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Response of balsam fir and red spruce to release from hardwood competition

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Response of balsam fir and red spruce to release from hardwood competition

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ABSTRACT—Seventeen to 25 years after varying amounts of hardwoods were removed from 15 uneven-aged mixed-wood stands, the average conifer production superiority of thinned over unthinned stands was 2.5 cords per acre; production superiority for the seven best stands was six cords per acre. Several general guide rules for releasing conifers in mixed-wood stands are suggested.

RESUME—Dans 15 peuplements mélangés inéquiennes, situés au Lac Edouard et à Valcartier où l'on avait pratiqué, il y a 17 à 25 ans, différentes intensités d'éclaircies parmi les arbres feuillus, la production en bois résineux des secteurs éclaircis était de 2.5 cordes à l'acre supérieure à celle des secteurs non éclaircis; dans les sept peuplements les plus productifs, la supériorité des secteurs éclaircis s'établissait à six cordes à l'acre. L'auteur suggère plusieurs moyens pouvant servir de guide en vue de dégager les conifères dans de tels peuplements mélangés.

LOGGING for conifer pulpwood and hardwood saw and veneer logs in mixed-wood forests of southern Quebec has often left a residual forest where understory conifers are severely suppressed by low-grade tolerant hardwoods. Many such forests are potentially highly productive but their potential will not be attained unless the silviculturist intervenes. Since very little is known of silvicultural techniques that might improve these forests, the conifer-release study reported here is of considerable value in assessing the benefits possible about 20 years after balsam fir (*Abies balsamea* (L.) Mill.) and red spruce (*Picea rubens* Sarg.) are released from severe hardwood competition. The relationship between spruce-fir response and several stand variables is examined.

The forest

From 1920 to 1928 several small experiments in thinning mixed-wood stands in Quebec were begun at the Lake Edward Forest Experimental Area, and from 1934 to 1936 similar studies were begun at the Valcartier Forest Experiment Station. Both Lake Edward (46°45' N, 72°56'W) and Valcartier (46° 58'N, 71°30'W) 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 Precambrian bedrock is usually 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 should be similar, higher annual temperature and precipitation at Valcartier being balanced by a warmer summer and a longer frost-free period at Lake Edward.

The study included two site types defined by Heimburger (1941). On upper slopes, the Viburnum-Oxalis mixed-wood forest is about 75 per cent sugar maple (*Acer saccharum* Marsh.), yellow birch (*Betula alleghaniensis* Britt.) and beech (*Fagus grandifolia* Ehrh.) and 25 per cent red spruce, balsam fir, and scattered white pine (*Pinus strobus* L.). The Oxalis-Cornus type that occupies the middle and lower slopes averages 60 per cent fir and red spruce, 30 per cent yellow birch and small amounts of white spruce (*Picea glauca* (Moench) Voss), red maple (*Acer rubrum L.*), sugar maple, beech and white birch (*Betula papyrifera* Marsh.).

The Lake Edward area was logged twice prior to establishment of the sample plots, about 1890 for white pine and spruce sawlogs and again in 1910-12 for pulpwood. In these two operations, 9.9 cords per acre were cut from the Oxalis-Cornus type (60 per cent of the area) and 4.6 cords from the Viburnum-Oxalis (20 per cent of the area). At Valcartier, the forest was privately owned until 1914 and fuel wood and sawlog cutting occurred in the study area. 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.

Method of study

Five experiments comprising 17 permanent plots were established at Lake Edward, and two experiments comprising eight plots were established at Valcartier. Two of the 25 plots were not used because of incomplete data, and one plot was rejected because of an abundance of aspen. The square or rectangular plots varied in size from 0.24 to 1.03 acres. The total area of 15 treated plots was 11.5 acres, and seven control plots covered 5.6 acres. Average number of trees and volume per acre before treatment were very similar for treated and control stands (Table I).

Stand treatment consisted in releasing the spruce and fir understory by girdling or felling of hardwoods. The average reduction in hardwood volume was 75 per cent (Table I) with a reduction range in treated stands from 35 to 100 per cent. The original proportion of conifers varied from one to 55 per cent. Small numbers of spruce and fir were broken or uprooted during the removal of hardwoods. This loss resulted in slightly lower post-treatment conifer values on treated than on control plots.

Each experiment contained one control stand and two or three treated stands in which different amounts of hardwoods were girdled or felled. A preliminary examination of individual experiments indicated that none of them were large enough to justify a separate analysis, and it was decided to combine the experiments. The same

TABLE I *Comparison of treated and control stands, per acre values, one inch d.b.h. and over.*

	Number of Trees				Volume (total cu. ft.)			
	Treated Stands		Control Stands		Treated Stands		Control Stands	
	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods	Conifers	Hardwoods
Original Stand	336	249	345	227	541	2192	526	2101
After Treatment	295	95	345	227	461	556	526	2101
Per Cent Reduction	*12*	*62*	*0*	*0*	*15*	*75*	*0*	*0*

preliminary examination revealed little difference between the girdling and felling treatments and they are not discussed separately.

The measure of success of the treatments is the degree of increased spruce and fir volume growth. Calculation of average annual conifer growth rates for treated and control plots revealed that growth was greater on treated plots. However, examination of increment for individual plots showed a wide variation in response (Table II). In order to investigate these response variations, the treated plots were arbitrarily grouped into two conifer-response categories—1) satisfactory, net annual conifer increment 20 cubic feet or more per acre, and 2) unsatisfactory, net annual conifer increment less than 20 cubic feet per acre.

To permit comparison of plots with unequal study periods, average annual conifer increment per plot was multiplied by 20 years, the average length of the study periods.

Results

Clearly the removal of large

TABLE II *Individual sample plot data.*

Sample Plots	*Years in Study Period*	*Conifer Increment, Total Cu.Ft./Acre*	*Annual Conifer Increment Total Cu.Ft./Acre*	*No. of Conifers per Acre One Inch d.b.h. and Over after Treatment*	*Volume Proportion of Sugar Maple plus Beech after Treatment, Per Cent*	*Volume Proportion of Total Hardwoods after Treatment, Per Cent*
Treated — Satisfactory Response						
1	19	1089	57	558	0.5	2.3
2	25	498	20	190	0	13.7
3	20	842	42	343	1.2	43.2
4	19	467	25	352	4.0	25.6
5	25	770	31	272	2.4	70.1
6	17	1197	70	776	0	41.3
7	17	925	54	926	0	32.2
Sub-total	142	5788				
Treated — Unsatisfactory Response						
8	20	112	6	42	33.6	57.0
9	20	301	15	135	.8	3.3
10	17	282	17	248	.1	.1
11	17	169	10	179	4.2	45.0
12	25	134	5	103	50.0	91.4
13	25	−23	−1	62	64.5	93.4
14	25	58	2	40	9.9	95.9
15	25	424	17	198	36.8	88.1
Sub-total	174	1457				
Grand Total	316	7245				
Control						
16	25	336	13	338	1.1	75.2
17	17	3	0	217	45.7	90.8
18	25	28	1	18	17.7	98.8
19	20	450	22	284	4.6	75.9
20	19	−53	−3	164	16.7	87.1
21	19	402	21	765	6.7	61.1
22	17	365	21	631	5.1	56.3
Total	142	1531				

TABLE III *Annual and 20-year conifer volume increment, total cubic feet per acre.*

	Treated Stands			Control Stands
	Satisfactory Response (Plots 1–7)	*Unsatisfactory Response* (Plots 8–15)	*Average Response* (Plots 1–15)	(Plots 16–22)
Average Annual Conifer Volume Increment.......	41	8	23	11
Average Conifer Volume Increment, 20 years.........	820	160	460	220

TABLE IV *Number of stems for plots with satisfactory and unsatisfactory conifer response to release.*

	Original Number of Conifers per Acre		*Original Number of Hardwoods per Acre*	
Conifer Response to Release	*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*
Satisfactory (Plots 1 – 7).........	2,990	492	9,111	104
Unsatisfactory (Plots 8 – 15)				
Original Number of Conifers per acre				
<6,000 (6 plots).....	1,092	116	19,542	113
>6,000 (2 plots).....	8,265	159	9,205	46

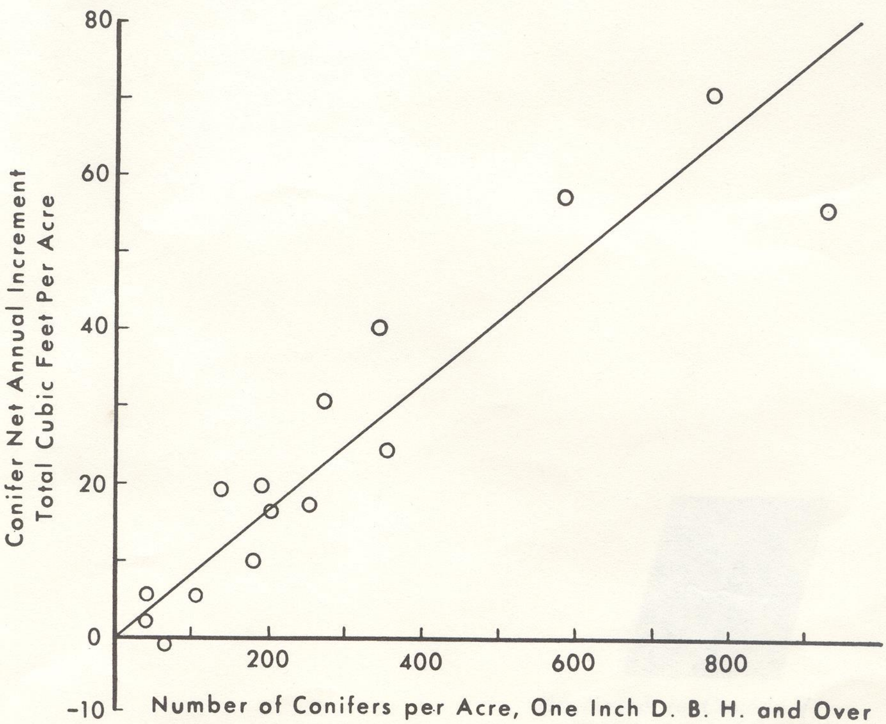

Fig. 1. The relation of conifer net annual increment to numbers of conifers per acre — treated stands.

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 240 cubic feet per acre (Table III), equivalent to a merchantable volume of about 2.5 cords. However, the seven stands classed as satisfactory produced an average of six cords more than untreated stands over the same period.

With two exceptions, satisfactory response stands averaged three times as many conifers and only half as many hardwoods as unsatisfactory stands (Tables II, IV). The poor response of the two exceptions is probably ascribable to the relatively few (159) conifer stems 0.6 inch d.b.h. and over as compared with the 492 such stems on satisfactory response plots, as a strong trend of increasing conifer growth with greater number of conifer stems per acre was discovered (Fig. 1).

Satisfactory response stands had smaller proportions of sugar maple and beech than unsatisfactory stands (Table II) and a trend of increasing conifer growth with decreasing proportion of sugar maple and beech was evident (Fig. 2). Conifer growth apparently was not related to the proportion of total hardwoods which suggests that yellow birch was a less formidable competitor than beech or maple.

In six of seven satisfactory stands, hardwood volumes had been reduced by the treatment to less than the volume of conifers. This thinning intensity occurred in only three of eight unsatisfactory stands (Table II).

Discussion

There is little doubt that residual conifers in mixed-wood 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 about 2.5 cords more conifer volume than untreated stands for an average 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 increase production by as much as six cords per acre over a similar period.

The results provide some guides for stand and treatment selection to maximize conifer increment. First, stands with the largest number of understory conifers should be given priority; apparently good results are obtained in stands with more than 250 conifer stems per acre over 0.6 inch d.b.h. Second, the girdling or felling of hardwoods should begin with sugar maple and beech and then, if necessary, proceed to less tolerant hardwoods. Stands containing only birch as the hardwood component should be avoided. Third, hardwood volumes should be reduced to a level equal to or below that of the conifers.

Releasing conifers from competition by felling hardwoods could be a valuable technique in woodlot management where low quality hardwoods can be utilized or sold. But conifer release by felling or girdling would be prohibitively expensive on large holdings under present economic conditions. Where low quality hardwoods have no markets, they could probably be

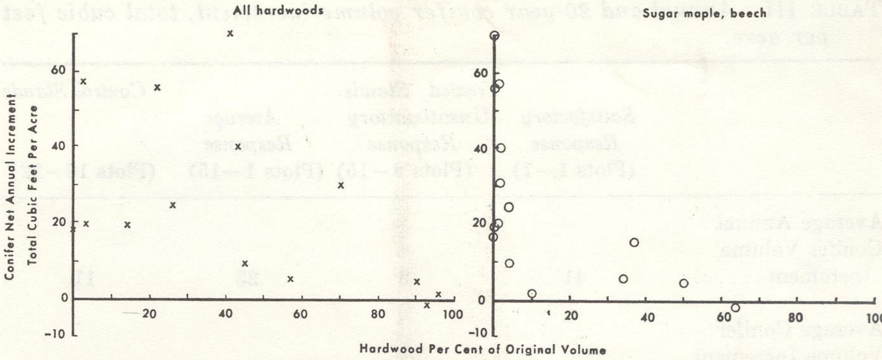

Fig. 2. The relation of conifer net annual increment to hardwood per cent of original volume — treated stands.

killed by aerial application of herbicides which recent information suggests would cost about $5 per acre. Increased conifer yields of up to six cords per acre in 20 years for an initial expenditure of $5 is an investment possibility that merits its attention.

References

HEIMBURGER, C. C. 1941. Forest site classification and soil investigation on Lake Edward Forest Experimental Area. Canada, Dept. of Mines and Resources, Silv. Res. Note No. 66.

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