COMMERCIAL THINNING IMPROVES GROWTH OF JACK PINE

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ABSTRACT

*Jack pine (*Pinus banksiana *Lamb.) stands on good sites showed improved tree and stand growth following commercial low and crown thinning at age 40. Data 15 years after thinning suggest that gross pulpwood and sawlog yields (thinning plus final yield) will be greater in treated stands.*

Growth response to crown thinning occurred later than response to low thinning, but its effect was of longer duration. Therefore, on good sites, a combination of low and crown thinning which removes up to 30-35% of basal area at a stand age of about 40 years may be advantageous because it reduces thinning costs, improves yield, and lowers harvesting and processing costs because of increased tree size.

RESUME

Par suite d'éclaircies commerciales par le haut et par le bas, au moment où ils étaient âgés de 40 ans, les peuplements de Pin gris (Pinus banksiana *Lamb.) en stations de bonne qualité poussèrent mieux. Quinze ans après les éclaircies, les rendements bruts en bois à pâte et en grumes (éclaircies plus récolte finale) seront plus élevés dans les peuplements traités.*

La croissance améliorée résultant d'éclaircie par le haut se produisit plus tard que celle résultant d'éclaircie par le bas, mais elle fut d'effet plus durable. Par conséquent, dans les stations de bonne qualité, des éclaircies combinées (par le haut et par le bas) diminuant de jusqu'à 30-35% la surface terrière au moment où le peuplement a 40 ans, peuvent se révéler avantageuses parce qu'elles réduisent les coûts d'éclaircies, améliorent le rendement et diminuent les coûts de récolte et de faconnage en raison des dimensions plus fortes des arbres.

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INTRODUCTION

Dense jack pine stands of fire origin are common in the Prairie Provinces. Efficient pre-commercial thinning techniques are now available to treat very young stands: mechanical strip thinning can be conducted with heavy equipment (Bella and De Franceschi 1971), or selective thinning can be done with light, portable brush saws (Riley 1973; Bella 1974). However, these methods are unsuitable in older stands which contain large trees.

Traditional selective thinning in older stands is more likely to be economically feasible if the revenue derived covers the cost of thinning. Thinning may also improve total merchantable yield, and the concentration of volume increment on fewer but larger trees would result in reduced harvesting and processing costs.

This study was initiated in the fall of 1957 to evaluate the effect of different kinds and intensities of commercial thinning on volume increment of the residual stand and to determine final merchantable yield at rotation. Establishment and the first 5-year results after thinning were reported by Cayford (1958 and 1963, respectively) and the 10-year results by Bella and De Franceschi (1973). This report contains results 15 years after thinning.

DESCRIPTION OF THE STUDY AREA

The study area is located in the Sandilands Forest Reserve in southeastern Manitoba. The forests in this area lie within the Rainy River Section (L.12) of the Great Lakes-St. Lawrence Region (Rowe 1972).

The topography is flat to undulating and the soils are sandy. The sample stands represent two fresh habitat types (Mueller-Dombois 1963), one with poor nutritional status, the other with intermediate. These two habitat types are considered to have similar productivity potential for jack pine and are among the best for this species in the region.

The stands selected for the study were essentially pure jack pine, although there were a few scattered white birch (*Betula papyrifera* Marsh.). At establishment in the fall of 1957 stand age was 40 years, dominant height averaged by treatment was between 50 and 52 ft,[a] and basal area density was between 130 and 149 ft^2 per acre (Table 1). These stands represented the lower levels of jack pine densities in this region in terms of number of trees per acre (Bella and De Franceschi 1973).

METHODS

In 1957, five blocks--one per treatment--ranging in size from 1.7 to 2.3 acres, were established. Four circular, 0.1-acre plots were located in each block at least ½ chain from block boundaries. All trees on each plot were tallied by species in 1-in. diameter classes, and the number and size of trees to be thinned were determined.

Two treatments were used: (1) Crown thinning that removed only dominant and codominant trees, and (2) low thinning that removed

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[a] Conversion factors to metric units are given in the Appendix.

trees of the intermediate and codominant crown classes. These treatments were applied at heavy or light intensity. The treatments applied and the basal area/acre removed were as follows (see also Table 1):

1. Light crown thinning: from 144 to 99 ft^2, 31% removed
2. Heavy crown thinning: from 149 to 83 ft^2, 44% removed
3. Light low thinning: from 133 to 103 ft^2, 23% removed
4. Heavy low thinning: from 130 to 84 ft^2, 35% removed
5. Control: no thinning, 133 ft^2.

Only merchantable trees above 4 in. dbh were cut. Care was taken to ensure a uniform spacing in the residual stand. Logging was done under the supervision of the Manitoba Department of Mines and Natural Resources during the summer and fall of 1957. Most stems were cut into 8-ft pulpwood bolts; the larger trees were cut into 10-ft. sawlogs.

In the spring of 1958, all living trees with dbh greater than 0.5 in. were tagged within each plot and dbh measured to the nearest 1/10 in. Total height was also measured of about five trees per dbh class. Detailed stand statistics are presented in Table 1.

At re-examination in 1963, 1968, and 1973 similar measurements were taken on living trees and the dbh of dead trees were recorded. Stand conditions for the four thinning treatments at last remeasurement are illustrated in Figure 1.

For the analysis, tree volumes were estimated using Honer's (1967) volume equations for jack pine (Table 2). Regression techniques were used to fit trends of diameter increment and covarience analysis to test for differences. T-tests were used to test for significant differences in basal area and volume yields.

RESULTS AND DISCUSSION

INDIVIDUAL TREE INCREMENT

Diameter

Thinning generally improved tree diameter increment in all size classes (Fig. 2). The biggest absolute improvement in diameter increment for the 15-year post-thinning period occurred after heavy low thinning among trees of intermediate size, 5- and 6-in. dbh (Fig. 2a). These trees had about 70% greater increment than trees of the same size in control stands: 1.8 in. *vs* 1.1 in. For the other treatments the increase among intermediate trees was around 30-40%. The least improvement occurred after light low thinning.

The stimulating effect of thinning on diameter increment continued beyond the first 10 years (Fig. 2b). In the third 5-year period following treatment, greatest increment occurred in stands that received heavy crown thinning, where the largest trees showed about 100% improvement in diameter growth rate. During the same period there was very little increase in growth after light low thinning.

This apparent delayed response after crown thinning suggests that it requires a considerable length of time, as much as 10 years in this experiment, even for the larger residual trees to take full advantage of strong release. This may be explained as follows. For a given thinning intensity, low thinning would result in a fairly even distribution of cut trees without creating openings in the stand. Crown thinning of the same intensity would remove fewer but larger trees, thus creating scattered openings. Because the most vigorous trees are removed by crown thinning, the remaining trees will be somewhat slow to respond to release and will require some time before they can re-occupy the site. The trees around the openings would grow at a much faster rate than those away from openings. This hypothesis seems to be borne out by the high variation in dbh increment in trees of similar size growing in stands that were crown-thinned.

Height

Difference in average dominant height (three of the tallest measured dominant trees per plot), between the initial and last measurement was used as an estimate of height growth for the 15-year post thinning period (Table 3).

No consistent relationship was found between height increment and kind or intensity of thinning (Table 1). Greatest height increment occurred in stands that received light crown thinning, and the smallest in stands with heavy crown thinning.

STAND INCREMENT

Basal Area

In comparison to untreated stands, there was a strong upward trend in basal area growth during the first 10 years after low thinning.

The rate of increase was similar for both light and heavy levels of treatment (Fig. 3). During the third 5-year period, the same rate of increase was maintained.

Basal area growth was slow in the first 5-year period after crown thinning, and was about the same as that in untreated stands (Fig. 3). However, basal area growth rate increased during the second 5-year period, and in the third it reached and even surpassed the rate of low-thinned stands. Both intensities of crown thinning showed the same trend.

These trends in basal area increment are in accord with diameter increment results presented earlier: strong and immediate growth response of residual trees to low thinning, and delayed but continuous diameter growth response of trees to crown thinning.

Trends in Fig. 3 also indicates that in the untreated stands basal area culminates at 135 ft^2/acre at around 45-50 years of age. The unexpected increase in basal area in the untreated stands during the last 5-year period is likely to be temporary and probably results from higher than normal precipitation and reduced mortality in that period.

Volume

Periodic Increment. Periodic increment is shown in Fig. 4 as the rate of change in volume (ft^3) over a growth period. Neither in total stem volume nor in merchantable pulpwood or sawlog volume was the periodic increment much affected by kind or intensity of thinning. In terms of total volume, stands grew best after low thinning, while the crown-thinned and control stands had very similar but somewhat lower periodic increments. In the third 5-year period, when the crown-thinned stands also picked up, all stands had the same increment. Much the same trends applied for periodic increment in terms of pulpwood and sawlog volumes. At no time did thinning intensity show a significant influence on periodic increment.

Mean Annual Increment. Mean Annual Increment, which included the volume removed by thinning, in total volume showed a gradual increase after both levels of low thinning when compared to the untreated stands (Fig. 5). Although there was a decline in MAI after crown thinning, the rate of decline was only slightly greater than that in unthinned stands. Crown-thinned stands showed a strong recovery in increment during the third 5-year period following thinning which brought their MAI trends nearly in line with those of the control stands. Figure 5 also indicates that MAI in terms of total volume culminates at 40-45 years in untreated stands, and the current upturn is probably just temporary.

MAI in pulpwood improved slightly after low thinning, but showed some decline in the first two periods following crown thinning (Fig. 5). However, an upturn in increment occurred in the latter stands during the last 5-year period. Generally, these MAI trends are still on the increase in terms of pulpwood, although the rate of increase suggests that they may culminate fairly soon, possibly within 5-10 years.

MAI in sawlog volumes has increased rapidly in all thinned as well as in unthinned stands (Fig. 5). The rate of increase lagged behind somewhat in the first 10 years following crown thinning, but in the last 5-year period caught up with the other stands. However, not even the control stands showed any signs of reaching the point of culmination of MAI in sawlog volumes within the next decade.

Mortality

Greatest tree mortality occurred in the densest stands and was highest on the control plots (Fig. 6); thus thinning undoubtedly utilized some of the volume that otherwise would have been lost. Mortality was not affected by kind of thinning, whether low or crown, but there was much more variation in mortality in thinned than in control stands. It seems that in the control stands mortality was caused mainly by suppression and hence was fairly stable, while in thinned stands a number of other factors such as thinning damage, snow damage, and lightning likely came into play and caused irregular mortality.

AVERAGE VOLUME PER TREE

Fifteen years after thinning, average volume per tree was greatest in heavily thinned stands and lowest in control stands (Fig. 7). The difference was about 25% in terms of total stem and pulpwood volume, and about 50% in terms of sawlog volume.

These relationships are useful for estimating logging and processing costs for specific stands, which depend mainly on tree size.

CONCLUSIONS

All of the stands sampled in this experiment were growing rapidly at current re-examination at age 55, 15 years after thinning, and still showed increasing MAI in merchantable volumes. Low thinning, whether heavy or light, did not reduce MAI in merchantable volume. Crown thinning, especially at heavy intensity, reduced MAI in the first 10 years after treatment (most of the reduction occurred during the first 5 years), but in the third 5-year period even these stands started to catch up with the others. Because MAI in merchantable volume (pulpwood or sawlogs) has not culminated in crown-thinned stands, further data is needed to provide conclusive answers regarding the kind and intensity of thinning which will increase merchantable volume production in wood fibre, and the extent of the increases. The preliminary results suggest that total merchantable volume yield (thinning volume plus final harvest) will be greater in thinned stands, especially for sawlogs. As well, greater tree size (dbh) and volume per tree is likely to result in reduced final logging cost. These benefits, together with intermediate yield and revenue from thinning, may make commercial thinning an economically viable management alternative in jack pine stands growing on good sites.

Although the first 10-year results indicated that crown thinning is an unsuitable treatment for jack pine (Bella and De Franceschi 1973), the latest results (15-year period) do not confirm this. While the initial 10-year growth response was smaller after crown thinning than after low thinning, current upsurge in growth of the former stands, if continued, could more than compensate for the initial slow growth. Because crown thinning removes fewer but larger trees, the cost of this treatment is considerably less than the cost of removing the same merchantable volume by low thinning.

Although remeasurement data to rotation age will be required to provide conclusive answers, results to date suggest that a combination of low and crown thinning which removes up to 30-35% of basal area and results in a regular tree distribution may be advantageous. This thinning combination would result in improved stand growth and yield and would lower logging costs at final harvest as a result of greater tree size.

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APPENDIX

Conversion factors: English to Metric units

1 in.	=	2.54 cm
1 ft	=	0.3048 m
1 per acre	=	2.47 per ha
1 ft^2 per acre	=	0.2296 m^2 per ha
1 ft^3 per acre	=	0.06997 m^3 per ha

TABLE 1. STAND STATISTICS AT STUDY ESTABLISHMENT IN 1958 (PER ACRE VALUES)

Treatment	Number of plots	Avg dominant height (ft)[a]	Number of Trees Before Thinning	Number of Trees After Thinning	Basal area (ft^2) Before Thinning	Basal area (ft^2) After Thinning	Average d.b.h. (in.) Before Thinning	Average d.b.h. (in.) After Thinning	Volume[b] Total ft^3 Before Thinning	Volume[b] Total ft^3 After Thinning	Volume[b] Merchantable[c] ft^3 Before Thinning	Volume[b] Merchantable[c] ft^3 After Thinning
Light crown thinning	4	51	1,015	812	144	99	5.0	4.8	3,213	2,120	2,567	1,595
Heavy crown thinning	4	52	882	618	149	83	5.5	4.9	3,288	1,750	2,747	1,363
Light low thinning	4	52	1,155	858	133	103	4.7	4.7	2,848	2,195	2,083	1,626
Heavy low thinning	4	50	1,178	760	130	84	4.6	4.5	2,706	1,736	1,938	1,234
Control	4	50	1,058	1,058	133	133	4.8	4.8	2,845	2,845	2,156	2,156

[a] Based on the heights of several tallest dominants per plot, after thinning.

[b] After Honer 1967.

[c] D.b.h. 4 in. and over; top diameter inside bark 3 in., stump .5 ft.

TABLE 2. STAND STATISTICS IN 1973 (PER ACRE VALUES)

Treatment	Plot number	Density: Number of trees	Density: Basal area	D.b.h. (in.): Avg[a]	D.b.h. (in.): Range	Dominant height (ft)[b]: Avg	Dominant height (ft)[b]: Range	Cubic Foot Volume[c]: Total ft³	Cubic Foot Volume[c]: Pulpwood	Cubic Foot Volume[c]: Sawlogs	Cubic Foot Volume[c]: Cords
Light crown thinning	21	500	120	6.6	4.3- 8.8	65.7	65.5-66.0	3,252	2,909	1,908	34.2
	22	490	121	6.7	4.2- 9.1	67.0	65.5-69.5	3,407	3,061	2,127	36.0
	23[d]	530	122	6.5	4.5- 8.5	66.3	64.5-68.0	3,423	3,054	1,927	35.9
	24[d]	480	117	6.7	4.2- 9.6	69.2	68.0-71.5	3,344	3,004	2,037	35.3
	Avg	500	120	6.6	4.2- 9.6	67.0		3,356	3,007	2,000	35.4
Heavy crown thinning	33	320	94	7.3	5.2-10.2	67.0	66.5-67.5	2,504	2,288	1,736	26.9
	34	480	116	6.6	4.2- 8.8	62.0	61.0-63.5	3,022	2,706	1,781	31.8
	35[d]	400	103	6.9	4.7- 9.8	65.1	63.3-68.0	2,901	2,617	1,790	30.8
	36[d]	450	103	6.5	3.8- 9.9	61.2	61.0-61.6	2,584	2,302	1,514	27.1
	Avg	412	104	6.8	3.8-10.2	63.8		2,753	2,478	1,705	29.2
Light low thinning	25	540	136	6.8	3.7- 9.1	66.8	66.7-67.0	3,793	3,409	2,397	40.1
	26[d]	560	132	6.6	4.0- 9.1	69.1	68.2-70.0	3,732	3,333	2,212	39.2
	27[d]	580	128	6.4	3.1- 8.9	68.9	67.5-70.3	3,484	3,072	1,990	36.2
	28	550	120	6.3	3.4- 8.6	62.4	61.2-63.5	3,112	2,747	1,734	32.[illegible]
	Avg	558	129	6.5	3.1- 9.1	66.8		3,530	3,140	2,083	37.0
Heavy low thinning	29	470	114	6.7	2.9- 9.2	63.3	62.5-64.7	3,001	2,670	1,949	31.4
	30	400	102	6.8	3.0- 9.5	64.4	64.0-65.3	2,813	2,534	1,842	29.8
	32	440	109	6.7	3.4- 9.5	60.7	60.5-61.0	2,898	2,586	1,849	30.4
	Avg	437	108	6.7	2.9- 9.5	62.8		2,904	2,597	1,880	30.5
Controls	37	730	154	6.2	3.8- 9.2	63.7	62.0-64.7	4,176	3,676	2,139	43.2
	38[d]	680	139	6.1	3.7- 8.6	64.2	64.0-64.7	3,767	3,306	1,818	38.9
	39	610	143	6.6	3.5- 9.9	66.0	64.7-67.8	3,960	3,531	2,302	41.5
	Avg	673	146	6.3	3.5- 9.9	64.6		3,968	3,504	2,086	41.2

[a] Average d.b.h. from squared d.b.h.

[b] Based on the heights of several tallest dominants per plot, 1973.

[c] After Honer 1967, 1 cord = 85 merch. ft³. Sawlogs : minimum d.b.h. 6 inches, top diameter inside bark 5 inches, stump .5 ft.

[d] Plot contains 1 to 5 birch trees.

TABLE 3. AVERAGE DOMINANT HEIGHT IN 1958 AND HEIGHT INCREMENT BETWEEN 1958-73 BY TREATMENT.

Treatment	Number of plots	Avg. dominant height[a] in 1958 (ft)	Avg. height increment of dominants, 1958-73 (ft)
Light crown thinning	4	51.0	14.6
Heavy crown thinning	4	51.6	9.8
Light low thinning	4	51.9	13.0
Heavy low thinning	3	49.5	11.7
Controls	3	49.7	12.4

[a] Based on 3 tallest measured dominants per plot.

Figure 1. The four photos illustrate stand conditions by treatment at age 55, 15 years after thinning: (a) Light Crown, (b) Heavy Crown, (c) Light Low, (d) Heavy Low.

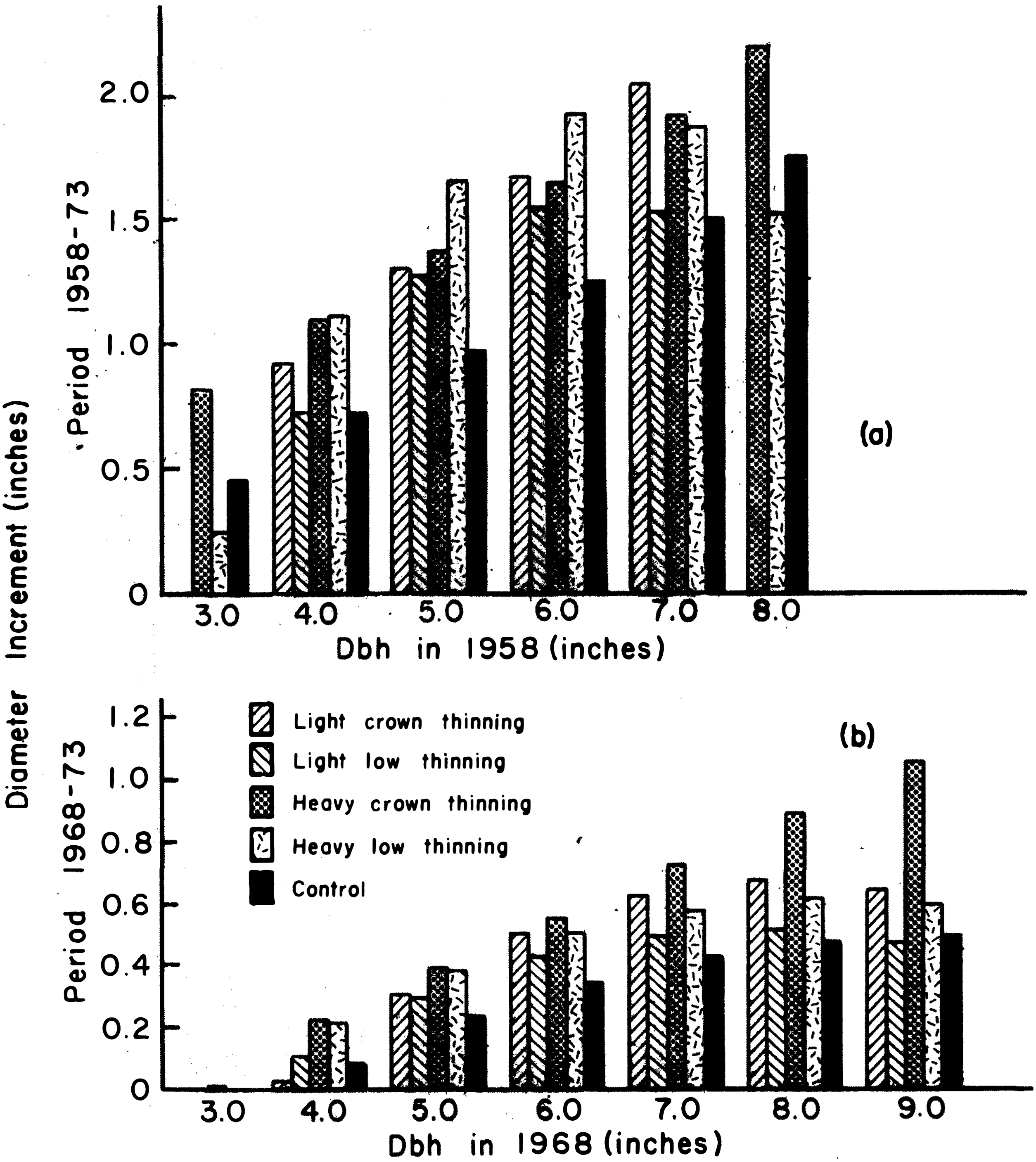

Figure 2. Diameter increment of dbh classes by treatment for two growth periods: (a) 1958-73 over dbh in 1958
(b) 1968-73 over dbh in 1968.

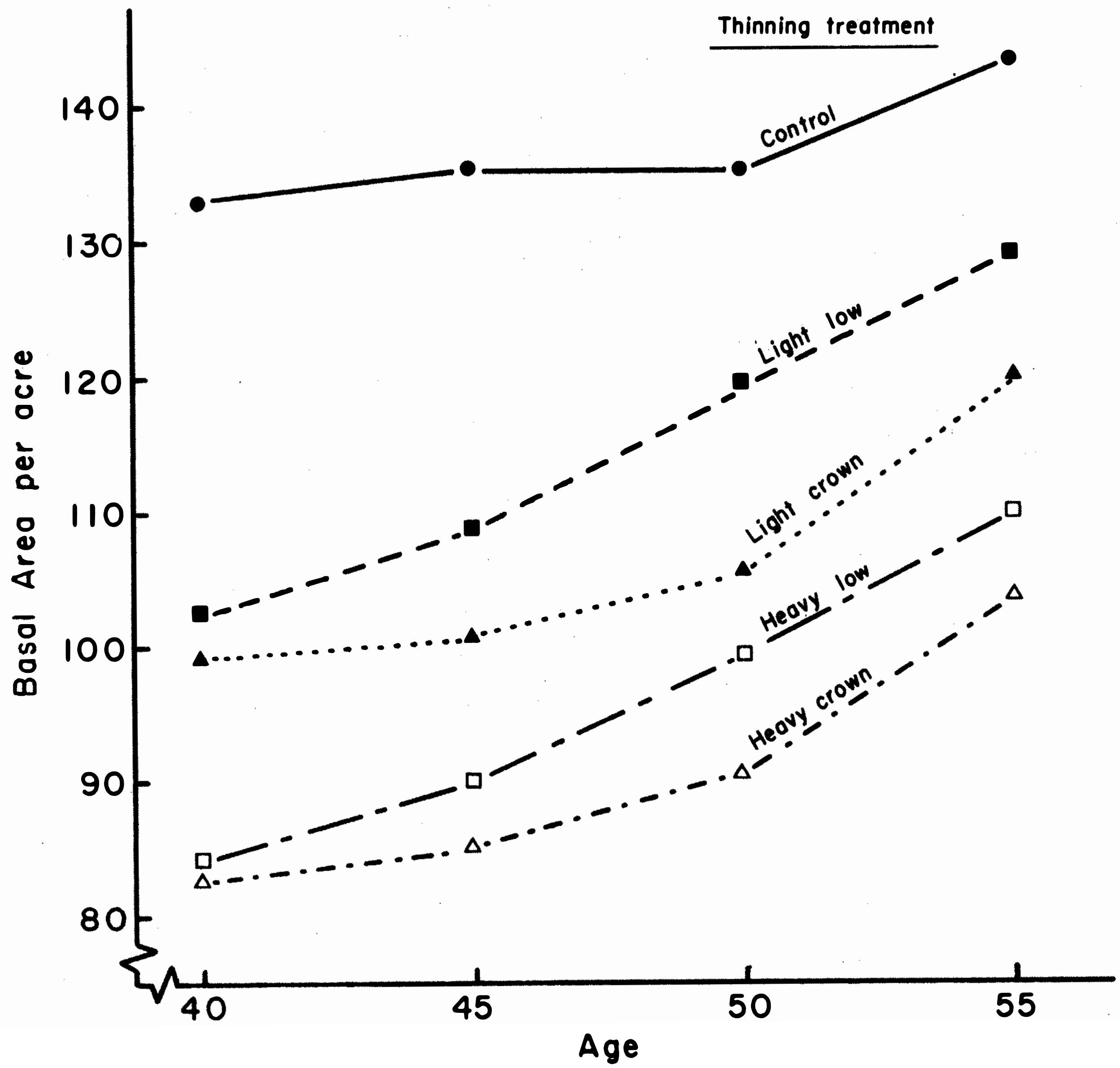

Figure 3. Basal area growth per acre by treatment.

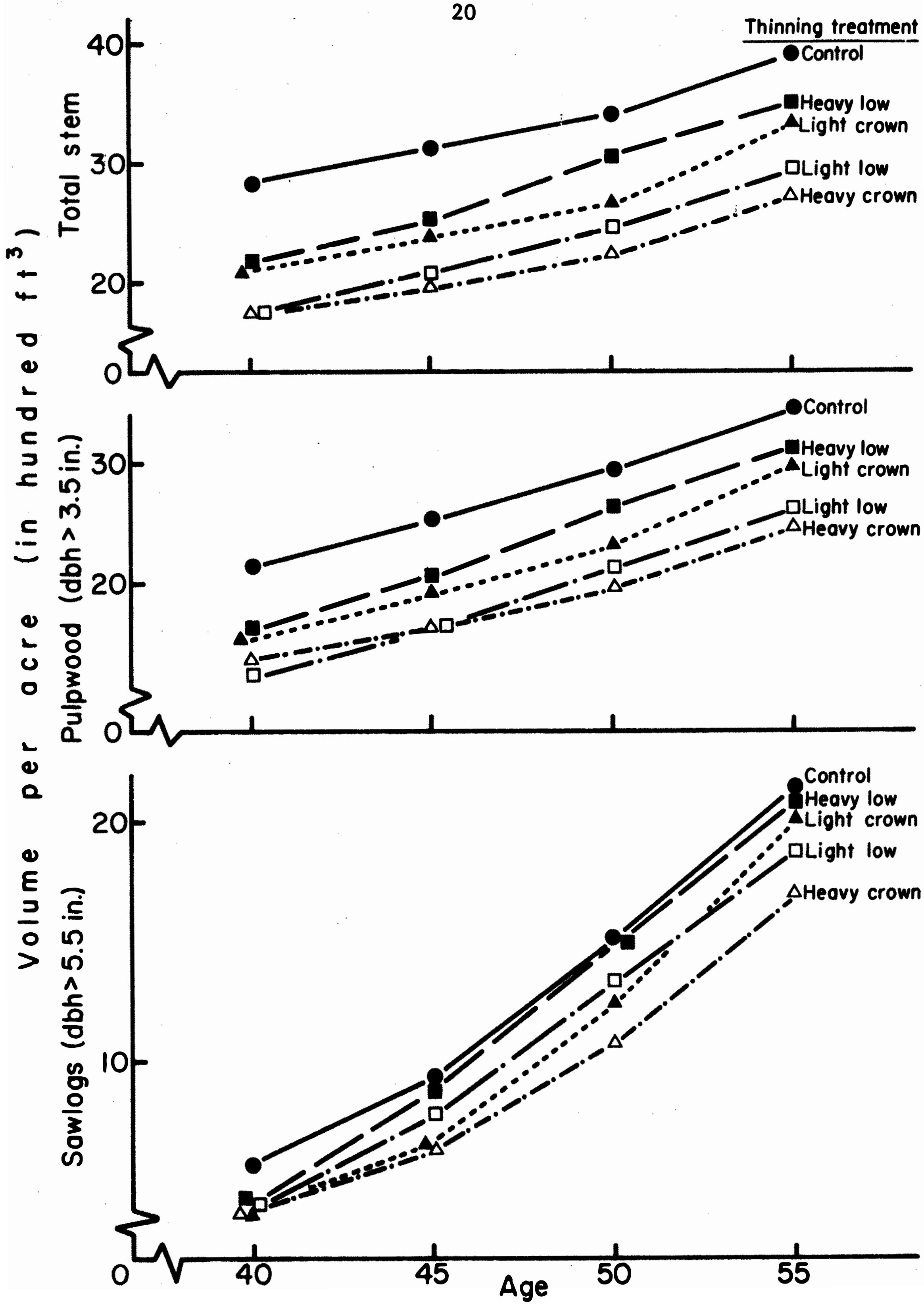

Figure 4. Volume growth trends per acre by treatment.

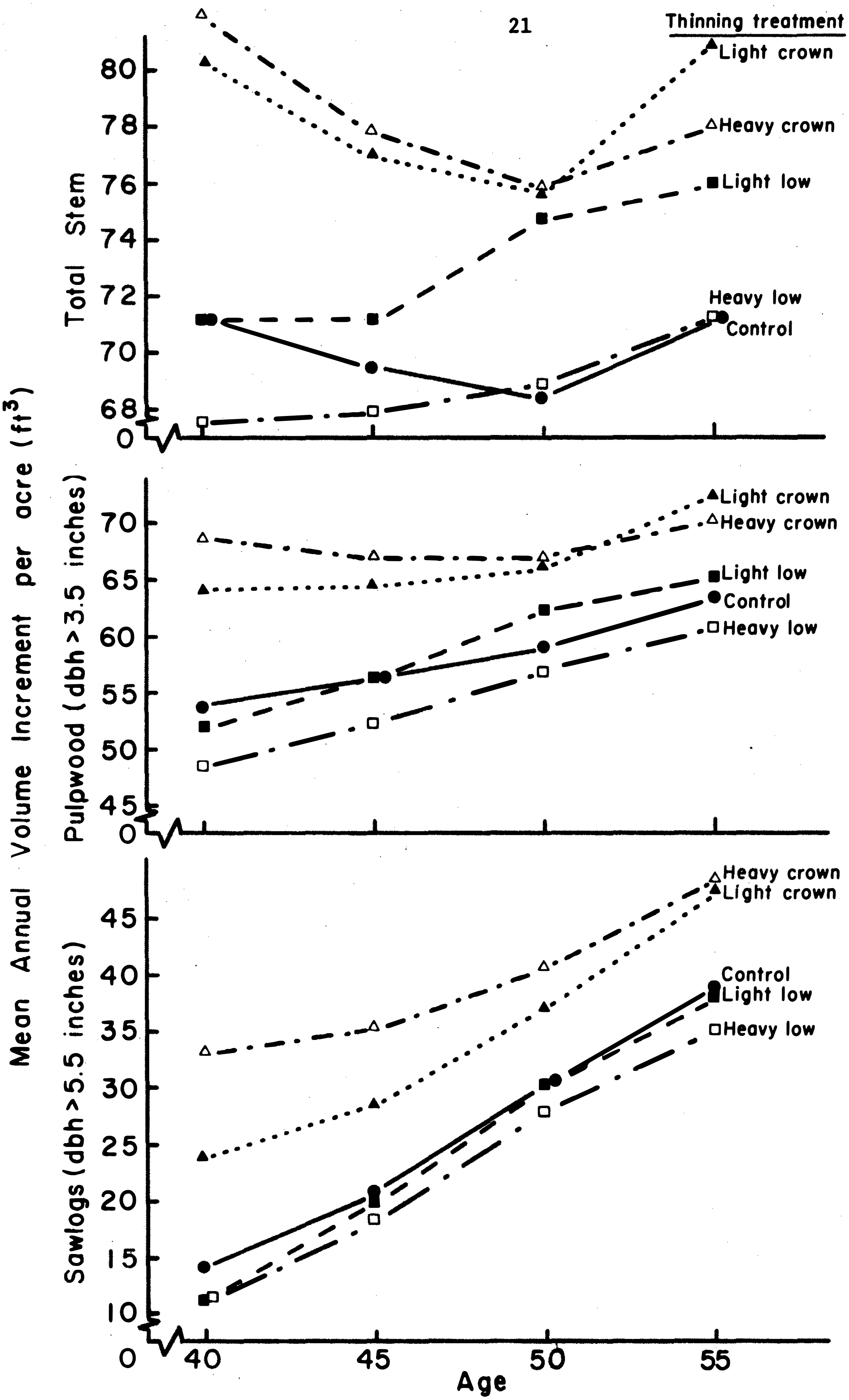

Figure 5. Mean annual volume increment per acre over age by treatment (includes volume removed by thinning).

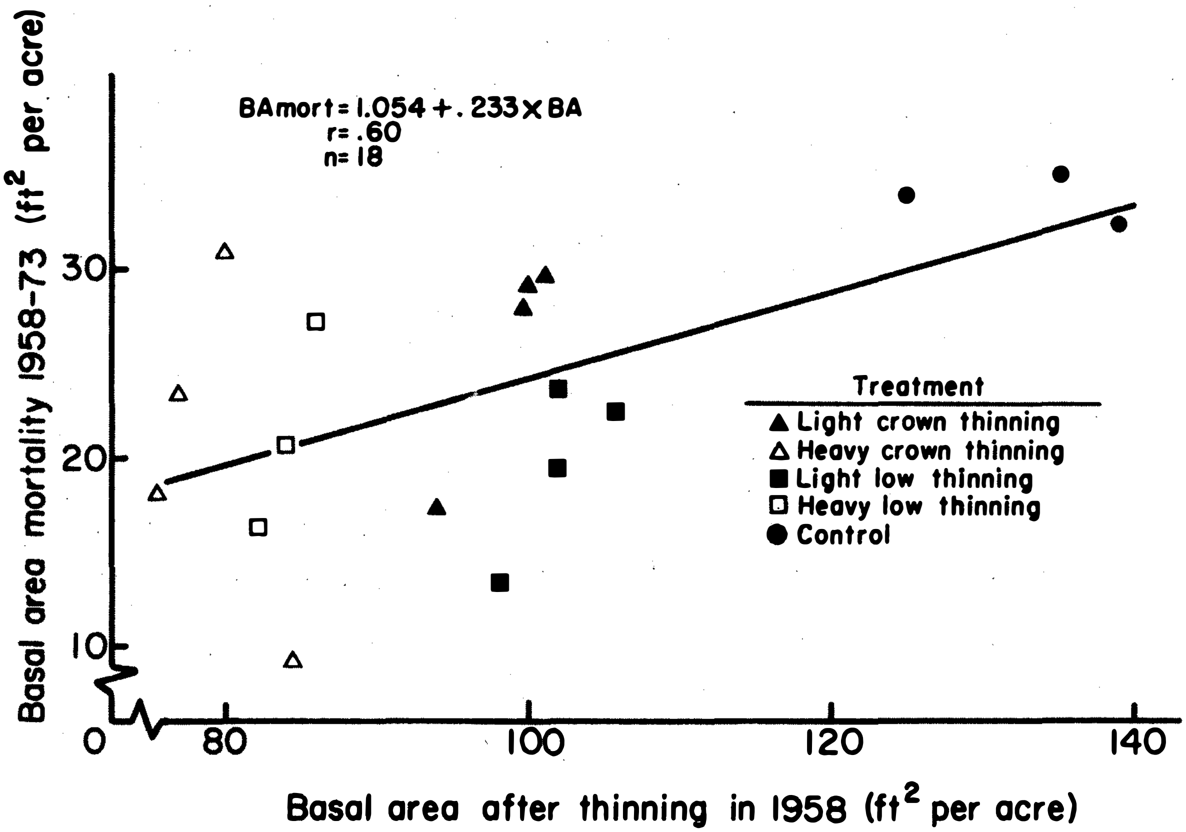

Figure 6. Mortality in basal area per acre in relation to basal area density.

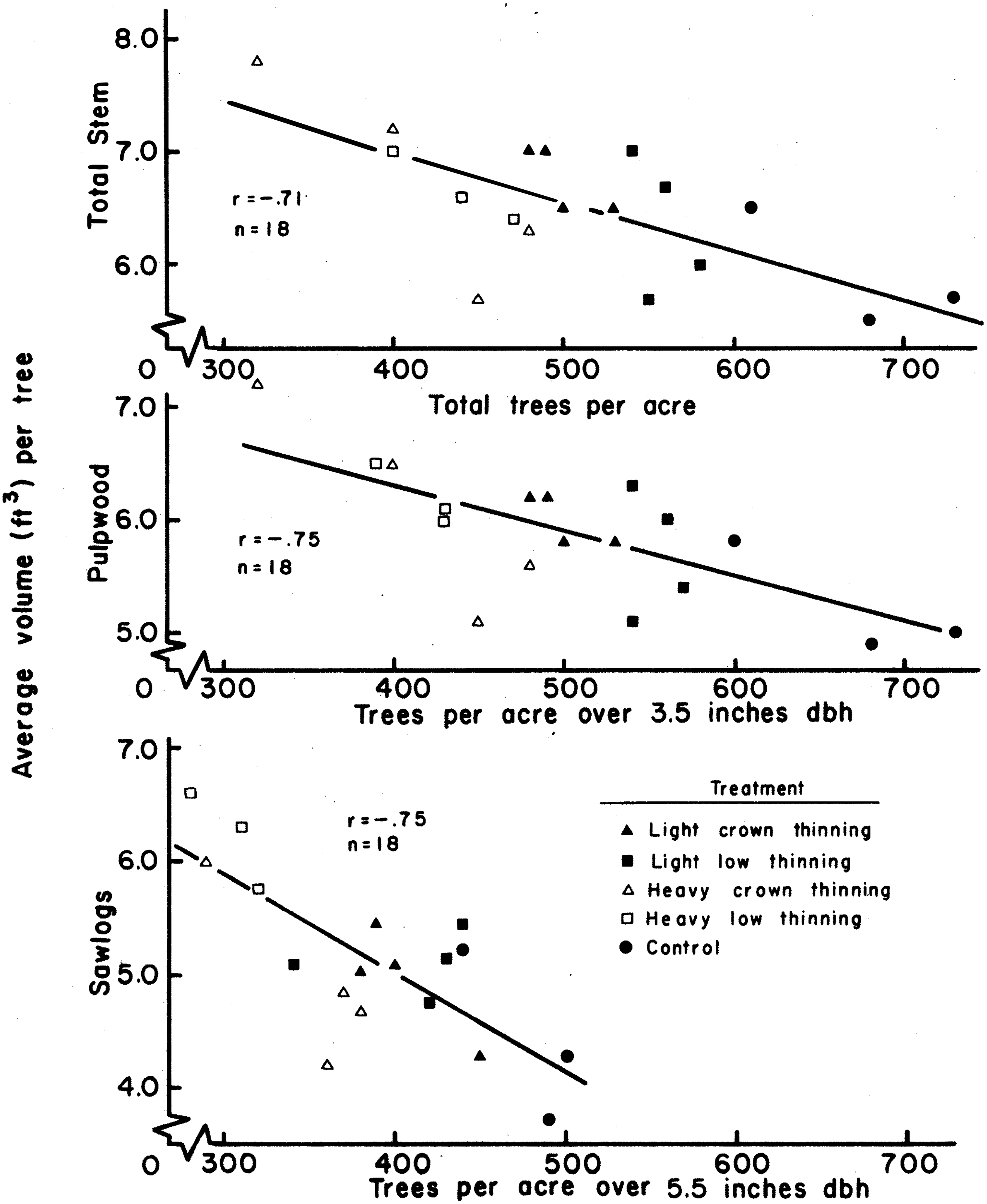

Figure 7. Average volume per tree in relation to number of trees per acre in 1973.