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Second Growth Hardwoods After Clear Cutting Fifty Years Ago. The Stand Contains Forty-eight Cords Per Acre

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BY P. L. BUTTRICK

The northwestern portion of the Lower Peninsula of Michigan is known as the "Hardwood Belt." It is a region of low hills, gravelly soils, lakes and swamps. Formerly, except the swamps and certain stretches of sandy pine lands, it was covered with a magnificent hardwood forest. Today most of it has been removed. The virgin forest exists only in a few small tracts and seems destined in a decade to disappear entirely under the lumberman's axe. The region is becoming one of farms, fruit ranches, and summer homes. The towns are small and their manufacturing and commercial life depends largely upon these farms and the products of the forest.

The region has yet to reach its full development as an agricultural section. Some of it can never be used as farm land, the forest must always play its part in the life of the region. If it disappears entirely, the lumber, chemical wood and wood-working industries go with it and thus will be lost many opportunities for industrial life and for wage-earning during the winter months. If it disappears the summer tourists will go elsewhere as they desire the forest for its beauty and because it shelters game and fish. The value of the tourist trade in this region is great.

Even from an agricultural viewpoint the forest is too valuable to be entirely sacrificed. If the farmer loses his woodpile and has to burn coal he must pay prices and use amounts far beyond those of his southern neighbor, and if the hilltops are denuded the light gravelly soil washes down onto fields and destroys their fertility.

This bulletin does not pretend to be a complete study of the forests of the region. It is written to call attention to the problem and to answer, as far as may be, the questions which the farmer, the lumberman, the chemical-wood man and the landowner are asking as to the future of the regions' once greatest resource.

THE VIRGIN HARDWOOD TYPE

The forests of northern Michigan are divided sharply into three distinct kinds or types. There is first the pine type, most of which has long been cut. It consists at its best of white and red pine, and at its poorest of jack pine. There is the swamp type consisting of a mixture of white cedar, balsam, tamarack and various other species and,

lastly, the hardwood type consisting of a mixture of various hardwood trees, sugar maple and American elm being the most common. There may also be a small proportion of coniferous trees, generally hemlock and white pine, in the mixture.

In southern Michigan the pine type entirely disappears and the swamp type is so much modified that it is almost a different type. A hardwood forest is the dominant type in the southern part of the State but it is not the same hardwood type as that found in the northern section. The southern, or, since it is not really southern, central hardwood type is characterized by an abundance of white and other species of oak. Oak occurs in northern Michigan, but when found it is always in the pine type rather than in the hardwood. Red oak appears occasionally along Lake Michigan with the hardwoods but it is not typical. Nothing in this report applies to the central hardwood type, since its composition, rate of growth and value all differ from the northern hardwood type. The discussion applies to that portion of the type found in the northwestern part of the Lower Peninsula.

The virgin hardwood type exists in what is called an uneven-aged form. That is to say, trees of many ages from seedlings to veterans past maturity exist side by side on the same area. As the mature trees die their places are taken by middle-aged trees which stand beside them, or if a group of veterans standing near together die out at the same time, as frequently happens, its place is taken by seedlings and saplings, which crowd into the opening thus formed. In this manner the forest is constantly being renewed as fast as it is destroyed, but it is not, except perhaps in the case of small areas, gaining in volume. Its growth is balanced by decay.

SECOND GROWTH HARDWOOD LANDS

The character of the second growth depends almost entirely upon the nature of the original cutting and the subsequent action of fire.

In the early days of lumbering in the region the hardwoods were neglected. There were substantial reasons for this. In the first place they had little or no merchantable value, and since they float badly, or not at all, they could not be transported when river driving was the only means of transportation. When the pine lands were cut over the lumbermen began removing the pine from the hardwood type and later the best of the hemlock and hardwoods which, with the growing scarcity of timber, had become merchantable. With the advent of railroad logging in the late eighties, it became possible to take out large quantities of hardwoods successfully. The early hardwood loggers, who culled out only the best timber, left a forest covering. As the demand increased the cutting became more and more severe until in recent years frequently little trace of a forest cover is left after the logger and the chemical-wood man, who follows him, have finished. Fire after logging is less frequent in the hardwoods than in the pine but despite the generally more moist soil and less inflammable slash, it occurs far too often.

The reasonable fertility of the hardwood lands, as compared with the usual sterility of the pine lands, early attracted attention and many

farms were cleared in the former type in advance of any market for the timber. The customary practice was to cut and burn the timber merely to clear the land. As the hardwoods became valuable this practice ceased. Later, changes in economic conditions following the removal of the pine, and the discovery that not all the hardwood land was agricultural caused the abandonment of many of these early farms.

The following classification of second-growth hardwoods, all depending upon the manner in which the original timber was removed and what has happened subsequently, is recognized:

Culled lands.
Clean cut lands unburned or largely unburned.
Culled or clean cut lands heavily burned over.
Cleared lands allowed to revert to forest.
Cut, cleared or burned lands reverting to pure or nearly pure stands of aspen.

Culled Lands: These are lands from which the best timber was removed in the early days of hardwood logging and which have since remained under forest. The timber removed generally consisted of practically all the pine, the larger and better hemlock, the ash, cherry and the largest and best maple, basswood and elm. The size of the trees which remain varies with the degree of utilization which was profitable at the time and place of cutting. At first the culling was so light that the character of the forest was unchanged. In fact most of the virgin hardwood land has been lightly culled at some time or other. As the cuttings became heavier the larger trees of the more valuable species were removed and the inferior ones were left, which resulted in a change in the character and composition of the forest. Immediately after the cutting it consisted of rather straggling stands, containing large trees of inferior species, chiefly beech and red maple, and large but defective trees of valuable species and also small and often injured trees of all species, the injury being due to breakage incident upon logging. If fire swept through these stands it did not usually result in complete destruction since the light slash did not afford sufficient fuel. It resulted chiefly in thinning out the younger trees and injuring the bases of the older ones.

As time has gone on these culled stands have either been still further culled, resulting eventually in their being practically clear cut, or they have been allowed to remain as they were and to recuperate. The recuperation has mostly progressed to the point where the stand is essentially a two-storied one, consisting of an upper story of scattering older trees left over from logging, and an under story of much smaller trees which were either present as undergrowth when the cutting was made or have come in since. The trees in the upper story are mostly trees of inferior species or inferior individuals of the more valuable species. Many of these older trees are worthless because of decay which has started in their tops as a result of breakage due to logging or at their bases due to fire. Others, usually the smaller ones, are sound and thrifty and are profiting by the removal of the competition of their neighbors. Certain species have largely disappeared, the white pine being the most conspicuous example. Hemlock has been greatly reduced in abundance; inferior species such as beech and red maple have

increased in numbers because of the removal of the other species. The percentage of basswood is often increased because of its superior sprouting ability. The new growth is a mixture of seedlings and sprouts from stumps of smaller trees injured in logging.

Table I gives the data on a typical culled area. It is interesting to note that the yield is slightly less per acre than for fully cut-over areas of the same age (see Table V) although it would not be safe to assume that this is always the case.

Table I.—Volume of Original and Second Growth on an Average Acre of Culled Hardwoods, 22 Years After Culling.*

Species.	Volume of remaining original growth.**		Volume of second growth.**		Total volume.	
	Cu. ft.	Cords.***	Cu. ft.	Cords.	Cu. ft.	Cords.
Elm	36.6	.41	53.76	.60	90.35	1.00
Basswood	6.1	.07	44.32	.49	50.42	.56
Maple	818.7	9.10	39.34	.44	858.04	9.53
Beech	212.7	2.36	29.57	.33	242.27	2.69
Hemlock	132.4	1.47	1.9	.02	134.30	1.49
Others ****	.....	.....	4.5	.05	4.50	.05
Total	1,206.5	13.41	173.39	1.93	1,379.88	15.32

*Based on one-half mile of strip survey, made in Coldsprings Township, Kalkaska county, Michigan April, 1922.

**Practically all the remaining old growth was cull material over 8 inches diameter breast high. It is fit for cordwood only. The second growth was largely sprouts, young and vigorous, with a few seedlings in mixture. Smallest diameter recorded was 2 inches. Part of this stand was being harvested for chemical wood, both original and second growth material being taken.

***One cord equals 90 cubic feet solid contents.

****Aspen, cherry, ironwood, and birch.

The culled type exists either in the form of farm woodlots or more or less extended tracts. In parts of Grand Traverse, Leelanau and Benzie counties, settlement has been carried on so long that most of the forest in the hardwood belt has disappeared or been reduced to relatively small areas on the poorer and steeper sites and is practically all in the form of woodlots attached to farms.

In Charlevoix, Kalkaska and Antrim counties, larger bodies of culled hardwood lands exist which are not attached to farms and which have generally not been disturbed since the culling took place. These are generally found along ridge tops and higher lands and contain more or less merchantable material. Some of these stands now, and more of them in a few years at most, can be utilized for chemical wood.

Clean Cut Lands Unburned or Largely Unburned: The renewal of the forest on clean cut lands depends almost entirely on whether or not they are burned over. Where a heavy fire has not run through the slashings a thrifty second growth has come up. A light fire may not prevent second growth but it is sure to reduce its density by at least 50 per cent.

This new stand is a mixed even-aged sprout and seedling stand, slightly different in composition from the original but largely resembling it otherwise and tending to resemble it more and more as it increases in age.

Scattering small trees from six to eight inches in diameter left over

from logging are usually present. They were generally damaged and tend to die out rather than to thrive. This class has little part in the new stand. In 20 years or less practically all have disappeared, although a few of the shorter, stockier boled ones remain.

FIG. 2.—A clear cutting on hardwood land with no slash disposal.

There were occasional thrifty saplings, two or three inches in diameter when the old stand was cleared, which escaped injury or speedily recovered. These trees, because of their growth and vigor, have profited by the removal of the older trees, have grown at a rapid rate and are the dominant trees of the new stand. Table II gives the data on four trees of this class picked at random from an area cut over 22 years before. Two years after cutting their average diameter breast high inside bark was 2.6 inches. In 20 years it had increased to 8.4 inches. The average growth per cent on these same trees for the same period was 8.4 per cent.

Table II.—Growth of Small Trees Left Standing After Logging the Surrounding Stand in 1899.*

Species.	1901.		1911.		1921.		1921.		
	D.B.H. I. B.†	Vol. Cu. ft.	D.B.H. I. B.	Vol. Cu. ft.	D.B.H. I. B.	Vol. Cu. ft.	D.B.H. O. B.‡	Ht. Ft.	Age 1921.
Hemlock	3.3	.937	6.1	3.352	9.3	6.514	9.6	41	120
American Elm	2.8	.370	5.6	2.208	8.0	5.247	8.7	43	91
Sugar Maple	2.2	.704	5.1	4.284	7.9	10.853	8.4	49	54
Beech	2.1	.452	4.9	2.304	8.4	8.410	8.7	50	54

*Chestonia Township, Antrim county, Michigan.
†Diameter breast high inside bark.
‡Diameter breast high outside bark.

The number of these trees depends upon the amount of young growth in the original stand and the character of the logging. In certain openings their number is considerable. They are generally more abundant near ridge tops where logging was less severe than further down the slopes, where nearly everything was destroyed. These saplings may be of any species but are most often elm since it is a tough wood and is less liable to breakage and has a high power of recovery from injury.

After cutting, many of the stumps sprout, the number and vigor of the sprouts depending upon the species and size of the original tree. The basswood is by all odds the best sprouter, the elm and maple sprout fairly well, the beech rather poorly and the birch scarcely at all. The conifers do not sprout. All species sprout more vigorously when they are small. Only the basswood produces sprouts from the stumps of mature trees. Sprouts from all the others are confined to smaller

FIG. 3.—Second growth hardwoods of mixed seedling and sprout origin about 25 years old, Grand Traverse County.

stumps. Consequently the best second growth is obtained from areas where all the trees down to about six inches in diameter are removed. These smaller non-merchantable trees are almost certain to be badly injured in logging or to suffer from isolation and die if they escape injury. Consequently it is best to cut them even though they are not merchantable.

These sprouts are usually the dominant element in a young new stand. An analysis of some ten plots scattered over a representative tract seven years after cutting showed an average of thirteen hundred sprouts per acre.* Their growth is rapid and vigorous. Where they do not occur, and dependence is placed upon seedlings, the resulting

*See Journal of Forestry, Vol. XIV, No. 8, December, 1921, page 872, "A Study of Regeneration on Certain Cut-Over Hardwood Lands in Northern Michigan." By P. L. Buttrick.

stand is less well stocked, slower in getting established and generally of a less satisfactory composition.

In a virgin forest that is not burned over there is usually a crop of seedlings on the ground. Few of these ever amount to much because they cannot secure light or growing space. On the hardwood lands of Michigan they have also to meet the severe competition of the ground hemlock, a coniferous shrub which grows in dense mats over the surface. With the removal of the old stand this largely disappears so that the seedlings are able to grow up with plenty of overhead light and without severe ground competition. Logging injures them only slightly. Even if they are broken or bent they straighten up and go on without their growth being especially interfered with. It is only in the roadways—skidway sites, etc., that logging removed them entirely. They are sometimes more important than the sprouts, but have less vitality and sometimes many of them die from exposure when the old stand is removed.

Seedlings come in to some extent after logging is completed, mostly from wind-borne seed of light seeded species or from bird-borne seed of edible-fruited species or from seed already in the ground. The common species are the cherries, the fire or pin cherry, the black cherry, and the aspens, both the trembling and the large-toothed species. These seed in along the old skid roads, skidway sites and other openings, but seldom very abundantly so that much of such space is, in a few years after logging, run over with a tangle of briars and remains treeless for many years. On poorer soils and where the original stand ran heavily to conifers, the per cent of cherry is much higher.

The resulting stand, even when composed of all these five types of trees, is fairly even-aged and uniform and its density is generally high. Its uniformity increases with age as the various classes of trees merge into the new stand.

The composition of the new stand does not differ essentially from that of the old, but there are certain minor and constant differences, notably the absence of conifers. The white pine and the hemlock practically disappear. Temporary additions to the list of species are pin cherry and the aspens, but in thirty years they are mostly gone, having given place to the more enduring but less rapidly growing species of the original stand. In half a century practically none remain. The percentage of basswood increases because of its superior sprouting ability and elm seems to gain something on maple in abundance, otherwise the second growth resembles the original forest.

It is impossible to average percentages of different species on plots of different ages and secure satisfactory results but Table III, showing percentages of different species on representative plots, is indicative of varying conditions.

Table III.—Composition of Acre Plots of Different Ages.*

Age.	Total number of of trees.	Maple per cent.	Elm per cent.	Basswood per cent.	Beech per cent.	Others per cent.
12	392	22.5	24.5	.....	.....	53
21	712	14.5	39.0	28.5	.....	18
22	1,296	.....	32.2	66.6	.....	1.2
22	588	27.9	29.3	.....	.....	42.8
25	560	17.1	27.2	45.7	.....	10.0
30	628	30.5	39.0	.....	.....	30.5
30	504	30.3	17.4	.....	30.9	21.4
30	824	86.5	7.7	.....	.....	5.8
32	1,344	41.0	31.0	.....	.....	28.0
34	1,344	27.4	44.0	.....	.....	28.6
38	844	58.7	17.6	.....	.....	23.7
40	724	53.0	17.2	.....	.....	29.8
44	884	77.8	8.1	.....	.....	14.1

*Percentages refer to number of trees.

Culled or Clean Cut Lands Heavily Burned: Virgin hardwood lands are not as great a fire risk as are some other forest types. They burn over occasionally but the immediate damage is mostly to the smaller trees and to the soil. After cutting, even if it is only a culling, the fire risk is augmented, first because of the amount of slash left on the ground, and second because the opening up of the crowns permits the drying out of the forest floor. The heavier the cutting, generally speaking, the greater the fire risk. After a clear cutting it is extremely high.

Hardwood slash remains a fire risk for about ten years. At the end of that time it has disintegrated sufficiently to cease to be a special hazzard. This does not mean that second growth hardwood stands do not burn over—they do. In fact most of those studied showed evidence of having been burned at some time or other, but fires occurring after their tenth year, although they damage the young trees, do not seem to be severe enough, having only the leaf litter to burn, to destroy the young stand.

A fire occurring immediately after cutting destroys the seedlings already on the ground and is apt to singe the stumps so they either fail to sprout or sprout more feebly. It injures, if it does not kill, the remaining standing trees. Such a fire is seldom sufficiently severe to consume all the slash. As time goes on this dries out more completely and the material killed but not consumed by the first fire becomes highly inflammable. A second fire is apt to destroy almost everything — if not, a third or fourth fire completes the devastation. Not only do these repeated fires destroy the young growth but they consume the vegetable mold and organic matter in the soil so that its fertility becomes too low to permit of rapid growth of the more valuable hardwood species and it is of no use for agricultural purposes even if it had agricultural value in the first place. On hardwood lands this repeated burning over of the tree growth results in a thin scattering of pin cherry, elm and aspen, the larger portion of the area being grass covered.

On hardwood lands lying on slopes, the process of devastation started by unrestricted fires is frequently carried even further by the washing away and gullying of the light soil when deprived of its protective covering.

The regeneration of hardwood lands, so badly burned that little basis for a new stand remains, depends first upon their protection from fire. With that accomplished, given time, they will gradually reclothe themselves in forests from seed transported by wind and birds. The only other recourse in forest planting.

Cleared Land Allowed to Revert to Forest: When the hardwood lands were first opened to settlement many settlers cleared lands for farms which, owing either to inferior soil or unfavorable economic conditions, were soon abandoned.

The chief element in the reforestation of such lands seems to be their relative fertility and moisture content, and the size of the clearing. The more fertile the soil and the smaller the clearing the more rapidly will it revert to forest. On fairly moist fertile soils a crop of aspens may spring up in a few years but on dry upland soils the process is extremely slow. Some of the early clearings are today as bare of tree growth as they were fifty years ago when the land was abandoned. The time element is of less importance. Here the process of regeneration consists of the seeding up of the area from its boundaries inward.

FIG. 4.—Pure aspen stand 30 years old seeded in on cut-over and burned land, the land being suitable for agriculture, in Antrim County.

The seed does not travel far. A few hardy elms push up beyond the zone in advance of the main body and grow in a more or less open park-like appearance. Only gradually are the intervening spaces recaptured. It may take as much as a half century for the forest to recapture a field as small as a "forty" even when surrounded by an untouched virgin growth. One contributory cause of this slow recovery is due to cattle grazing. Cattle ranged in the woods like to congregate in these "parks." When the grass is poor they browse on the leaves and twigs of the young seedlings. The elm with its harsh rough leaves, is best able to repel their attacks.

The stand resulting from the recovery of old fields on poor upland soils is uneven-aged. The stands coming in on the moister, more fertile soils are, on the other hand, largely even-aged. The light seed is borne by the wind and distributed well over the area.

Cut-Over, Cleared or Burned Lands Which Have Reverted to Pure or Nearly Pure Aspen: This last type occurs on the better and moister soils chiefly in the zone where the hardwood and swamp types meet. It seems that the chief requirement is that the original growth be removed in such a manner that a large crop of sprouts is not formed. This may have been accomplished after the felling of the original stand by the burning of the slash sufficiently to kill the sprouts but not to destroy the soil, or it may be that the land has been cleared for agriculture. Under such conditions an even-aged stand of poplar or aspen springs up from wind-borne seed and grows very rapidly. But the aspens are very intolerant—that is they will not grow well in dense stands, so the number of trees falls off rapidly with increasing age. The space left is occupied by the slower growing and more tolerant hardwoods of the upland and conifers of the swamp. In time the aspen disappears and the original type regains possession. The data regarding two sample plots taken in poplar stands are summarized in Table IV.

Table IV.—Growth of Poplar Stands on Cleared Land.*

	Plot I.		Plot II.	
	Age, 30 years.		Age, 38 years.	
	Aspen	Others**	Aspen	Others**
Number of trees per acre	648	24	216	484
Average diameter, inches	4.2	2.3	8.1	3.6
Average height, feet	45	.....	75	35
Volume of plot, cubic feet	1,694	25	2,439	1,499
Volume of plot, cords	18.8	0.28	27.1	16.7
Rate of growth, cords per acre per year	0.63	.....	0.73	0.43

*Chestonia Township, Antrim County, July, 1921.
**Maple, elm, basswood, etc.

GROWTH RATE ON SECOND GROWTH HARDWOOD LANDS

In order to study the rate of growth and yield of second growth hardwoods, the Forestry Department of the Michigan Agricultural College has measured the volume on different areas of second growth of various ages and constructed a preliminary yield table on the basis of the results obtained (Table V). The plots chosen represent as far as possible averages for second growth stands following clear cutting where fire has not interfered with restocking, although most of them showed evidence of having been burned to some extent at one time or another after regeneration was complete. The age determinations were based entirely upon the number of years since cutting of the original stand which in some cases was slightly more than the average age of the trees. It is very difficult to secure plots meeting the requirements of a yield table study, since most of the early cuttings were cullings and have not been succeeded by an entirely even-aged stand and since, owing to fire, much of the cut-over land exhibits a very low degree of stocking. Consequently the yield table is less complete than could be desired. It was found impracticable, from the plots obtained, to make a satisfactory differentiation into site classes based on soil qualities. Most of the plots were on land not locally classed as agricultural, although not the poorest in the region, consequently it was thought that the figures obtained correspond to Site Quality II and represent average conditions.

The table shows an average growth of eight-tenths of a cord per acre per year up to the 50th year. It was not practicable to secure data for a longer period. The volume growth is most active between the 20th and 30th years. At 30 years of age the volume slightly exceeds 25 cords per acre of wood suitable for distillation. This, when transportation conditions are satisfactory, is considered a sufficient yield to justify operations under present economic conditions.

Table V.—Yield Table for Second Growth Hardwoods in Michigan.*

Age.	D. B. H. of average tree, inches.	Height of of average tree, feet.	Stand per acre.		Mean annual growth.		Average number of trees per acre.
			Cubic feet.	Cords.**	Cubic feet.	Cords.	
5	.4	4.25	350	3.9	70	.8	1,350
10	1.2	9.25	730	8.0	73	.8	1,290
15	2.4	15.00	1,140	12.5	76	.83	1,220
20	3.2	21.00	1,540	17.0	77	.85	1,130
25	4.0	27.00	1,936	21.5	77.4	.86	1,020
30	5.0	32.2	2,310	25.6	77.0	.85	930
35	5.7	38.1	2,650	29.3	75.7	.84	820
40	6.5	45.5	2,880	32.0	72.0	.80	710
45	7.2	55.0	3,180	35.3	70.6	.78	600
50	8.4	62.0	3,435	38.2	68.7	.76	480

*Data assembled from Antrim and Leelanau counties.
**Ninety cubic feet equals one cord.

FIRE PROTECTION AND A SECOND CROP

Since much of the hardwood land of the region is non-agricultural, it is to the advantage of owners and the State to have it covered with a productive crop of timber. The first step in the solution of the problem is fire protection. Unless the forests are protected from fire there will be no forests. Fire protection is both a duty which the State owes to the landowner and which the landowner owes to himself. He must be prepared to take the initiative in first fighting fires on his own holdings until the State, with its larger but less local organization, can come to his aid, just as a factory owner installs sprinklers but expects the municipality to back up his efforts with an efficient fire department. Most large owners today appreciate the necessity of fire protection for their mature timber and attempt to attain it. Not all of them appreciate its importance for their cut-over lands and many thousands of acres of such lands burn over unnecessarily each year, so that their future productivity is lost or seriously impaired.

Granted fire protection, the problem of maintaining the productivity of the hardwood lands divides itself into two main parts:

(1) The problem of harvesting timber on virgin hardwood lands so that they will be left in the best possible condition to produce new crops.

(2) The problem of caring for the various classes of cut-over or cleared lands, so that their productivity will be restored, maintained or increased.

CUTTING VIRGIN HARDWOODS TO SECURE A SECOND CROP

There are two practical ways of accomplishing this. The first is the so-called method of *selective cutting*. The second is *clear cutting*.

A selective cutting means simply removing certain classes of trees, usually the larger and more valuable ones, and protecting the remaining ones to form the basis of a future corp. It is the careful application of the old culling system where the more valuable trees were removed. It differs from it in that care is taken that in the removal of the trees the remaining ones are not injured, and in that trees whose presence is a detriment to the forest are likewise removed.

The theory of the selective cutting is that each cutting takes out timber equal to the growth that has been made since the previous cutting. In this way the productivity of the forest may be maintained indefinitely. It follows that the heavier the cut the longer the time which must elapse before another cutting is possible or else the following cut must be made smaller. If the time is progressively shortened between cuts and the same amount cut each time the forest will eventually be destroyed by the process, since each cutting removes smaller and smaller trees. It is possible to work out by scientific studies the precise amount which may be cut at fixed intervals from an all-aged forest and still maintain its productivity.

The trees to be cut must be selected so as to leave a sufficient amount of growing stock to give another cut within a reasonable period. Often a rough diameter limit, above which all trees are to be cut, may be used, the diameter limit varying with the character of the stand. The person designating the trees to be cut under the selection cutting must have constantly in mind the following objectives:

(1) To obtain from trees now standing in the woods a supply of logs sufficient to insure the financial success of the operation.
(2) To leave in the woods trees whose future growth will be as interest on the investment made by not harvesting them at the first cut.
(3) To leave the woods in such a condition that they will, besides adding to the growth of trees already merchantable or approaching merchantability, produce the basis for future cuttings.
(4) To remove from the woods all trees whose presence will interfere with the attainment of the second and third objects provided it can be done without too great present financial sacrifice.

Clear cutting means what its name implies; cutting everything. It is financially possible only when the entire or practically the entire content of the stand is merchantable. As a system of forest management clear cutting involves some definite provision for securing a second crop of trees on the area. Second growth may be secured in a number of ways, as by planting, from wind-borne seed from nearby uncut trees, and from sprouts sent up from the stumps of the cut trees. In the case of cut-over Michigan hardwoods, reproduction is usually by a mixture of seedlings and of sprouts from the smaller stumps.

Trees below 10 inches in diameter, when left in a clear cutting, are generally too badly injured to recover, but they may send up sprouts from the stump when cut. They should therefore be removed in logging. Exceptions to this are hardwoods which are short-boled, uninjured and evidently able to grow successfully despite their isolation. Old non-merchantable trees, dying or dead, are sooner or later blown over and destroy young growth in their fall and are an added fire risk. Their removal is therefore essential. On the other hand young trees under 6 inches in diameter have a very high recuperative power and grow rapidly. They should be protected in so far as is consistent with good logging practice. If badly injured they should be removed. Occasional trees of desirable species should be left to furnish seed for the future stand. It is best to select for this purpose short, heavy crowned trees as they will be more wind-firm than slender, long stemmed trees.

Trees cut in the fall or winter produce a crop of sprouts the following spring. Sprouts produced in summer are often killed back by fall frosts. It is therefore advisable to cut as much as possible in fall and winter. Browsing by cattle or sheep on the tips of the tender young seedlings and sprouts is quite destructive to their growth. On cut-over areas where many cattle are run, the growing stock is reduced to a straggling stand of inferior value.

Hardwood cuttings create a large amount of refuse or "slash." It is composed of tree tops, small branches and other portions of the felled trees which are non-merchantable. The heavier the cutting the greater is the amount of slash left. The closer the utilization of small sized material the less will be the quantity of slash left.

This slash, if not disposed of, becomes a fire risk and remains so for many years and interferes with the growth of small trees. Consequently if a good second crop is sought, after the clear cutting system has been applied, some system of slash disposal is highly desirable. There are several methods of slash disposal applicable to hardwood lands. One is to pile and burn it, either in the course of logging or after logging has been finished. The burning, however, should be done in winter or early spring when snow is on the ground. It is generally cheaper to pile the brush as logging proceeds than to make a separate operation of it later. Another method is to lop and scatter the brush so that it will lie flat on the ground and decay rapidly.

There is one phase of the brush disposal problem which deserves further consideration, and that is its relationship to the chemical wood industry. This industry consumes cordwood of the hardwood species plus a small amount of softwood used as fuel in the industry. The chemical plants of the region obtain their supply of wood largely from the tops and waste wood left after logging. This materially decreases the amount of slash and also results in more or less lopping and scattering of what remains.

Unfortunately it is often carried on in such a way as to do more harm than good. A common practice is for the lumber company to sell the cordwood on its cut-over lands outright, giving the chemical company the right to cut or leave material at its discretion. Generally a term of years is allowed for removal to permit seasoning. This often results in unfavorable conditions. The slash remains a fire risk and an impediment for young growth for several years. The smaller trees which are left, either die or are weakened in the attempt to recover from injury. If felled during logging operations or soon after, they would have produced vigorous sprouts. When the slash is finally worked over it results in destroying much of the young growth already started. Owing to the carelessness of the wood cutters the fire risk is temporarily vastly increased. Because the work is usually unregulated as far as slash disposal is concerned, it frequently leaves an unnecessary fire risk even after it is finished.

The value of the chemical-wood industry as an aid to brush disposal could easily be realized by drawing up instructions as to the work of the wood cutters and requiring that their operations follow closely after the lumber operation itself. The chemical plants desire seasoned wood, and the space consumed by seasoning it in their yards is given as the reason for allowing the slash to remain on the ground. But there would seem to be no reason why it could not be cut and stacked immediately following the lumber operation and allowed to season in the woods.

RELATIVE ADVANTAGES OF SELECTIVE AND CLEAR CUTTING SYSTEMS

The selection system has the following advantages: It does not result in clear cutting the forest, and consequently it is well adapted for parks, game preserves, and on areas where complete removal of the forest would result in damage to the soil, or where a retention of the thriftier portion of the stand to secure added growth is desirable. It permits to a certain degree the control of species. By cutting more of the undesirable species they are not left to reproduce themselves and tend to disappear in the second crop. By leaving more of the desirable species their importance will be increased in the future. For the owner having a small mill, the selection system, if properly applied, offers an opportunity of placing lumber production on a sustained basis. For the owner having a park or game preserve, it offers the chance of obtaining an added revenue from the tract without injuring the forest. By the use of the selection system it is possible to cut over a tract in so much shorter time that much of the timber annually dying can be reached before it deteriorates.

The clear cutting system, however, permits the obtaining of the greatest immediate returns from the tract, and if fire is kept out after logging a new growth of timber can be obtained, although it will be a longer time before it becomes merchantable.

FIG. 5.—A farm woodlot in a culled hardwood type, Grand Traverse County.

MANAGEMENT OF CUT-OVER HARDWOOD LANDS

Since there are thousands of acres of second growth hardwoods in various stages upon lands which are either too steep or too sterile for cultivation, or which will not be needed for agriculture for some time, it is worth while considering how this second growth material can best be managed for the advantage of the owner.

In order to do this we have to consider the objects of management, that is, to what use the owner wishes to put his woods. These objects are commonly as follows: lumber production, fuel, pulp or chemical wood production, farm woodlots, or shelter belts.

Management for Lumber Production: The length of time which is necessary to grow second growth hardwoods to lumber size is not definitely known. There are no second growth stands in the region which have as yet reached sufficient size. At 50 years of age they are mostly able to yield but little first class material. In the virgin forest it takes 100 years to grow a 10-inch maple or elm, 60 years for a basswood of the same size and 115 years for a similar sized beech. In second growth it is not probable that a period of less than 75 years will permit the growing of saw logs except under very favorable conditions. If it is desired to manage the culled stands for lumber, they should be thinned so as to remove the trees which will never make lumber. Second growth on the clear cut lands should be thinned at about 40 years of age, at which period the material is large enough for chemical wood. The larger and thriftier trees should be left to grow for lumber.

On sites where no forest exists and planting is the only recourse, the planting of conifers is recommended rather than hardwoods. White pine will grow on hardwood lands at a rate greatly exceeding that of the hardwoods. It should be possible to obtain saw logs from pine plantations on hardwood soil in 40 years.

Management for Cordwood, Chemical or Pulpwood Production: Cordwood can be grown in much less time, since it can be made from smaller-sized timber. Referring to Table V, it is seen that at the age of 30 years a yield of slightly more than 25 cords per acre may be expected and that up to the 50th year the growth averages about 0.8 of a cord per acre per year. In the opinion of chemical and pulpwood men a yield of 20 cords per acre amply justifies operations when transportation conditions are favorable. Consequently it would be possible and profitable to manage second growth hardwood lands for the production of chemical and pulpwood. In fact, lands heavily culled over 20 years ago are now being cut for chemical wood at a profit, some of the yield coming from the new growth and some of it from the older trees left in the culling operations.

It is probable that if the lands now in second growth, or about to be cut over, were protected from fire and properly handled, they would yield in perpetuity enough fuel wood to keep busy all of the chemical plants of the region. By protecting the second growth, this valuable industry can be conserved for the region; otherwise it will be gone in 20 years or less.

The actual details of the management of second growth stands largely concern the protection of the young growth until it is ready to cut. In the case of culled lands, a cutting for chemical wood to remove the older material already suitable for such use, so as to give the young growth room to develop, would be desirable at any time that it can be made. On clear cut lands having a mixed hardwood stand, the growth should be removed every 30 or 40 years as an even-aged stand. On lands seeded up to aspen, the timber should be removed for pulp or excelsior bolts at the earliest period at which it is merchantable, provided a sufficient stand of the more enduring species has established itself underneath.

Management for Farm Woodlots: Much of the region is a farming and fruit-raising country. The demand for farm timbers and wood fuel is constant and bound always to continue. Each farm should be provided with a woodlot to provide fuel and timbers. In a region having as vigorous winter climate, as steep hillsides, and as easily eroded soil as much of the hardwood section, the importance of the forest in checking the winter winds and holding the soil in place on steep slopes cannot be overlooked. The maintenance of forests as protection belts requires that they be managed under some system which does not involve clear cutting—just as does the farm woodlot. Frequently these two uses will be found to coincide. The farmer can establish his woodlot on the rougher and more exposed sites, where it will protect the soil and cut off the winds. He can remove progressively the larger trees for fuel or lumber, improve the composition of the forest by cutting out the beech and slower-growing species, and make the woodlot a big asset to his farm.