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Observations on Thinning and Management of Eastern White Pine (Pinus strobus Linnaeus) in Southern New Hampshire

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OBSERVATIONS ON THINNING AND MANAGEMENT OF EASTERN WHITE PINE

(*PINUS STROBUS* LINNAEUS) IN SOUTHERN NEW HAMPSHIRE

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OBSERVATIONS ON THINNING AND MANAGEMENT OF EASTERN WHITE PINE IN SOUTHERN NEW HAMPSHIRE

INTRODUCTION

IN October, 1905, several permanent sample plots were established in the white pine type near Keene, New Hampshire, by the United States Forest Service in cooperation with the Faulkner and Colony Manufacturing Company on lands owned by the latter. The purpose of the investigation was to study some effects of thinnings and of partial (shelterwood) cuttings for establishing natural regeneration. The plots were remeasured in 1909 and again in 1915 by representatives of the United States Forest Service, but after the 1915 measurement they were turned over to the Yale School of Forestry.* In 1920, 1925, 1930, and 1935 the plots were remeasured. Subsequent to the 1920 remeasurement a *Progress Report* was published as Bulletin 7 of the Yale School of Forestry, and in 1927 a *Second Progress Report* appeared as Bulletin 20 of the same series.

More than thirty years have now elapsed since the experiment was started, and the purpose for which it was initiated has in large measure been accomplished. The plots will, however, continue to be maintained as demonstrations of thinning practice and natural seeding.

Since the number of plots in the experiment is small and there are only single plots illustrating a given type of treatment, the quantitative results cannot be relied upon too closely. However, the differences in character of stand, reproduction, financial return, and other points are too pronounced to be otherwise than significant, particularly as the same tendencies are revealed in successive remeasurements.

Conceiving the information which has been accumulated to be of interest and practical value to landowners engaged in managing white pine lands, this report has been prepared summarizing the more important results of the thinning experiments and making suggestions for the management of

* As a result of a gift made in 1923 by the Faulkner and Colony Manufacturing Company, most of the territory within which the principal plots lie is now included within the park system of the city of Keene. The Park Commissioner of Keene also is coöperating with the University in the experiments.

white pine stands. Most of the data which form the basis for this discussion are taken from the plots already mentioned, but observations made on the near-by Yale demonstration and research forest at Keene are freely drawn upon in order to give the reader a clear picture of the effect of thinning and the rôle which thinning should play in the management of white pine crops.

LOCATION AND DESCRIPTION OF THE EXPERIMENTAL AREA

THE area is located in the southwestern part of New Hampshire at Keene, an important center for the white pine box and woodworking industries, and lies within the New England white pine region in which at least two distinct classes of upland (or well-drained) sites can be distinguished. One consists of the heavier, more fertile soils; the other comprises the lighter, more sandy and less fertile soils. Pure stands of second-growth white pine are found on both classes of site, principally on areas cleared for pasture or cultivation and later allowed to grow up to forest. Upon the heavier soils the pine meets severe competition from many hardwoods and from hemlock, since several of these species grow faster in height and are more shade-enduring than the white pine. On the lighter, sandier soils fewer hardwoods compete with the pine, and those which do, offer weaker competition than the same species on the more fertile soils. This difference in character of competition between the pine and hardwoods has an important bearing upon the management of the white pine type. Treatment which may be successful upon one class of site will not necessarily be satisfactory upon the other.

The Keene plots are located upon the river plain of the Ashuelot about 50 feet above stream level. The soil is a fine, deep sand, droughty in summer. Although level and free from stones, the land is rather light for agricultural use and may be considered as typical of the second class of upland sites, just described, upon which hardwood competition with pine is relatively weak. Hence, the information presented is applicable primarily to this class of upland site.

DESCRIPTION OF THE EXPERIMENTS

THE experimental plots include a series to compare thinnings of different degrees of heaviness and a series to show results of natural regeneration under shelterwood. Some of the lighter degrees of thinning

were not continued throughout the whole thirty-year period, and the chief comparison will be made between an unthinned control plot (No. 604) and a heavily thinned plot (No. 601) which has received six thinnings.

The original condition of these two plots, as first measured in the early fall of 1905, was nearly identical, as indicated in Table 1. The advantage, if any, lay with the control plot 604 in that it contained a greater number and volume of trees 10 inches and over in diameter at breast high than did plot 601. Both plots were located approximately 250 feet apart on an almost level sand plain in a pure evenaged white pine stand estimated to be thirty-eight years of age in 1905.

TABLE 1. COMPARISON OF PLOTS 601 AND 604 AT THE BEGINNING OF THE EXPERIMENT IN 1905

	Plot 601	*Plot 604*
Number of trees per acre:		
Total	778	828
10 inches and over in diameter breast high	14	24
Height of average dominant tree in feet	41.5	41.5
Diameter* of average tree in inches	6.1	5.9
Volume per acre in feet, board measure:		
Total	14,268	13,996
Contained in trees 10 inches and over in diameter	1,162	1,944

* As a further test the trees on each plot were separated into four diameter groups, starting with the largest trees and progressing downward. Each group contained the same number of trees, with the exception of the lowest groups which comprised the trees of smallest diameter. The diameter of the average tree within each group on each plot was computed. When these diameters for the corresponding groups on the two plots were compared, they were found to have a maximum variation of only 0.2 inch.

Plot 604 received no treatment during the thirty-year period 1905 to 1935. Plot 601 was thinned in the fall of 1905, 1915, 1920, 1925, 1930, and 1935-six times in all. The thinning may be described as a moderately heavy one which removed chiefly the trees of the smaller diameters occupying positions more or less subordmate to the larger individuals in the stand. This method is termed a low thinning and in principle is easy to apply, since a start is made with the smallest trees and the operation is carried into successively larger-sized trees as the heaviness of the thinning is increased.

PLATE 1

THE unthinned stand (plot 604) in September, 1930, twenty-five years after the start of the experiment. Note the density of the stand and the scarcity of vegetation on the forest floor. A few deformed maples and other hardwoods can be seen. The thousands of one-year-old pine seedlings and the relatively few 4- to 6-inch pine seedlings are not visible. (See Table 5, figures for 1930.) Compare with Plate 2. Dead limbs are seen protruding from the trees down to within a few feet of the ground. Many of the lower limbs have been knocked off during the last thirty years to facilitate measurement.

PLATE 2

PLOT 601 immediately after the thinning in September, 1930. Note the long side branches, the size of the trees, the spots of sunlight reaching the ground, and the abundant vegetation on the forest floor. White pine seedlings are more abundant than hardwood but much harder to see. Refer to Plates 3 to 5 for closer views of the reproduction.

PLATE 3

PLOT 601 just before a thinning was made in September, 1935. An understory of vigorous hardwood seedlings is in evidence as well as abundant reproduction of white pine. Three samples of the pine seedlings are shown in front of the white papers. These seedlings, like most of the pine reproduction, are not in first-class condition because the degree of opening obtained by systematic thinning is not sufficient to furnish adequate light and freedom from root competition. Compare with Plate 5.

Table 5 indicates that there are 80,000 one-year-old white pine seedlings per acre in this stand and 9,440 older white pine seedlings and 3,360 hardwood seedlings. The latter, however, average older and are growing faster than the pine seedlings.


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PLATE 4

THE same view of plot 601 as shown in Plate 3 except that the 1935 thinning has now been completed. Several of the felled trees are seen lying on the ground. The hardwood understory so prominent in Plate 3 has in part been destroyed in logging and in part been felled in a release cutting to uncover the pine seedlings. These are abundant over the whole area but are not easily seen in the picture. The pine limbs and hardwood slash are left scattered on the ground but are not so thick as to kill the white pine seedlings. The small hemlocks seeded in ten to twenty years ago and, though growing slowly, remain healthy in the thinned stand. Before the stand is reproduced, these hemlocks should be cut.

PLATE 5

THE tallest group of pine seedlings in the thinned stand taken in September, 1935, after the thinning of that year. There was an unusually large opening made at this spot ten years before, and it was enlarged five years ago. The result has been to hasten the height growth and general development of the white pine seedlings as compared to other portions of the plot. (See Plates 2, 3, and 4.) The thrifty appearance of the pine reproduction is more characteristic of the results to be expected after a cutting which removed half the volume than after a typical thinning. It illustrates what may be expected throughout the entire thinned areas when heavier cuttings to reproduce the old stand are started.

PLATE 6

A NEW crop of white pine, containing several thousand trees per acre, established by natural seeding following the removal of the old timber in two cuttings, each taking out approximately half of the volume. The final cutting took place about ten years ago. This stand is within a half mile of the thinned plot 601 on the same type of soil.

In applying the principle some measure for regulating the heaviness of the cut must be employed. Where the man marking the trees to be cut is experienced, personal judgment is adequate to secure a uniform thinning of the desired heaviness. Moderately heavy thinnings, such as were used on plot 601, repeated every five years in white pine, usually remove less than 15 per cent of the volume* in feet, board measure, standing on the area before the thinning; although the first thinning, if delayed until the stand is thirty-five to forty years of age, may remove as much as 20 per cent of the volume.

EFFECT OF THE THINNINGS

THE comparison between the heavily thinned and the unthinned plots thirty years after the initiation of the experiment is shown in Table 2.

TABLE 2. COMPARISON OF PLOTS 601 AND 604 IN THE FALL OF 1935

	Plot 601 (thinned six times)	*Plot 604 (never thinned)*
Number of trees per acre:		
Total	104	456
10 inches and over in diameter	98	156
Height of average dominant tree in feet	74.6	73.2
Diameter of average tree in inches	13.2	9·3
Volume per acre in feet, board measure;		
Total	21,070	41,640
Contained in trees 10 inches and over in diameter	20,544	26,452
Volume per acre removed in thinnings in feet, board measure:		
Total	21,610	0
Contained in trees 10 inches and over in diameter	9,090	0

REDUCTION IN NUMBER OF TREES

It is evident that a great reduction in the number of trees per acre has taken place on both the thinned and unthinned plots. From an original

*Volumes throughout this report are expressed in feet, board measure, since white pine is utilized principally in the form of lumber.

number of 828 trees per acre, normal death from crowding on the unthinned plot has brought about a decrease to 456 trees per acre. On the thinned plot a reduction from 778 to 104 trees per acre has been a consequence of the six thinnings. While reduction in number of trees is thus seen to be a natural function in an unthinned stand, yet the rate of decrease is greatly accelerated by thinning. Indeed, reduction in number of trees is in a sense a crude definition of thinning, and this reduction in numbers is the cause for the principal effects of the thinning.

TABLE 3. DIAMETER DISTRIBUTION OF THE EIGHTY LARGEST TREES ON THE THINNED AND UNTHINNED PLOTS

Diameter breast high in inches	*Largest trees in* 1935 (*number per acre*)		*Same trees in* 1905 (*number per acre*)	
	Thinned plot	*Unthinned plot*	*Thinned plot*	*Unthinned plot*
6			8	
7			20	4
8			26	20
9			22	24
10				20
11			4	
12	26	32		12
13	12	12		
14	16	12		
15	18	16		
16	2	8		
17	2			
18	2			
20	2			
	80	80	80	80

Increased Growth in Diameter

One effect easily seen concerns the growth in diameter and the arrangement within various diameter classes of the trees in the stand. In 1935 (see Table 2) the average tree on the thinned plot was 13.2 inches in diameter breast high and on the unthinned plot only 9.3 inches, although in 1905 the average trees on the two plots were almost identical in size. A large share of the difference existing in 1935 is due to the method used in thinning,

\which removed each time mainly the smaller-sized trees. However, as a result of the thinnings, there has been a real increase in diameter growth of the trees on the thinned plot as compared to those on the unthinned plot.

This is best illustrated by Table 3, in which the eighty largest trees on plots 601 and 604 have been arranged according totheir diameters in 1935 and also according to their diameters in 1905. The largest rather than all the trees have been used, because it can only be these largest trees, if any, on the unthinned plot which will grow as fast as those on the thinned plot.

The data in Table 3 show clearly that the eighty largest trees on the thinned plot were in 1935 on the whole larger than the eighty biggest on the unthinned plot; and further that in 1905, at the beginning of the experiment, these same trees were on the whole smaller.than the similar group of trees on the unthinned plot. In other words, the best diameter growth has taken place on the thinned plot. This is to be expected,. since thinning reduces the number of trees and gives each individual tree a large amount of space for expansion both above and below ground. (Compare Plates 1 and 2.)

HEIGHT GROWTH NOT CHANGED SIGNIFICANTLY

Growth in height has not been stimulated significantly by the thinnings. Height of the average dominant tree in 1935 was 74.6 feet on the thinned plot and 73.2 feet on the unthinned plot and, in 1905, 41.5 feet on each plot. The difference is too small in this experiment to be more than an indication of a tendency toward stimulation of height growth by thinning which has been found in other investigations.

VOLUME GROWTH INCREASED

Significant differences in volume in feet, .board measure, have resulted from the thinnings. At the beginning of the experiment plot 601, prior to the first thinning, had a volume per acre of 14,268 feet, board measure, which was 272 feet, board measure, more than the volume on the control plot. (See Table I.) In 1935, after the thinning of that year, the volume per acre in the thinned stand was 21,070 feet, board measure, and that on the unthinned plot was 41,640 feet. (See Table 2.) However, in the six thinningsmade from 1905 to 1935, 21,610 feet,board measure, per acre have been removed. This added to the 21,070 feet still standing in 1935 gives a total production of 42,680 feet, board measure, or 1,°4° feet more than on the unthinned plot. The actual growth during the thirty-year period

amounted to 27,644 feet, board measure, on the unthinned plot and 28,412 feet on the thinned plot-a small but not significant advantage for the thinned stand. Expressed in average annual growth per acre during the thirty-year period, the figures are 921 feet, board measure, on the unthinned plot and 947 feet on the thinned plot.

When the volume is more closely analyzed, one of the really great advantages for the thinned stand becomes apparent. For this purpose the volume has been divided into that coming from trees 10 inches and over in diameter breast high and that from trees below that size. From trees of the larger class considerable square-edged lumber 6 inches and over in width can be sawed, while from the trees less than 10 inches in diameter breast high the output is chiefly round-edged box and other material of narrow widths. The average grade, and consequently the selling price, of lumber produced from trees 10 inches and over in diameter is much higher than that from smaller trees.

Thinning has a more marked effect in increasing the proportion of larger-sized material produced than it has upon the total production of all sizes. Turning again to Table 2, it is seen that the thinned stand now has a volume of 20,544 feet, board measure, per acre in trees 10 inches or bigger and that 9,090 feet of similar-sized material have been removed in the thinnings. Hence, 29,634 feet per acre in trees 10 inches and over in diameter have been secured on the thinned plot in contrast to only 26,452 on the unthinned plot. The volume in trees 10 inches and over in diameter at the beginning of the experiment was 1,162 feet, board measure, on the thinned plot and 1,944 feet on the unthinned. These figures subtracted from the figures of 1935 give the increase in volume in trees 10 inches and over on each plot for the period 1905 to 1935. The increase amounts to 28,468 feet, board measure, per acre in the thinned stand and 24,508 feet in the unthinned area, or a difference of 3,960 feet per acre in favor of the thinned stand.

BETTER FINANCIAL RESULTS

Money income derived from the sale of the material removed in the thinnings when the stand is relatively young is one of the most important consequences of thinning. In this case the unthinned stand has furnished no timber for the entire sixty-eight years of its life. The thinned stand, beginning with 1905, has furnished six cuts of timber at intervals of either five or ten years, as shown in Table 4, amounting to 21,610 feet, board measure, of which 9,090 feet came from trees 10 inches and over in diameter.

TABLE 4. VOLUME PER ACRE IN FEET, BOARD MEASURE, REMOVED IN THINNINGS ON PLOT 601

Age of stand in years	*Year of thinning*	*Volume from trees less than 10 inches in diameter*	*Volume from trees 10 inches and over in diameter*	*Total volume*
38	1905	2,820	180	3,000
48	1915	5,744	628	6,372
53	1920	1,084	356	1,440
58	1925	2,446	1,822	4,268
63	1930	426	2,348	2,774
68	1935		3,756	3,756
		12,520	9,090	21,610

The first thinning in 1905 furnished in trees that were 10 inches and over in diameter only 6 per cent of the total volume cut and required the cutting of 168 trees too small to furnish logs. A conservative estimate is that the value of the logs was sufficient only to cover the expenses of the first thinning. All the subsequent thinnings furnished a better grade of logs and enabled a profit to be made on each operation. In each successive thinning the percentage of the total cut composed of trees 10 inches and over in diameter increased, rising from 6 per cent in 1905 to 100 per cent in 1935.

Furthermore, it should be remembered that, as the result of these profitable cuttings, the stand has been brought into condition to produce in future years a greater amount of the larger-sized material than can possibly be grown in the unthinned stand, which still contains numerous small-sized trees. The thinned stand is in much more vigorous and healthy condition than the unthinned stand. In the former every tree has a chance to expand its crown, while in the latter even the very largest trees are crowded by their neighbors. (See Plates 1 and 2.)

In studying Table 2 the reader is apt to be impressed by the fact that the volume on the unthinned plot in 1935 is nearly double that on the thinned plot and to consider this an advantage for the unthinned stand. As a matter of fact it is a decided disadvantage. As already explained, a larger volume than is now standing has been removed in the thinnings, which, added to the present volume, makes the total production greater for the thinned plot. In addition, profits from cuttings have been coming in for the last quarter

century_ At the present time, although the volume standing is only half that of the unthinned plot, still the growth in the thinned stand is greater in amount, particularly as concerns trees 10 inches and over. If the growth is considered as a percentage figured on the volume of standing timber, then the thinned stand is giving much higher returns than the unthinned, even though the growth in amount remains nearly the same.

Another advantage of the relatively small volume per acre on the thinned plot is that valuation for purposes of taxation should be appreciably less than for the unthinnedstand. This may be a point of considerable importance where assessed valuation for purposes of taxation is based on the volume of standing timber.

SOIL CONDITION IMPROVED

Thinnings in white pine stands tend to improve soil conditions, particularly upon the less fertile soil types. The reason for this may be found in the increases in soil temperature and soil moisture, effected through the openings created by cuttings in thinned as contrasted to unthinned stands, and in some cases in the development of hardwood reproduction, the leaves from which mix with the pine needles on the ground and thus reduce the acidity and increase the fertility of the soil. Improvement in soil conditions becomes reflected ultimately in increased growth of timber.

REPRODUCTION ENCOURAGED

The thinningshave not had as their primary object the establishment of a new crop. Nevertheless, the repeated opening of the stand has encouraged the development of white pine reproduction. Seeds are thickly scattered over the forest floor after a good seed year in both the thinned and unthinned stands. Thousands of them germinate, and the tiny seedlings compete with the older trees for moisture, light, and nutrients.

In the unthinned stand, with its dense cover and large number of trees, this competition is too severe for the young white pine seedlings to survive. They may live a few \veeks or occasionally a year or two and are then replaced by a new lot of seedlings after the next seed year (Plate I). In the thinned stand, however, ,vith its broken canopy and smaller number of trees, many seedlings are able to live for several years, although not in vigorous condition (Plate 3). The thinned stand is too dense for white pine reproduction to grow luxuriantly, but the repeated thinnings enable many seedlings to live and develop slowly (Plate 4) _When eventually released by

TABLE 5. REPRODUCTION (NUMBER OF SEEDLINGS PER ACRE) ON THINNED AND UNTHINNED PLOTS IN 1920, 1925, 1930, AND 1935*

Species	*Plot* 601 (*thinned*)				*Plot* 604 (*never thinned*)			
	1920	1925	1930	1935	1920	1925	1930	1935
White pine								
One-year-old seedlings	1,320	2,400	27,200	80,000		2,560	34,880	80,000
Seedlings more than one year old†	14,360	10,400	12,640	9,440	7,200	4,480	1,280	0
Hemlock								
One-year-old seedlings		160				1,120		8,000
Seedlings more than one year old‡			320	160	320	320	1,120	640
Hardwoods								
One-year-old seedlings	1,600	not counted	960	480	4,800	not counted	2,720	1,760
Seedlings more than one year old‡	640	not counted	1,920	2,720	320	not counted	3,840	4,000

* Based on counts of seedlings on one square rod of the area in each plot.

† These seedlings range in height from less than 3 inches to more than 2 feet.

‡ These seedlings range in height from less than 3 inches to more than 4 feet.

removal of the old timber, these seedlings become vigorous and form the new crop (Plates 5 and 6). As a result of systematic low thinnings, an adequate number of white pine seedlings gradually develop under the old timber.

In addition to white pine, seedlings of other species of trees, particularly hemlock and a variety of hardwoods, become established and compete with the white pine seedlings. Oftentimes the latter are overtopped by the other species (Plates 3 and 4). Since the hemlock and hardwood are both more tolerant than the pine, they develop better in shaded positions.

Comparative conditions in the thinned and in the unthinned stands as regards the development of reproduction are illustrated in Table 5.

Table 5 shows that there are more hemlock and hardwood seedlings on the unthinned plot than there are in the thinned stand. This may be explained by the fact that seed trees of hemlock and hardwoods are numerous close by the unthinned plot, but are few and relatively far away from the thinned plot.

In the case of the white pine an abundant supply of seed is available on both plots, and the differences in amount and condition of reproduction may consequently be attributed to the thinning.

SUGGESTED PLAN FOR GROWING EVENAGED CROPS OF WHITE PINE ON SANDY SOILS

THE assumption made in this discussion is that white pine will be the tree to favor on light, sandy soils. It thrives here, meets less severe competition from other species than on heavier soils, is characterized by valuable technical qualities, and, so far as human foresight can predict, is one of the species most likely to remain in demand throughout the coming years. During the present depression white pine has suffered less curtailment in demand than most other northeastern species. It may be desirable to encourage a mixture of hardwoods with the white pine in order to improve the fertility of the soil, but such mixture should not occupy more than 15 to 25 per cent of the area.

REMOVING THE OLD TIMBER

Granting then that white pine is the desired crop, details for its management may be discussed. As a concrete illustration and a convenient place to start, the present sixty-eight-year-old stand on plot 601 which has been

thinned for thirty years may be taken. This is already old enough to harvest but is growing rapidly andean advantageously be left to grow for ten to thirty years, being thinned meanwhile every five years. Indeed, the age at which one of these systematically thinned stands is finally harvested is quite at the option of the owner and, depending upon the individual, may prove desirable as early as the sixtieth year or maybe deferred until approximately the one hundredth year of the life of the stand.

In any case the thinnings have resulted in establishing thousands of seedlings under the old timber. These seedlings are too completely overtopped to be growing vigorously. Approximately five years before it is planned to remove the old timber a cutting, heavier than the previous thinnings, should be made which will take out 40 to 60 per cent of the volume. After this cutting the seedlings should grow more rapidly. The branches and tops of the felled trees may be left scattered loosely over the ground, but preferably not windrowed. Deep piles or windrows of slash either prevent or destroy reproduction. Some owners may prefer to pile and burn the slash which comes from the final cutting, but this is not essential where utilization is reasonably close.

About five years later, when all portions of the area are stocked with white pine seedlings totaling more than 10,000 per acre, and when many of the seedlings are over 2 feet in height, the remainder of the old timber can be cut. Thousands of white pine seedlings die of heat or drought on the cutover area, are destroyed in the logging, or are killed within two years by the pales weevil *(Hylobius pales* Herbst), an insect which is attracted by the freshly cut timber and eats the tender bark principally on seedlings over one year in age.

After all these losses enough white pine seedlings should still remain to fonn a new crop. Fifteen hundred per acre will be ample.

RELEASE CUTTING TO FREE THE PINE REPRODUCTION

This new crop now occupies the entire area. (See Plate 6.) The first treatment usually required is a release cutting, which consists in cutting back seedlings of hemlock and of undesirable hardwoods that are overtopping the white pine. Sometimes two to four such release cuttings have to be made at intervals of three to five years before the white pine attains sufficient height to keep ahead of its competitors. The first release cutting can advantageously be made five to ten years before the last of the old timber is removed. In fact, at the time of each thinning it is excellent practice to cut

back to the ground or pull up any hemlock and hardwood seedlings which may have started. (See Plates 3 and 4.) This facilitates the logging operation and releases the white pine seedlings. Hardwoods of good species may be left either as single trees or preferably in clumps of three to ten trees on the moister spots, provided not over IS to 25 per cent of the area is devoted to this purpose.

THINNINGS STARTED EARLY

As soon as the trees in the new crop close together and crowd one another, it is time to start the thinnings, which are repeated at intervals until the crop is grown to maturity and ready to harvest. In the case of the experiment on plot 601, the first thinning was made when the stand was thirty-eight years old. This stand, however, should have been thinned several times previously, probably at the fifteenth, twentieth, twenty-fifth, and thirtieth years of its life.

The first three of these thinnings, when the stand is fifteen, twenty, and twenty-five years of age, cannot be expected to return a direct revenue sufficient to pay the expense of the cutting, unless pine cord\vood can be sold. Later thinnings should be profitable. The expense of the first three thinnings can be kept at a minimum by modifying the method used in the experiment on plot 601. Approximately 125 trees per acre,* well spaced, should be selected as final crop trees and marked with paint. Only the trees which are seriously interfering with the crowns of these crop trees should be felled. If the trees cut are too small to be utilized profitably, they should be left lying on the ground. In each successive thinning the selected crop trees are again set free from serious competition.

Many of the logs which come out in thinning twenty-five- to forty-year-old stands are both small in diameter and short in length and contain only a low grade of lumber. Where the landowner runs a manufacturing plant or sawmill, he should plan to use these logs as a matter of course in order to allow trees to develop which will yield better grades of material in subsequent thinnings. The landowner who must sell his output may have difficulty in disposing of these small logs. Industrial plants should be willing to take them (at a lower price than the average run) and thus encourage

* One hundred final crop trees per acre are enough, but in the original selection sufficient extra trees should be picked out to provide for possible losses as the crop grows older.

the landowners in their territory to practice thinnings. In the long run a better quality of logs will be produced from a region where thinning is practiced than from one where such treatment is neglected. This should be of practical interest to the industry.

Pruning to Improve Quality

As has been stated previously, increase in quality of the crop is one of the most valuable results of thinning. In the experiment described (plots 601 and 604) the increase in quality was due to more rapid diameter growth centered on fewer trees in the thinned than in the unthinned plot rather than to freedom from knots. White pine stands, even when dense, retain for at least seventy years most of the dead limbs down to within a few feet of the ground. (See Plate 1.)

For best results thinning, systematically carried on during the life of a forest crop, should be accompanied by pruning the limbs from the butt log of the selected crop trees which are being favored in the thinning. When this is done, a large proportion of the butt log will yield lumber free from knots. Pruning in naturally seeded stands of white pine should be done as soon as the trees to be pruned have reached a height of 25 feet, at which time both dead and live limbs can be pruned to a height of 17 feet, providing for a log at least 16 feet long. The lower branches can be cut off earlier, at the time when the first thinning is made.

Branches which can be reached from the ground are best pruned with a handsaw of the curved orchard type or with powerful pruning shears capable of making cuts flush with the bole of the tree. For pruning above 7 feet either a light ladder and the pruning saw or the Rich pruning tool on an extension handle is recommended. Pruning up to 17 feet from the ground of 125 selected crop trees per acre which were picked out at the time of the first thinning should be done in approximately two days.

Protection of the Crop

If the growing of white pine crops is to prove profitable, infection by the white pine blister rust must be prevented. This may be accomplished by the eradication of all currant and gooseberry bushes within 900 feet of pine stands. The actual work usually is accomplished through the coöperation of the State Forestry Department, which also is responsible for the control of forest fires. Protection against fire, the blister rust, and other pests is essen-

tial and should be planned for wherever the growing of white pine crops is started.

Skilful use of release cuttings and pruning and thinning accompanied by adequate protection throughout the life of the crop should assure the production of excellent quality white pine.

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