Initial Thinning in Red Pine Plantations

John H. Cooley

Michigan, Minnesota, and Wisconsin have approximately ¾ million acres of red pine plantations in which the trees are now, or soon will be, large enough to produce pulpwood. Thinning these plantations without delay can increase financial return and reduce the risk of insect and disease damage associated with intense, prolonged competition. The return that will be derived, however, will depend to a large extent on selecting the method and intensity of thinning best suited to each management situation. Fortunately, many thinning studies have been conducted in both natural and planted stands, and the economic implications of many alternatives have been compared. The purpose of this paper is to point out the consequences of certain thinning alternatives and to develop a prescription for initial thinning that will have wide application in the Lake States.

A primary objective of thinning studies has been to determine optimum stocking level, but most have shown that basal area growth varies little over a wide range of residual stand density (Buckman 1962a, b). Similarly, basal area growth seems to vary little over a broad range of thinning methods. Buckman (1962a) and Buckman and Wambach (1966) found no consistent differences among thinnings from above, below, and a combination of above and below. Day and Rudolph (1966) found that basal area growth in the first 3 years after thinning was at least as great where entire rows were removed as where individual trees were selected. In contrast, both residual stand density and cutting method have a major influence on tree diameter. The average stand diameter can be increased by cutting mostly smaller trees (thinning from below), or decreased by cutting mostly larger trees (thinning from above), and diameter growth rate can be stimulated by reducing stand density. Thus rotation length for trees of any given size will vary with density and cutting method even though total yield will not.

The economic implications of stand density have been worked out by Lundgren (1965) on the basis of growth and yield estimates for natural red pine stands in Minnesota (Buckman 1962a). He found the highest expectation value for red pine land to be associated with the lowest density included in his analysis — 90 square feet of basal area per acre. Apparently, differences in diameter growth rate have more effect on value yield than differences in cubic foot volume, even when there is no price differential associated with size. When large trees are worth more than small ones, differences in growth rate become more important. Buckman and Wambach (1966) found that thinning from below yielded a better return than thinning from above; again, this can be attributed to differences in the rate at which diameter increased.

Testing a variety of thinning methods and intensities in plantations at different locations in Lower Michigan generally corroborated findings of previous growth studies. Basal area growth was found to be nearly the same for a broad range of treatments, including: (1) removal of every other row, (2) removal of every third row, (3) selective thinning from above leaving densities ranging from 60 to 120 square feet of basal area per acre, (4) crown release of selected trees leaving the same range of densities, and (5) selective thinning from below leaving 60 square feet of basal area per acre or more.

Thinnings that reduced density to 40 square feet of basal area per acre or less usually reduced basal area growth. Diameter growth was closely related to stand density, but did not seem to be influenced to any extent by thinning method, although the immediate effect on average stand diameter varied with the thinning method.

Study Description

Thinning plots were established in six plantations in Lower Michigan (table 1); Three 5-year growth periods have elapsed since these plots were first thinned and compartments have been thinned to the prescribed basal area at the beginning of each period.

During this 15-year period a number of other thinning methods were tried in Plantation 4. One compartment was initially thinned by removing every other row and another by

Table 1. — Characteristics of plantation in which thinning plots were established

Plantation	Age	Site index	No. of trees/acre	Basal area	Mean d.b.h.
	Years			Square feet/acre	Inches
1	19*	70	1,200	150	4.8
2	22*	68	1,080	135	4.8
3	24	66	720	130	5.7
4	39	49	1,500	205	5.0
5	34	48	810	115	5.1
6	34	39	760	100	5.0

* Replicated studies were established in these stands only.

plots in Plantations 1 and 2 constituted replicated studies. In both plantations, treatments included thinnings from below leaving 30, 60, 90, 120, and 150 square feet of basal area per acre, removal of every other row, and removal of every third row. In Plantation 1 treatments were replicated four times and in Plantation 2 they were replicated three times. In addition, thinnings from above to 60, 90, and 120 square feet, and crown thinnings to the same densities were tried in Plantation 2. Crown thinning was much the same as thinning from above and below to release the crowns of selected trees. One 5-year growth period has elapsed since these plots were first thinned.

In the other four plantations, compartments were thinned from below to 60, 80, 100, and 120 square feet of basal area per acre and each compartment was sampled with systematically located plots. These could not be treated as replications because of differences in age, site quality, and initial stand density, so they were compared subjectively.

removing every third row. These row thinnings were made at the same time as the selective thinnings, but the row-thinned compartments were left for 10 years, and then thinned from below to leave 100 square feet of basal area per acre. Five years after the first selective thinnings, one compartment was thinned from below to 160 square feet, another was thinned leaving only intermediate and suppressed trees, and two others were thinned to 140 and 120 square feet leaving trees with the best potential for utility poles. Five years after this, one more compartment was thinned from below leaving 40 square feet of basal area per acre.

Results

Because Plantations 1 and 2 had the greatest diversity of thinning treatments and the treatments were replicated, the data obtained from them provide a frame of reference for evaluating results at other locations (table 2). Variance analysis of basal

Table 2. — Basal area growth after thinning in Plantations 1 and 2
(In square feet of basal area per acre)

Thinning method	Prescribed residual density	Plantation 1		Plantation 2	
		Residual density	Periodic growth	Residual density	Periodic growth
Unthinned	---	150.6	33.0	136.6	34.4
Thinned from below	150	145.2	32.6	134.5	35.9
Thinned from below	120	118.8	30.6	119.8	33.8
Thinned from below	90	85.7	33.3	89.3	36.1
Thinned from below	60	58.2	33.4	61.2	35.4
Thinned from below	30	29.5	20.4	29.4	25.7
Thinned from above	120	*	*	116.7	32.4
Thinned from above	90	*	*	88.4	37.3
Thinned from above	60	*	*	58.9	37.6
Crown Release	120	*	*	119.7	34.5
Crown Release	90	*	*	87.6	34.5
Crown Release	60	*	*	60.9	34.2
Remove every other row	---	72.2	31.1	66.6	34.1
Remove every third row	---	104.6	34.1	91.1	39.2

* No thinning from above or crown release in Plantation 1.

area growth showed significant differences among treatment means for each of the two plantations. According to Duncan's multiple range tests, reduced growth on plots thinned to 30 square feet of basal area per acre accounted for the difference in both cases. Comparing the three selective thinnings in Plantation 2 indicated no differences due to cutting method and no interaction between residual basal area and cutting method. Basal area growth on row-thinned plots was not significantly different from that on plots thinned selectively to residual densities between 60 and 90 square feet per acre. However, all treatments that were tried in both plantations resulted in less growth in Plantation 1 than in Plantation 2, even though age and site index were nearly the same. This difference was significant at the 95 percent level.

Increases in mean stand d.b.h. were inversely related to residual basal area up to about 120 square feet (figs. 1 and 2). Check plots and those maintained at 150 square feet of basal area, from which only a few trees were cut, had about the same rate of diameter increase as those thinned to 120 square feet. On the average, these lightest thinnings had little effect on diameter growth. Each 10-foot reduction in basal area below 120 square feet per acre increased 5-year diameter growth by .119 inches in Plantation 1 and .140 inches in Plantation 2 whether trees were removed selectively or systematically.

Even though mean stand diameter growth was largely independent of cutting method, some methods immediately changed mean stand diameter. Thinning from below increased mean stand diamter by 1.5, 0.9, 1.2, and 0.4 inches d.b.h. in plots thinned to 30, 60, 90, and 120 square feet of basal area, respectively. Row thinning and crown thinning had almost no immediate effect, and

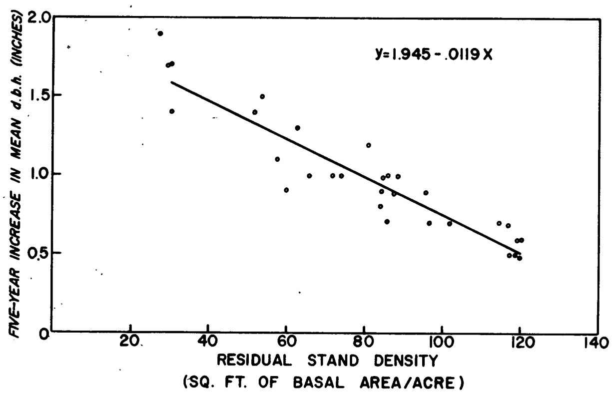

FIGURE 1. — Average 5-year d.b.h. increase in Plantation 1 on all plots thinned to between 30 and 120 square feet of basal area per acre.

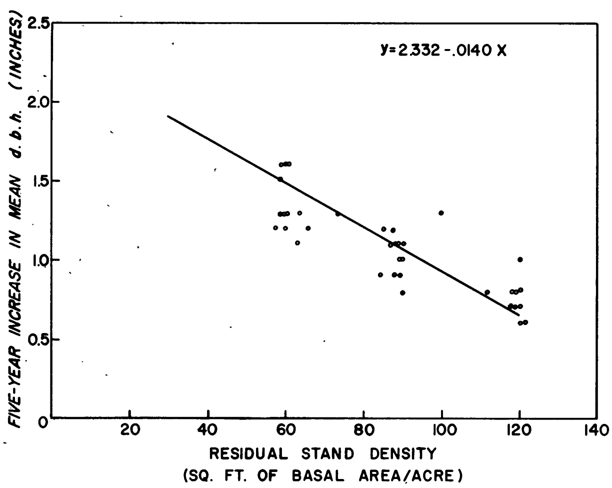

FIGURE 2. — Average 5-year d.b.h. increase in Plantation 2 on all plots thinned to between 30 and 120 square feet of the basal area per acre.

thinning from above decreased mean stand diameter by 0.6, 0.3, and 0.0 inches d.b.h. in stands thinned to 60, 90, and 120 square feet of basal area, respectively.

Basal area growth at each density level varied widely in the other four plantations, but these variations generally did not contradict the relationships observed in Plantations 1 and 2. The one plot in Plantation 4 that was thinned to less than 60 square feet of basal area per acre grew much less than any of the others in that plantation. In all plantations, plots thinned to between 60 and 120 square feet of basal area grew best during the first and second growth periods. During the third period unthinned plots made the best growth in Plantations 3 and 4; otherwise those thinned to between 60 and 120 square feet grew best during this period also. Most of the special thinnings in Plantation 4, including both row thinnings, resulted in as much growth as thinning from below. The only exceptions were the first thinning to release intermediate and suppressed trees, and the first pole thinning leaving 140 square feet of basal area.

Diameter growth trends in the other four plantations were generally consistent with those in Plantations 1 and 2. Thinning from below to the higher residual densities elicited little response, if any, because only a few intermediate and suppressed trees were cut (table 3). But in Plantation 4, where the initial density was over 200 square feet per acre, thinning to 140 square feet did increase growth. In other words, if the thinning removed enough basal area to increase growing space for residual trees, there was a strong and consistent relationship between diameter growth and residual density.

In Plantation 4 this relationship was evident for other methods as well as for thinning from below. On row-thinned plots, which averaged 99 square feet of basal area per acre after their first thinning and were thinned selectively to 100 square feet 10 years later, 15-year d.b.h. increase was about 2.6 inches. During the same period on plots thinned selectively every 5 years to 100 square feet, d.b.h. increase was 2.4 inches. Pole thinnings to 120 square feet resulted in a mean 5-year d.b.h. increase of 0.6 inches. Thinning from above left a stand of 120 square feet after the first thinning, and the mean d.b.h. increase was 0.4 inches during the next 5 years. The second thinning from above left a residual stand of 116 square feet, and ensuing 5-year d.b.h. increase was 0.9 inches. So the 10-year increase on this plot was about 1.3 inches, which was comparable to plots thinned selectively to 120 or 140 square feet.

As in Plantations 1 and 2, site index was weakly related to growth. In Plantation 4,

Table 3. — Five-year increase in mean stand d.b.h. after thinning from below and in unthinned plots in Plantations 3, 4, 5, and 6
(In inches d.b.h.)

Plantation	Prescribed residual density (sq. ft. of basal area/acre)							Unthinned plots
	40	60	80	100	120	140	160	
3	(1/)	1.3	0.8	0.7	0.7	0.5	(1/)	0.4
4	2/1.7	1.4	1.0	0.8	0.6	0.6	0.3	0.3
5	(1/)	1.0	0.8	0.5	0.4	0.4	(1/)	0.4
6	(1/)	0.7	0.6	3/0.5	2/0.3	2/0.4	(1/)	0.4

1/ No plots thinned to this density.
2/ Growth during third period.
3/ Average growth during second and third periods.

which had a site index of 49, the average 5-year growth on all plots thinned to between 60 and 120 square feet of basal area per acre was 28 square feet, but in Plantation 3, which had a site index of 66, it was only 24 square feet. Furthermore, Plantation 3 was younger when it was thinned for the first time, and thus might have been expected to respond better. After the second and third thinnings to the same range of densities, average 5-year growth in Plantation 5 was 10 square feet less than in Plantation 4, even though their site indexes were nearly the same. In Plantation 6 growth averaged only 2 square feet less than in Plantation 5, although its site index was nine units lower.

Discussion

Although some of the comparisons given here are subjective, they suggest that basal area growth after thinning in a red pine plantation depends largely on factors that cannot be controlled by the forester. Residual basal area has a marked effect on basal area growth only when it is so low that there are not enough trees to fully utilize the site, or when it is so high that trees are lost to mortality. In young red pine plantations, 60 square feet of basal area per acre apparently represents the lowest stocking that will fully utilize most sites. If it is assumed that above this level of stocking basal area growth is the same, higher densities will yield more volume growth. However, diameter growth will be faster at lower densities, and economic analyses based on growth in natural stands (Lundgren 1965) suggest that differences in diameter growth influence value return more than differences in volume growth as long as the site is fully stocked. Therefore, many owners would find densities of about 60 square feet of basal area per acre most profitable.

The method of selecting trees to cut does not appear to influence either basal area or diameter growth. Apparently, red pine in plantations is so uniform that growth is about the same no matter which trees are removed, as long as the residual trees are reasonably well distributed. However, thinning from above will reduce average stand diameter at the time of thinning, thus lengthening the rotation. Thinning from below has the opposite effect, whereas crown thinning has little immediate effect on average stand diameter.

Systematic removal of rows also has little immediate effect on average stand diameter, and mean stand diameter growth is as rapid after this kind of thinning as it is after selective removal of individual trees. It follows that dominant and codominant trees must grow at the same rate in plantations that are row-thinned as in those that are thinned selectively from below. Therefore, if rows were removed systematically in the initial thinning and subsequent thinnings were from below, rotations should be as short as if the first thinning were from below. Row thinning requires a minimum of marking and reduces logging costs by concentrating material in access trails. These access trails also facilitate future logging operations. For the first thinning, then, most owners will find removal of complete rows desirable.

Obviously, a strictly mechanical row thinning will not leave a uniform stand of 60 square feet per acre, but this can be modified by varying the number of rows cut or by thinning from below in rows that are not removed completely. Where trees were not planted in regular, parallel rows, row thinning, as such, will not be feasible, but some of the advantages can be realized if all trees are removed from closely spaced trails to provide access and the remaining stand is thinned from below leaving about 60 square feet of basal area per acre.

Summary

A variety of thinning methods and intensities were tested in red pine plantations in Lower Michigan. Replicated studies in two plantations showed that neither residual density nor method of selecting trees for removal influenced subsequent basal area growth, except where plots were thinned to 30 square feet per acre. This was confirmed by observations in four additional plantations. Thinning from below increased mean stand diameter, thinning from above decreased it and these changes were roughly proportional to reduction in stand density. Diameter growth was shown to be strongly influenced by residual density if enough basal area was removed to increase growing space for residual trees.

It was concluded that thinning to about 60 square feet would be most profitable to most owners because it shortens the rotation as much as possible without seriously reducing volume yield. It was further concluded that row thinnings minimize costs and facilitate both current and future logging operations. To leave approximately 60 square feet of basal area per acre, it is necessary to vary the number of rows cut and cut selectively in uncut rows. Where trees were not planted in parallel rows, the stand can be reduced to 60 square feet of basal area per acre by removing enough trees to create closely spaced access trails, and by thinning the rest of the stand from below.

Literature Cited

Buckman, Robert E. 1962a. Growth and yield of red pine in Minnesota. U.S. Dep. Agr. Tech. Bull. 1272, 50 p., illus.

Buckman, Robert E. 1962b. Three growing-stock density experiments in Minnesota red pine: a progress report. U.S.D.A. Forest Serv., Lake States Forest Exp. Sta., Sta. Pap. 99, 10 p., illus.

Buckman, Robert E. and Wambach, R. F. 1966. Physical responses and economic implications of thinning methods in red pine. Soc. Amer. Forest. Proc. 1965: 185-189, illus.

Day, M. W. and Rudolph, V. J. 1966. Early growth results of thinning plantation red pine by three methods. Mich. Agr. Exp. Sta. Quart. Bull. 49 (2): 183-188.

Lundgren, Allen L. 1965. Thinning red pine for high investment returns. U.S.D.A. Forest Serv. Res. Pap. LS-18, 20 p., illus. Lake States Forest Exp. St., St. Paul, Minn.