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RESPONSE OF YOUNG FIR AND SPRUCE TO RELEASE FROM SHRUB COMPETITION

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Response of Young Fir and Spruce to Release From Shrub Competition

by

G. L. Baskerville[1]

INTRODUCTION

In 1949 a study of the response of young balsam fir[2] and white spruce to release from shrub competition was established[3] on the Green River Watershed in northwestern New Brunswick (latitude 47°50′N., longitude 68°20′E.). The purpose was to determine (1) the response in height growth of the softwood reproduction to a given level of release; (2) the relation between initial size of the softwood stems, and the degree of response; and (3) the duration of the response. Early results, which showed that height growth of fir doubled in the first four years after release, were reported by Vincent (1954). This paper summarizes results nine years after release.

The area is an upland with elevations between 1,000 and 2,100 feet. The climate is characterized by long, cold winters and short, wet summers. Annual precipitation is 42 inches, of which 18 inches falls between June and September. The frost-free period begins the last week of May and lasts about 110 days. The forest is an association of balsam fir, white spruce, black spruce, white birch, and scattered yellow birch. The principal commercial species is balsam fir.

As a result of stand openings created by pulpwood operations from 1936 and birch dieback from 1940, mountain maple has become widely established on the watershed. In the 10 years after opening up of the forest, mountain maple increases in height at a rate of about a foot a year. It forms a closed canopy some 10 feet above the ground and overtops most softwood advance growth. Maple height growth is variable after this period, and crowns tend to flatten out, rather than increase in height, although individual stems may reach 20 feet in as many years. Deterioration usually follows with the oldest maple dying from the top downwards. However, on good sites the canopy, which shades the smaller softwoods, and both shades and whips the larger, may suppress them for 40 years (Vincent, 1953).

STUDY METHODS

The study consists of two one-acre plots on an upper slope at an elevation of 1,600 feet. The soil is a fresh well-drained silt loam of moderate depth. Such sites support upwards of 20 cords of merchantable softwood per acre at maturity. The area was clear cut in 1941 leaving 46 living, and 63 dead, white and yellow birch on the treated plot and 22 living, and 96 dead, on the untreated. Subsequently, all the large birch have died from dieback.

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[2] Nomenclature as in "Native Trees of Canada", Forestry Branch Bulletin 61.

[3] By Mr. A. B. Vincent, Forestry Officer, at that time on the staff of the Maritimes District Office.

Treatment consisted of removing all shrubs in or overhanging a circle of three-foot radius about each softwood stem. The treated plot was selected randomly and the shrubs removed with axes in September, 1949. On both plots annual height growth from 1946 to 1958, determined by measuring internodes, and total height in 1949 were recorded for all softwoods. Stems over six feet in 1949 were too tall by 1958 to permit measurement of annual growth. For these only total height was recorded. The data presented are based on measurements from 728 fir and spruce on the treated plot and 1,422 on the untreated.

In 1949 the reproduction averaged about 15 years old and ranged from 1 year to 30 years.

On each plot the shrubs were sampled by 155 milacre quadrats. Tallies were made by species in one-foot height classes.

COMPETING SHRUBS

Treatment reduced the number of shrubs from 24,700 to 19,100 per acre (Table 1). On the control plot there were 17,800 stems per acre in 1949. In each instance mountain maple represented about 30 per cent of the shrubs. Treatment had no effect on the height of the shrub stand. The canopy level was nine feet on both plots in 1949. This is the height at which mountain maple (and to a lesser extent the other species) forms a more or less continuous closed canopy.

On this site raspberry is an aggressive invader of openings up to 15 years following cutting after which it is crowded out. The openings created by the release offered ideal conditions of light and humification, and raspberry increased from 11,400 stems per acre in 1949 to 57,700 in 1951. There were also moderate increases in the number of mountain maple, but the influx of raspberry was chiefly responsible for the increase in number of stems from 19,100 in 1949 to 70,500 in 1951 (Table 1).

TABLE 1.—DEVELOPMENT OF SHRUB VEGETATION, 1949 TO 1958

Date	Number of stems per acre (thousands)		Height of canopy (feet)	
	Released plot	Control plot	Released plot	Control plot
1949 before	24.7 (7.4)[1]	17.8 (5.3)	9	9
1949 after	19.1 (6.5)	—	9	—
1951	70.5 (9.7)	20.6 (6.8)	10	10
1953	63.9 (9.0)	23.6 (7.1)	11	11
1958	20.4 (5.7)	8.5 (5.5)	11	11

[1] Numbers in brackets refer to mountain maple. Other shrubs are: red elderberry, serviceberry, currant, and red raspberry.

Mountain maple proved more aggressive than the fir and spruce and by 1951 it and raspberry filled most of the openings. The canopy level then stood at 10 feet on both plots. In 1953 the shrubs had closed in around the released softwoods and numbered 63,900 per acre on the treated plot and 23,600 on the control. The canopy levels had increased to 11 feet.

From 1953 to 1958 there was a marked decrease in the number of raspberry, and a moderate decrease in the number of mountain maple (Table 1). In 1958 the total number of shrubs per acre was 20,400 on the treated and 8,500 on the control plot. The canopy levels remained at 11 feet.

RESPONSE OF BALSAM FIR

In 1949 there were 685 fir on the treated plot and 1,345 on the control; the distribution by size classes was proportionally similar (Figure 1A). Fir averaged 2.0 and 1.8 feet high on the treated and control plots, respectively.

Prior to 1949 annual height growth had been variable on both plots, but showed a general decline. Following release the rate of height growth increased steadily, reaching a peak in 1953 for all height classes, after which it levelled off. However, in 1958, nine years after release, there was no evidence of a slackening in the growth rate which stood at a level five times greater than that of the control (Figure 1B and 1C).

On the control plot height growth continued to decline and was less in 1958 than in 1949.

Developments on the treated plot may be characterized by four periods; a pre-release period of declining height growth from 1946 to 1949, a period of rapidly increasing growth from 1950 to 1952, the peak years from 1953 to 1955, and a period of relatively stable growth from 1956 to 1958. Average height growth for fir of all sizes during these periods was as follows:

	1946 to 1949	1950 to 1952	1953 to 1955	1956 to 1958	1950 to 1958
	Average annual height growth (feet)				
Treated	.22	.44	.67	.64	.59
Untreated	.18	.14	.16	.13	.14
Ratio treated to untreated	1.2	3.1	4.2	4.9	4.2

Although growth fell off slightly in the period 1956 to 1958 on the treated trees, there was a proportionally greater decrease on the controls.

Trees less than one foot in height at release suffered from the intense competition of invading raspberry. These smaller stems did not gain sufficient height to compete successfully and they are still suppressed.

The greatest and most rapid response occurred on trees between one and four feet high at the time of release (Figure 1B and 1D). Height growth increased in proportion with initial size up to a height of about four feet. Above this, although the taller trees had greater average growth rates, there was less variation among height classes.

Height growth on the six- to seven-foot trees fell off the year following release, but increased steadily after 1951 and these taller stems were less affected by the reclosure of the shrubs.

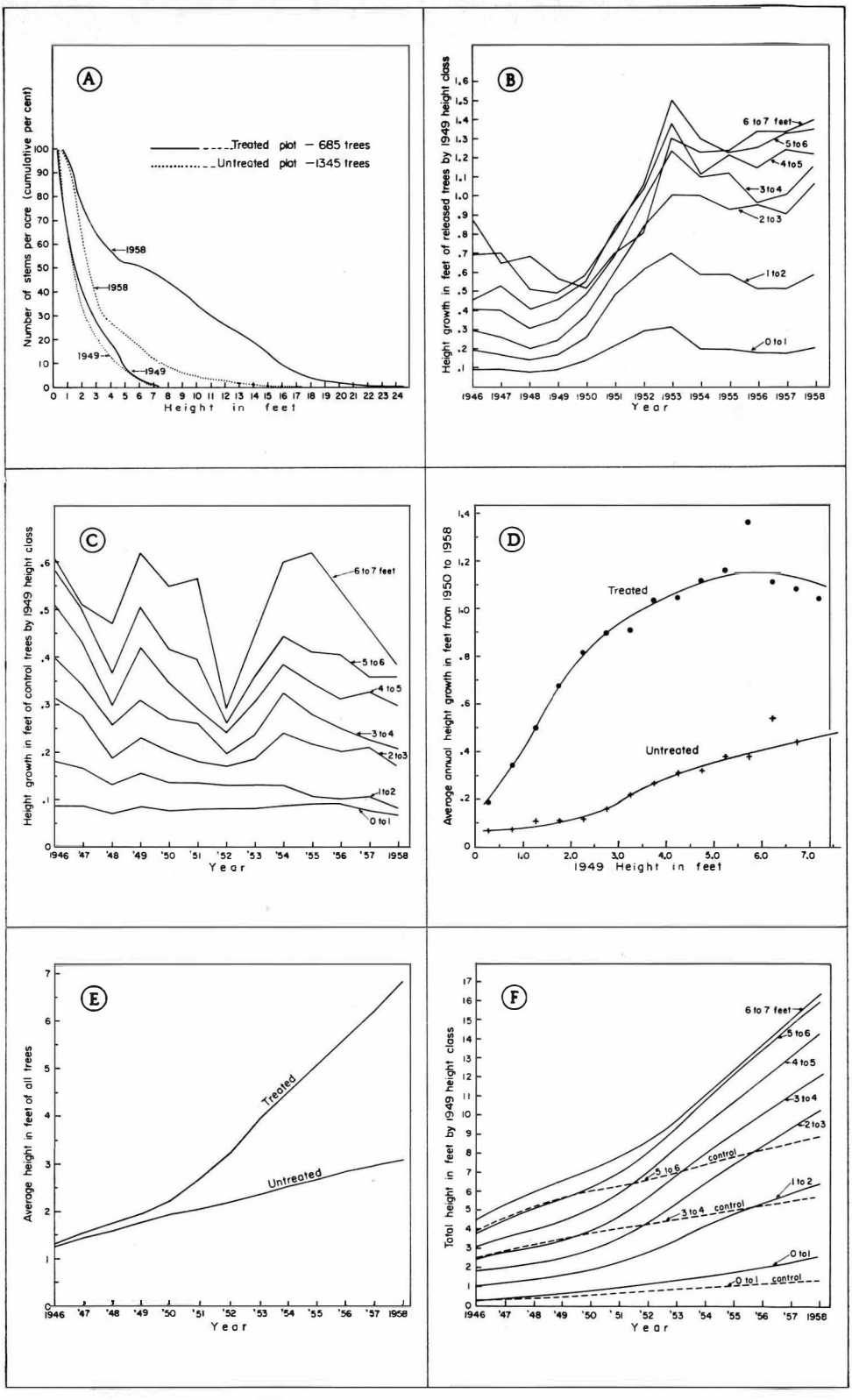

Figure 1. Development of balsam fir.

The average growth of the largest trees (those six to eight feet high at release) was less than for slightly shorter trees (Figure 1D). Early in the experiment it was felt that: (1) this was a result of the small sample of larger trees; (2) such trees had passed their peak of maximum growth; and (3) the tallest trees had roots beyond the cleared radius of three feet and thus did not receive sufficient release from root competition. In 1953, 30 paired fir between six and eight feet in height were chosen for further examination. One tree in each pair (15 in all) was released by removing the shrubs from a radius of six feet.

Height growth on the 15 released trees averaged 0.54 foot in 1953 and 1.06 feet in 1958. The results may be summarized thus:

—	1949 to 1953	1954 to 1958	Ratio
	Average annual height growth (feet)		
Treated (1953)	.46	.72	1.6
Untreated	.44	.42	1.0
Ratio treated to untreated	1.0	1.7	—

The increased growth following the six-foot release was no greater than after the three-foot release (Figure 1). This indicates that growing space was not the limiting factor. These data verify the findings from the plots that the maximum rate of height growth on free-growing (released) fir occurs at a height of about six feet. Thus the steepest part of the height/age curve is in the range five to seven feet (Figure 1F).

On the treated plot the average height increased from 2.0 feet in 1949 to 7.2 feet in 1958; the corresponding change on the untreated plot was from 1.8 to 3.1 feet (Figure 1E and 1F).

By 1958 the proportion of stems in the taller height classes was greatly increased by the release (Figure 1A). On the treated plot the percentage of stems above six feet in height increased from 3 in 1949 to 51 per cent in 1958; on the control the change was from 3 to 18 per cent. In 1958, 30 per cent of the released stems were above the shrub canopy, whereas only 3 per cent of the controls were in this state.

The control plot showed reduced height growth in 1948 and in 1952 (Figure 1C, note scale). In both instances the reductions were most noticeable in the taller, more rapidly growing stems. There were comparable reductions on the treated plot in 1948, but there was only a slight slackening in an increasing growth rate in 1952 and no systematic variation among the height groups. No single explanation can be given for the poorer growth. Two factors which may be related are: (1) short growing seasons occasioned by late spring and early autumn frosts, especially in 1952, and (2) a warm-dry June in 1948 and a cool-wet June in 1952.

RESPONSE OF WHITE SPRUCE

The data for white spruce are from 43 released trees and 77 controls. While this is a much smaller sample than was available for fir, it provides sufficient information on developments to allow comparisons.

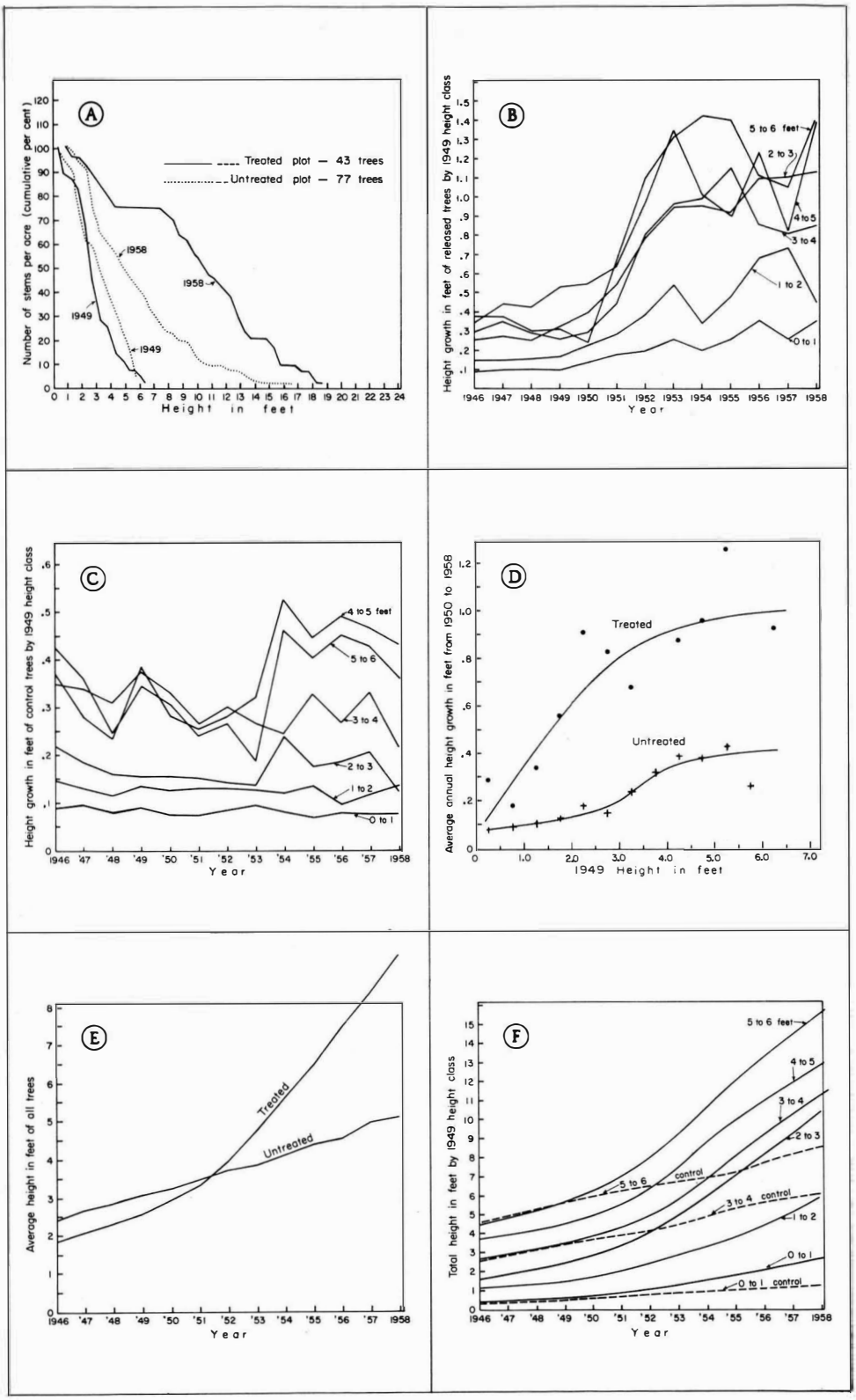

Figure 2. Development of white spruce.

In 1949 the treated plot had a smaller percentage of tall stems than the control (Figure 2A). The average height of spruce was 2.6 and 3.0 feet on the treated and control plots, respectively.

Prior to 1949 the annual height growth of spruce was relatively stable on both plots. Although the spruce did not respond as rapidly to release as fir, their height growth increased steadily up to 1958 (Figure 2A). There was no peak in 1953, such as occurred in fir, although that year did show a decrease in the rate of increase. The general height development was as follows:

—	1946 to 1949	1950 to 1952	1953 to 1955	1956 to 1958	1950 to 1958
	Average annual height growth (feet)				
Treated	.25	.46	.84	.94	.74
Untreated	.23	.20	.24	.25	.23
Ratio treated to untreated	1.1	2.3	3.5	3.8	3.2

The response of trees less than two feet high at release was slow but more or less continuous despite the effects from closure of the shrubs in 1953 (Figure 2B). The most rapid response was on trees three to four feet tall. Larger trees responded less quickly; growth of the five- to six-foot stems decreased the year after treatment.

Owing to the small sample there is considerable scatter in the points from which the curve of average height growth over initial height was derived. However, the data indicate that the greatest relative response was in trees two to three feet high at release. There is also an indication that the maximum rate of growth for free-growing spruce may occur at about six feet (Figure 2D).

The proportion of taller spruce stems was increased as a result of the treatment (Figure 2A). On the released plot the percentage of stems above six feet in height increased from none in 1949 to 75 per cent in 1958 compared to an increase on the control plot from 4 to 40 per cent. In 1958, 45 per cent of the released stems were above the canopy level of 11 feet, whereas only 9 per cent of the controls exceeded this height.

Average total height of the released spruce increased from 2.6 feet in 1949 to 9.6 feet in 1958. The corresponding increase on the controls was from 3.0 to 5.1 feet.

Both treated and untreated spruce showed somewhat poorer height growth in 1948, as did balsam fir. However, neither plot showed evidence of poorer growth in 1952. Data for the controls indicate that there was an increased rate of height growth for the larger spruce during the period 1954 to 1958.

DISCUSSION

Cary (1928) discussed the growth of softwoods under hardwood and shrub canopies and noted that annual height growth on a four-foot fir was increased from 2.5 inches at release to 16 inches three years later. Westveld (1935) in discussing the same problem stated that spruce and fir two to five feet high at release made the best response.

In the present study young fir and spruce increased their height growth when given a three-foot release from competition. The increase occurred in varying degrees for all heights up to eight feet at the time of treatment. In 1958 most of the released trees were as tall as or taller than the maple which overtopped only the smaller stems (Figure 3). However, on the control plot the mountain maple still formed a closed canopy over most of the softwoods (Figure 4).

Initially it was doubted that the softwoods could maintain the increased growth rates in the presence of renewed shrub competition. The results reported here indicate that raspberry invaded the openings the year after release and mountain maple had begun to close in by the second year. Four years after release the shrubs had closed in on the softwoods and were denser than before treatment. Despite this competition the rate of height growth on released fir increased steadily for four years following release before stabilizing at a level several times greater than on the controls. Spruce height growth increased steadily over the period. There is no indication of the increased growth rates falling back towards the level of the controls. Mulloy (1941) found that similarly increased growth rates on larger trees were sustained for at least 16 years.

Balsam fir responded more rapidly to release than did spruce, with the most rapid response on stems between one and four feet high for fir and between three and four feet for spruce. Although fir height growth levelled off when the

Figure 3. Released balsam fir in 1958. The centre stem was the same height in 1949 as the one in the foreground of Figure 4.

shrubs closed in, spruce height growth continued to increase. This was particularly true for the smaller spruce indicating that they are more tolerant to competition than fir. Mulloy (1941) reached the same conclusion. Mulloy also noted that released fir less than 1.5 feet tall died before attaining sufficient height to compete with the hardwoods. In the present study these small fir made some height growth and their numbers were increased.

The greatest relative response was on trees two to three feet high at release. In this range, fir grew six times, and spruce five times faster, than their controls. Although growth on the untreated spruce was greater than that on equivalent untreated fir, released spruce did not grow as fast as equivalent released fir. Thus the relative increase resulting from release was less for spruce than for fir at all heights. This indicates that spruce was growing nearer to its maximum rate before release, again suggesting that it is more tolerant than fir with respect to shrub competition.

There was little variation in the response of released trees over four feet tall in either species. Beyond this point, total height is no longer limiting and the released stems grew at or near the maximum for the site. For both spruce and fir these taller stems are more subject to seasonal fluctuations in height growth.

For fir, initially six to eight feet tall, the response was similar following a release of either three or six feet. That is, for this size class and probably for smaller trees as well, release beyond three feet did not yield additional increases in height growth.

Figure 4. Balsam fir overtopped by mountain maple on the control plot in 1958.

The 1958 frequency curves for fir and spruce both show breaks or points of inflection at about six feet. Apparently once these species reach this height they are in a competitive position relative to the shrubs. The average height of the released fir reached six feet in 1956, seven years after release. At that time some 300 stems were above six feet in height. The control trees will not average six feet in height until some time after 1970 and even with a greater number of stems per acre it will be 1966 before the control plot will have 300 softwood stems above six feet in height.

Released spruce averaged six feet in height in 1955. On the control plot spruce will not reach this height until about 1963.

While the technique of axe cleaning employed in the study has no practical application, one fact stands out; if a young fir or spruce is given a moderate amount of release it will not only increase its rate of height growth but will maintain the increased rate even after the shrubs have closed in again. This indicates that it is not necessary to totally destroy the shrubs. Only the tops need to be killed back for about four years. This will permit the softwoods to increase their rate of height growth and to rise above the shrubs.

SUMMARY

In 1949 all softwood reproduction on a one-acre plot at Green River, New Brunswick, was released by removing the shrubs within three feet of each stem. An untreated plot was observed as a control. The object was to determine the response to release, in terms of height growth, in relation to the initial size of softwoods and shrub competition. For each stem annual height growth was recorded for the nine years following release. Both spruce and fir responded. Height growth increased up to six times that of control stems of the same size. Although shrubs re-occupied the openings in four years, the softwoods continued to grow at the increased rates throughout the study period.

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