FOREST RESEARCH BRANCH

CONIFER RELEASE EXPERIMENTS IN QUEBEC

(Project Q-5)

by

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ABSTRACT

Varying amounts of hardwood were removed from uneven-aged stands containing red spruce[3], balsam fir, yellow birch, sugar maple and beech, and the results in the best stands after 20 years showed a spruce-fir production superiority of 6 cords per acre over untreated stands. Recommendations for treating specific stands were not forthcoming but the evidence permits three guide rules to be suggested; 1) for good results, more than 250 spruce-fir stems per acre over 0.6 inch d.b.h. should be present before treatment; 2) removal of hardwoods should begin with the most tolerant species, and 3) hardwoods should be reduced to a volume level equal to or below that of the conifers.

INTRODUCTION

In 1920 the first in a series of experiments in mixedwood stands was begun at the Lake Edward Forest Experiment Area in Quebec with two objectives, 1) to study the response of red spruce and balsam fir to girdling or removal of varying amounts of hardwood, and 2) to determine the degree of release necessary to provide satisfactory development of conifer regeneration.

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3/ Nomenclature as in "Native Trees of Canada".

The forest had been logged twice, for large white pine and spruce sawlogs in 1890 and for conifer pulpwood in 1910. A short time later it was feared that future mill requirements would not be forthcoming from this and similar forest because hardwoods had begun to occupy what previously had been mixedwood areas and were suppressing the conifer regeneration. In 1934, additional studies were begun in similar forest at the Valcartier Forest Experiment Station.

Ray's (1956) growth study has already indicated that for the Lake Edward area as a whole the early fears of hardwood domination did not materialize. Spruce and fir competed successfully and provided sufficient volume for a third harvest cutting that began in 1951. Thus attention is focussed on the first objective, the study of conifer response to release.

This report presents the relationship of spruce-fir growth to the factors of percent basal area removed, residual number of conifers, basal area, and volume per acre. Conifer and hardwood volume fluctuations on individual plots also are presented to indicate the varying response of conifers and hardwoods to release.

THE FOREST

Both the Lake Edward Forest Experimental Area (46°45'N, 72°56'W) 20 miles north of Shawinigan, and the Valcartier Forest Experiment Station (46°58'N, 71°30'W) 20 miles north of Quebec City are within Forest Section L.4a of the Great Lakes-St. Lawrence Forest Region

(Rowe, 1959). The topography of both places is hilly but not rugged. The bedrock usually is covered with a shallow layer of glacial till, and exposed rock outcrops and ledges are common.

The effect of climate on tree growth in the two areas would be about equal, with higher annual temperature and precipitation at Valcartier being balanced by the warmer summer and longer frost-free period at Lake Edward, as shown below:

	Valcartier	Lake Edward
Average Annual Temperature	38°F.	37°F.
Average Temperature, Four warmest months	61°F.	63°F.
Annual Precipitation	49 ins.	36 ins.
Number of Days Above 32°F.	114	128

On the uplands, the typical forest is hardwood composed of sugar maple, yellow birch and beech with an occasional red spruce and balsam fir. On middle and lower slopes and in valleys typical stands are mixedwoods of fir, red spruce and yellow birch with scattered white spruce, red and sugar maple and white birch.

The Lake Edward area had been logged twice prior to establishment of the sample plots, in about 1890 and again in 1910-12. The first logging removed only very large white pine and spruce sawlogs; the second was for pulpwood under diameter limits of 10 inches for spruce and seven inches for fir at one foot above the ground. In these two operations, 9.9 cords of spruce and fir per acre were cut from the Oxalis-Cornus (O-Co) type (60% of the area) and 4.6 cords from the Viburnum-Oxalis (Vi-O) type (20% of the area). At Valcartier, the forest was privately owned up to 1914 and fuelwood and sawlog cutting undoubtedly occurred on the study area. No further logging was recorded up to establishment of the sample plots beginning in 1934.

Thus when the studies were begun the forests were in stages of recovery from logging and most of the residual spruce and fir were immature stems in an intermediate crown position or in the understory.

In the 1950's, Lake Edward was logged for a third time and some recent logging also has occurred in the Valcartier study area.

MATERIALS AND METHODS

Sample plots were established in uneven-aged stands of both the O-Co and Vi-O types defined by Heimburger (1941). The Vi-O type, usually found on upper slopes, is about 75% sugar maple, beech and yellow birch, and 25% red spruce and fir. The O-Co type, which occupies the middle and lower slopes, averages 60% fir and red spruce, 30% yellow birch, and 10% other hardwoods.

From 1920 to 1928, 17 permanent sample plots, with individual tree numbering, were established at Lake Edward and from 1934 to 1936, eight plots were established at Valcartier. Three of the 25 plots were not used in this study, two because of incomplete data and one because of an abundance of aspen.

Treatments usually were applied only on the sample plots and a narrow surround strip. The square or rectangular plots varied in size from 0.24 to 1.03 acres.

The treatment was a release of the spruce and fir understory by girdling or felling hardwoods. The intensity of treatment varied from 35 to 100 per cent hardwood removal from stands where the original proportion of conifers was from 1 to 55 per cent by basal area.

Average values for treated and control stands usually were very similar (Table 1). Treatment reduced numbers of hardwoods to 38 per cent, basal area to 27 per cent and volume to 25 per cent of their original values. It should be noted that the small amount of spruce and fir removed resulted in lower average conifer values on treated than on control plots.

Each experiment comprised two or three plots with varied treatment, plus one control plot. After a preliminary examination of individual experiments it was decided to study combined average values for treated and control areas. A second preliminary study revealed little difference between the girdling and felling treatments for the stand factor studied. The study results are presented for average periods of 21 and 20 years since treatment for treated and control plots respectively. The range of the study periods for individual plots is from 17 to 25 years.

RESULTS

Clearly the removal of large amounts of hardwoods has proved beneficial to spruce and fir over a 20-year period since treatment. Average conifer production superiority of treated over untreated stands was 264 cu. ft. per acre (Table 1), equivalent to a merchantable volume of about 2.5 cords. Volume in treated stands increased annually at about twice the rate for untreated stands (Table 2).

Although the average conifer response was favourable, all the treated stands did not respond equally well. From examination of net annual increments and individual volume fluctuations (Figures 3 and 4), stands were grouped into favourable (n.a.i. more than 20 cu. ft./acre) or unfavourable (n.a.i. 20 cu. ft./acre or less) conifer response categories. Only seven of fifteen treated stands were considered to have responded well. The average conifer yield for these seven stands after 20 years was 13 cords per acre, 6 cords more than untreated stands. Three possible reasons for the variation in stand response may be put forward: 1) stands that responded well had only small amounts of sugar maple and beech compared to poor response stands (Table 3); 2) stands that responded well averaged three times the number of conifers and only one-half the number of hardwoods compared to poor response stands (Table 4); 3) smaller amounts of hardwoods were removed from stands with the smaller number of conifers and the larger number of hardwoods (Table 4). Two stands were exceptions to these general findings and why they responded poorly is perhaps ascribable to their initial relatively large numbers of codominant conifers which subsequently were windthrown.

It is interesting to note that since the initial increase in spruce-fir volume proportions caused by the treatments, there has been only a moderate conifer increase from 69 to 75 per cent of the total volume in favourable response stands and actually a decrease from 41 to 31 per cent in stands that responded poorly (Table 3).

The discovery of these group differences led to examination of individual stands and the possible relationship between conifer volume growth and several stand factors. The following trends were noted: 1) a strong trend of increasing conifer increment with greater number of conifer stems per acre but weak trends between growth and conifer basal area and conifer volume (Figure 1); 2) a trend of increasing conifer growth with decreasing sugar maple-beech proportion (Figure 2, Table 3); 3) a weak trend of increasing conifer growth with increasing per cent hardwoods removed (Figure 2). Conifer growth apparently was not related to total hardwood proportion (Figure 2), which suggests that yellow birch is a less formidable competitor than beech or maple.

The variables of conifer growth per cent (Pressler's formula) and conifer net annual increment per unit basal area for individual plots were plotted over four stand factors in order to discover any relation between these factors and the rate of conifer growth, and to indicate increment differences between stands independent of their original conifer differences. Although considerable variation was evident, no relationships were apparent between either variable and the factors of per cent of total basal area removed, and number, basal area and volume of conifers after treatment.

In six of seven stands wherein conifers grew well after treatment, hardwood volumes had been reduced by the treatment to below that of the conifers (Figure 4). This was true in only three of **eight** poor-response stands. Untreated stands registered only small volume increases over the 20 years since treatment (Figure 5) and species proportion changed very little (Table 3).

DISCUSSION

There is little doubt that residual conifers in mixedwood stands benefit from the removal of hardwoods. The question has usually been one of how much benefit to expect from a given effort. The treated stands in this study produced an average of 2.4 cords more conifer volume than untreated stands for the 20-year period following treatment. But more important than this average superiority is the evidence that a careful selection of suitable stands plus the proper treatment could lead to production advantages of up to six cords per acre over a similar period.

An experiment reported by Westveld (1934) on three ½-acre sample plots in the northeastern United States where two consecutive hardwood girdlings were done shows that of the two girdled plots, one produced 47 cu. ft. per acre more red spruce and the second 26 cu. ft. more than the control plot, over a 30 year period since the initial treatment. While the difference between average conifer growth rates for treated and control stands in the study herein is only 12 cu. ft. per acre, the differences between the three best treatment plots and the control average are 59 cu. ft., 46 cu. ft. and 45 cu. ft., which compare favourably with Westveld's data.

The study results provide some guides for determining what stands to treat and what treatment to apply. First, stands with the largest numbers of conifers over one inch d.b.h. should be treated first and seemingly for good results there should be more than 250 conifer stems per acre over one inch d.b.h. Stands with less than 200 conifers per acre should be avoided, or should first be underplanted to raise the conifer stocking level. Second, the girdling or felling of hardwoods should begin with sugar maple and beech and then proceed to less tolerant hardwoods. Third, hardwood volumes should be reduced to a level equal to or below that of the conifers

Additional research, conducted on a sound statistical base, is needed to determine with more precision the amounts of hardwoods which should be removed from stands with varying amounts of conifers. Concurrent studies on minimum and optimum light requirements of spruce and fir seedlings and saplings would be useful.

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Rowe, J.S. 1959. Forest regions of Canada. Canada, Dept. of Northern Affairs and National Resources, For. Br. Bull. 123.

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Table 1. Comparison of Treatment and Control Stands, Per Acre Values, One Inch D.b.h. and Over

	Number of Trees				Basal Area (sq. ft.)				Volume (total cu. ft.)			
	Treated		Control		Treated		Control		Treated		Control	
	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods
Original Stand	336	249	345	227	28	82	30	78	541	2192	526	2101
After Treatment	295	95	345	227	25	22	30	78	461	556	526	2101
Twenty years later*	402	440	297	254	46	43	34	90	944	1003	745	2466

* Treated stands average 21 years later

Table 2. Conifer Growth Comparisons

	Average Study Period Years	Per Cent of Basal Area Removed	Annual Conifer Volume Growth, per Acre		
			Net Cubic Feet	Growth Per Cent	Per Unit Conifer Basal Area
Treated Stands (15 plots, 11.5 acres)	21	58	23	3.2	.92
Control Stands (7 plots, 5.6 acres)	20	0	11	1.6	.37

Table 3. Twenty Year Changes in Species Composition

Conifer Response to Release	Measurement	Per Cent of Total Volume						
		Spruce	Fir	Other Conifers	Yellow Birch	Sugar Maple	Beech	Other Hardwoods
Rapid, Favourable (7 plots)	Original Stand	5	16	1	63	4	1	10
	After Treatment	18	47	4	24	1	0	6
	Twenty Years Later	23	49	3	15	3	1	6
Slow, Unfavourable (8 plots)	Original Stand	3	13	1	46	25	8	4
	After Treatment	8	31	2	32	18	7	2
	Twenty Years Later	9	20	2	32	23	8	6
Untreated Stands (7 plots)	Original Stand	4	16	1	57	8	6	8
	Twenty Years Later	6	16	1	50	11	6	10

Table 4. Comparison of Numbers of Stems for Plots with Favourable and Unfavourable Conifer Response to Release

Conifer Response to Release	Per Cent Hardwood Basal Area Removed	Original Number of Conifers		Original Numbers of Hardwoods	
		Below 0.6" d.b.h.	0.6" d.b.h. and Over	Below 0.6" d.b.h.	0.6" d.b.h. and Over
Rapid, Favourable (7 plots)	82	2,990	492	9,111	104
Slow, Unfavourable; Original Number of Conifers per acre					
< 6,000 (6 plots)	61	1,092	116	19,542	113
> 6,000 (2 plots)	81	8,265	159	9,205	46

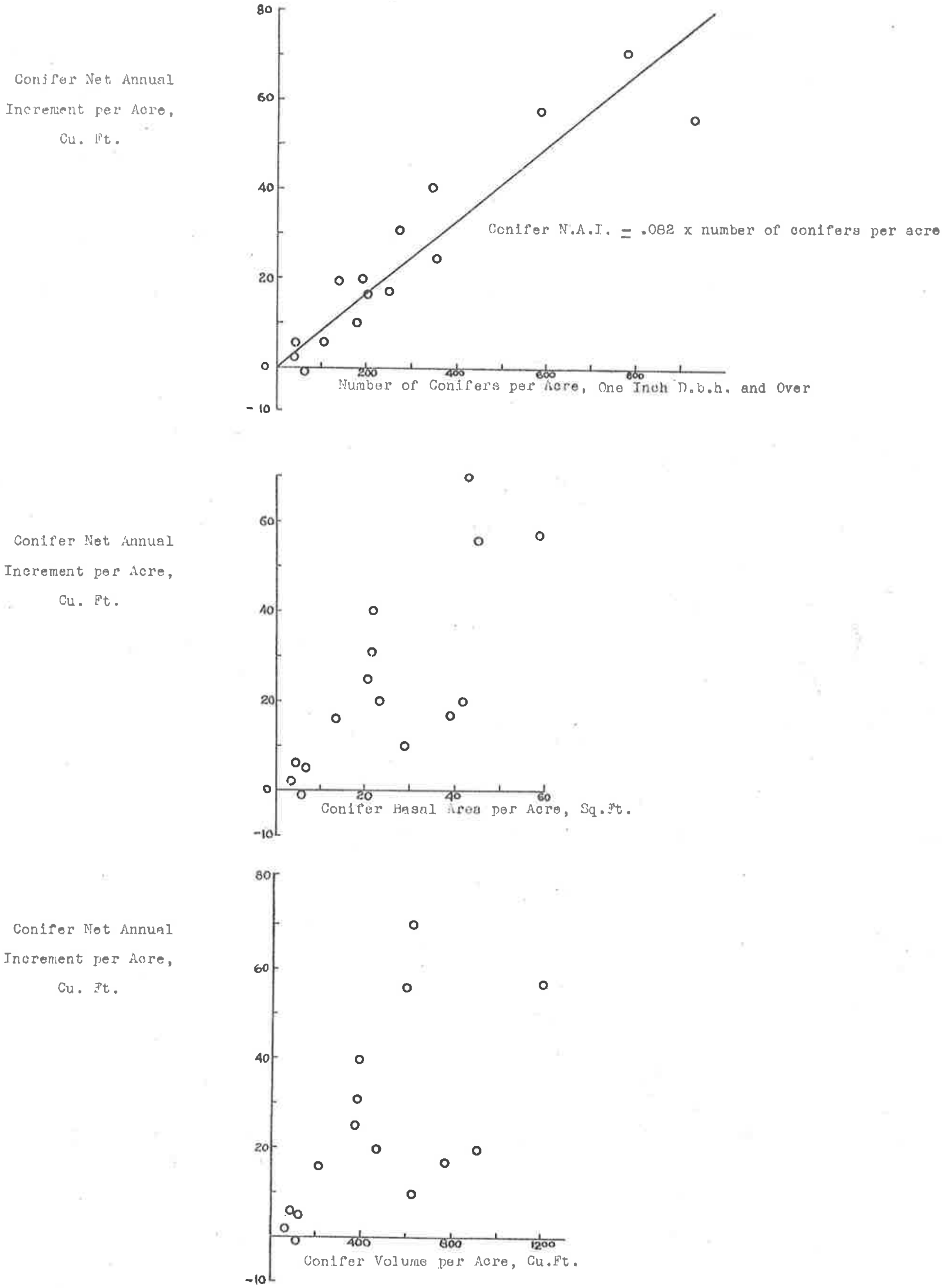
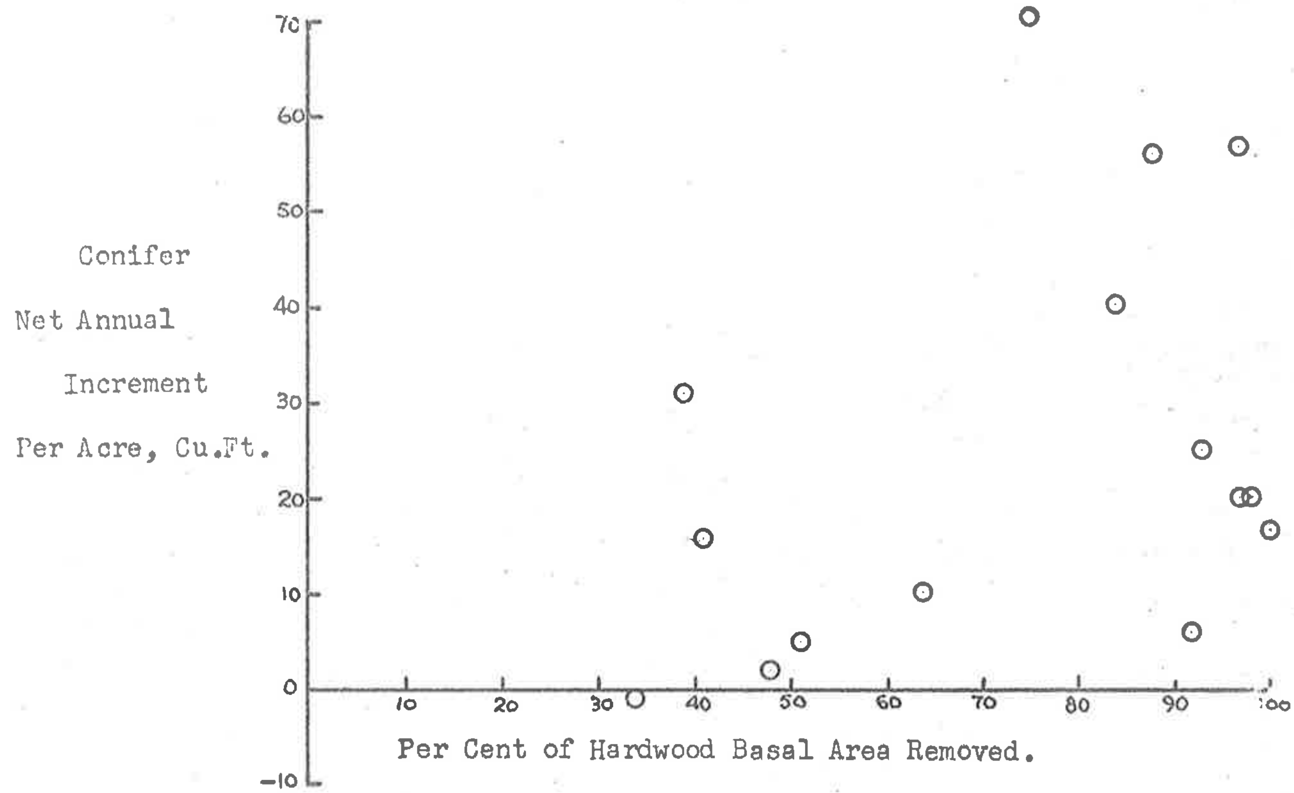


Figure 1 . The relation of conifer net annual increment to various stand factors, for individual treated stands.



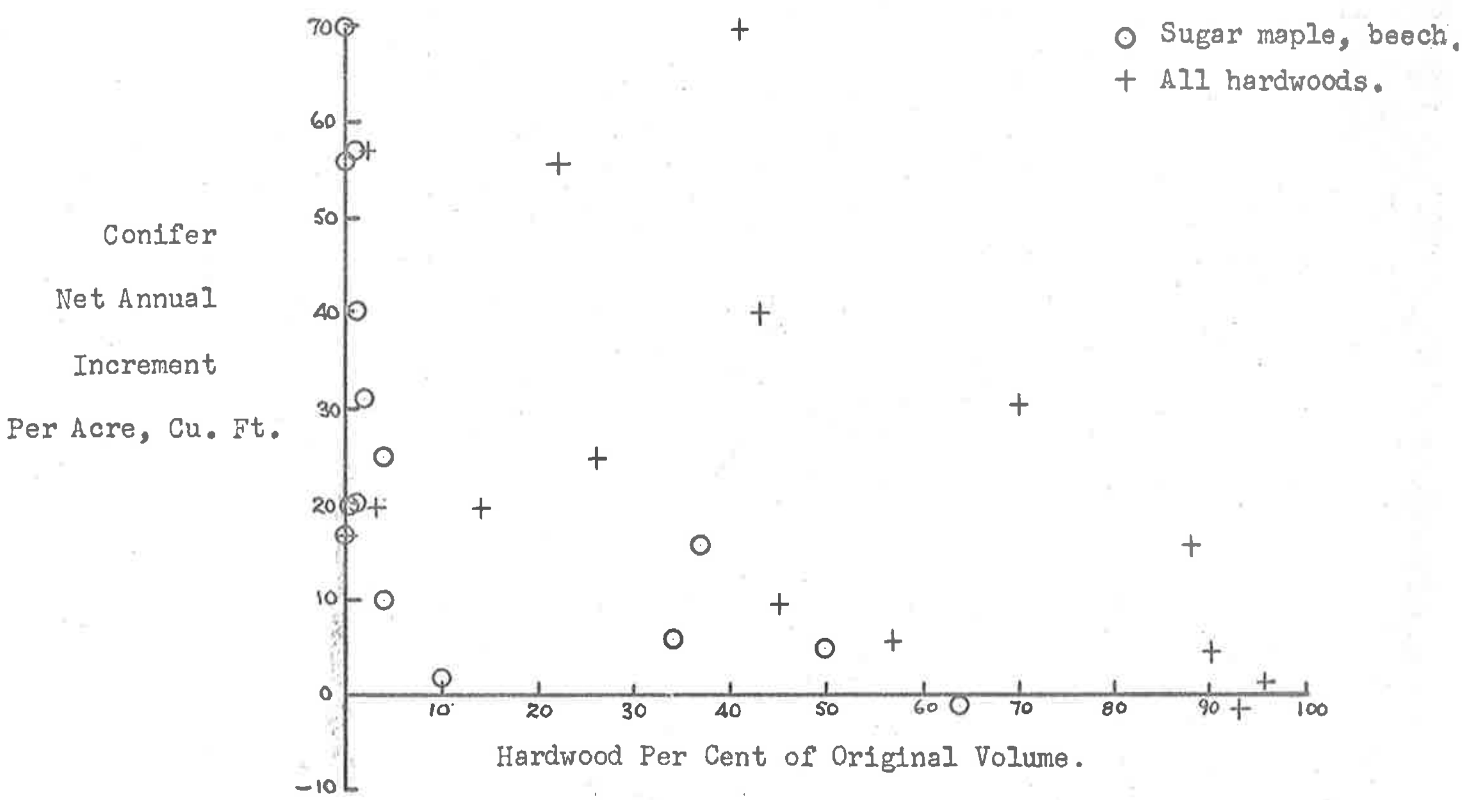


Figure 2. The relation of conifer net annual increment to per cent hardwood basal area removed, and to hardwood per cent of original volume, for individual treated stands.

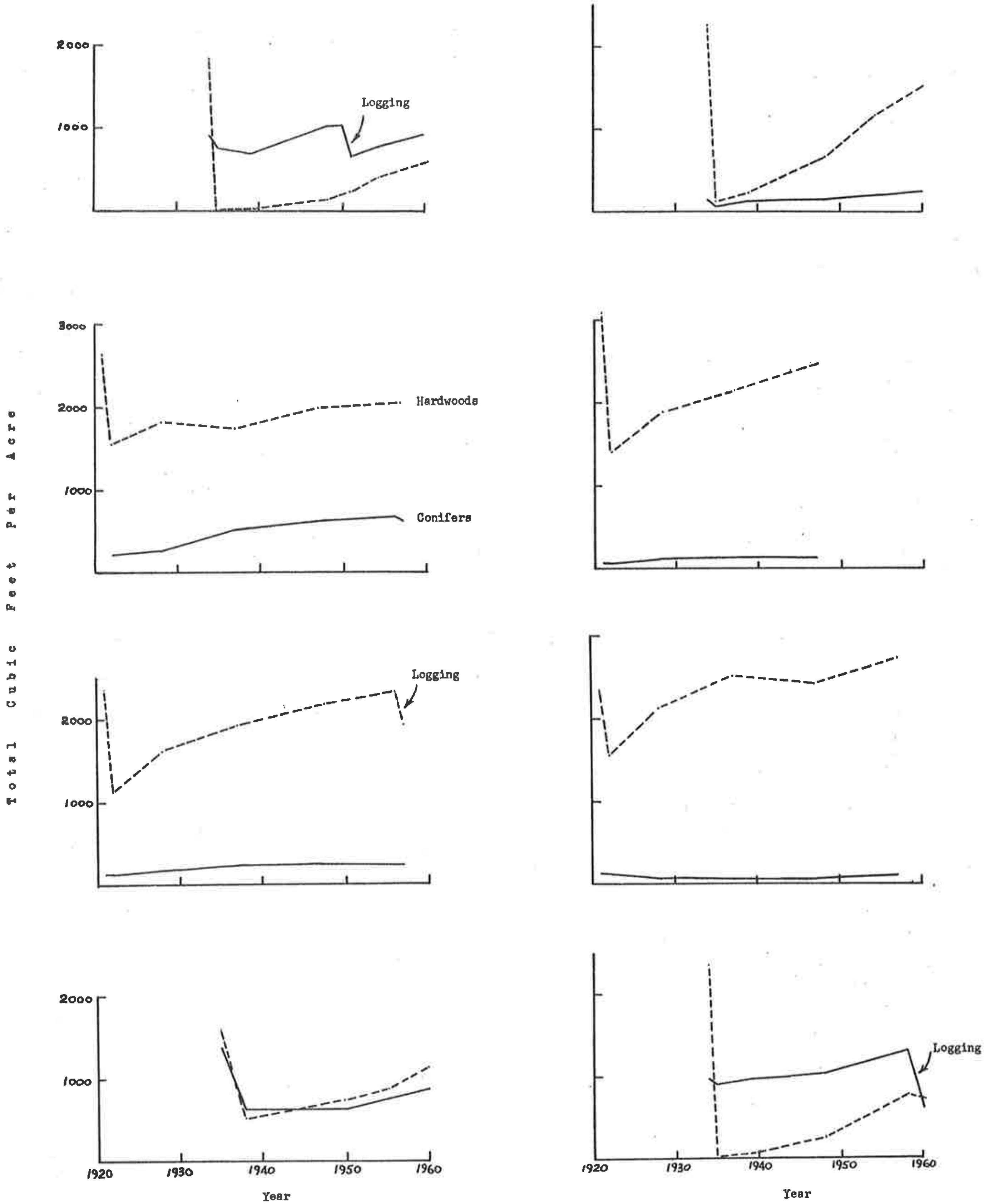


Figure 3. Conifer and hardwood volume changes, 1920-1960, for plots with an unfavourable response to treatment.

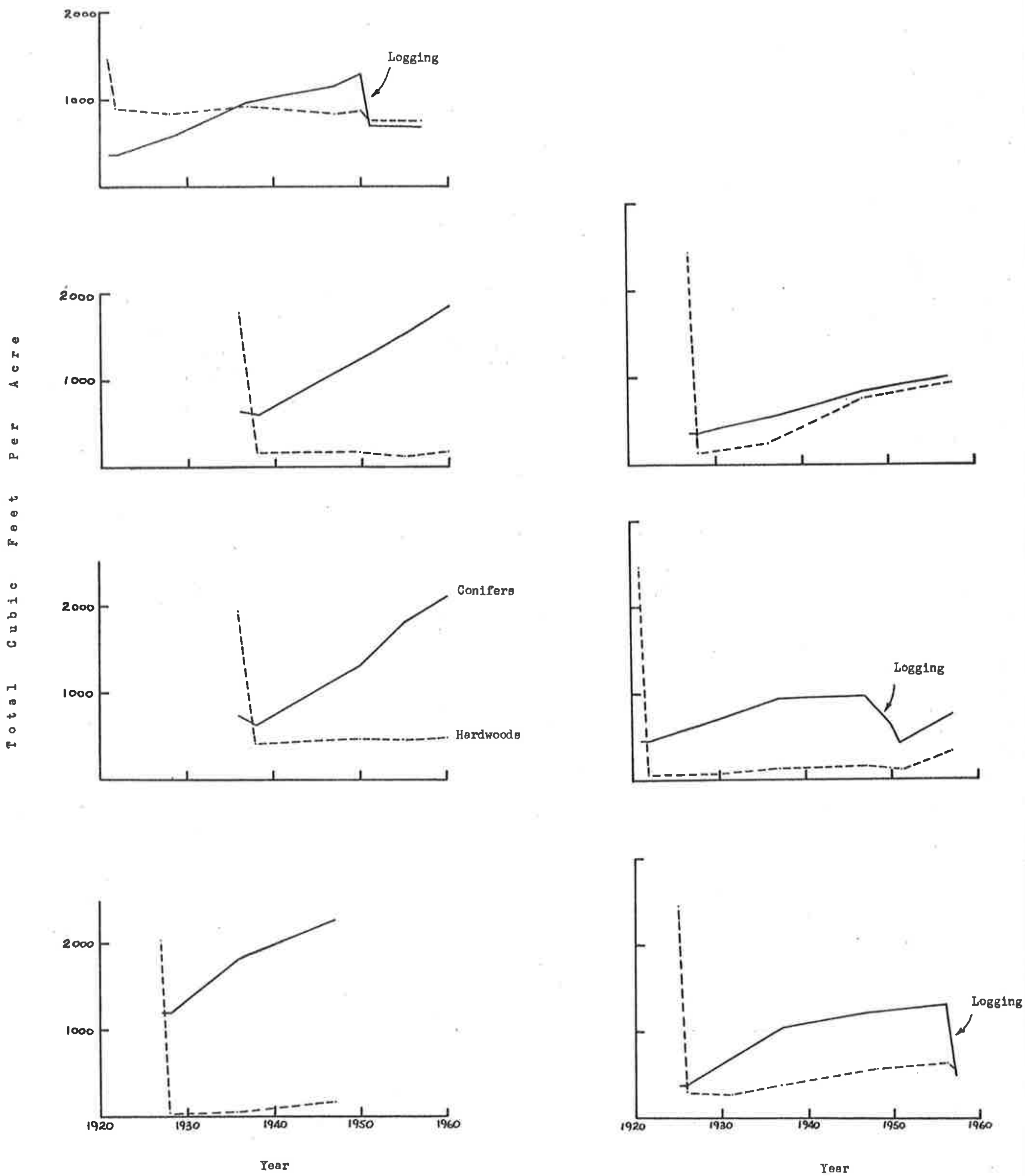


Figure 4. Conifer and hardwood volume changes 1920-1960, for plots with a favourable response to treatment.

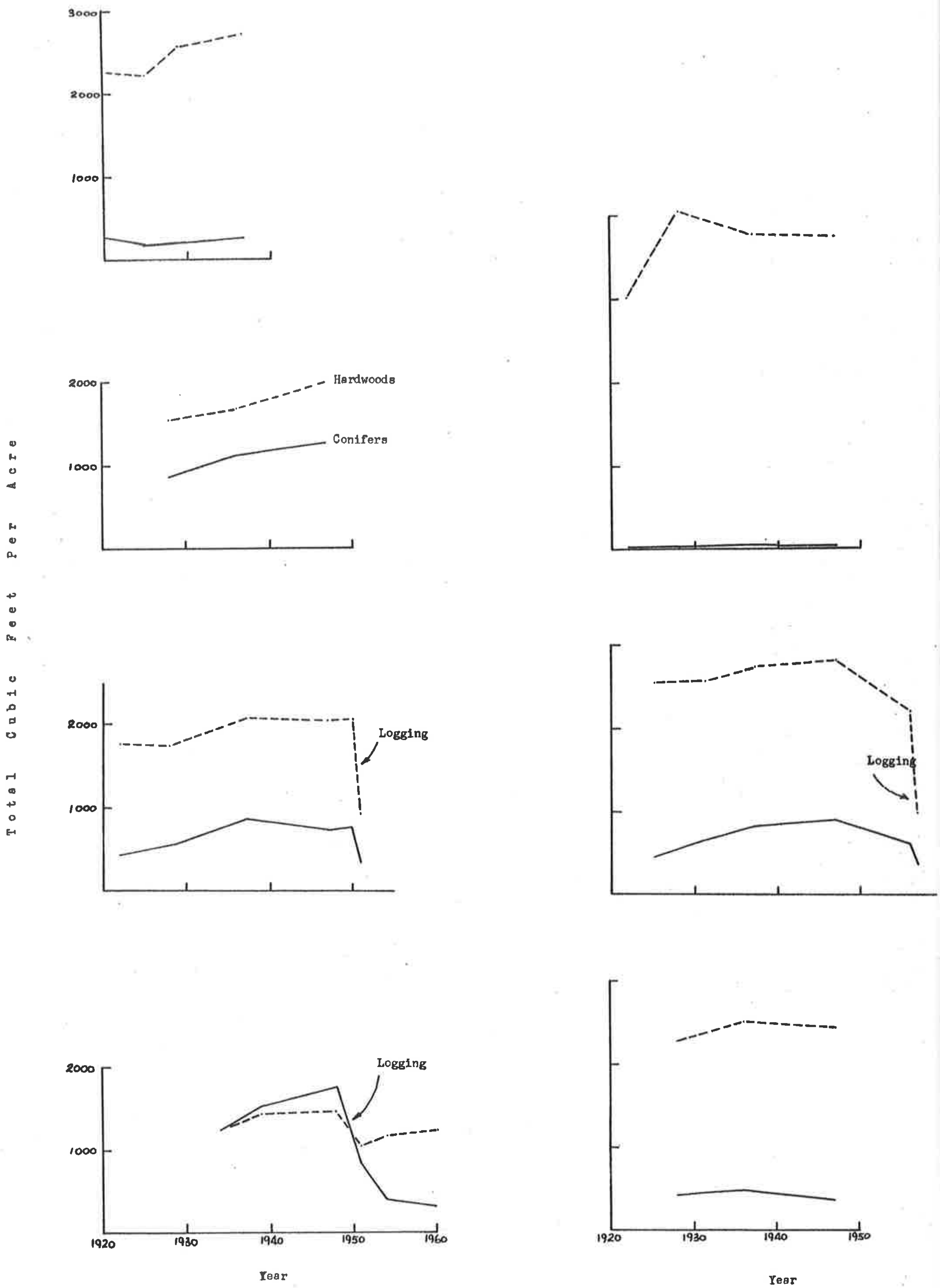


Figure 5. Conifer and hardwood volume changes, 1920-1960, for control plots.