THINNING IN TREMBLING ASPEN STANDS

MANITOBA AND SASKATCHEWAN

by

G. A. Steneker and J. M. Jarvis

Sommaire en français

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ABSTRACT

Results of eight thinning experiments in trembling aspen (*Populus tremuloides* Michx.) have been pooled, chiefly for the purpose of developing tentative thinning regimes for the eastern plains area of Canada.

Thinning regimes to age 40 were developed, and they indicate that total volume production can be increased by as much as 25 per cent by thinning at 5-year intervals. Under a heavy thinning schedule, crop trees at age 40 can be expected to average 8.0 inches in diameter at breast height as compared to 6.0 inches in unthinned stands.

Maximum net periodic total volume increments for 10-, 20-, 30-, 40-, and 50-year-old stands were achieved at about 30, 50, 65, 85 and 100 square feet basal area per acre respectively.

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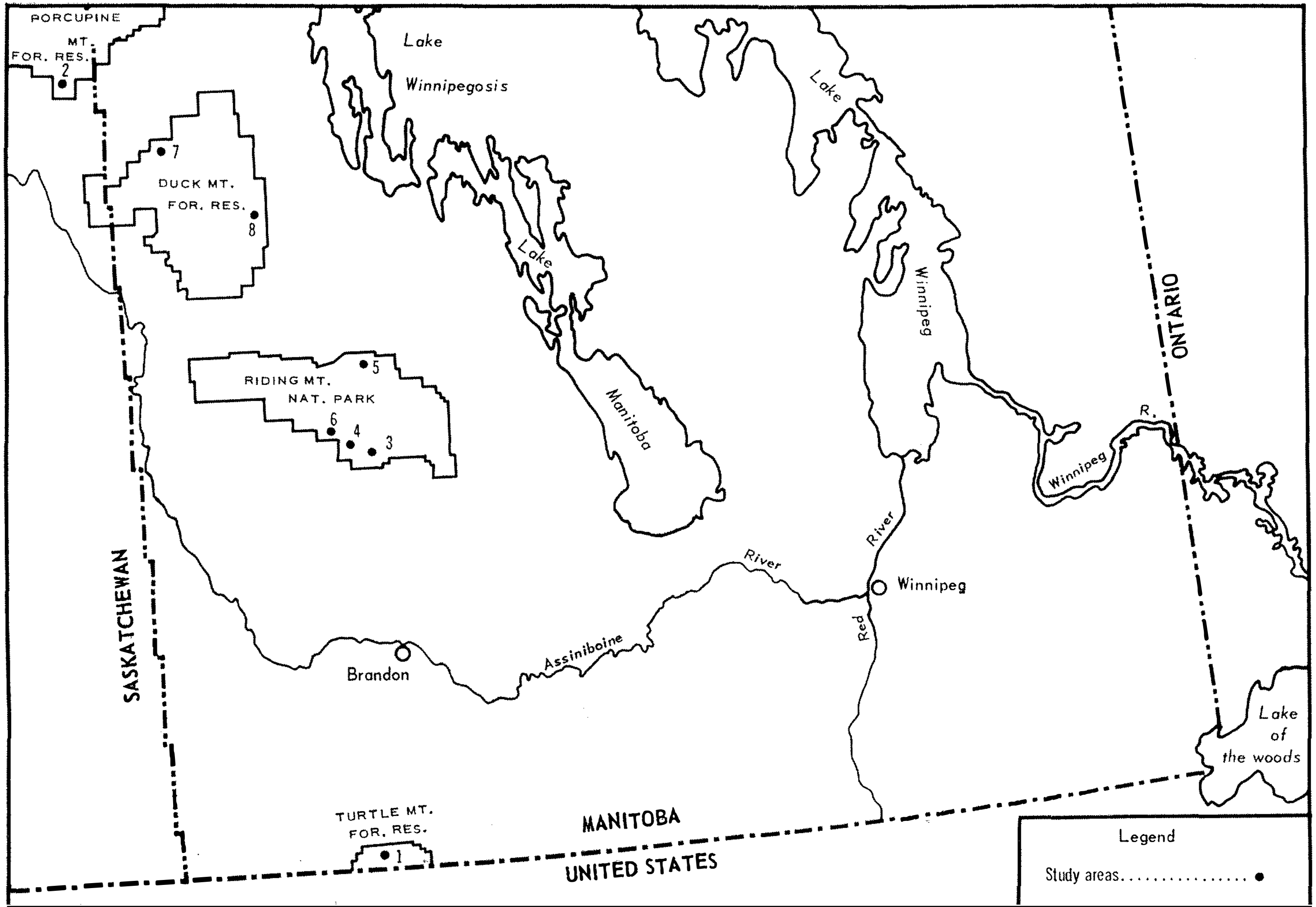

Location of study areas

Thinning in Trembling Aspen Stands Manitoba and Saskatchewan

by

G. A. Steneker and J. M. Jarvis[1]

INTRODUCTION

Trembling aspen (*Populus tremuloides* Michx.) is one of the most abundant commercial tree species in Manitoba and Saskatchewan. Recent inventory records show that hardwood stands, primarily aspen, in these two provinces occupy respectively a little more than one-tenth and about one-third of the productive forest land. The volume of trembling aspen in Manitoba and Saskatchewan is over 2.1 and 3.5 billion cubic feet respectively (Anon. 1959 and Gill 1960). The species is adaptable to a wide variety of sites and has an enormous capacity to regenerate, so is likely to remain one of the region's most abundant trees.

Trembling aspen has a high susceptibility to decay[2]. Although gross volumes of fully stocked aspen stands (80-100 years) in Manitoba and Saskatchewan compare favourably with those of fully stocked coniferous stands of the same age, very little can be utilized because of rot. Trembling aspen must be cut before it reaches maturity (Gill 1960) and it has been reported that in Saskatchewan rotation age on most sites should not exceed 80 years (Kirby *et al.* 1957). At this rotation many trees in natural stands are still too small to be utilized for veneer and lumber. As a result potential merchantable volume is greatly curtailed.

At present very little trembling aspen in Manitoba and Saskatchewan is utilized. During the 1940's and 1950's the average annual cut was about 12 to 19 million fbm, respectively (Anon. 1940 to 1961 and Anon. 1942 to 1959). Economic surveys (Anon. 1956) indicate, however, that the demand for trembling aspen for use in newsprint, corrugated board, hardboard, insulating board, plywood and lumber, will increase considerably. Just recently two waferboard mills, one at Hudson Bay, Saskatchewan, and one at Sprague, Manitoba, each capable of utilizing about 20,000 cords of trembling aspen per year have been constructed. Further evidence of increasing utilization is seen in the pulpwood production figures for the Lake States. Trembling aspen pulpwood production in Michigan, Wisconsin and Minnesota has increased from 486,000 cords in 1949 to 1,708,000 cords in 1959 (Horn 1960, 1964).

Foreseeing the time when trembling aspen will be in great demand, and being aware of the effect that decay has on natural stands, the Department of Forestry, as early as 1926 began thinning studies in trembling aspen stands. Between then and 1951 a total of eight experiments were undertaken in Manitoba and Saskatchewan. Although the purpose of each was to determine stocking levels necessary for maximum volume production and maximum diameter growth, thinning specifications differed between experiments. In some studies stands were thinned to specific spacings and in others to specific basal areas or specific stand density indices. In some experiments stands were re-thinned at periodic intervals whereas in others only one thinning was made. Furthermore, periods between remeasurements differed for the various experiments.

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[1]Research Officers, Department of Forestry of Canada, Manitoba-Saskatchewan Region, Winnipeg, Manitoba.

[2]Black, R. L. and P. S. Kristapovich 1954. Decay of trembling aspen in Manitoba and eastern Saskatchewan. Canada, Dept. Agri., Sci. Serv., For. Biol. Div., For. Path. Lab. Saskatoon. Unpub. Interim Rep.

This paper combines the results of all eight experiments. To facilitate comparisons thinning intensity for each study has been expressed in terms of basal area immediately after treatment. Results are based on data from individual studies in some instances and on combined data from several or all studies in others[3]. The reader is reminded that because of differences in experimental methods the combined data express only general trends and it is on these general trends that the hypothetical thinning schedules, presented later, are based.

LOCATION AND DESCRIPTION OF STUDY AREAS

The study areas are located in the Turtle Mountain, Duck Mountain and Porcupine Mountain Forest Reserves, and in the Riding Mountain National Park (Frontispiece). All are in the Mixedwood Forest Section of the Boreal Forest Region (Rowe 1959).

The study areas have a dry continental climate. Mean January and July temperatures, except in the Turtle Mountain, are approximately −3°F and 64°F respectively (Turtle Mountain 2°F and 67°F). Frost free periods average 80 days (Turtle Mountain 100 days). Annual precipitation is about 18 inches, of which 7 inches falls during May, June and July (Turtle Mountain 18 inches and 8 inches) (Anon. 1960a).

Representative trembling aspen stands, ranging in age from 11 to 45 years were selected for study. All had originated after fire or cutting. Pertinent stand data are given in Table 1.

[3]Basic data for individual studies may be obtained on short-term loan by writing to the Regional Director, Department of Forestry of Canada, Winnipeg, Manitoba.

TABLE 1. STAND AND SITE DATA OF STUDY AREAS.

Study	Location	Stand age at establishment	Number of trees per acre B.T.*	Average d.b.h. (″) B.T.*	Height (′) of dom. trees B.T.*	Stand origin	Physiographic Site
1	Turtle Mt. Forest Reserve	11	3400	1.7	22	Clear-cut	Non telluric mesic clay-loam till.
2	Porcupine Mt. Forest Reserve	14	3400	1.8	24-34	Burn	Non telluric mesic clay-loam till.
3	Riding Mt. National Park	14	6000	1.4	20	Clear-cut	Non telluric mesic clay-loam till.
4	"	19	2600	2.4	27-33	Burn	Non telluric mesic silty clay-loam till.
5	"	23	2200	2.9	41	Clear-cut	Telluric mesic silty clay-loam till.
6	"	30	1600	3.5	49	Burn	Non telluric mesic clay-loam till.
7	Duck Mt. Forest Reserve	35	1800	3.3	46	Burn	Non telluric mesic clay-loam till.
8	"	45	1000	4.8	49-56	Burn	Non telluric mesic glacio-fluvial clays and gravel.

*Before thinning.

Seven areas are located on mesic sites[4] on gently rolling terrain; the other (study 5) is on a somewhat moist site and has a telluric moisture supply. Soils belong to the Grey Wooded Great Group of the Podzolic Order (Anon. 1960b). Parent materials on seven areas are clay loam tills; on one area (study 8) they are glacio-fluvial clays and gravels (Table 1).

METHODS

Methods of thinning must take into account the silvical characteristics of the species. Trembling aspen is a highly intolerant species, and unless trees can maintain their position in the upper canopy they quickly become suppressed and die. Consequently in all studies thinning was done to favour dominant and codominant trees whenever possible.

Treatments, including thinning to specific spacings, specific basal areas and specific stand density indices (Reineke 1933), were carried out on permanent sample plots (ranging in size from 0.1 to 1.0 acre) and their surrounds. In six of the studies stands were thinned once; in studies 2 and 6 they were thinned more than once (Table 2). Axes and saws were used for felling. In some studies felled trees were left on the plots but in other studies they were removed.

In all but two studies (6 and 7) residual trees were numbered and mapped. Diameter at breast height of all trees before and after thinning and at remeasurement was tallied to the nearest one-tenth inch. In some studies every tree was measured for height at each remeasurement; in others only some of the trees were measured.

In 1961 some of the sample plots belonging to study 4 were partially destroyed. Since the plots, as such, could no longer add useful information to the experiment, stem analysis studies were made on a number of the residual trees.

RESULTS

Individual Tree Increment

Diameter

All studies showed that the diameter increment of individual trees increased as competition (expressed in terms of residual basal area per acre immediately after thinning) was reduced. All size classes were affected. Larger trees maintained a higher increment than smaller ones, although the latter showed a greater percentage response. These findings are illustrated below by data from specific studies.

Annual diameter increment for the 25 and 200 largest trees per acre between 1951 and 1962 for study 2 (14-year-old stand first thinned in 1951) is shown in Figure 1. Rate of growth increased as intensity of thinning increased; however, for the 25 largest trees growth rate levelled off at about 45 square feet of residual basal area per acre. For given levels of stocking the 25 largest trees grew faster than the 200 largest.

Differences in 10-year diameter increment (1950-1960) between trees on control and thinned plots for study 5 (23-year-old stand thinned in 1950) show that thinning stimulated the growth of all size classes (Figure 2). Large trees maintained a higher growth rate than smaller ones but per cent increase was less. The increment of residual trees was not significantly increased when basal area per acre was reduced below 34 square feet. This supports the trends shown in Figure 1.

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[4]Sites with adequate moisture for optimum development of mesophytic plants throughout the growing season.

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TABLE 2. SUMMARY OF THINNING TREATMENTS.

Study	No. of Sample plots	Plot Size (acres)	Date of establishment	Date of remeasurement	Stand age at establishment	Thinning Method	Intensity of thinning
1	4	0.2	1948	1953, 1960	11	Regular spacing	Control, no thinning—2 plots Treatment, 5′ x 5′—1 plot, 7′ x 7′—1 plot
2	14	0.2	1951	1957, 1962	14	Thinning to fixed S.D.1. in 1951, 1957 and 1962	Control, no thinning—2 plots Treatment, thinned to and maintained at 120, 100, 80, 70, 60 and 50% of S.D.1. of control in 1951—2 plots to each intensity.
3	4	0.1	1950	1960	14	Regular spacing	Control no thinning—1 plot Treatment 8′ x 8′—1 plot, 10′ x 10′—1 plot, 12′ x 12′—1 plot
4	8	0.2	1950	1960	19	Regular spacing	Control, no thinning—2 plots Treatment, 8′ x 8′—2 plots, 10′ x 10′—2 plots, 12′ x 12′—2 plots
5	8	0.2	1950	1960	23	Regular spacing	Control, no thinning—2 plots Treatment, 8′ x 8′—2 plots, 10′ x 10′—2 plots, 12′ x 12′—2 plots
6	3	1.0	1926	1940, 1945, 1950 & 1960	30	Thinned to fixed basal area in 1926 & 1940	Control, no thinning—1 plot Treatment, 14% b.a.cut in 1926 and 23% in 1940—1 plot, 24% b.a. cut in 1926 and 33% cut in 1940—1 plot
7	3	1.0	1926	1946 1960	35	Thinned to fixed basal area	Control, no thinning—1 plot Treatment, 30% b.a. cut—1 plot, 36% b.a. cut—1 plot
8	3	0.5	1937	1946	45	Thinned to fixed basal area	Control, no thinning—1 plot Treatment, 25% b.a. cut—1 plot, 50% b.a. cut—1 plot

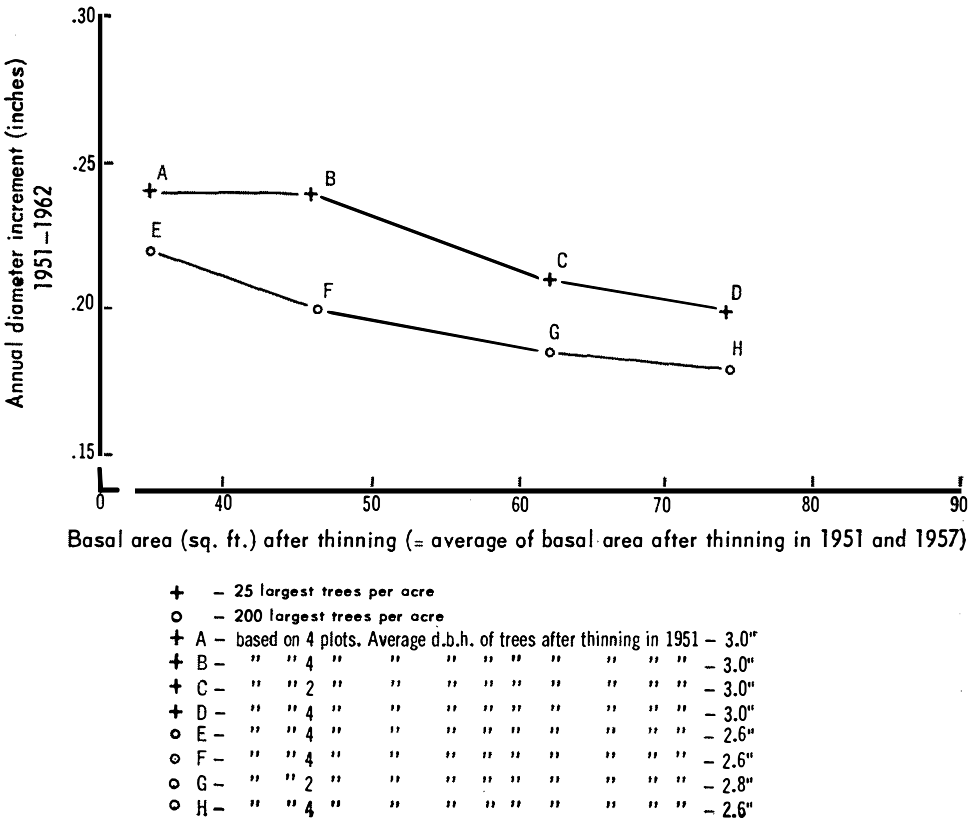

FIGURE 1. Annual diameter increment (1951-1962) of the 25 and 200 largest trees per acre in relation to the residual basal area per acre. Study 2—14-year-old stand, thinned in 1951 and 1957.

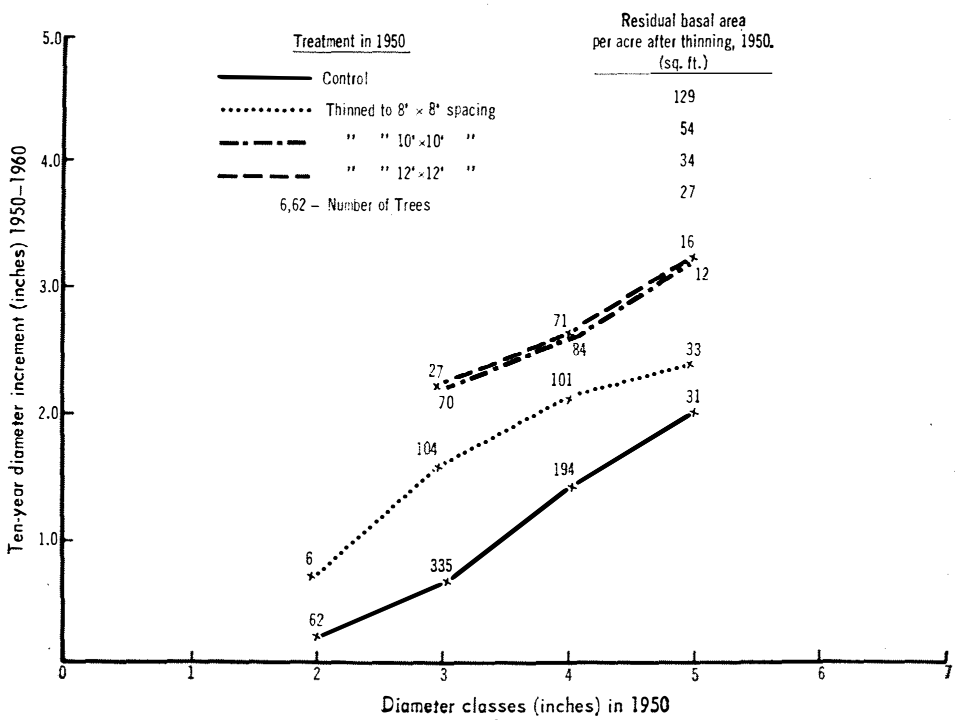

FIGURE 2. Ten-year diameter increment (1950-1960) by diameter classes and treatment. Study 5—23-year-old stand, thinned in 1950.

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Growth ring analysis of a number of dominant and codominant trees from study 5 (19-year-old stand thinned in 1950) provided a measure of year-by-year diameter increment over the period 1942-1961. Three years after thinning, maximum increment had been reached with all treatments, then a general decline occurred (Figure 3). However, trees on treated plots maintained a higher increment than trees on control plots. Furthermore, heaviest thinning provided the highest increment.

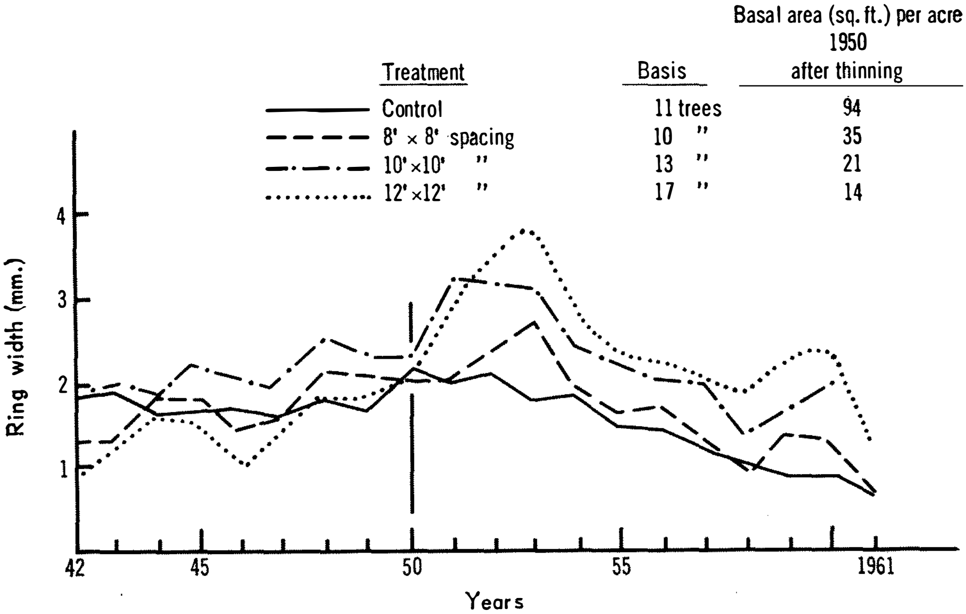


FIGURE 3. Annual radial increment (1942–1961) dominant and co-dominant trees (all trees 3 inches d.b.h. in 1950). Study 4—19-year-old stand thinned in 1950.

The lasting effect of thinning is illustrated also by Table 3. The diameter increment of the 50 largest trees on the thinned plots of study 7 (35-year-old stand thinned in 1926) was greater than that of the largest trees on the control during both remeasurement periods (1926 to 1946) and (1946 to 1960).

TABLE 3. TOTAL BASAL AREA PER ACRE AFTER THINNING AND AVERAGE DIAMETER AND DIAMETER INCREMENT OF THE 50 LARGEST TREES, STUDY 7, 35-YEAR-OLD STAND IN 1926.

Treatment	Basal area after thinning 1926 (sq. ft.)	Average diameter 50 largest trees			Diameter increment 50 largest trees			
					Periodic		Annual	
		1926	1946	1960	'26-'46	'46-'60	'26-'46	'46-'60
Control	106	6.6	8.9	10.5	2.3	1.6	.12	.11
Thinned (30% b.a.cut)	74	6.5	9.1	10.8	2.6	1.7	.13	.12
Thinned (36% b.a.cut)	65	5.9	9.1	11.0	3.2	1.9	.16	.14

Basal area

The average periodic annual basal area increment for the 200 largest trees per acre (all studies) in relation to residual basal area per acre by 10-year age groups is shown in Figure 4. As the data for all age groups (except study 5) fall in one band it may be inferred that age has had little influence on the basal area increment of the 200 largest trees. Therefore the younger trees (small d.b.h.) increased in diameter at a faster rate than older trees (large d.b.h.) for given residual basal areas. The data show also that the basal area increment of the 200 largest trees is inversely related to residual basal area per acre.

The high increment shown by the 20-29 year age group (study 5) has been attributed to site (Table 1).

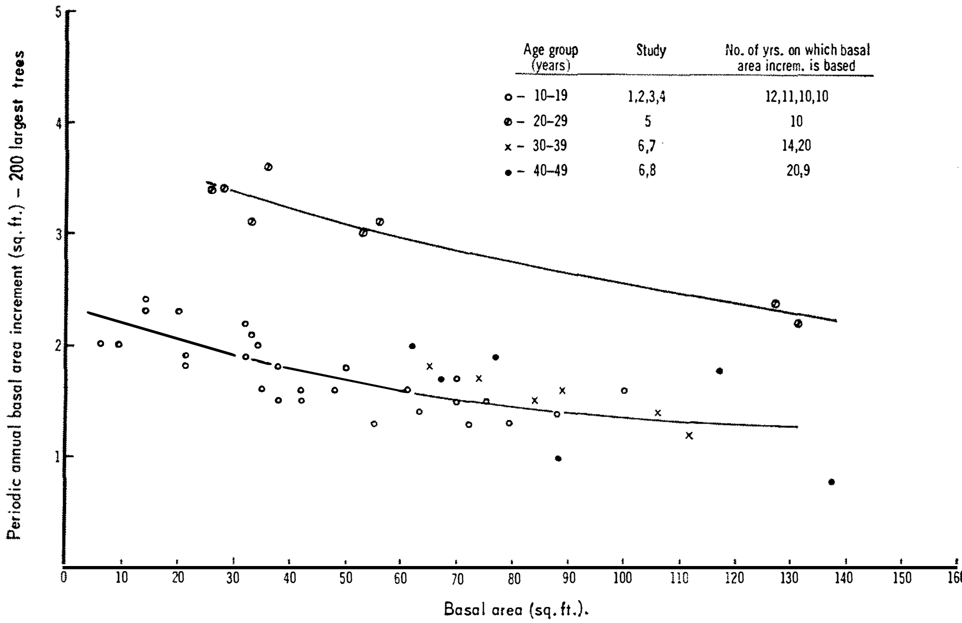


FIGURE 4. Periodic annual basal area increment of the 200 largest trees per acre related to residual basal area per acre (by 10-year age groups)—all studies.

Height

All studies have indicated that height increment was not affected by thinning. Data from study 5 (23-year-old stand thinned in 1950) are given in Table 4. Height increment of the 100 largest trees per acre between 1950 and 1960 on thinned and control plots was about the same.

TABLE 4. TEN-YEAR HEIGHT INCREMENT OF THE 100 LARGEST TREES PER ACRE. STUDY 5, 23-YEAR-OLD STAND, THINNED IN 1950.

Treatment	Height increment (feet) 1950-1960
12′ x 12′ spacing	13
10′ x 10′ "	13
8′ x 8′ "	14
Control	13

Stand Increment per Acre

Basal area

Results indicate that within certain wide limits basal area increment (and furthermore volume increment) is influenced very little by density of stocking. Data from study 5 are presented which show net and gross periodic basal area increment at various levels of stocking (Figure 5). The data for gross basal area increment (curve A) indicate very little change at residual densities between 60 and about 130 square feet. The slight drop in increment which does occur at the higher densities is attributed to the effect of overly dense stocking which has probably resulted in some stagnation of growth. The marked drop in basal area increment with residual basal areas below 50 square feet is attributed to inadequate use of the site by residual trees. Similar growth trends have been presented by Möller *et al.* (1954) for Norway spruce and beech. He showed that only at density levels of less than 50 per cent of normal was there any significant reduction in basal area and volume increment.

The loss in periodic basal area increment due to mortality is shown also in Figure 5. It is the difference between the gross and net periodic basal area increment curves (A and B). As can be seen mortality increases at the higher density levels.

The net basal area increment curve (B) in Figure 5 indicates that for this particular stand (23 years old) 50 to 60 square feet per acre was about the optimum basal area for maximum future per acre production. At this density level mortality was relatively low and individual trees had adequate growing space. Furthermore, density was high enough to prevent loss in increment due to inadequate stocking.

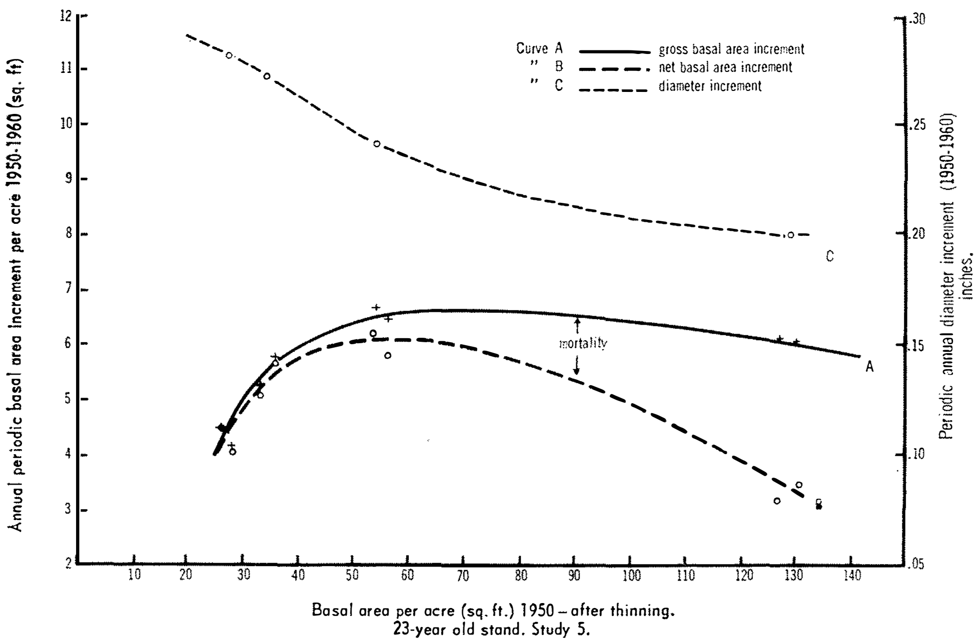


FIGURE 5. Annual periodic net and gross basal area increments and annual periodic diameter increment of the 200 largest trees per acre related to residual basal area after thinning in 1950. Study 5—23-year-old stand.

Curves of net basal area increment are presented for all studies in Figure 6. They show optimum basal area levels for maximum periodic net increment. As stands increase in age optimum basal area levels also increase.

The basal area of undisturbed stands (Appendix I) and the basal area at which maximum periodic net basal area increment occurred (Figure 6) have been related to age. Curved values at 10-year intervals are presented in Table 5. The data show that the basal area of untreated stands can be reduced, depending on age, by between 36 per cent (age 10) and 17 per cent (age 50) without any marked loss in increment. These findings support those by Assman (1961) for Norway spruce. He found that with increasing age the optimum degree of stocking approaches the normal or maximum stocking. Smithers (1954) found also that the basal area of 40- to 80-year-old red and white pine stands could be reduced up to 30 per cent at 10-year intervals without a substantial loss in gross basal area increment.

Basal area development on all thinned plots (study 5 excluded) in relation to the average basal area of all control plots (Appendix I) is shown in Figure 7. In the young age classes (10-30 years) rate of increment, as indicated by the slope of the straight lines, is greater than that for older stands (30 years and over). Figures 6 and 7 show that for a given age increment has been higher with intermediate residual basal areas than with either low or high residual basal areas.

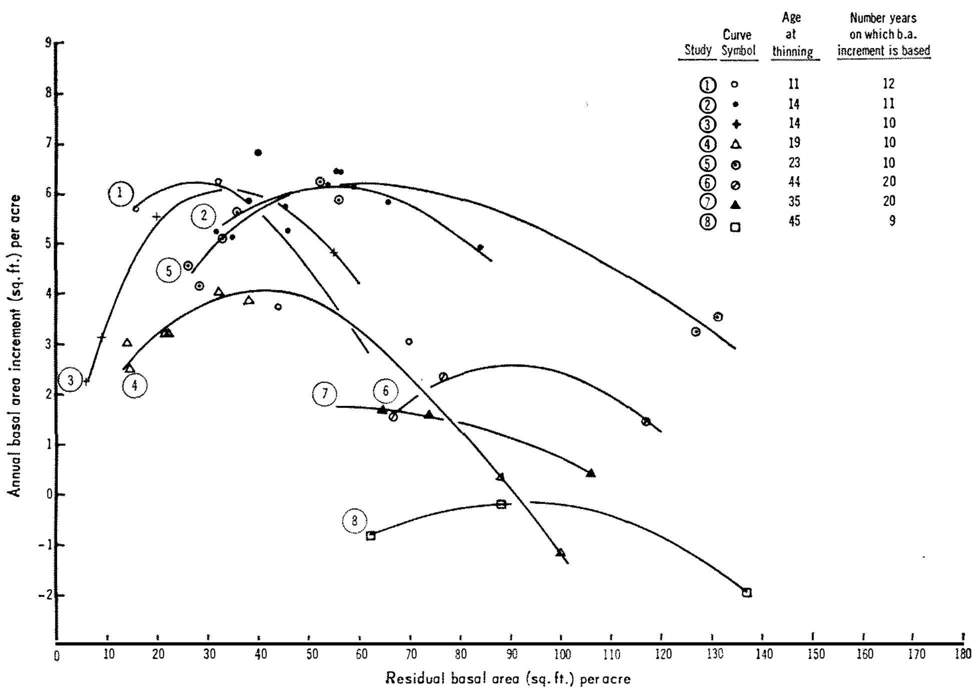


FIGURE 6. Periodic annual net basal area increment related to residual basal area after thinning, all studies.

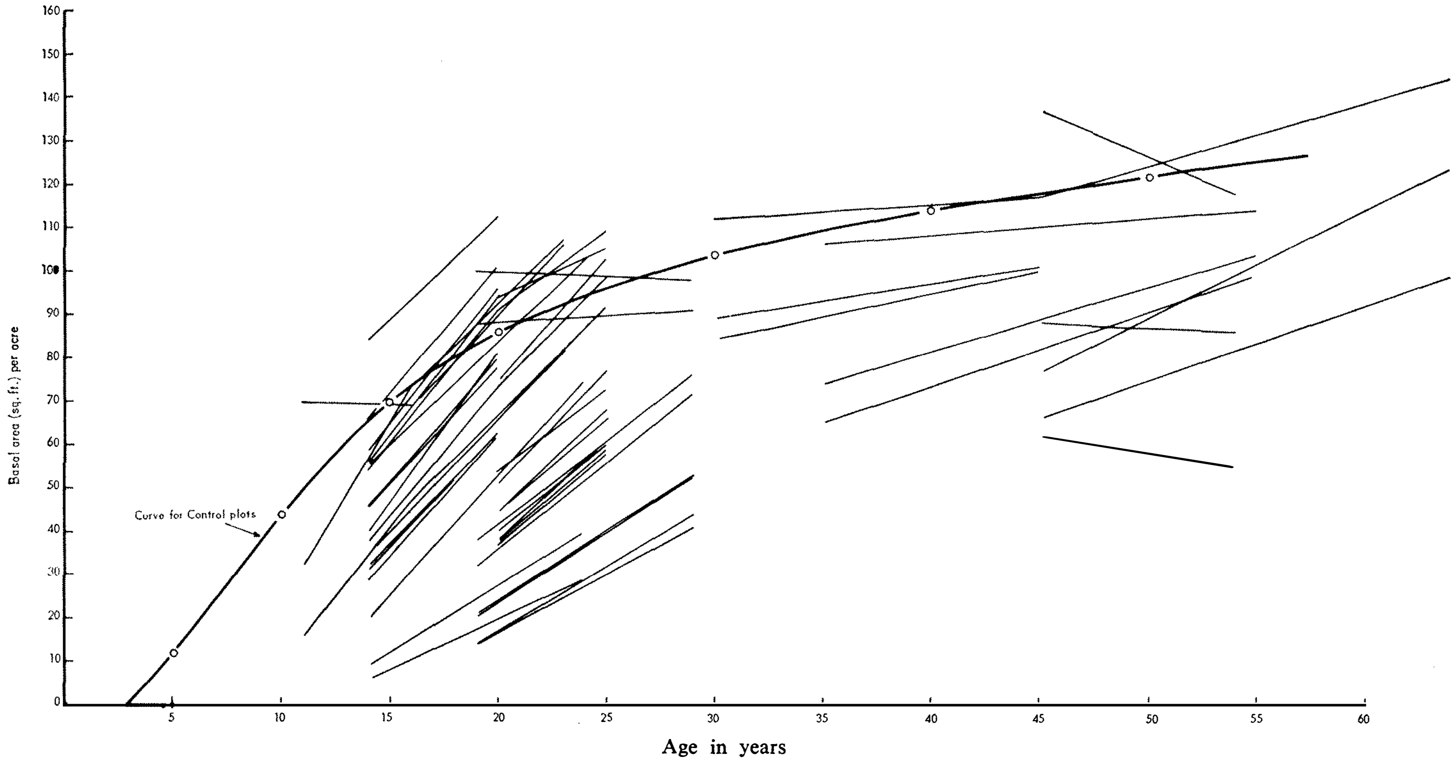


FIGURE 7. Average basal area per acre of control plots and individual thinned plots over age. All studies except No. 5.

TABLE 5. BASAL AREA PER ACRE OF UNDISTURBED STANDS AND BASAL AREA PER ACRE AT WHICH MAXIMUM BASAL AREA INCREMENT OCCURRED IN THINNED STANDS, BY AGE.

Age	Basal area of undisturbed stand (sq. ft.)	Basal area producing max. net basal area increment	
		(sq. ft.)	As per cent of basal area or undisturbed stands
10	44	28	64
20	86	48	56
30	104	67	60
40	114	84	74
50	122	101	83

Total volume

Periodic net annual volume increment per acre showed a similar trend to that of periodic net annual basal area increment; that is, above and below certain basal areas net volume increment was reduced. This relationship is illustrated with data from study 5 (23-year-old stand thinned in 1950) in Figure 8. Maximum net annual increments (basal area and volume) occurred at a residual basal area of about 60 square feet per acre.

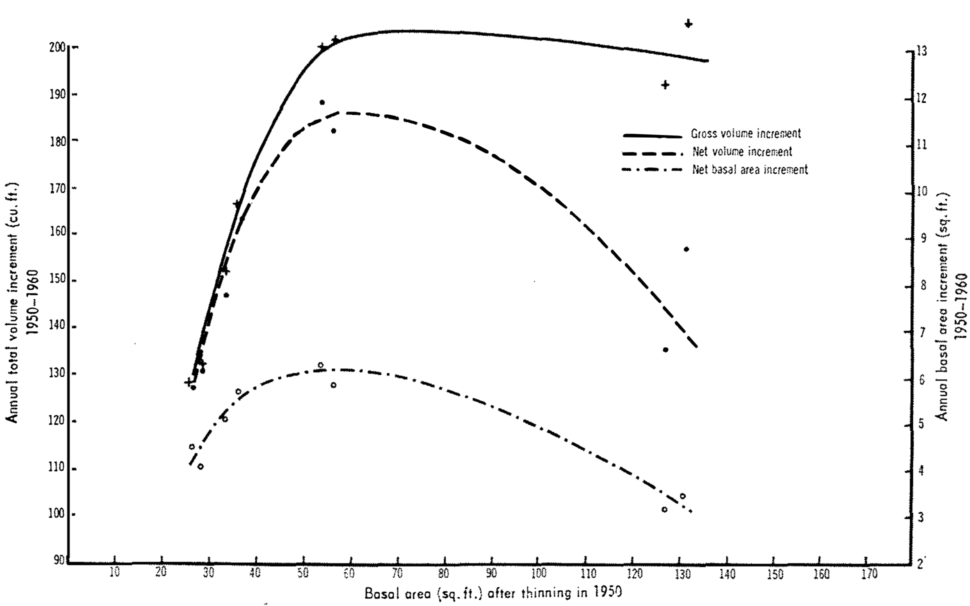


FIGURE 8. Periodic annual net and gross total volume increment and net basal area increment per acre related to basal area per acre after thinning. Study 5—23-year-old stand thinned in 1950.

Within a range of about 60 to 130 square feet per acre, gross annual volume increment between 1950 and 1960 remained at about 200 cubic feet per acre. Below 60 square feet, gross annual volume increment dropped abruptly. This again is in agreement with Möller *et al.* (1954) (see above).

TABLE 6. NET MERCHANTABLE VOLUME PRODUCTION RELATED TO THINNING INTENSITY AND PERIOD SINCE THINNING.

Study number	Initial stand age	No. of years between establishment and last remeasurement	Basal area after thinning (% of control)	Basal area necessary to give max. net total volume increment (% of control)	Merchantable volume production/acre: cords[3] Trees ⩾ 4″ d.b.h.		Merchantable volume production/acre: board feet[4] Trees ⩾ 8″ d.b.h.	
					Control	Thinned	Control	Thinned
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9
1	11	12	28 and 56	63	19	20 and 23	[5]	[5]
2	14	11	52 to 150	61	8	7 to 13	[5]	[5]
3	14	10	10 to 36	61	4	3 to 4	[5]	[5]
4	19	10	25 to 37	58	13	8 to 12	[5]	[5]
5	23	10	21 to 42	59	40	25 to 36	135	821 to 937
6	30	34	75 and 80[1] 57 and 65[2]	65 78	54	56	8997	10966
7	35	20	60 and 70	70	34	36 and 36	2688	3116 and 3698
8	45	9	45 and 65	78	39	31 and 32	859	363 and 1386

[1]Thinned in 1926.
[2]Thinned in 1940.
[3]Volume of peeled stem above 1-foot stump to a 3-inch top-diameter inside bark. Table 17 Univ. of Minn. Tech. Bull. No. 39. 1934.
[4]Stump height 1-foot; log lengths 12.6 and 16.8 feet; top diameter to 6.5 inches. Table 203, Form Class Volume Tables, Canada Dept. Mines and Resources, 1948.
[5]Trees not large enough to contain board foot volumes.

By thinning this 23-year-old stand to about 60 square feet of basal area in 1950, approximately 90 per cent of the potential increment was realized during the following 10 years. However, by thinning to 25 square feet or by not thinning in 1950 only about 65 and 70 per cent of the potential increment were realized during the same period. The lower net increment on the heavily thinned plots was the result of inadequate stocking; on the unthinned plots it was the result of greater mortality.

For some species, gross volume increment declines at excessively high densities as a result of stagnation (Braathe 1957, Smithers 1957). There is slight evidence of this in Figure 8.

Merchantable volume

The effects of thinning on merchantable volume production are illustrated in Table 6. When consideration is given to the intensity of thinning actually achieved (column 4), it is apparent that on some plots stocking after thinning was lower than that necessary for maximum volume increment, which resulted in a loss in cordwood production. On other plots residual basal area after thinning approximated that necessary for maximum volume increment and cordwood production was increased slightly.

Only four studies had trees large enough to contain board foot volumes. On each thinned plot except one for study 8 production was increased by thinning. The low board foot production on the one thinned plot in study 8 has been attributed to the fact that it supported smaller trees before thinning than the control.

Relationship Between Diameter and Basal Area Increment

The relationship between the diameter increment of individual trees and basal area increment per acre is illustrated in Figure 5. Curve C shows the periodic annual diameter increment of the 200 largest trees per acre at basal area levels which vary from 28 to 130 square feet per acre. With a residual basal area of 60 square feet (which provides maximum periodic net basal area increment), only 44 per cent (or .035 inches) of the observed total increase in annual diameter increment had taken place. An additional reduction to 28 square feet provided for the remaining 56 per cent. In other words the greatest observed diameter increment was obtained at the expense of basal area increment per acre.

Mortality

Trembling aspen is an intolerant species and as a result mortality among the smaller trees is very high. An illustration of this is given in Table 7 which records the per cent mortality by size classes on the unthinned plots of study 3 (14-year-old stand). The greatest part of the mortality occurred among the smallest trees. Since all stands were thinned from below, mortality was reduced in proportion to the intensity of the thinning, as indicated by Figure 8.

TABLE 7. MORTALITY (NO. OF TREES) BY DIAMETER CLASSES UNDISTURBED PLOTS (1951-1962) STUDY 3, 14-YEAR-OLD STAND.

D.b.h. class 1951	Mortality 1951-1962 (per cent)
1	86
2	25
3	12
Weighted average	52

DISCUSSION AND APPLICATION OF RESULTS

Thinning has two important aims: (a) to maximize volume production and (b) to increase and possibly maximize the growth rate of residual trees. Unfortunately it is not possible to create conditions by means of thinning which will achieve both (a) and (b) simultaneously to the fullest extent. As has been shown earlier, only a portion of the possible increase in diameter increment of individual trees is obtained at basal area levels necessary for maximum periodic net basal area and volume increment.

Whether thinning is undertaken to maximize volume production or to maximize diameter increment on individual trees the greatest benefits will occur if treatment is done when the trees are capable of achieving their fastest growth rate. For the stands studied this occurred up to about 20 years of age. Since young trees are capable of faster growth than older ones it follows that thinning (in terms of per cent basal area removed) can be heavier in young stands than in older ones.

None of the studies were designed to compare the effects of site on response to thinning. However, it has been shown that trees on telluric sites are capable of faster growth than trees on other sites. Therefore, in a thinning program these sites should normally be treated first.

Based on basal area data for all studies, six thinning regimes (Figures 9 and 10) have been set up to show probable stand development to age 40. Data were too scanty to extend the regimes further. Regimes are labelled, light, moderate and heavy for convenience. Those in Figure 9 are based on a 5-year cutting cycle while those in Figure 10 are based on a 10-year cycle. Thinning intensity for the moderate regimes was chosen so the standing basal area half-way

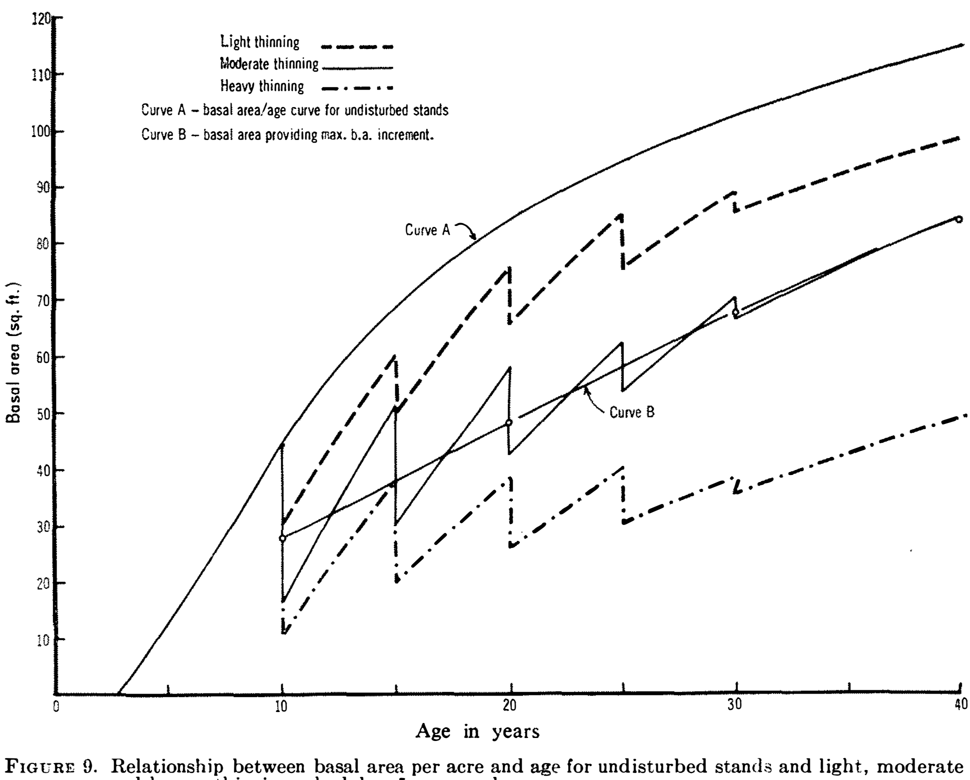


FIGURE 9. Relationship between basal area per acre and age for undisturbed stands and light, moderate and heavy thinning schedules, 5-year cycle.

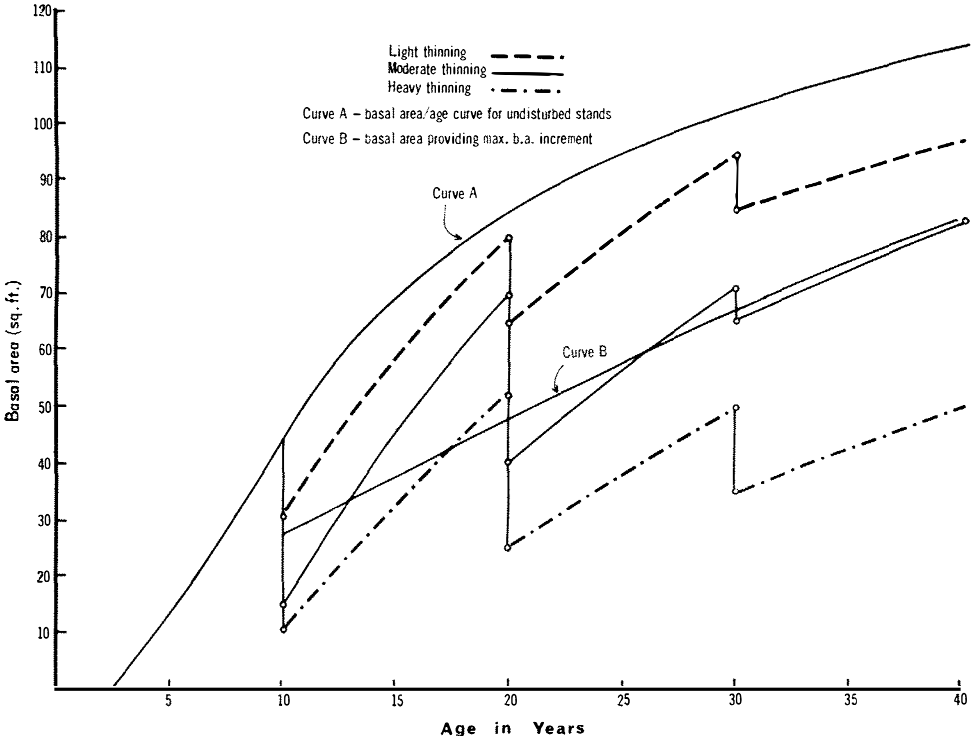


FIGURE 10. Relationship between basal area per acre and age for undisturbed stands and light, moderate and heavy thinning schedules, 10-year cycle.

between two consecutive thinnings would approximate that found to give maximum periodic net basal area increment (Table 5). The light and heavy regimes were chosen arbitrarily. The curves showing development of untreated stands were taken from Appendix I.

Total basal area, total volume, cordwood volume and average breast-height diameter of the 200 largest trees per acre at various ages, for all regimes, are presented in Table 8. Data for the untreated stands were derived from Appendices I to IV. For the treated stands, cordwood and total volumes shown are interpolated values derived from individual plot data (all studies). Data for average breast height diameter of the 200 largest trees were obtained by interpolation using Figure 4 and the data contained in Appendix IV.

Total basal area production at 40 years (for both 5- and 10-year cutting cycles) ranked in descending order by thinning intensity is: (1) moderate thinning, (2) light thinning, (3) heavy thinning, and (4) control. Total volume yield at 40 years ranked in the same manner is: (1) light thinning, (2) moderate thinning, (3) control, and (4) heavy thinning. As can be seen, light and moderate thinnings can be expected to produce greater basal area and total volume yields than either heavy thinning or no thinning.

Cordwood production at age 40, for both 5- and 10-year cutting cycles ranked in descending order by thinning intensity is: (1) control, (2) moderate and light thinning, and (3) heavy thinning. At age 25 production is higher for thinned stands than for unthinned stands. This may be explained by the fact that cordwood includes only material 4 inches in diameter at breast height and up. Therefore, because of increased diameter growth of trees in the thinned stands they reach the minimum diameter sooner than trees in unthinned stands. However,

TABLE 8. YIELD PER ACRE THINNED AND UNTHINNED TREMBLING ASPEN STANDS.

Age	Basal area (sq. ft.)		Total volume[1] (cu. ft.)		Cordwood[1]		D.b.h. 200 largest	
	Standing	Thinning	Standing	Thinning	Standing	Thinning[2]		
			No thinning					
10	44	0	400	0	0	—	2.0	*Yield at age 40*
15	68	0	1,000	0	0	—	2.8	B.A. = 114 sq. ft.
20	84	0	1,500	0	3	—	3.6	Total volume =2,650 cu. ft.
25	94	0	1,900	0	9	—	4.3	Cordwood = 30 cords
30	102	0	2,200	0	16	—	5.0	
40	114	0	2,650	0	30	—	6.0	
			Light thinning (5-year cycle)					
10	30	14	260	140	0	—	2.0	*Yield at age 40*
15	50	10	650	110	0	—	3.2	B.A. = 147 sq. ft.
20	65	11	1,060	200	3.5	—	4.2	Total volume = 3,375 cu. ft.
25	75	10	1,460	225	10	—	5.0	Cordwood = 27 cords
30	85	4	1,885	100	15	—	5.6	
40	98		2,600		27	—	6.6	
			Moderate thinning (5-year cycle)					
10	16	28	130	270	0	—	2.0	*Yield at age 40*
15	30	21	370	280	0	—	3.1	B.A. = 162 sq. ft.
20	42	16	650	290	4	—	4.2	Total volume = 3,305 cu. ft.
25	53	9	970	190	14	—	5.2	Cordwood = 28 cords
30	66	4	1,400	100	19.5	—	6.1	
40	84		2,175		28		7.3	
			Heavy thinning (5-year cycle)					
10	10	34	70	330	0	—	2.0	*Yield at age 40*
15	20	18	240	235	0	—	3.2	B.A. = 127 sq. ft.
20	25	13	370	215	4.5	—	4.4	Total volume = 2,195 cu. ft.
25	30	10	510	190	11	—	5.5	Cordwood = 21 cords
30	35	3	685	65	13.5	—	6.6	
40	49		1,160		21		8.2	
			Light thinning (10-year cycle)					
10	30	14	260	140	0	—	2.0	*Yield to age 40*
20	65	15	1,065	275	3	—	3.9	B.A. = 136 sq. ft.
30	85	10	1,885	265	16.5	—	5.2	Total volume = 3,180 cu. ft.
40	97		2,500		27		6.2	Cordwood = 27 cords
			Moderate thinning (10-year cycle)					
10	15	29	120	280	0	—	2.0	*Yield to age 40*
20	40	30	620	540	3	—	4.1	B.A. = 147 sq. ft.
30	65	6	1,380	150	17	—	5.8	Total volume = 3,090 cu. ft.
40	82		2,120		27		7.0	Cordwood = 27 cords
			Heavy thinning (10-year cycle)					
10	10	34	70	330	0	—	2.0	*Yield to age 40*
20	25	27	370	465	4	—	4.3	B.A. = 126 sq. ft.
30	35	15	685	315	15	—	6.3	Total volume = 2,310 cu. ft.
40	50		1,200		23		7.8	Cordwood = 23 cords

[1]Total volume and cordwood values are interpolated.
[2]Thinning from below, no cordwood volume removed.

when the unthinned stands reach the 4-inch minimum, cordwood yields increase rapidly because of the greater number of trees. It should be noted that material removed as thinnings is not of cordwood size.

The effect of thinning on board foot production is still unknown since most stands were too young to produce board foot volumes (Appendix V). However, the beneficial effect of thinning on tree increment has been demonstrated. Heavy thinning at 5- and 10-year intervals should produce crop trees with an average diameter of about 8 inches at 40 years of age as compared to 6 inches for similar trees in unthinned stands.

CONCLUSIONS

If all sized material could be used, total volume production to age 40 could be increased by about 25 per cent with light to moderate thinning at 5-year intervals. To achieve this, stands would have to be maintained at densities between 15 square feet per acre at age 10 and 85 square feet at age 40. For the stands on which the thinning regimes were based this would have meant a reduction in basal area of between 65 and 75 per cent (Table 5).

Thinning has little effect on cordwood production to age 40, mostly because the material removed is not of cordwood size (minimum diameter at breast height 4 inches). If thinnings have to meet this minimum size, treatments will have to be postponed until stands are about 30 to 40 years of age, when volumes will be between 15 and 30 cords per acre. For maximum cordwood growth of residual trees, density should be varied from about 65 square feet per acre at age 30 to about 100 square feet per acre at age 50.

If thinning is carried out for lumber (board measure) production, stands will have to be maintained at basal areas well below those optimum for total volume or cordwood production.

SUMMARY

Between 1926 and 1951 eight thinning studies, comprising 47 sample plots ranging in size from 0.1 to 1.0 acres, were established in 11- to 45-year-old trembling aspen stands in Manitoba and Saskatchewan. Thinning was carried out to specific spacings, specific basal areas and specific stand density indices.

Within the range of basal areas created by thinning, diameter increment of individual trees (both large and small trees) increased as intensity of thinning increased. The most severe thinnings left basal areas that were about 15 per cent of those of untreated stands.

Greatest net basal area and total volume increment for 10-, 20-, 30-, 40-, and 50-year-old stands occurred at residual basal area levels of 28, 48, 67, 84 and 101 square feet per acre, respectively.

There was a marked difference of growth rate between sites; response to thinning on the best site followed a similar trend to that on the other sites.

Data suggest that thinning should be initiated before the age of 20 years to be most beneficial to further stand development.

Six thinning regimes were prepared, describing stand development for various cutting intensities up to an age of 40 years. These regimes suggest that gains in total volume production of up to 25 per cent may be obtained at an age of 40 years by moderate thinning at 5-year intervals.

Thinning for cordwood production is recommended only when thinning material can be utilized. This is expected to be at an age between 30 to 40 years when stands will contain between 15 and 30 cords per acre.

Sufficient data were not available to predict the effect of thinning on board foot production. However, up to the age of 40 years crop trees in stands under a heavy thinning schedule can be expected to average 8 inches d.b.h. as compared to 6 inches in untreated stands.

SOMMAIRE

De 1926 à 1951, on a procédé à huit éclaircies expérimentales dans 47 placeaux dont la superficie variait de 0.1 à 1 acre, établis dans des peuplements de peupliers faux-trembles de 11 à 45 ans, au Manitoba et en Saskatchewan. Les coupes d'éclaircie ont été faites selon des indices déterminés d'espacement, de surface terrière et de densité de peuplement.

Dans la marge des surfaces terrières obtenues à la suite des coupes d'éclaircie, la croissance en diamètre de tous les arbres (gros et petits) a été accélérée en proportion directe de l'intensité des coupes d'éclaircie. Les coupes d'éclaircie les plus intensives laissaient des surfaces terrières égales à environ 15 p. 100 des surfaces terrières occupées dans les peuplements laissés intacts.

L'accroissement le plus élevé du volume total des arbres et la plus grande surface terrière nette, dans les peuplements de 10, 20, 30, 40 et 50 ans, ont été constatés dans les placeaux dont la surface terrière après les coupes d'éclaircie était respectivement de 28, 48, 67, 84 et 101 pieds carrés à l'acre.

L'allure de croissance des arbres était sensiblement différente d'une station à l'autre; les coupes d'éclaircie ont eu un effet bienfaisant aussi bien dans les meilleures stations que dans les autres.

D'après les données recueillies au cours de l'étude, les coupes d'éclaircie devraient commencer avant que les peuplements n'atteignent leur vingtième année, afin de favoriser au mieux la croissance des arbres. Six régimes de coupes d'éclaircie ont été préparés, d'après la croissance des peuplements qui avaient subi des coupes d'éclaircie d'intensité variable, jusqu'à 40 ans d'âge. D'après ces régimes, il est possible d'obtenir des gains de volume total de l'ordre de 25 p. 100 à 40 ans, grâce à des coupes d'éclaircie modérées faites tous les 5 ans.

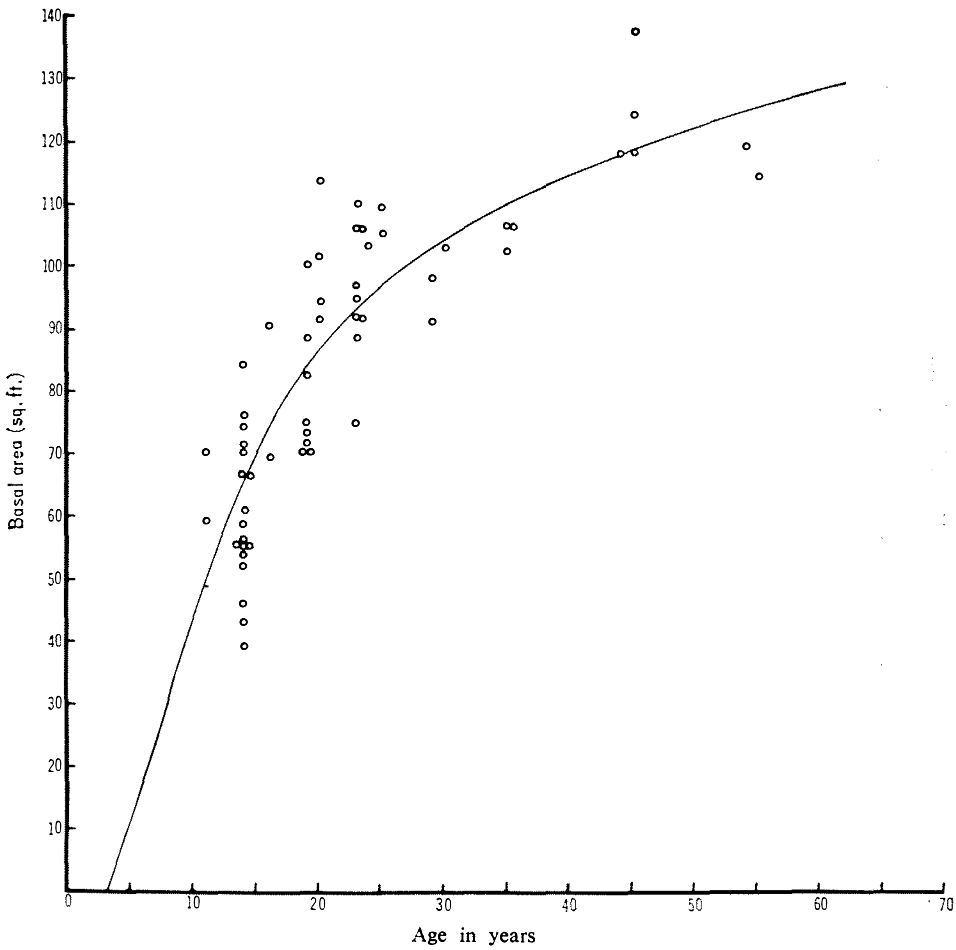
Les coupes d'éclaircie en vue de favoriser la production de bois à pâte ne devraient se faire que lorsqu'on peut utiliser les bois provenant de ces coupes. Cette condition sera probablement remplie lorsque les peuplements auront de 30 à 40 ans, alors qu'ils pourront produire de 15 à 30 cordes à l'acre.

Les données recueillies ne permettent pas de déterminer l'effet des coupes d'éclaircie sur la production de bois d'œuvre. On a toutefois pu établir que dans les peuplements de 40 ans soumis à des coupes d'éclaircie intensives, le d.h.p. moyen des arbres atteint 8 pouces, alors que dans les peuplements laissés intacts il ne dépasse pas 6 pouces.

APPENDIX I

Relationship between basal area and age of untreated stands.

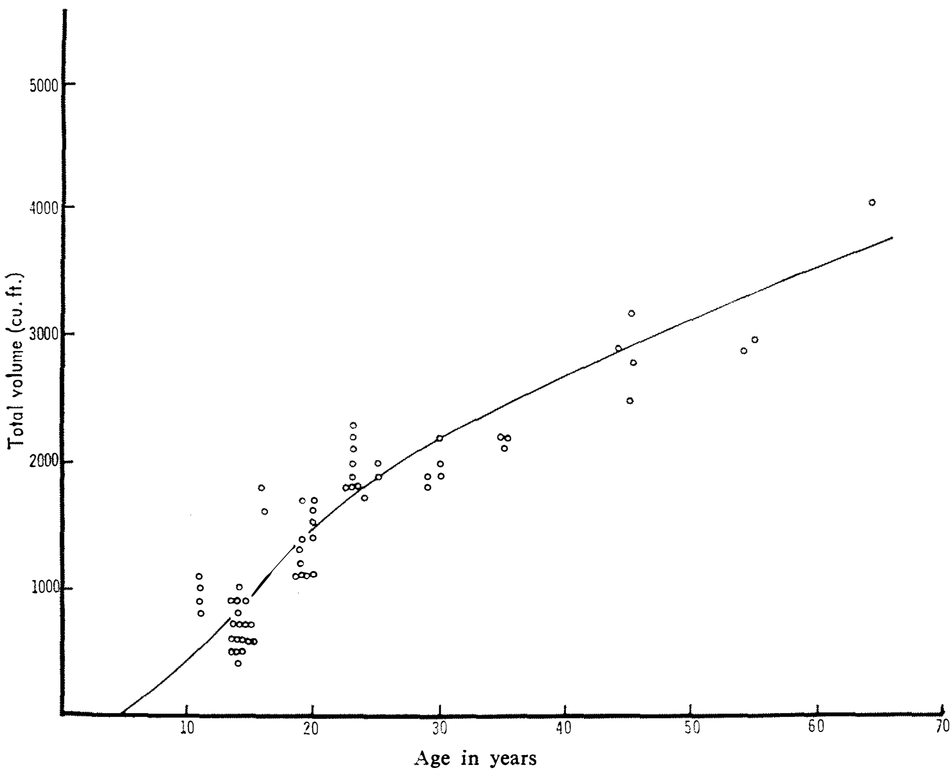
Basis: Control plots from all studies.



APPENDIX II

Relationship between total volume and age of untreated stands.

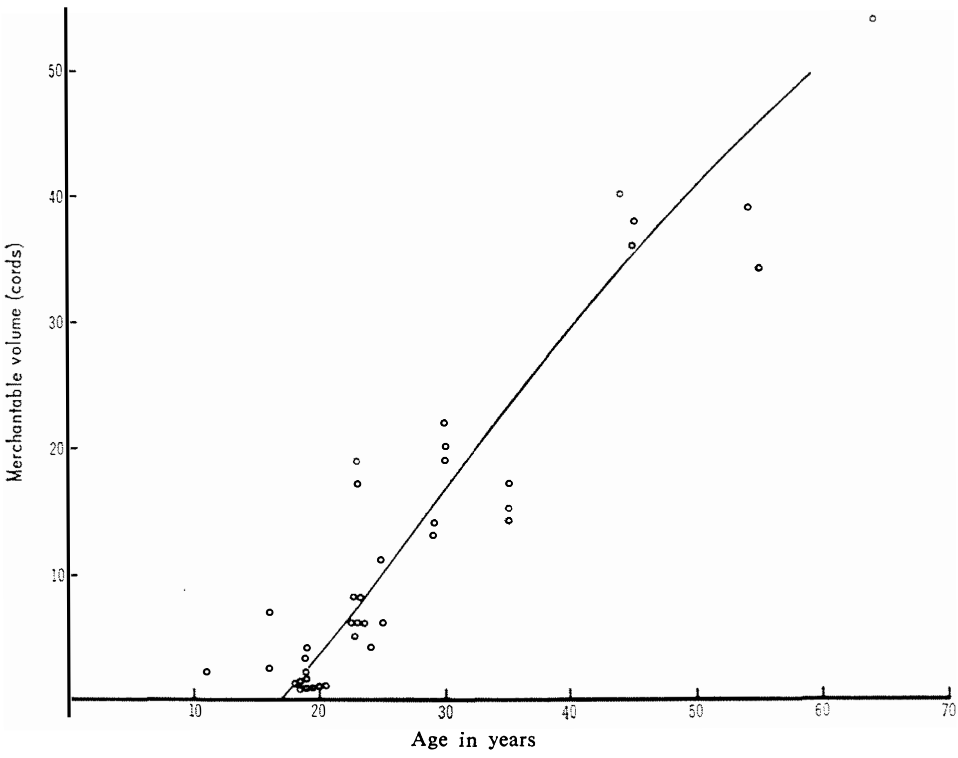
Basis: Control plots from all studies.



APPENDIX III

Relationship between cordwood merchantable volume and age of untreated stands.

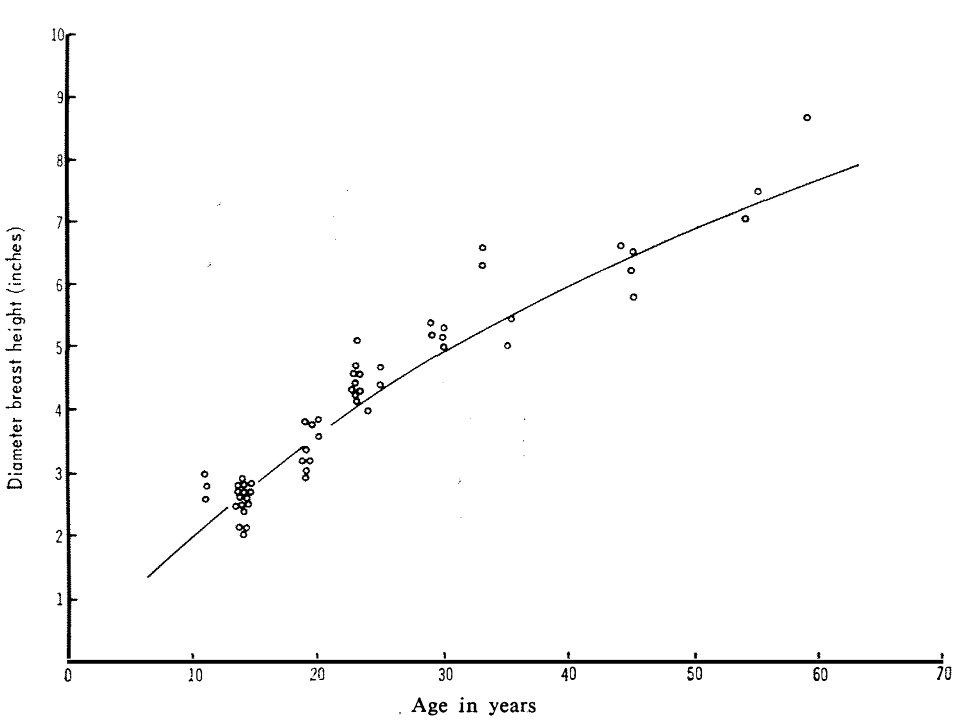
Basis: Control plots from all studies.



APPENDIX IV

Relationship between the breast height diameter of the 200 largest trees per acre and age of untreated stands.

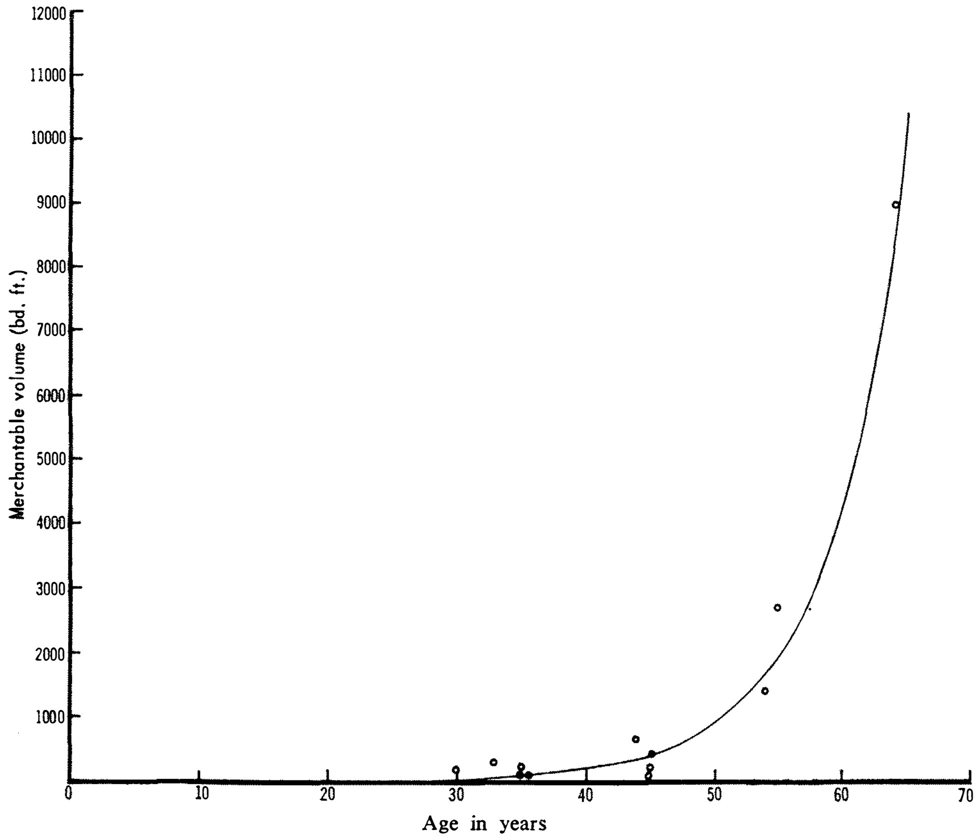
Basis: Control plots from all studies.



APPENDIX V

Relationship between board foot merchantable volume
and age of untreated stands.

Basis: Control plots from all studies.



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