.3	87.4	58.5	1004.0	10.50
18	2.38	2.33	1.04	0.36	0.30	6.41	460.3	445.1	179.2	77.5	50.8	1212.9	11.32
20	1.59	1.64	0.90	0.26	0.32	4.71	425.8	435.0	204.8	70.5	74.3	1210.4	9.58
22	1.27	1.06	0.54	0.15	0.14	3.16	445.8	364.2	153.2	79.8	42.1	1085.1	8.35
24	0.88	0.86	0.39	0.11	0.03	2.27	386.9	379.0	135.5	75.6	11.3	988.3	7.14
26	0.61	0.40	0.12	0.07	0.01	1.21	331.7	220.2	53.6	59.9	4.6	670.0	4.45
28	0.32	0.23	0.18	0.03	-	0.76	210.1	150.4	87.7	45.7	-	493.9	3.24
30+	0.33	0.31	0.20	0.14	-	0.98	299.7	245.2	118.6	144.4	-	807.9	4.80
Total	25.12	20.17	8.75	3.63	3.46	61.13	3644.9	3082.9	1293.8	729.1	332.5	9083.2	85.22

(1) Adapted from U. S. Forest Service Forest Survey Stand Tables for Northeastern Wisconsin. Modified to fit special conditions of study.

TABLE B

Number of Trees and Volume Removed in First Selective Cutting

(60% of Volume Removed)

DBH in In.	NUMBER OF TREES						NET SCRIBNER VOLUME - Board Feet						Basal Area Sq.Ft.
	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	
10	0.46	0.65	0.28	0.15	0.09	1.63	10.0	8.5	3.5	2.0	1.0	25.0	0.89
12	0.39	0.21	0.12	0.10	0.74	1.56	20.0	10.5	5.5	6.0	33.0	75.0	1.22
14	0.59	0.47	0.13	0.16	0.47	1.82	50.0	41.0	11.0	12.0	36.0	150.0	1.83
16	0.64	0.46	0.19	0.11	0.42	1.82	86.1	61.5	23.6	19.2	49.6	240.0	2.54
18	1.03	0.84	0.35	0.19	0.24	2.65	200.0	160.0	60.0	40.0	40.0	500.0	4.67
20	1.04	0.82	0.35	0.29	0.30	2.80	280.0	218.0	78.0	56.0	68.0	700.0	6.12
22	0.91	0.79	0.38	0.12	0.12	2.32	320.4	270.7	107.9	64.0	37.0	800.0	6.12
24	0.88	0.86	0.39	0.11	0.03	2.27	386.9	379.0	135.5	75.6	11.3	988.3	7.15
26	0.61	0.40	0.12	0.07	0.01	1.21	331.7	220.2	53.6	59.9	4.6	670.0	4.46
28	0.32	0.23	0.18	0.03	-	0.76	210.1	150.4	87.7	45.7	-	493.9	3.26
30+	0.33	0.31	0.20	0.14	-	0.98	299.7	245.2	118.6	144.4	-	807.9	4.80
Total	7.20	6.04	2.69	1.47	2.42	19.82	2194.9	1765.0	684.9	524.8	280.5	5450.1	43.06

TABLE C

Stand and Stock Table for Northern Hardwood and Hemlock Forest Type[1]

(Northeastern Wisconsin)

Average Acre - Merchantable Timber - Volumes in Net Scribner

Immediately After 60% Selective Cutting:

DBH in In.	NUMBER OF TREES						NET SCRIBNER VOLUME - Board Feet						Basal Area Sq.Ft.
	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	
R	15.13	101.74	83.50	3.21	38.21	244.29							
2	14.09	64.36	15.75	11.88	9.39	115.47							
4	9.61	16.49	8.97	3.54	6.31	44.92	--- Negligible ---						
6	8.14	8.11	4.51	2.80	2.49	26.05							
8	6.48	6.78	3.04	2.13	1.06	19.49							
Total	38.32	95.74	32.27	20.35	19.25	205.93							
10	5.62	3.31	1.05	0.73	0.66	11.37	120.9	44.0	13.0	9.7	7.5	195.1	6.20
12	4.51	3.56	1.16	0.44	0.09	9.76	222.6	176.7	54.1	26.0	4.4	483.8	7.66
14	3.31	2.82	1.31	0.43	0.11	7.98	277.4	257.0	105.8	32.6	9.0	681.8	8.53
16	2.22	1.86	1.14	0.39	0.08	5.69	297.6	244.6	144.7	68.2	8.9	764.0	7.94
18	1.35	1.49	0.69	0.17	0.06	3.76	260.3	285.1	119.2	37.5	10.8	712.9	6.64
20	0.55	0.82	0.55	0.07	0.02	2.01	145.8	217.0	126.8	14.5	6.3	510.4	4.38
22	0.36	0.27	0.16	0.03	0.02	0.84	125.4	93.5	45.3	15.8	5.1	285.1	2.22
24						-						-	-
26						-						-	-
28						-						-	-
30+						-						-	-
Total 10"+	17.92	14.13	6.06	2.26	1.04	41.41	1450.0	1317.9	608.9	204.3	52.0	3633.1	43.57
Total 2"+	56.24	109.87	38.33	22.61	20.29	247.34							

(1) Adapted from U. S. Forest Service Forest Survey Stand Tables for Northeastern Wisconsin. Modified to fit special conditions of study.

TABLE D

Stand and Stock Table for Northern Hardwood and Hemlock Forest Type[1]

(Northeastern Wisconsin)

Average Acre - Merchantable Timber - Volumes in Net Scribner

Seven Years After Selective Cutting:

DBH in In.	NUMBER OF TREES						NET SCRIBNER VOLUME - Board Feet						Basal Area Sq.Ft.
	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	Hem-lock	Sugar Maple	Yellow Birch	Bass-wood	Misc. Hdwds.	Total	
R	75	2370	590	200	320	3555							
2	25	114	64	18	32	253							
4	14	38	13	6	7	78							
6	11	10	7	5	3	36	---	Negligible	---				
8	9	8	4	3	2	26							
Total 2-8"	59	170	88	32	44	393							
10	5.87	5.02	1.91	1.65	0.89	15.34	126	67	24	22	12	251	8.36
12	5.01	3.27	1.06	0.62	0.46	10.42	248	163	49	36	23	519	8.20
14	3.97	3.10	1.18	0.42	0.09	8.76	338	282	96	54	9	774	8.82
16	2.84	2.32	1.19	0.41	0.09	6.85	382	307	150	71	12	922	9.55
18	1.87	1.65	0.88	0.32	0.08	4.80	362	314	150	69	15	910	8.47
20	1.06	1.17	0.60	0.13	0.05	3.01	284	309	136	29	14	772	6.12
22	0.47	0.58	0.35	0.06	0.02	1.48	165	198	100	16	7	487	3.90
24	0.24	0.15	0.08	0.02	0.02	0.51	106	65	28	11	8	218	1.60
26						-						-	-
28						-						-	-
30+						-						-	-
Total 10"+	21.33	17.26	7.25	3.63	1.70	51.17	2006	1705	734	308	100	4853	55.02

(1) Adapted from U. S. Forest Service Forest Survey Stand Tables for Northeastern Wisconsin. Modified to fit special conditions of study.

TABLE E

Logging Costs(1) per M Bd. Ft. for Trees of Different Sizes

Case Study Operation - Based On 15,000 M Bd. Ft. Log Sc.

Straight Liquidation Method

DBH in In.	DIRECT COSTS(2)				INDIRECT COSTS(3)						Total Costs Log Scale	Over-run Factors	Total Costs Mill Scale
	Log Making	Skid-ding	Loading & Un-loading	Trans-porta-tion(1)	Camps	Super-vision and Scaling	Gen'l Ex-pense	Dep'n on Logging Equip't	Road & RR Con-struc-tion	Deple-tion			
10	2.70	5.74	2.37	2.22							19.52	1.50	13.00
12	2.32	4.58	1.90	2.10							17.39	1.41	12.32
14	2.05	3.59	1.50	1.99							15.62	1.32	11.82
16	1.83	2.90	1.23	1.88							14.33	1.25	11.48
18	1.66	2.38	1.05	1.80							13.38	1.20	11.15
20	1.57	1.95	0.90	1.73	0.25	0.50	0.23	0.18	0.93	4.40	12.64	1.16	10.90
22	1.43	1.72	0.81	1.66							12.11	1.13	10.72
24	1.35	1.55	0.73	1.62							11.74	1.107	10.60
26	1.28	1.43	0.69	1.57							11.46	1.09	10.50
28	1.21	1.32	0.66	1.53							11.21	1.08	10.38
30+	1.19	1.26	0.66	1.51							11.11	1.04	10.60
					Total	6.49							
Woods Run	1.60	2.30	1.00	1.75									

(1) Costs based on 1936 average.

(2) Costs varying with the diameter of the tree cut.

(3) Costs constant with the diameter of the tree cut.

TABLE F

Logging Costs[1] per M Bd. Ft. for Trees of Different Sizes
Case Study Operation - Based on 15,000 M Bd. Ft. Log Scale

"Two-Cut" Liquidation Method

DBH in In.	DIRECT COSTS				INDIRECT COSTS						Total Costs - Log Scale	Over-run Factors	Total Costs - Mill Scale
	Log Making	Skidding	Loading & Unloading	Transportation	Camp Construction	Supervision and Scaling	Gen'l Expense	Dep'n on Logging Equip't	Road & RR Construction	Depletion			
10	2.70	5.74	2.37	2.22							19.10	1.50	12.72
12	2.32	4.58	1.90	2.10							16.88	1.41	11.95
14	2.05	3.59	1.50	1.99							15.11	1.32	11.45
16	1.83	2.90	1.23	1.88							13.82	1.25	11.06
18	1.66	2.38	1.05	1.80							12.88	1.20	10.70
20	1.57	1.95	0.90	1.73	0.30	0.60	0.23	0.16	0.83	3.86	12.13	1.16	10.45
22	1.43	1.72	0.81	1.66							11.60	1.13	10.25
24	1.35	1.55	0.73	1.62							11.23	1.107	10.17
26	1.28	1.43	0.69	1.57							10.95	1.09	10.02
28	1.21	1.32	0.66	1.53							10.70	1.08	9.90
30+	1.19	1.26	0.66	1.51							10.60	1.04	10.20
					Total 5.98								

[1] Cost based on 1936 average.

TABLE G

Milling Costs[1] per M Bd. Ft. for Trees of Different Sizes

Case Study Operation
Based on Annual Cut of 17,750 M Bd. Ft. Mill Scale

Straight Liquidation Method

DBH in In.	Sawing Labor and Supplies	Sorting and Piling	Planing	Ship-ping	Selling	Insur-ance	Over-head	Taxes on Mill & Town	Depreciation On Mill & Town	TOTAL MILLING COST
10	3.12									10.96
12	2.92									10.76
14	2.72									10.56
16	2.53									10.37
18	2.38									10.22
20	2.28	1.00	1.13	1.50	1.18	0.42	0.87	0.74	1.00	10.12
22	2.18									10.02
24	2.10									9.94
26	1.97									9.81
28	1.94									9.78
30+	1.90									9.74
		7.84								
Woods Run	2.31									

[1] Costs Based on 1936 Average.

TABLE H

Milling Costs[1] per M Bd. Ft. for Trees of Different Sizes
Case Study Operation
Based on Annual Cut of 15,000 M Bd. Ft. Mill Scale

"Two-Cut" Liquidation Method

DBH in In.	Sawing Labor and Supplies	Sorting and Piling	Planing	Shipping	Selling	Insurance	Overhead	Taxes on Mill & Town	Depreciation On Mill & Town	TOTAL MILLING COST
10	3.12									10.84
12	2.92									10.64
14	2.72									10.44
16	2.53									10.25
18	2.38									10.10
20	2.28	1.00	1.13	1.50	1.18	0.42	0.87	0.74	0.88	10.00
22	2.18									9.90
24	2.10									9.82
26	1.97									9.69
28	1.94									9.66
30+	1.90									9.62
		7.72								
Woods Run	2.31									

(1) Costs Based on 1936 Average.

TABLE I

Average Dry Lumber Value,

Mill Scale Per Thousand, For Trees of Different Sizes
(Includes 5% Deduction for Loss in Drying)

D.B.H. in inches	Sugar Maple	Yellow Birch	Basswood	Misc. Hardwoods	Hemlock
10	$20.45	$22.90	$28.75	$18.65	$24.50
12	21.64	24.60	31.20	20.35	24.50
14	24.03	27.48	33.85	22.40	24.50
16	26.47	29.24	36.40	23.95	24.50
18	28.77	30.85	38.30	25.55	24.50
20	31.01	33.55	39.70	27.05	24.50
22	33.22	36.45	40.70	29.00	24.50
24	35.38	40.35	41.50	31.15	24.50
26	37.07	41.60	42.20	32.10	24.50
28	38.66	42.45	42.85	-	24.50
30+	42.00	45.00	45.00	-	24.50

Obtained from Phelps Logging and Milling Study and Welsh's Data.
Average figures for late 1935 and early 1936 - after N.R.A. Code prices.

TABLE J

Stand Volumes Converted From Log Scale to Mill Scale

Dry Lumber Values by Diameter Classes

DBH in In.	Over-run Factor	BEFORE CUTTING			REMOVED IN CUTTING			AFTER CUTTING			7 YEARS AFTER CUTTING		
		Log Scale Bd.Ft.	Mill Scale Bd.Ft.	Lumber Value ($)	Log Scale Bd.Ft.	Mill Scale Bd.Ft.	Lumber Value ($)	Log Scale Bd.Ft.	Mill Scale Bd.Ft.	Lumber Value ($)	Log Scale Bd.Ft.	Mill Scale Bd.Ft.	Lumber Value ($)
10	1.50	220.1	330.0	$ 7.74	25.0	37.0	$ 0.89	195.1	293.0	$ 6.85	251.0	376.0	$ 8.79
12	1.41	558.8	786.0	18.58	75.0	105.0	2.37	483.8	681.0	16.21	519.0	732.0	17.50
14	1.32	831.8	1097.0	27.59	150.0	197.0	4.93	681.8	900.0	22.66	774.0	1022.0	25.87
16	1.25	1004.0	1250.0	33.68	240.0	295.0	7.82	764.0	955.0	25.86	922.0	1153.0	30.98
18	1.20	1212.9	1460.0	40.79	500.0	601.0	16.74	712.9	859.0	24.05	910.0	1093.0	30.66
20	1.16	1210.4	1408.0	41.41	700.0	817.0	23.68	510.4	591.0	17.73	772.0	896.0	26.25
22	1.13	1085.1	1230.0	37.45	800.0	907.0	27.68	285.1	323.0	9.77	487.0	549.0	17.05
24	1.107	988.3	1094.0	34.80	988.3	1094.0	34.80				218.0	241.0	7.51
26	1.09	670.0	730.0	23.07	670.0	730.0	23.07						
28	1.08	493.9	533.0	18.03	493.9	533.0	18.03						
30	1.04	807.9	840.0	30.15	807.9	840.0	30.15						
Total		9083.2	10,758.0	$313.29	5450.1	6156.0	$190.16	3633.1	4602.0	$123.13	4853.0	6062.0	$164.61

TABLE Ka

Tax Schedule - Straight Liquidation

Wisconsin - 70¢ per acre land tax.

Tax Period	Merchantable Timber (Acres)	Total Tax at 70¢ per Acre	Cutover Land (Acres)	Total Tax at 12¢ per Acre	Total All Land Taxes
1 - 1939	21,320	$ 14,924.00			$ 14,924.00
2 - 1940	19,670	13,648.00	1,650	$ 198.00	13,846.00
3 - 1941	18,020	12,572.00	3,300	396.00	12,968.00
4 - 1942	16,370.	11,459.00	4,950	594.00	12,053.00
5 - 1943	14,720	10,304.00	6,600	792.00	11,096.00
6 - 1944	13,070	9,149.00	8,250	990.00	10,139.00
7 - 1945	11,420	7,994.00	9,900	1,188.00	9,182.00
8 - 1946	9,770	6,839.00	11,550	1,386.00	8,225.00
9 - 1947	8,120	5,684.00	13,200	1,584.00	7,268.00
10 - 1948	6,470	4,529.00	14,800	1,782.00	6,311.00
11 - 1949	4,820	3,374.00	16,500	1,980.00	5,354.00
12 - 1950	3,170	2,219.00	18,150	2,178.00	4,397.00
13 - 1951	1,520	1,064.00	19,800	2,376.00	3,440.00
14 - 1952			21,320	2,574.00	2,574.00
15 - 1953					
Total		$103,759.00		$ 18,018.00	$121,777.00

TABLE Kb

Tax Schedule - "Two-Cut" Liquidation

Wisconsin - Forest Crop Law
(Special Classification)

Tax Period	Merchantable Timber (Acres)	Tax per Acre	Total Tax	Selectively Cut Land (Acres)	Total Tax at 10¢ per Acre	Per Cent Yield Tax	Total Yield Tax(1)	Total All Taxes
1 - 1939	21,320	$0.40	$8,528.00			2	$ 900.00	$ 9,428.00
2 - 1940	18,570	0.35	6,499.50	2,750	$ 275.00	3	1,350.00	8,124.50
3 - 1941	15,820	0.30	4,746.00	5,500	550.00	4	1,800.00	7,096.00
4 - 1942	13,070	0.25	3,267.50	8,250	825.00	5	2,250.00	6,342.50
5 - 1943	10,320	0.25	2,580.00	11,000	1,100.00	6	2,700.00	6,380.00
6 - 1944	7,570.00	0.20	1,514.00	13,750	1,375.00	7	3,150.00	6,039.00
7 - 1945	4,820	0.20	964.00	16,500	1,650.00	8	3,600.00	6,214.00
8 - 1946	2,070	0.15	330.50	19,250	1,925.00	9	4,050.00	6,305.50
9 - 1947				21,320	2,132.00	10	4,500.00	6,632.00
10 - 1948				21,320	2,132.00	10	4,500.00	6,632.00
11 - 1949				21,320	2,132.00	10	4,500.00	6,632.00
12 - 1950				21,320	2,132.00	10	4,500.00	6,632.00
13 - 1951				21,320	2,132.00	10	4,500.00	6,632.00
14 - 1952				21,320	2,132.00	10	4,500.00	6,632.00
15 - 1953				21,320	2,132.00	10	3,210.00	5,342.00
Total			$28,429.50		$22,624.00		$50,010.00	$101,063.50

(1) Based on an annual cut of 15 million board feet, with a stumpage value of $3 per M board feet.

TABLE La

Tax Schedule - Straight Liquidation

Michigan - 60¢ per acre land tax.

Tax Period	Merchantable Timber (Acres)	Total Tax at 60¢ per Acre	Cutover Land (Acres)	Total Tax at 12¢ per Acre	Total All Land Taxes
1 - 1939	21,320	$ 12,792.00			$ 12,792.00
2 - 1940	19,670	11,802.00	1,650	$ 198.00	12,000.00
3 - 1941	18,020	10,812.00	3,300	396.00	11,408.00
4 - 1942	16,370	9,822.00	4,950	594.00	10,416.00
5 - 1943	14,720	8,832.00	6,600	792.00	9,624.00
6 - 1944	13,070	7,842.00	8,250	990.00	8,832.00
7 - 1945	11,420	6,852.00	9,900	1,188.00	7,840.00
8 - 1946	9,770	5,862.00	11,550	1,386.00	7,248.00
9 - 1947	8,120	4,872.00	13,200	1,584.00	6,456.00
10 - 1948	6,470	3,882.00	14,800	1,782.00	5,664.00
11 - 1949	4,820	2,892.00	16,500	1,980.00	4,872.00
12 - 1950	3,170	1,902.00	18,150	2,178.00	4,080.00
13 - 1951	1,520	812.00	19,800	2,376.00	3,188.00
14 - 1952			21,320	2,574.00	2,574.00
Total		$ 88,976.00		$ 18,018.00	$106,994.00

TABLE Lb

Tax Schedule - "Two-Cut" Liquidation

Michigan - Selectively Cut and Listed under Forest Tax Laws

Tax Period	Merchantable Timber (Acres)	Total Tax at 60¢ per Acre	Selectively Cut Land (Acres)	Total Tax at 5¢ per Acre	Total Yield Tax (10% @ $3 per M)	Total All Taxes
1 - 1939	21,320	$ 12,722.00				$12,722.00
2 - 1940	18,570	11,142.00	2,750	$ 137.50		11,279.50
3 - 1941	15,820	9,492.00	5,500	275.00		9,767.00
4 - 1942	13,070	7,842.00	8,250	412.50		8,254.50
5 - 1943	10,320	6,192.00	11,000	550.00		6,742.00
6 - 1944	7,570	4,542.00	13,750	687.50		5,229.50
7 - 1945	4,820	2,892.00	16,500	825.00		3,717.00
8 - 1946	2,070	1,242.00	19,250	962.50	$ 1,140.00	3,344.50
9 - 1947			21,320	1,066.00	4,500.00	5,566.00
10 - 1948			21,320	1,066.00	4,500.00	5,566.00
11 - 1949			21,320	1,066.00	4,500.00	5,566.00
12 - 1950			21,320	1,066.00	4,500.00	5,566.00
13 - 1951			21,320	1,066.00	4,500.00	5,566.00
14 - 1952			21,320	1,066.00	4,500.00	5,566.00
15 - 1953			21,320	1,066.00	3,210.00	4,276.00
Total		$56,066.00		$11,312.00	$31,350.00	$98,728.00

PLATE I. Typical Lake States Lumber Mill Showing Yards and Timber Supply

PROGRESSION OF THE STAND UNDER THE "TWO-CUT" SYSTEM OF LIQUIDATION

PLATE II
Mature Northern Hardwood-Hemlock Stand Marked for Selective Cutting (heavy reproduction coming in at the edge of an earlier partial cutting)

PLATE III
Same Forest Type Seven Years after a 60% Partial Cutting (Note vigor of small trees and reproduction)

PLATE IV
Same Forest Type One Year after Final Liquidation Cutting

PLATE V
A Well Handled Job of Partial Cutting. Breakage is kept to a minimum and forest conditions maintained.

PLATE VI
Same Type Several Years Later. The merchantable timber now remaining may be cut and will be replaced by the thrifty reproduction.

PLATE VII
Immediately After Clear-Cutting in Lake States Hardwoods. Small trees destroyed and reproduction of new forest delayed for a long period.

PLATE VIII
Hardwood-Hemlock Type Ten Years After Clear-Cutting. Degeneration of the site is complete.

TYPES OF AVOIDABLE FOREST WASTE

PLATE IX
Waste in Cutting High Stumps
means heavy losses in merchantable timber.

PLATE X
Types of Available Waste in Top Material
Fifty board feet in every thousand feet
of standing timber is lost in top waste.

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