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THINNING YOUNG AND OLD LODGEPOLE PINE STANDS IN THE SUBALPINE REGION OF ALBERTA

Project No. A/T 262

by

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INTRODUCTION

One of the problems in the management of lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) stands is overstocking. This species often regenerates over-abundantly as a result of wildfire and unless remedial measures, such as thinning, are undertaken, a harvest is unlikely from a large segment of the forest land in western Alberta. Densities in young stands of as high as 500,000 stems per acre have been reported by Smithers (1957), and even as many as 100,000 living stems per acre have been reported in a 70-year-old stand (Mason, 1915). Smithers (1961) states that when the stocking exceeds 2,000 stems per acre at 90 years of age, it is unlikely that a reasonable merchantable yield will be forthcoming. To overcome this apparent stagnation and to concentrate the growth on a selected number of trees, it may be beneficial to thin or weed very dense stands.

A series of trials were established at the Kananaskis Forest Experiment Station in the late 1930's and early 1940's to determine the

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growth response of very dense stands after thinning. This report presents the results to date of thinning a seventy-year-old stand and a very dense thirteen-year-old stand.

STAND AND SITE DESCRIPTION

Both stands were located in the S.A.1 Section of the Subalpine Forest Region (Rowe, 1959), and were of fire origin. The seventy-year-old stand is at an elevation of approximately 4,500 feet, on a degraded brown wooded soil developed on fine textured deltaic and alluvial fan deposits with a moderately high lime content. Lodgepole pine was the main covertype (in excess of 85 per cent by volume) with some white spruce (Picea glauca (Moench) Voss. var. albertiana (S. Brown) Sarg.) and aspen (Populus tremuloides (Michx.)) in the understory. At the time of thinning the average stand d.b.h. was 3.6 inches, the maximum height of the pine was 55 feet, and the number of stems per acre totalled 2,900.

The thirteen-year-old stand was at an elevation of 5,400 feet, on a bench of an east-facing slope. The soil is moderately-well-drained orthic grey wooded developed on colluvium over coarse-textured till. At the time of thinning, the density was 226,000 stems per acre of which 78 per cent was lodgepole pine, with the remainder composed of spruce, willow (Salix L.), alpine fir (Abies lasiocarpa (Hook.) Nutt.) and aspen. No diameter measurements were taken at the time of thinning because the average stand height was only 4.1 feet.

THINNING IN SEVENTY-YEAR-OLD PINE

Methods

In 1941, the stand was thinned for fuelwood. A post-thinning examination revealed that the treatment removed trees throughout the range of diameter classes present although most trees were removed from the smaller diameter classes. Quaite (1949) reported that the treatment, which removed 70.4 per cent of the total basal area, was a combination of heavy thinning from above and below.

In 1949, four permanent fifth-acre sample plots were established in the treated area and two permanent tenth-acre sample plots were located in a control area adjacent to the thinning. In each plot all of the trees were tagged and measured for d.b.h. A number of these trees, sufficient to provide data for a height-diameter curve, were then measured for:

1. D.b.h.,
2. Average diameter increment (bh) for the past 8 years,
3. Total height.

In addition, a number of trees were felled in the area immediately adjacent to the plots in order that the diameter and height of the trees in 1941 might be obtained. In the thinned plots, the stumps were tallied and their numbers before treatment thereby found. The count showed that the treated plots, before thinning, had approximately the same number of stems per acre as the control plots (Quaite, 1949).

The plots were remeasured in 1953 and in 1963. In 1963, twenty-five of the largest trees from quarter-acre plots established in both the treated and control areas (the hundred largest trees per acre) were felled and subjected to stem analysis. Consequently it was possible to reconstruct and compare the growth of the hundred largest trees per acre in the thinned and control areas.

Results

Diameter growth

Periodic annual diameter-growth was greatest in the thinned stands where average diameter growth of all trees was 0.084 inches compared to 0.068 in the unthinned stands--an increase of 23.5 per cent. The periodic annual diameter-growth of the lodgepole pine trees in the thinned stand was 0.084 inches, an increase of 176.5 per cent over the 0.034 inch periodic annual diameter-growth of the lodgepole pine trees in the unthinned stand. If a comparison is made between the 100 largest trees per acre, the difference in diameter growth is even more pronounced. The 100 largest pine trees in the unthinned stand attained an average periodic annual diameter growth of 0.066 inches while the 100 largest pine trees in the thinned stand attained an average of 0.102 inches--an increase of 54.5 per cent. In basal area, the increase in periodic annual growth of the 100 largest trees was 57.1 per cent.

These results suggest that stimulation of diameter growth increases with increasing tree size. As shown in Figure 1, this does occur in trees up to the 6-inch d.b.h. class after which the curve levels off. This is probably related to the fact that trees less than 6 inches in d.b.h. have been greatly influenced by competition and

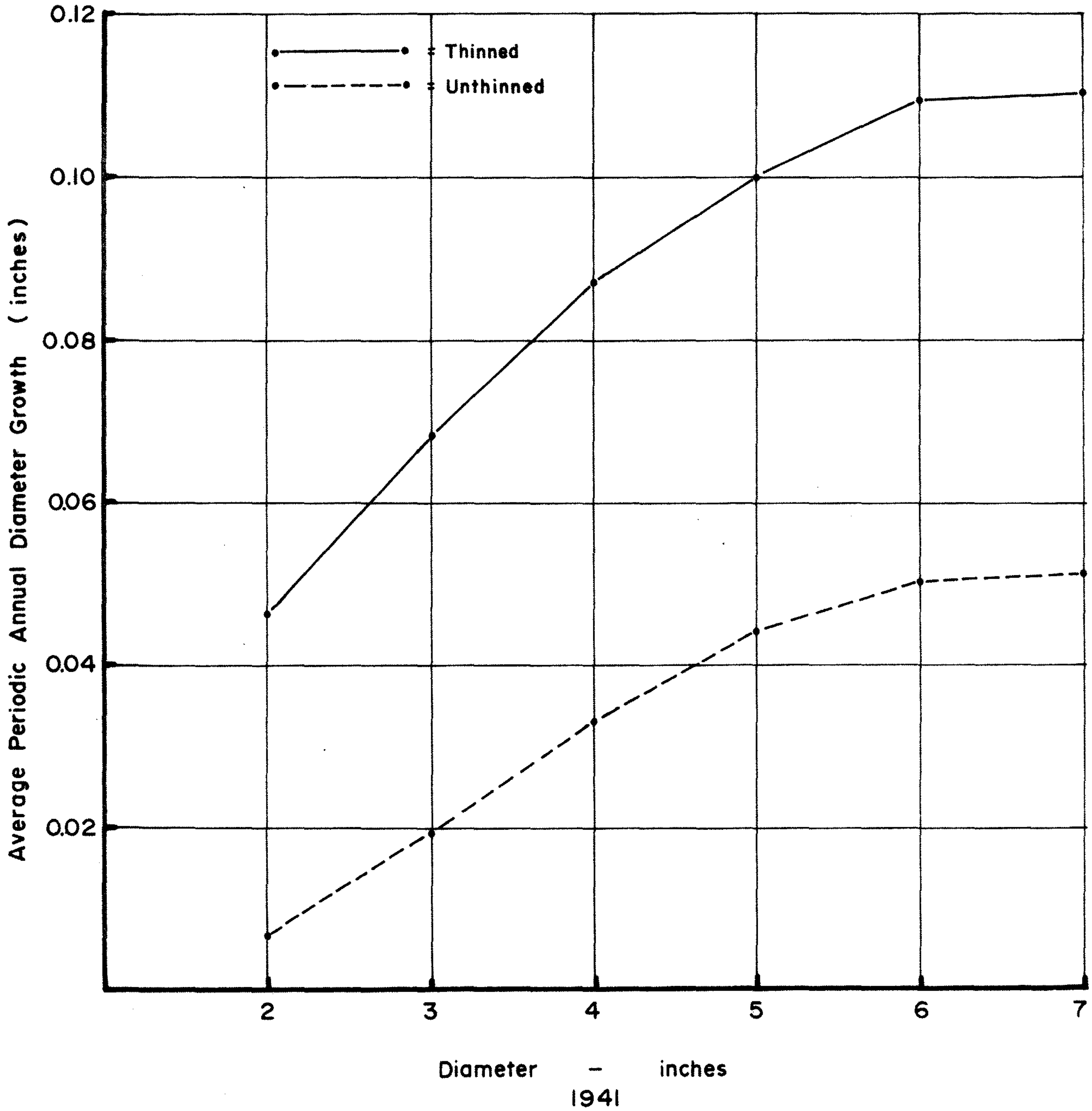

Figure I. Comparison of Periodic Annual Diameter Growth (1941-1963) on Thinned and Unthinned Areas.

(Lodgepole Pine only)

thus respond to release, whereas trees larger than this 6-inch limit have been less affected by competition and respond less to release.

Height growth

Owing to the difficulty of measuring the height growth of mature trees, the analysis of height growth was limited to an examination of the stem analyses of the 100 largest trees per acre in the treated and control plots. The height-age relationships indicated that before thinning, the height growth in the control area slightly exceeded that in the treated area. A short period after thinning, this trend was reversed, which suggests that height growth was slightly stimulated by thinning. The periodic annual height-increment of the 100 largest trees in treated stand after thinning was 0.517 feet yearly as opposed to 0.451 feet yearly in the control area. Although small, the response was demonstrated by those trees least likely to show release in height growth and it is probable that a more dramatic stimulation occurred in smaller trees which had been subjected to greater competition.

Basal area increment per acre

Thinning resulted in a large increase in the net periodic annual basal-area-increment per acre and also increased the gross periodic annual basal-area-increment by 55 per cent (Table 1). In addition, the amount of basal area lost through mortality in the treated stand was reduced to nearly one-tenth of that in the control.

TABLE 1. THE INFLUENCE OF THINNING ON NET AND GROSS PERIODIC ANNUAL INCREMENT EXPRESSED IN BASAL AREA PER ACRE (SQ. FT.).

	Control	Treated
1941 Before Thinning	205.9	205.9
Thinnings	-	144.9
1941 After Thinning	205.9	61.0
1963 All living trees	208.3	122.4
Net increment 1941-63	2.4	61.4
Net periodic annual increment	0.11	2.9
Mortality 1941-63	39.1	4.0
Gross increment 1941-63	41.5	65.4
Gross periodic annual increment	2.0	3.1

1.15% 50.2% in 1963 thinned had 58.8% BA of control.

The basal area in the control stand was maintained for the 21 years after thinning, as opposed to the rapid increase in the treated stands (Figure 2). This suggests that a maximum basal area per acre, consistent with site and climatic factors, had been reached in the control area, where increment balanced mortality, and that the only possible way of increasing productivity was to provide increased growing space. Barrett (1961) observed that the greatest basal area growth stimulation was in intermediate (12' x 12' spacings) thinnings as opposed to heavily thinned (16' x 16' spacings) and unthinned stands of 55-year-old lodgepole pine.

Volume increment per acre

Table 2 presents a comparison of net and gross periodic annual increments in stand volume.

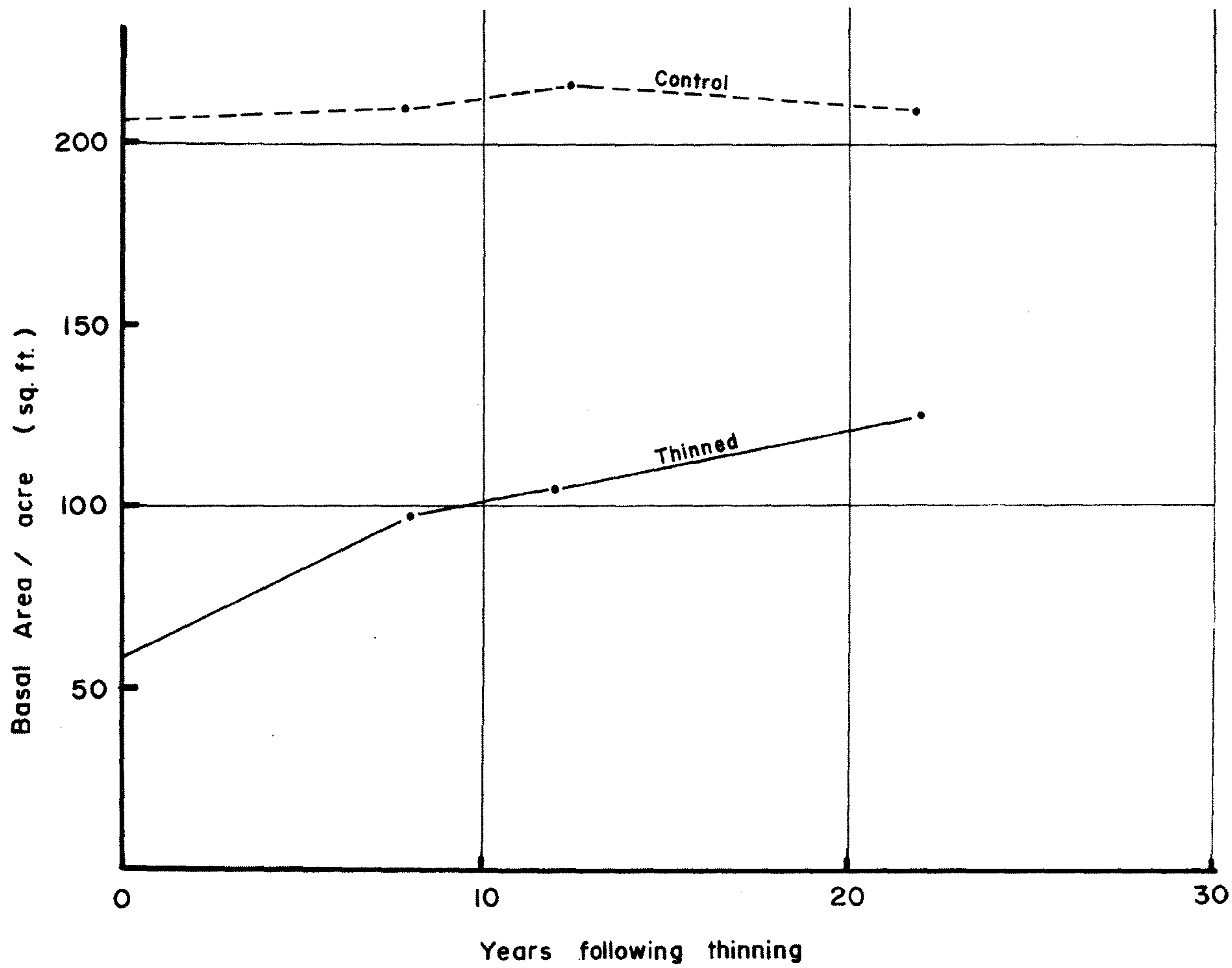

Figure 2. The Relationship Between Time Following Thinning (years) and Stand Basal Area per Acre (sq. ft.) for Thinned and Unthinned Stands.

TABLE 2. THE INFLUENCE OF THINNING ON NET AND GROSS PERIODIC ANNUAL INCREMENT EXPRESSED IN TOTAL VOLUME PER ACRE (CU. FT.).

	Control	Treated
1941 Before thinning	3812	3812
Thinnings	-	2675
1941 After thinning	3812	1137
1963 All living trees	5015	2940
Net increment 1941-63	1203	1803
Net periodic annual increment	57	86
Mortality 1941-63	512	90
Gross increment 1941-63	1715	1893
Gross periodic annual increment	82	90

Table 2 shows that thinning increased the net periodic annual volume increment of the stand by 51 per cent and the gross periodic annual volume increment by 9.8 per cent.

The influence of thinning is also reflected by the volume increments of the 100 largest trees per acre in the treated and untreated areas. In the thinned area, an average periodic annual volume-increment of 0.279 cubic feet, within a range of 0.197 cubic feet to 0.456 cubic feet yearly, was observed as compared to an average of 0.185 cubic feet, and a range of from 0.097 to 0.343 cubic feet in the control.

Mortality

One of the most striking influences of thinning upon stand development is the degree to which mortality is reduced (Figure 3). The number of trees per acre in the thinned stand remained relatively constant while the number of trees in the control decreased in a near linear fashion with time. In the stands examined, the heaviest mortality in the unthinned stands occurred in the smallest diameter classes. Over the 21-year period between 1941 to 1963, 49.3 per cent of the growing stock (in terms of number of stems) succumbed in the

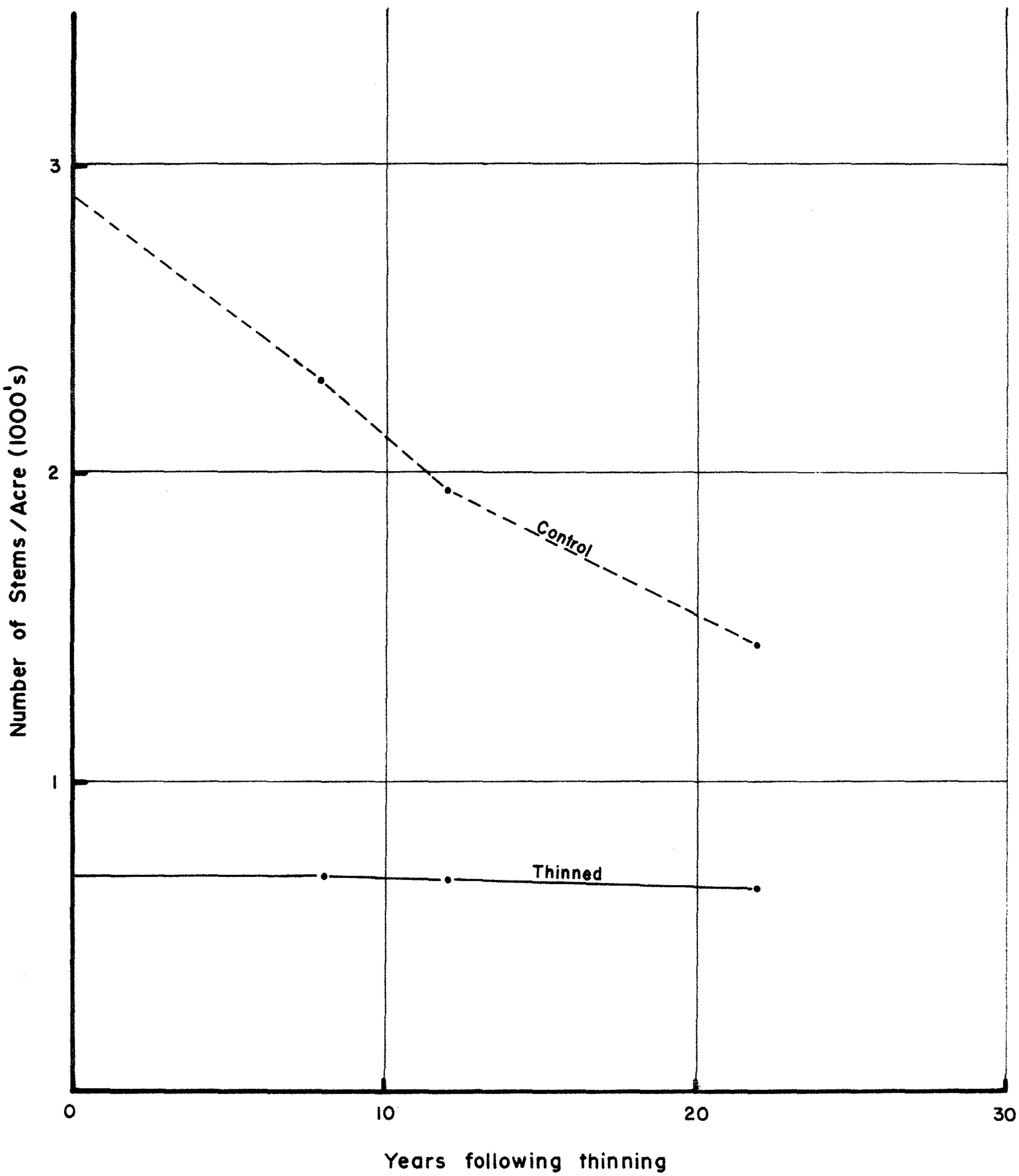

Figure 3. The Relationship Between Time Following Thinning (years) and Number of Stems per Acre for Thinned and Unthinned Stands.

control compared to 5 per cent in the treated area. In volume losses, 30 per cent of the gross increment of the control plots was lost through mortality compared to 3.8 per cent in the thinned plots. In the treated and control areas, the mortality losses in merchantable cubic feet were nearly equal, with 66.9 and 68.8 cubic feet per acre yearly, respectively (Table 2).

THINNING IN THIRTEEN-YEAR-OLD PINE

Methods

During the summer of 1949, two different methods of thinning were applied in a dense, 13-year-old stand of lodgepole pine. Two one-half acre plots were established in the treated areas and a third plot was selected as control.

The first treatment was a method of controlled burning to effect a total release of crop trees. This was done by using an "Aeroil" fire torch which generated a flame of 2,000° F at a distance of one foot in front of the nozzle. Semicircular metal shields covered with asbestos were used to protect the crop trees while the torch was used to completely defoliate and kill all competitors. The crop trees were selected to provide a 6.6 x 6.6 foot spacing although some variation was allowed to permit the selection of the best crop trees. This treatment required approximately 68 man-hours per acre.

The second treatment was a manual clearing to release the crop trees from immediate competition. A brush hook was used to destroy the competition within a radius of 1.5 feet of each crop tree.

As in the previous treatment, a 6.6 x 6.6 foot spacing was maintained with some latitude to allow the choicest trees to be favored. All competition within the radius was cut off at ground level and any trees not within the radius about the crop trees were left untouched. This treatment required approximately 25 man-hours per acre (Crossley, 1950).

After treatment, total heights (to the nearest one-tenth foot) were recorded for all of the crop trees and a selected number of individuals in the control. No diameter measurements were taken because very few trees had grown to breast height. Yearly height measurements were taken from 1949 to 1960 and a final height measurement was taken in 1963.

Results

Height growth

The influence of the treatments on height growth is shown in Figure 4. Fourteen years after thinning, the average height of the crop trees in the fire treatment exceeded the average height of the manually released crop trees. Both treatments resulted in higher average heights than the control although the average heights in all three plots were very similar immediately after thinning. For the first fourteen years after treatment, the mean annual height-growth in the fire thinning, manual thinning, and control were 0.90, 0.75, and 0.68 foot, respectively. The fire treatment resulted in the greatest increase (31.8 per cent) in height growth over the control as opposed to a 9.8 per cent increase over the control for the manual thinning. The increase in height growth resulting from the fire treatment is largest, probably because the crop

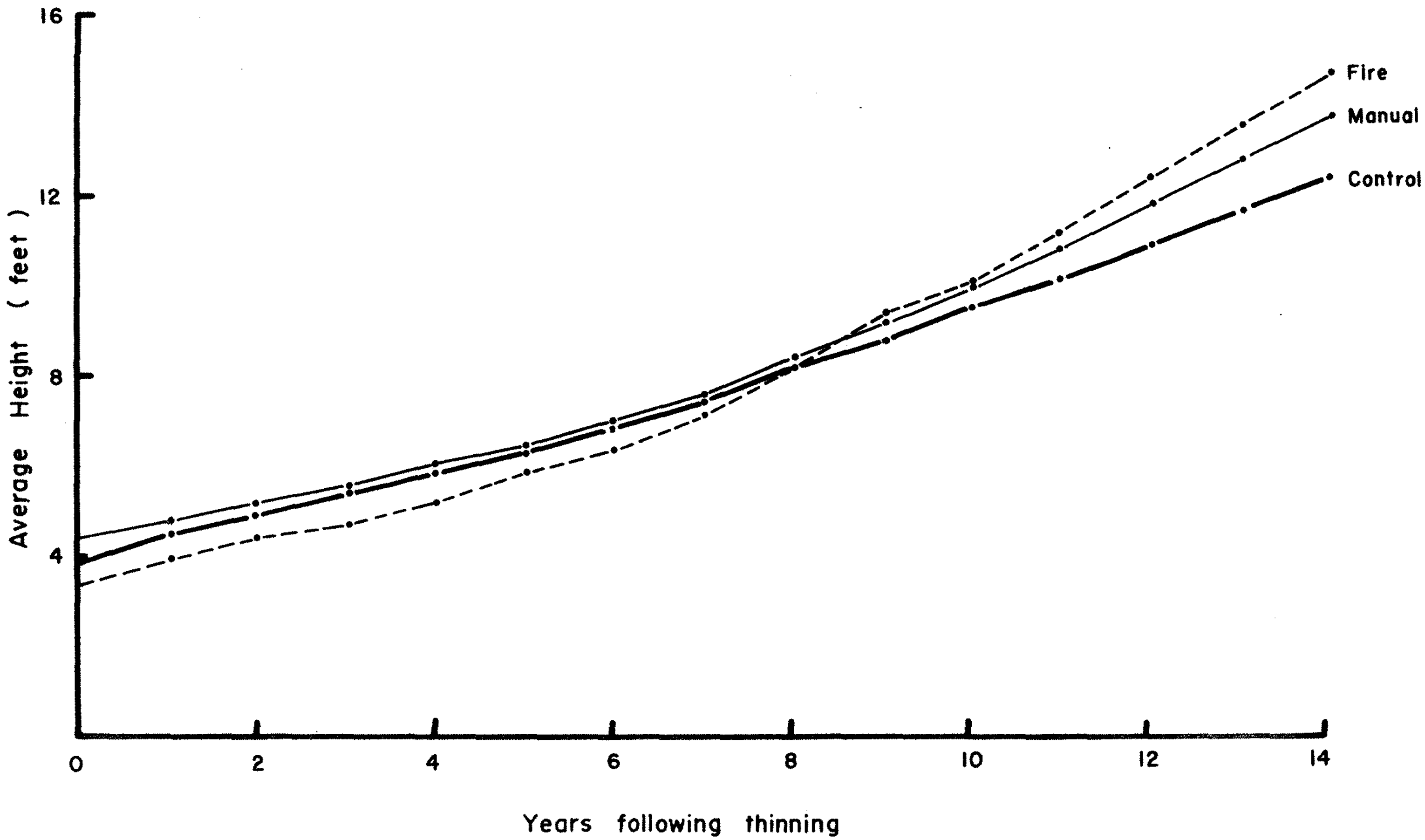

Figure 4. The Relationship Between Time Following Treatment and Average Stand Height in Thinned and Unthinned Stands of Young Lodgepole Pine.

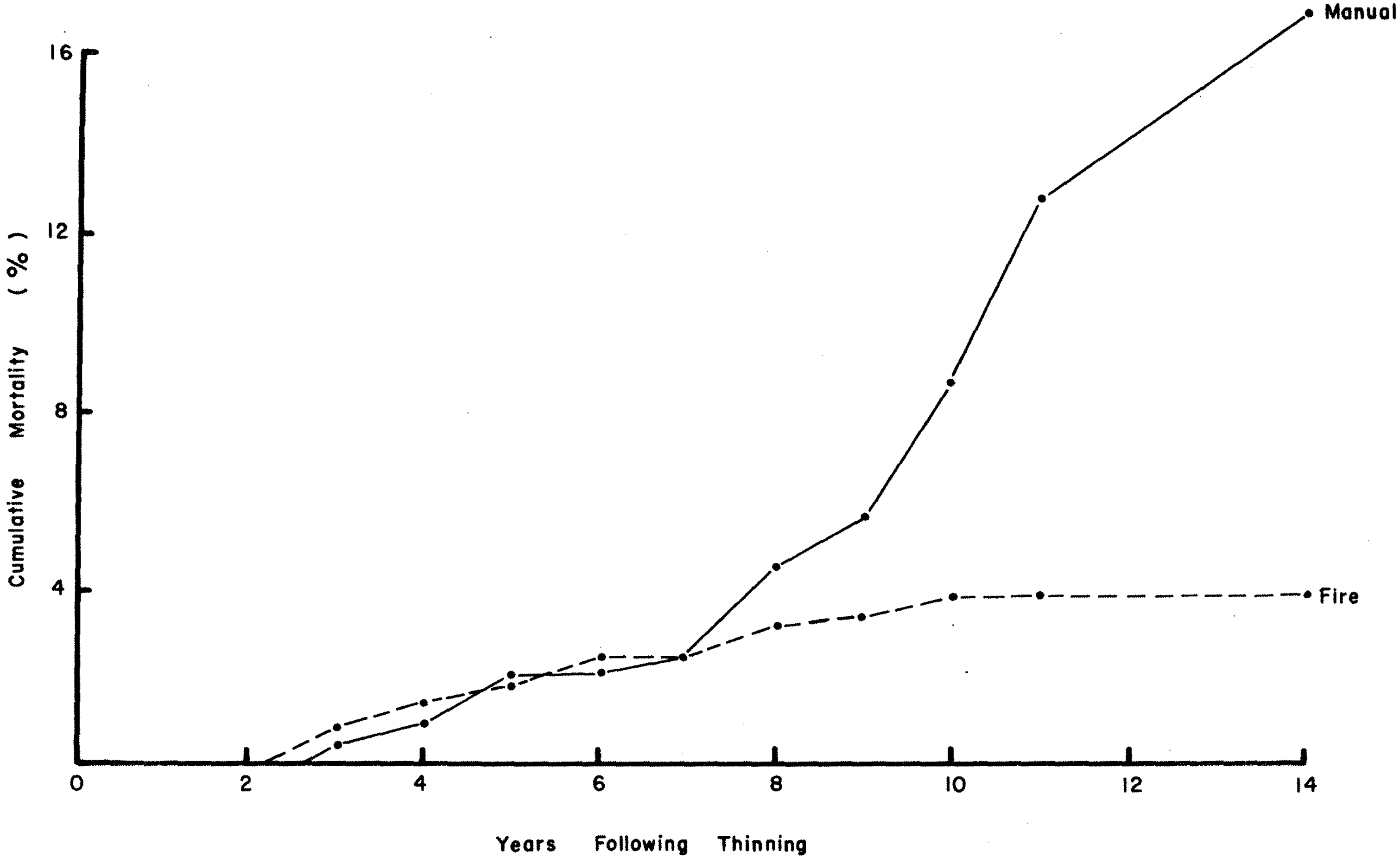

Figure 5. The Relationship Between Time Following Treatment and Cumulative Per Cent Mortality in Thinned and Unthinned Stands of Young Lodgepole Pine.

trees in this treatment had more growing space.

Mortality

Cumulative mortality, expressed as a percentage of the residual (crop) trees, is shown for manual and fire thinnings in Figure 5. Least mortality of crop trees occurred in the stand thinned by fire probably as a result of the greater growing space made available by this treatment.

The nature of the treatments and measurements do not permit a meaningful comparison with mortality in the unthinned stand. Nevertheless, from a few trees selected for measurement at the start of the experiment, approximately 10 per cent or 23,000 stems per acre succumbed during the study period.

DISCUSSION AND CONCLUSIONS

Examination of the first twenty-one years of growth after thinning has a pronounced effect upon diameter growth. Thinning not only resulted in large increases in net periodic increment in both volume and basal area per acre but also resulted in increases in the gross increments of these parameters per acre. Thinning also resulted in a large reduction in mortality.

The influence of thinning on the height growth of seventy-year-old pine trees is not clear. The small response and the slow growth rates in both the thinned and control stands are probably explained by the late age at which the experiment was carried out. Undoubtedly the trees had passed the period of rapid height-growth and little stimulation was observed because the crowns were unable to utilize the increased growing space afforded by the thinning. Similar results were reported by Quaite (1950), Smithers (1957), Barrett (1961), Holmes (1961), and Alexander (1965) in their studies of lodgepole pine stand development after thinning. Smithers (1954) working with red pine (*Pinus resinosa* Ait.) and white pine (*Pinus strobus* L.); Buckman (1962) and Stiell (1966) working with red pine; and Bella (1967) working with jack pine (*Pinus banksiana* Lamb.) and Scots pine (*Pinus sylvestris* L.) reported no significant relationships between the height growth of these species and stand density.

Thinning in thirteen-year-old, dense stands of lodgepole pine resulted in significant increases in height growth, and reduced mortality. These data show that thinning in dense lodgepole pine stands will result in greater average and dominant stand heights, and suggest a need to adjust for stand density when assessing site quality on the basis of height growth.

Although diameter and height growth, and yield per acre were substantially increased, these data are inadequate for considering the economics of thinning or for evaluating thinning as a management alternative. Nevertheless, the cost of thinning must be reduced, by profitable utilization of small material and development of efficient mechanized thinning methods, before advantage can be taken of potential increases in productivity.

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