FIFTY YEARS FROM SEED
The Star Lake Plantation

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by
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The author has followed the development of these trees since they sprouted in the nursery, and has conducted the thinnings, the last two since his retirement as Superintendent of the Forest Management Division.

Edited by Harry W. Thorne and Ruth L. Hine

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STAND ESTABLISHMENT

The Star Lake Plantation was established in the spring of 1913 under the guidance of E. M. Griffith, Wisconsin's first State Forester. Griffith pictured this as "a fairly large and permanent experimental plantation" on which a permanent accurate record would be kept. His objective was to provide "a very valuable guide to all future tree planters in northern Wisconsin" (Griffith, 1913).

The planting site chosen was a point of land projecting westward into Star Lake, Vilas County. During the years while a nearby sawmill was operating, a fence had been built across the base of this peninsula so that it served as a cow pasture. During this period, the area to be planted had developed a tight bluegrass sod free from weeds and brush. Huge white pine stumps testified to a highly productive site which we now know to be a podzolic loamy sand. Griffith's sense of esthetics called for reconversion to pine on this denuded lake shore.

Planting stock came from the first forest nursery in Wisconsin which was established at Trout Lake in the spring of 1911. Land clearing and sowing of seed beds were still in progress during the last days of June (Fig. 1). Thus, in the spring of 1913, two-year-old seedlings were available.

Planting was done by students of the Ranger Short Course of the College of Agriculture. The planters worked in pairs: one man scalped an 18-inch square of sod and dug a hole, the other followed and planted the seedlings. Periodically they alternated, for scalping sod with a grubhoe was hard work for the then current 10-hour day. This was not planting in slits with a planting bar. Pay was a dollar a day and board, and the labor cost of planting was $3.42 per acre.

The species planted were red pine *(Pinus resinosa, Ait.)* eastern white pine *(P. strobus, L.)* ponderosa pine *(P. ponderosa Laws.)* and Scotch pine *(P. sylvestris L.)*. There are no records as to the source of the western and the European species, but seed of the two native pines came from cones collected from felled trees when the virgin stand was being logged on and immediately adjoining the Trout Lake Nursery site in the fall of 1910. There being yet no seed-extracting plant, the cones were dried in the sun.

The Scotch pine was planted inside the old fence at the base of the peninsula to make a good early showing in those years when the first efforts at forest planting were subject to ridicule. Survival after planting was good for all species for the deer population was very low during those years. However, only the red pine proved highly successful in growth and survival during the ensuing years. By 1920, damage by the white pine weevil *(Pissodes strobi* Peck) in the original white pine plot had deformed so many trees that it appears this species definitely should not be planted in full sunlight unless the weevil is to be controlled by spraying. With many trees of very poor form, the Scotch pine was thinned heavily in the spring of 1948 and underplanted with 4-year white pine transplants. This experiment sought to grow white pine under

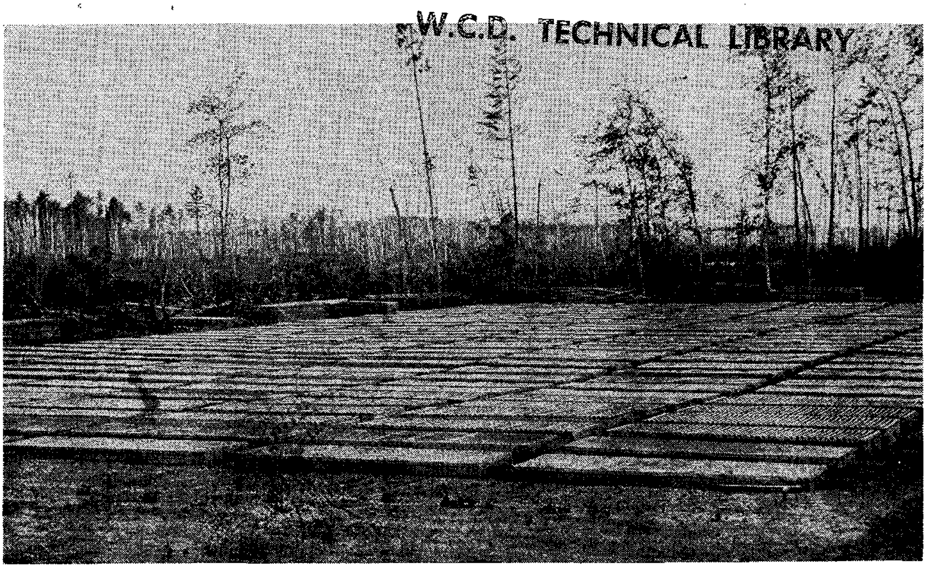

Figure 1. First seed beds in the Trout Lake Nursery (June, 1911).

the thin shade of the Scotch pine overstory to avoid killing of the leaders by the white pine weevil, but this attempt at conversion failed because of browsing by deer.

The ponderosa pine of unknown provenance grew well but more slowly than other pines for several decades, but only a few trees survived a winter of extremely low temperature.

THINNING EXPERIMENT

Establishment of Plots

By 1943 there were successful plantations in every county in Wisconsin, with red pine the leading species. Public opinion now fully supported fire control and reforestation, but had swung to opposition against any form of cutting. The time had come to demonstrate that there was more to forestry than planting trees and protecting them from fire. Specific authorization from the Conservation Commission was obtained to establish a thinning plot, with the provision that any cutting was to be well back in the plantation where it would be less conspicuous.

Two 1-acre plots were laid out, each with a 1-chain wide isolation strip so that growing conditions at the plot borders would be similar to those in the interiors (Fig. 2). The trees on each plot were serially numbered with paint just below the breast height level at which diameters were to be measured. The two plots were well matched, with 172 and 174 square feet of basal area, the latter plot having 57 fewer trees. Being a young plantation, there were no head dominants, though there were many suppressed trees. Defects were limited to several forked trees, some face scars following a year with considerable lammas growth, and

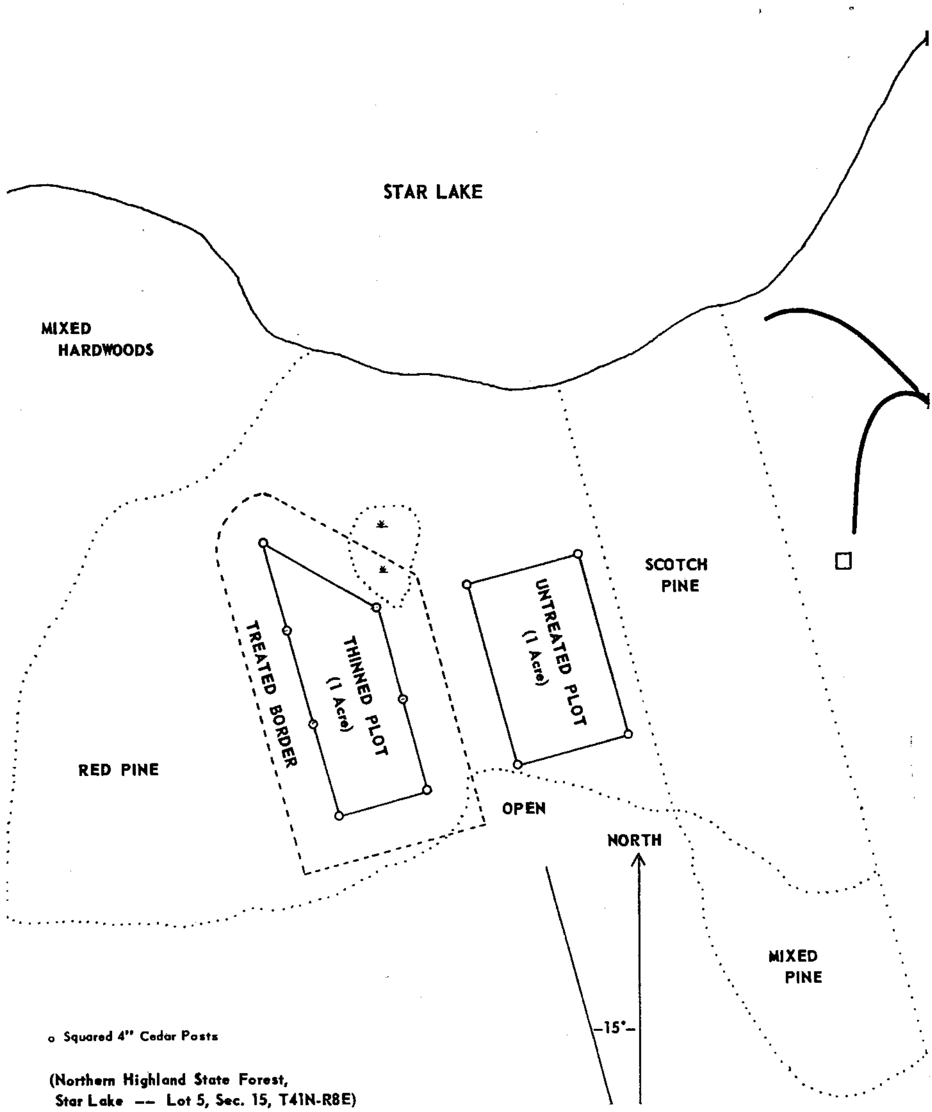

Figure 2. Permanent sample plots established for thinning experiment.

occasional minor butt scars resulting from severing some dead secondary stems at the ground line at the time of the early pruning.

To some foresters it may appear that with so high a basal area thinning was too long deferred. Yet, the live crown still occupied half of the total height of the trees composing the main stand. When marking the first thinning, we tried the Schwappach yield tables for Scotch pine as a guide. By proceeding carefully with serially numbered tags, however, it developed that thinning to the indicated basal area would leave far fewer trees than the yield table called for. The discrepancy was of course due to the excessive taper of trees planted at 6 x 6 feet and the resulting longer period of high live-crown ratio (Fig. 3), as compared to the more cylindrical stems resulting from the much closer spacing practiced in Germany. Instead of using any numerical control, therefore, the first thinning was marked on a feeling of what seemed right.

The first thinning was primarily from below, as is appropriate for so intolerant a species, but trees showing defect were discriminated against. The cut also took some larger trees with coarse branching to assure some larger sticks in the pulpwood pile, for the intent of the thinning experiment was practical application and sound economics. All trees under 3 inches d.b.h. were cut because they were not honest growing stock, and also because it required less work to eliminate them than to keep records on them. Of the nine trees under 4 inches, six yielded one stick of 100-inch pulpwood at the time of the second thinning. The first thinning left 580 trees and 140 square feet of basal area, and was endorsed by foresters who visited the plot as "about right." To enhance the appearance of this plot, the remaining trees were pruned to a height of 20 feet which removed only a few green branches (Fig. 4). Admittedly the pruning of all of the trees was not justified as a forestry practice, yet it is

Figure 3. Red pine of the Star Lake Plantation (age 20 years). Note large diameters and excessive taper resulting from long period of high live-crown ratio.

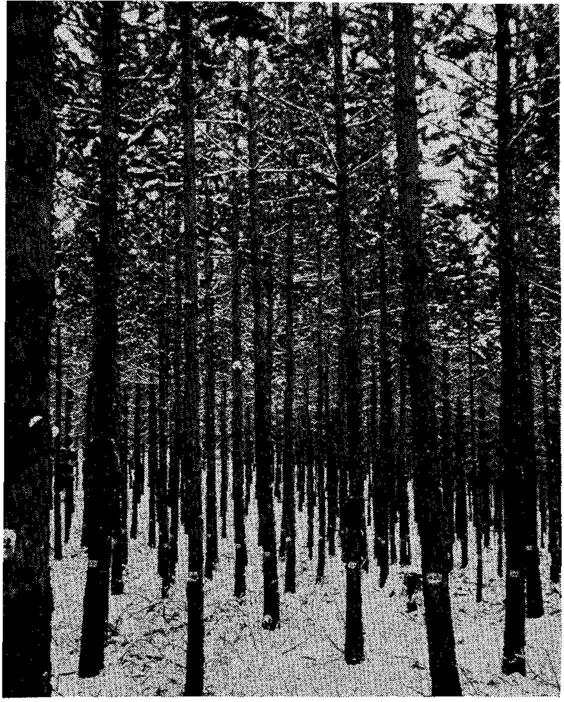

Figure 4. Red pine plot after first thinning (age 32 years; 580 trees per acre). Pruned to 20 feet.

doubtful whether this pruning with pole saws involved much more work than would have been required later to trim limbs from the pulpwood sticks. After each thinning the tops were limbed and the branches scattered and left to decay, since burning would have introduced a practice not applied to the untreated plot.

Measurements and Computations

Procedures for measurements and computations were worked out in conference with S. R. Gevorkiantz of the Lake States Forest Experiment Station. Diameters at breast height were measured with a steel tape to the nearest one-tenth inch, and the previous diameter of each tree was referred to at the time of each remeasurement to guard against personal error. The first height measurements were made on felled trees, while prior to each subsequent thinning, heights were measured with a transit. Heights were read from a height-over-diameter curve, average height being that of the tree of average basal area.

For volume computations, curves were drawn for board feet and total cubic stem volume inside bark, based on tables by Brown and Gevorkiantz (1934). With the aid of cord volume tables for other pine species, curves were also drawn on the basis of diameter and total height, and each time adjusted until the computed cut equaled the measured volume of the pulpwood piles. For all volume computations, values were read from these curves for each one-tenth inch diameter class. To assure that the results would be comparable, the same procedures were followed at the time of each thinning. The periodic measurements for the untreated plot and the data on the four thinnings are summarized in Table 1.

Development of a Stand Density Concept

Citing Braathe (1957) with respect to grades of thinning: "We are not interested too much in what is taken out but in what is left. What is needed in fact is a definition of the density of the remaining stand rather than a degree of thinning." Stand density is a numerical expression on a per area basis, and no such expression can be written without including the number of stems as a factor. Thus the number of trees is basic, though meaningless except when expressed in terms of some measure of their size, for they require more space as they grow larger. Basal area, which had proven so unsatisfactory as a guide in marking the first thinning, uses diameter as

TABLE 1 – Star Lake Plantation – Summary Table – Red Pine – Permanent Sample Plots – One Acre.

Age from Seed	Height Dom.	Height Ave.	D. B. H. Range	D. B. H. Ave.	No. of Trees	Stand Density	Basal Area	Stem Vol. Peeled	Cords Rough	Saw Timber
	Feet		Inches			Per Cent (1)	Sq. Ft.	Cu. Ft.	(2)	Bd. Ft. (3)
UNTREATED PLOT										
Age 32	42	40	1.0-9.2	6.0	893	16.6	172	2,842	35.4	1,770
5 year increment	+7			+.4			+22	+741	+9.5	+2,390
Age 37	49	46	2.1-9.5	6.4	872	14.4	194	3,583	44.9	4,160
Mortality			*1.0-4.4*	*3.1*	*–22*		*–1*	*–6*	*–0*	*–00*
6 year increment	+6			+.3			+11	+1,029	+12.6	+5,030
Age 43	55	52	3.4-10.5	6.7	841	13.1	205	4,612	57.5	9,190
Mortality			*2.2-8.5*	*4.2*	*–30*		*–3*	*–50*	*–.4*	*–60*
7 year increment	+9			+.5				+1,228	+13.3	+5,280
Age 50	64	59	3.7-10.9	7.2	800	12.5	229	5,840	70.8	14,470
Mortality			*3.4-6.2*	*4.4*	*–41*			*–91*	*–1.1*	*–00*
THINNED PLOT										
Age 32	42	40	1.8-9.9	6.2	836	17.2	174	2,885	35.9	2,770
Cut in Thinning			*1.8-9.0*	*5.0*	*–256*		*–34*	*–539*	*–5.9*	*–120*
1st Residual	42	41	3.0-9.9	6.6	580	20.6	140	2,346	30.0	2,650
5 year increment	+7			+.5			+22	+771	+9.0	+3,330
Age 37	49	47.5	3.1-10.7	7.1	580	17.7	162	3,117	39.0	5,980
Cut in Thining			*3.1-8.8*	*6.0*	*–150*		*–30*	*–538*	*–6.7*	*–450*
2nd Residual	49	48.5	5.0-10.7	7.5	430	20.6	132	2,579	32.3	5,530
6 year increment	+8			+.6			+21.5	+1,003	+12.6	+6,040
Age 43	57	56.5	5.1-11.2	8.1	429	17.7	153.5	3,582	44.9	11,570
Cut in Thinning			*5.1-10.5*	*7.4*	*–109*		*–32.5*	*–738*	*–9.3*	*–1,870*
3rd Residual	57	57	6.0-11.2	8.3	320	20.5	121	2,844	35.6	9,700
7 year increment	+9			+1.0			+31	+1,485	+11.5	+7,920
Age 50	66	65	6.3-12.2	9.3	320	17.6	152	4,302	47.1	17,620
Cut in Thinning			*6.3-10.8*	*8.3*	*–80*		*–30*	*–820*	*–9.5*	*–2,860*
4th Residual	66	66	7.6-12.2	9.7	240	20.4	122	3,482	37.6	14,760
Four cuts plus last residual								6,117	69.0	20,060

(1) Spacing in per cent of height of dominants. (2) Cords 4 x 4 feet by 100 inch sticks. (3) Decimal C rule in trees 7 " and over.

a measure of tree size. But Hummel (1954) has pointed out that "diameter increment, and hence diameter, are influenced by thinning treatment, and it is clearly undesirable to use, as a criterion for the definition of a treatment, a character which is itself influenced by the treatment."

Since basal area is a resultant value, reflecting the past history of stocking, attention was turned to height of dominants as a measurement which is unaffected except at the extremes of stand density (Wilson, 1946). Attention was also called to the fact that height "combines the components of age and site in one measurement." The formula then submitted was:

$$n = \frac{43{,}560}{(hf)^2}$$

where n = number of trees per acre
h = height of stand in feet, and
f = a certain fraction of height

But it soon became apparent that percentage would serve better than fractions. The formula plots as straight lines on logarithmic paper for any chosen value of f. The trend of stand density for the thinned plot to date is shown as the stepped course in Figure 5.

The same article proposed timing of thinnings by added height growth. Since height growth is more rapid in youth, this automatically complies with the old admonition that thinnings should be more frequent in young than in older stands.

The first residual stand represented a spacing of 20.6 per cent of the height of average dominants, and this line was followed to the nearest 10 trees per acre, for the same number of trees has always been left on each square chain to provide uniform distribution over the acre. At five years after the first thinning, the height of dominants had increased by 7 feet, and thinnings were then timed by each 7 - 8 feet of added height. Thus two specific controls have been imposed, and all other values must necessarily be accepted as resultants.

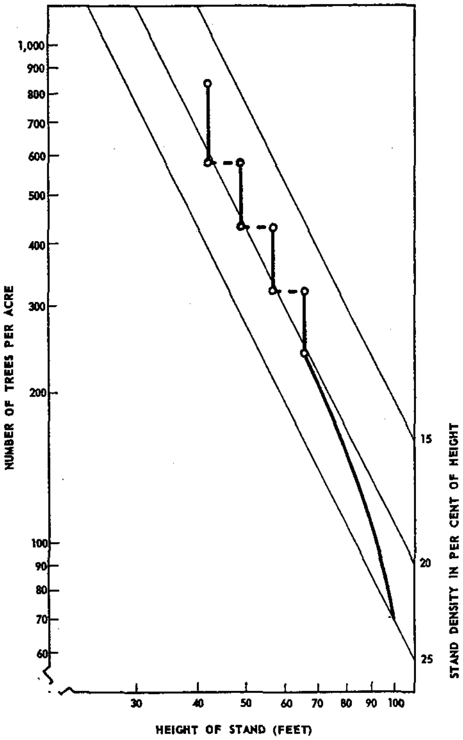

Figure 5. Stand density control.

Discussion and Observations

Thinning prevented any mortality due to competition (though one tree was killed by lightning). There is no evidence of root rot in either plot. While a difference in the height of the average tree is to be expected, height of dominants is beginning to fall behind on the untreated plot because of extreme stand density, rather than site deterioration. Naturally, thinning has also increased the diameter of the average tree, both by better growth and by the arithmetic effect of eliminating the smaller trees. Here the writer wishes to register a plea that others also report diameter ranges. In the present case thinning has narrowed the spread of diameters. The smallest tree on the thinned plot is now slightly larger than the average tree where no thinning was done. Too often plot data are limited to those required to support comparatively narrow findings.

The levels of residual basal area are contrasted in Figure 6 with those for Scotch pine after heavy thinning (Wiedemann, 1949). Heights at 50 years are identical, so that sites are comparable. Even between thinned plots, taper resulting from past differences in stand density affects the behavior of basal area. One may not safely assume that the trend of basal area in plantations established at 6 x 6 foot spacing resembles that resulting from the European practice of close spacing followed by early and frequent thinning. The last two residual basal areas, lying slightly above the curve for Scotch pine, are appropriate in view of the somewhat greater tolerance of red pine, while their leveling-off would indicate that this value has become more valid. But before the third thinning an inflation of basal area values must be acknowledged.

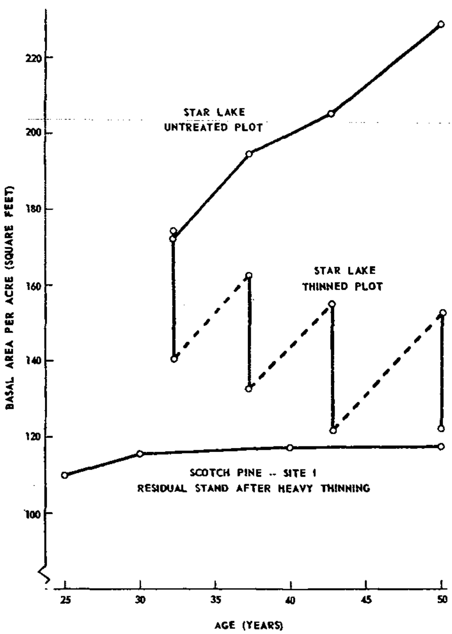

Figure 6. Basal area trends.

When measurements revealed that during the first two intervals diameter growth had been at the low rate of 20 annual rings per radial inch, there were comments that thinning had not been heavy enough to "bring response." Yet during those 11 years, pulpwood grew at a rate of slightly more than 2 cords per acre per year, which is no indication of stagnation. What had happened was both normal and desirable: the trees were improving their form by adjusting to the stand density being maintained. Excessive taper was being corrected by wider rings higher up on the trees as the base of the live crown moved upward. The form of the stem within the live crown approaches that of a cone, but upward movement of the base of the crown brings rapid correction of taper, which in the present case resulted in ingrowth of additional 100-inch pulpwood sticks. This was undoubtedly a factor in the cordwood increment. It follows that reliance on a high basal area, even when supported by increment borings revealing narrow annual rings at breast height, can lead to premature and excessively heavy thinning in young stands established at our usual spacing.

Volume yield in total cubic feet measures productivity for site and species. Subtracting the initial volume from the sum of the four cuts plus the last residual shows that the thinned plot has added 3,232 cubic feet during the intervening 18 years. During the same period, the untreated plot has produced 3,145 cubic feet (including 147 cubic feet lost in mortality). This close agreement would support the conclusion that the several thinnings did not reduce growing stock below a level for full volume production.

Yield in merchantable products is the test of applied practices. A yield of 69 cords in 50 years from seed demonstrates the superiority of intensive forestry when compared with the yield of natural stands of the same age, and has resulted largely from the uniform distribution in plantations. But thinning has not increased cordwood volume, for the untreated plot is slightly ahead. This difference is explained by the fact that with the larger diameters the thinned plot is now giving more cubic feet of wood per piled cord. The several thinnings have successively required 75, 67, 53 and 44 sticks per cord.

In terms of logs the thinned plot naturally has the better record by far. While all cut products have been sold by the cord, still by crediting this plot with the board-foot volume sold as cords, it has produced 20,060 board feet as against 14,470 for the untreated stand, which still has 32 per cent of its trees below 7 inches d.b.h. To summarize this point: the present residual stand with 240 trees has at least as much board-foot volume as the untreated plot with 800 trees, despite the cut and sale of 31.4 cords of pulpwood. It should be of interest that the thinned plot has been growing at an average of over a thousand board feet annually for the last two intervals.

PRUNING EXPERIMENT

Some pruning of dead branches had been done in February of 1929, and this was extended in March of 1934 to 7½ feet by a work crew from the Civilian Conservation Corps Camp, located on the east shore of Star Lake. These dead branches were burned, being careful that no trees were injured by heat. Leaching from the resultant ash heaps, however, increased alkalinity to the point that some adjoining trees did subsequently die. The purpose of this early pruning was to make the entire plantation more accessible in case of fire.

A pruning experiment was initiated at age 43 years from seed. At the time of the second thinning, 100 trees (10 on each square chain) had been selected to be somewhat favored in later thinnings. They were chosen more on the basis of their height and pointed crown rather than on their diameter. These trees were marked with blue paint and pruned to a height of 34 feet so that they might eventually yield 2 clear 16-foot logs. A 20-foot magnesium extension ladder was topped with a plywood "table" from which a semicircle of 4-inch radius was cut and edged with a piece of split rubber hose. This cutout fits the bole as the ladder is set vertically against the tree. According to German safety rules hands are kept off the rungs and hold on to the tree, as when climbing a pole with lineman's spurs. Then the top of the ladder is strapped to the tree, after which one can stand on the "table," snap on a lineman's safety belt and work all around the tree. In this case a 10-foot pole saw served to remove limbs to a height of 34 feet (Fig. 7). Five trees were thus pruned per hour, at a cost of 25 cents per tree.

Much has been written to the effect that the cost of pruning above the first log becomes excessive, thus ignoring the fact that pruning can improve the grade of the second log more than that of the butt log. In another half century this point can be tested by sawing and grading the lumber from these trees with a knotty core 8 inches in diameter and comparing it with the lumber from trees of the same size from the similarly thinned isolation strip but pruned to only 7½ feet. For those who will make that determination, the cost of the several pruning operations with 3 per cent compound interest to 50 years for these 100 trees is $ .4011 per tree. They need merely apply the same interest rate for another 50 years.

Figure 7. Pruning to 34 feet.

COSTS AND RETURNS

Costs and returns present the economic case for good silviculture, for in addition to the more intangible values, forestry is expected to earn a return on the investment. The old formula for computing the cost of a plantation was:

$$(C+S+E)\ 1.0P^n - (S+E)$$

where: C = cost of planting
S = soil or land value, and
E = annual expense, capitalized

After applying the interest rate, which throughout this computation was 3 per cent compound interest, the cost of the land and the capitalized value of annual expense was deducted. Both were introduced to draw interest, which in the case of the land represented annual rental.

The old records gave the cost of planting labor as $3.42 per acre, and the cost of producing the first 2-year-old seedlings as 47 cents per thousand. Six by six foot spacing required 1,210 trees per acre which added 57 cents, but by using 58 cents we could round off the cost of planting to $4.00. State forest lands were purchased in those years at an average of $2.50 per acre. To evaluate this project as a private venture, an annual tax of 10 cents per acre was used even though the Forest Crop Law prescribing that land tax was not enacted until 1927. But that act also repealed the former 30-year tax exemption for plantations, so the use of the 10 cent tax from the beginning cannot be an objection. In addition 5 cents annually was allowed for supplemental protection from fire. Capitalizing this annual expense of 15 cents at 3 per cent gave $5.00. Applying the formula:

$ 4.00 Cost of planting
2.50 Soil value
5.00 Expense capitalized

$11.50 x 4.133 (3% compound interest for 48 years) equals
$47.53
—7.50

$40.03 Cost of the untreated acre

But there was further cost chargeable to the thinned plot. The cost of pruning the remaining 240 trees may properly be applied, dismissing the pruning cost of trees previously cut for pulpwood as mere window dressing. Using the cost per foot for pruning from 7½ to 20 feet as a rate for pruning from the ground up to 20 feet, the cost was 5½ cents per tree, which for 240 trees amounted to $13.20. Pruning 100 of them from 20 to 34 feet at 25 cents adds another $25, but these items must also earn interest, so:

$13.20 x 1.702	(3% compound for 18 years)	= $22.47
25.00 x 1.230	(3% compound for 7 years)	= 30.75
Cost of untreated plot		40.03
Present cost of thinned plot		$93.25

However, the thinned plot had been earning money, which would be entitled to interest from the time the income was received. Using stumpage receipts after deduction of the 10 per cent severance tax levied under the Forest Crop Law:

$23.72 x 1.702	(3% compound for 18 years)	= $40.37
30.62 x 1.468	(3% compound for 13 years)	= 44.95
43.71 x 1.230	(3% compound for 7 years)	= 53.76
57.00	No interest	57.00
Total Income		$196.08
Present cost		—93.25
Net profit		$102.83

With the investment at 3 per cent compound interest fully recovered, so that no charges remained against the choice residual stand, plus a profit of $102.83 per acre, the advantage of practicing intensive forestry is evident. Some have protested that this presents too rosy a picture which could not be duplicated with today's higher land and planting costs. But this argues that the trend to dollar devaluation will be checked. One thing is clear: the trees have been growing while the dollar has been shrinking, and intensive forestry is an excellent hedge against inflation. Less intensive forestry could have grown the same volume of products, but with higher land investment and annual carrying charges.

Contrasting the two plots (Figs. 8 & 9) at 50 years from seed on a straight pulpwood production basis, clear cutting of the untreated acre could have provided an income of $424.80 gross or $384.77 net. Similarly, clear cutting of the residual stand would have added $225.60 to the $196.08 present value of four thinnings, with a gross of $421.68 or $381.65 net income, since pruning costs would not have been incurred for pulpwood. This negligible difference of $3.12 shows that the interest earned on income from the first three thinings was fully offset by the rise of stumpage prices. Yet most owners would prefer earlier periodic income from thinnings. Liquidating these stands now would require replanting at present higher costs, and incur the hazards to which young stands are susceptible, while postponing income from thinnings for three decades.

CONCLUSIONS

General

Stem volume is derived from the product of basal area and height which gives the volume of a cylinder, which must then be reduced by the appropriate form factor. To ignore height and form and rely only on basal area may not be done with impunity. Upper diameters govern merchantability, whether the product be logs, poles or pulpwood. There is no market for d.b.h. or basal area.

Thinning to 20.6 per cent of height was not so severe as to reduce yield nor to retard correction of form. An increase in the rate of d.b.h. increment during the last interval would indicate that form is now fairly well adjusted for the maintained stand density, and better diameter growth may be expected.

Referring to Figure 5, it may be noted that timing thinnings by height growth has resulted in attaining the same stand density before each subsequent thinning, which would not be the case if thinning had been timed by a fixed number of years. This timing control also resulted in removal of almost exactly 25 per cent of the trees in the second, third and fourth thinnings.

By accidental good fortune as to the initiation of thinning and the intervals based on height growth, remeasurements and a fourth thinning fell at age 50 years from seed. At the several measurements, height for age had fallen both above and below the curve for Site 65 of the Lake States Forest Experiment Station site index graph for red pine. Thus the Star Lake plot may be said to occupy Site 65. Cycles of temperature and precipitation will affect a single stand, so that it should not be expected to coincide at each measurement with a site index curve representing an average of many stands.

Field Application

In thinning, the prime purpose is to assure proper growing space. It is necessary to remove entire trees from the place they occupy, and though the remaining trees cannot be rearranged, there is always a conscious effort to leave them uniformly distributed over

Figure 8. Residual stand after four thinnings (age 50 years; 240 trees per acre).

Figure 9. Untreated plot (age 50 years; 800 trees per acre).

the area. Of course spacing guides are not to be applied rigidly; better trees are favored, but even poorer trees may be left temporarily as trainers. Marking can be done rapidly when using a spacing guide, which has been a factor in the use of spacing guides based on diameters. While the case for the superiority of height as a factor has been stated, it is clear that any spacing guide, however well or poorly chosen, must inevitably improve uniformity of distribution in irregularly stocked stands.

For red pine, a spacing of 20 per cent of height would be a good rule. It requires but little work to measure the height of several dominants and divide the average by 5 to secure the desired spacing guide. Where poles for preservative treatment are to be grown, the use of 18 per cent of height would contribute to reduction of taper and size of knots and also increase the number of poles per acre. For red pine on poor sites or for jack pine, a spacing of 21 or 22 per cent could be applied. For the more tolerant spruces and balsam fir one-sixth of height would assure the closer spacing needed to secure better natural pruning.

Present interest is now centered on thinning of pine plantations, where uniform spacing permits a commercial cut of pulpwood for the first thinning. This may well be deferred until the extreme early taper is partly corrected, and trees composing the main stand have reduced their live-crown ratio at least below 50 per cent. The growing practice of cutting entire rows to expedite hauling out of cut products at the time of the first thinning is proper, but to take every third row results in excessive reduction of growing stock and retardation of natural pruning on one side of each remaining tree. To take out every seventh row permits a more normal thinning of the interior rows, without appreciable reduction of total yield for the rotation. As to subsequent thinnings, the period of return may properly be lengthened to assure an adequate cut. Uneconomic "tickle cuts," resulting from too frequent returns, increase marking and supervision costs.

Research Application

The two specific controls imposed at Star Lake were advocated for use on experimental plots to provide data for construction of yield tables for managed stands as long ago as 1946 (Wilson, 1946). It was urged that these controls be applied to adjoining plots held to three defined residual stand densities differing by 2 per cent, that the inclusion of an untreated plot would make no contribution to the objective, and that such series should be replicated over the range of sites. It was also recognized that poorer sites might require wider spacing, while an evaluation of tolerance would serve in deciding on the range of stand densities to be used for any species.

Meanwhile, continuing studies of stand density (Wilson, unpubl.) included plotting the courses for residual number of trees over height, as given in many European yield tables for managed stands. From these resultant curves plotted on logarithmic sheets, three basic principles clearly emerge:

1. Poorer sites carry fewer trees for *height.*
2. Tolerant species are grown at

closer spacing than intolerants. However, the tolerance scale is modified by crown form.

3. There is a characteristic downward trend of these curves toward the end of the rotation.

The curve to define future residual stand densities for the Star Lake plot is based on the latter principle (Fig. 5). It is, of course, due to the declining rate of height growth, and appears to be correlated with site index graph curves.

By now the failings of allegedly normal yield tables, based on single measurements of unmanaged stands, are even more apparent. Nor should truly normal tables, based on remeasurements and light thinnings, be our objective. In discussing his 1949 yield tables, Wiedemann (1951) rejects the concept of normal yield tables as carrying a silent propaganda that normal full stocking is desirable. Instead, he offers tables for moderate, heavy and even accretion thinning, that the practicing forester may choose as a guide the table best suited to his stands and markets.

In effect, Table 1 is a yield table for red pine on Site 65 to age 50 years. Though based on data for a single plot, it represents accurate records of a known population with specific controls. The current project of Day and Rudolph (1962) for red pine on excellent site is reducing plots to 16, 18, 20, 22, and 24 per cent of height, which is amply wide to determine how broad a range will still give full volume increment. With the long internodes on an excellent site, the closer spacing should disclose the possibilities of pole production. The present three-year thinning interval will result in earlier attainment of the prescribed stand density on the plots designated for wider spacing. Replication of these treatments permits eventual statistical evaluation.

The extensive areas of red pine plantations of recorded age in the Lake States present an opportunity for leadership to win cooperation for agreement on the controls to be applied, the number of plots required over the range of sites, and the assignment of plots to be established and managed on public and industrial forests. By including measurements of taper and bark thickness, volume as well as yield tables could be compiled for red pine plantations, as data are periodically reported to a central agency.

CONTINUATION OF THE STAR LAKE PLOTS

Some decision must be made as to the future of the untreated plot, now that it has served to show that thinning has not reduced total volume production. If left untouched, it will presumably develop openings in the canopy of crowns as the trees become still more slender and less resistant to loads of wet snow or glaze. In other words, it can be left to demonstrate the results of neglect. But is it still necessary to prove that thinning is good practice?

On the other hand, it may still not be too late to initiate very light and frequent thinnings. In that case the aim of management would be the production of items sold by the lineal foot, such as poles, piling and cabin logs. This might bring higher financial returns than those earned by the thinned plot, which aimed at the standard products of pulpwood and logs.

Because the entire red pine block is of known provenance, and its isolation reduces the probability of pollination from other sources, the opportunity for developing a "plus stand" deserves consideration. This would require thinning both in the unthinned plot and its isolation strip and in the red pine stand outside the experimental area, thereby preventing pollination from inferior trees and assuring a future superior seed source.

Adherence to past procedures for the thinned plot is indicated, but with modification of the residual stand as defined by the curve which has been added to the stepped course shown in Figure 5. Assuming that this stand will continue to approximate the 65 site index curve, then continued use of 7 feet of added height will extend the past arithmetic progression of 5, 6, and 7 years to 8, 9, 10, 11, and 12 years to age 100. It appears desirable to use this series of year intervals, but each time reducing to the number of trees indicated by the actual measured height of dominants and the curve defining the residual. With the declining number of trees, it will no longer make sense to thin to the nearest 10 trees. Retention, so far as possible, of the "blue ribbon trees" will contribute to uniform distribution over the acre.

With a height of 100 feet at 100 years, the cut should provide some 20 trees which have been pruned to 34 feet. The lumber from these trees and from an equal number of trees from the similarly thinned border strip should be graded to determine whether pruning for two clear logs shows a profit or a loss, based on the grade prices then prevailing.

Though the rotation, in the absence of catastrophe, may well be extended to 140 years or more, recommendations beyond the next half-century cannot logically be made at this time. Eventually the stand must be regenerated, though European experience does not indicate that the deer problem will have been solved by then. But long before that time the responsibility for this plot will have passed to succeeding generations of foresters. Though they never had the privilege of serving under Griffith, they are the beneficiaries of his early work and thus inherit the obligation fully to redeem his pledge of 1912. Fortunately, foresters are trained to think in terms of decades and century-long rotations, always aware that the quality of their work will be judged by others yet unborn.

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