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RELEASE OF WHITE SPRUCE FROM ASPEN COMPETITION IN ALBERTA'S SPRUCE-ASPEN FOREST

by
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Sommaire en français

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ABSTRACT

Ten-year remeasurement of white spruce stems released from aspen competition in Alberta's spruce-aspen forest indicated that over a wide diameter and age range, growth of spruce increased significantly after treatment. Trees above a 5-inch breast height diameter limit increased in mean merchantable cubic foot volume by 20-40 per cent. Release of spruce from aspen competition should be carried out before the spruce grows into the aspen overstorey. Poisoning cut aspen stumps with ammonium sulphamate prevents regrowth of aspen suckers and sprouts.

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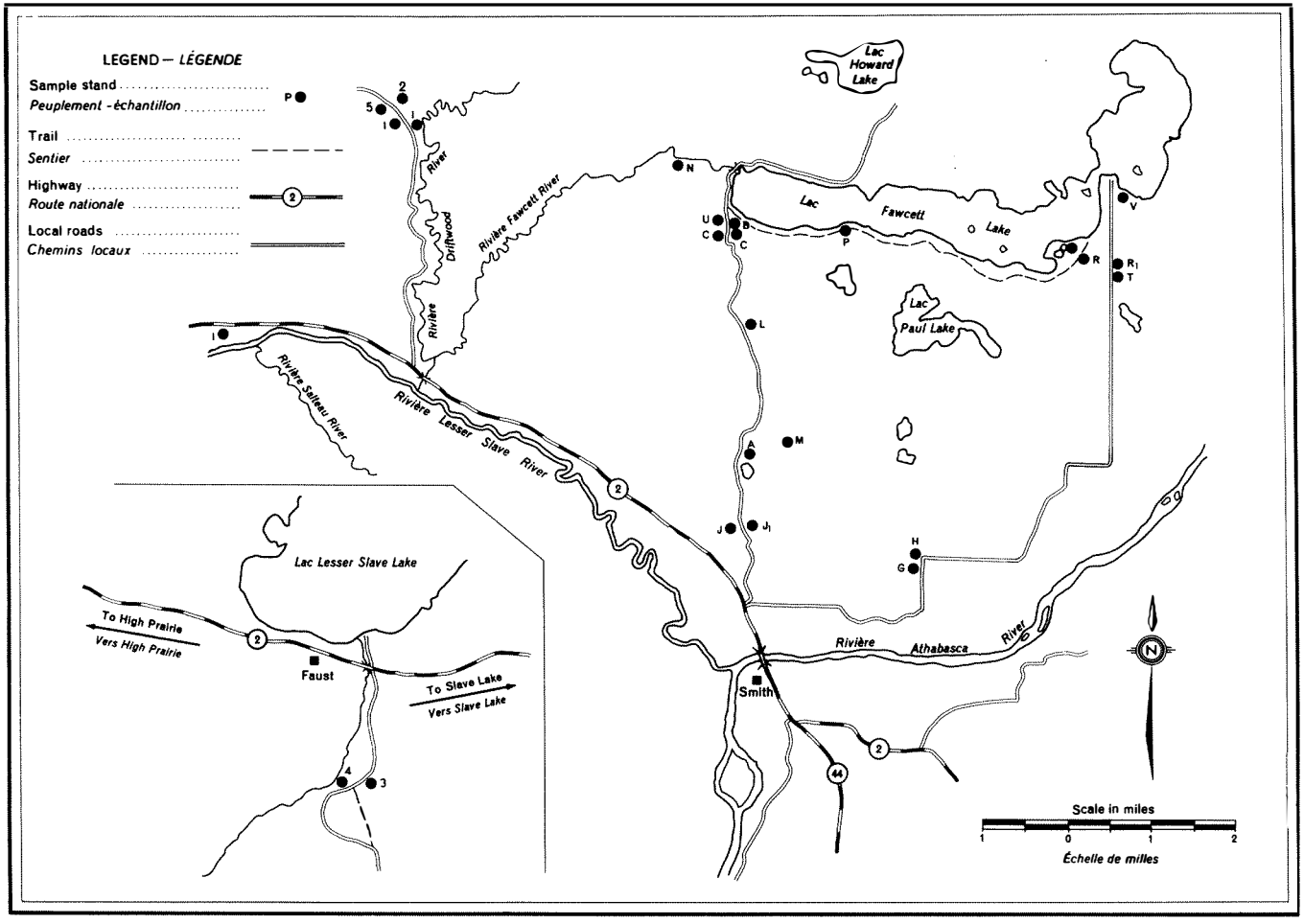

FRONTISPIECE. Sample stand locations

FRONTISPICE. *Localisation des peuplements-échantillons*

Release of White Spruce from Aspen Competition in Alberta's Spruce-Aspen Forest

by

J. C. LEES[1]

INTRODUCTION

Two-storied stands are typical of the spruce-aspen forest in Alberta. The aspen, a vigorous pioneer species, forms the overstorey for most of the natural rotation of the stands. When 55 to 75 years old the spruce grows through the overstorey as the older aspen goes into an increasingly decadent stage. During this stage mechanical damage to spruce crowns is a factor added to competition for crown space and root space. Recent studies from Manitoba (Steneker 1963) illustrate that the spruce at age 50 shows a definite response to release over a wide diameter range and that a valuable increase in merchantable spruce volume results. However, it is not known how early competition for the commercially important spruce begins, or how late the spruce will respond to release from aspen. This report deals with the results of a release study, initiated by J. Quaite[2] in 1951. Selected spruce stems under an aspen canopy were released and control stems were selected. Remeasurement in 1956 was carried out by G. Ontkean[2] (Ontkean and Smithers, 1959). The current remeasurement was carried out by the writer in 1962.

DESCRIPTION OF THE AREA

Location

Spruce-aspen stands of varying age were selected for this study within a 30-mile radius of Smith, Alberta, 55° 10′N. 114° 01′ W., in the B-18a Mixedwood Section of the Boreal Forest Region (Rowe 1959). Sample stand locations are shown in the Frontispiece. The terrain is gently rolling. There are distinct low ridges and wide shallow depressions with grassy sloughs and seasonal watercourses. Physiography derives from extensive glacial deposits, lacustrine deposits from the Lesser Slave Lake basin, and from the recent river action in the Athabasca, Lesser Slave, Salteau and Fawcett river drainages.

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Forest

The forest is white spruce (*Picea glauca* (Moench), Voss) and aspen (*Populus tremuloides* Michx.), of fire origin. Balsam poplar (*Populus balsamifera* L.) and black spruce (*Picea mariana* (Mill.) BSP) occur with white spruce and aspen on depressions. Occasional white birch (*Betula papyrifera* Marsh.), jack pine (*Pinus banksiana* Lamb.) and larch (*Larix laricina* (Du Roi) K. Koch) are found throughout the stands. In the sample stands selected for this study, aspen was the main stand component and was generally 10 to 20 years older than the understorey.

Soils

Soil textures range from stony sandy loams to heavy clays. Ridges and upper slopes are well drained. A shallow gley horizon prevails in the depressions. A layer of raw humus varying from 2 to 3 inches on upland soils to more than one foot on wet bottomland overlies the soil profile. The soils on well-drained glacial tills resemble Braeburn soils and have a well-defined leached A_e layer and a dark brown clayey B_t horizon over a calcareous parent material; depressional podzolic soils with heavy clay B_t horizon, and gleying often close to the surface, resemble the Snipe soils; and the ponded stratified silts and clays resemble the Kathleen series as described by Odynsky, Wynnyk and Newton (1952).

Sample Stands

Brief descriptions of the sample stands are presented in Table 1.

Table 1. Sample stand description

Tableau 1. Description du peuplement étudié*

Stand *Peuplement*	Average age (1962) White sp. *Âge moyen en 1962 Épinette blanche*	Aspen *Peuplier faux-tr.*	Parent material *Roche-mère*	Soil texture *Texture du sol*	Drainage *Égouttement*
A	45	56	Lacustrine	Silty Clay	Moderate
B	45	56	Till, Fresh	Clay Loam	Moderate
C	45	56	Till, Moist	Clay	Mod./Slow
G	25	30	Till, Moist	Clay	Slow
H	35	40	Till, Fresh	Clay Loam	Moderate
I	45	56	Recent Alluvium	Silt	Mod./Rapid
J	45	56	Waterwashed Till	Sandy Loam	Mod./Rapid
L	15	20	Lacustrine	Sandy Silt	Mod./Rapid
M	45	56	Waterwashed Till	Sandy Loam	Mod./Rapid
N	65	85	Recent Alluvium	Silt	Moderate
P	15	20	Till, Fresh	Clay Loam	Moderate
Q	35	43	Till, Moist	Clay	Mod./Slow
T	35	43	Till, Fresh	Clay Loam	Moderate
U	75	99	Till, Fresh	Clay Loam	Moderate
V	45	56	Till, Fresh	Clay Loam	Moderate
1	65	77	Till, Moist	Clay Loam	Moderate
2	35	44	Till, Fresh	Clay Loam	Mod./Rapid
3	55	63	Recent Alluvium/ Till (variable)	Silt/Clay Loam	Mod./Slow
4	25	39	Till, Moist	Clay Loam	Moderate
5	65	81	Till, Moist	Clay Loam	Moderate

* Termes descriptifs employés dans le tableau. Clay: *argile;* Clay Loam: *limon argileux;* Lacustrine: *lacustre;* Moderate: *modéré;* Mod./Rapid: *modéré à rapide;* Mod./Slow: *modéré à lent;* Recent Alluvium: *alluvions récentes;* Sandy Loam: *limon sableux;* Sandy Silt: *limon siliceux fin;* Silt/Clay Loam: *limon argileux;* Silt: *limon;* Silty Clay: *argile limoneuse;* Slow: *lent;* Till, Fresh: *till frais;* Till, Moist: *till humide;* Till (variable): *till variable;* Waterwashed Till: *till lessivé.*

METHODS

In 25 stands a total of 333 spruce stems were individually released from aspen competition and 323 were left as controls covering the same age and diameter range.

The following treatment was carried out in 1951 and 1952:

Individual spruce trees having only aspen competition were subjectively selected and all competition within a radius of twice the crown width of the treated spruce trees was removed by cutting. A minimum radius of 8 feet regardless of crown width was applied. To prevent aspen suckering and root competition, all aspen stumps were treated with "ammate" crystals, (ammonium sulphamate).

In each stand, control trees comparable to the treated spruce in d.b.h., age, and height were selected. Spruce sample trees were tagged, d.b.h. and total height were measured. Below 0.8 inches d.b.h. only height measurements were taken. All aspen and other species within a radius of twice the crown width of each spruce sample tree were mapped and their diameter and height recorded. The treated stands were segregated into three broad site classes; good, medium, and poor, as defined by site index curves (MacLeod and Blyth, 1955) for spruce.

good—80 feet at 80 years
medium—70 feet at 80 years
poor—60 feet at 80 years.

A spruce sample tree is shown in Figures 1 and 2 before and after release.

Results of the 1956 remeasurement showed that all ages and diameters of spruce had responded to release but no differences were revealed between site index classes. It was then decided to reclassify the stands on a physiographic site basis using the classification developed for the region by J. Quaite.[1]

By 1962 many of the stands had been lost to road construction and fire. However, a total of 461 stems were located in 20 stands and remeasured that year. The distribution of the treated stems by age and diameter classes is shown in Tables 2A and 2B. Distribution of control stems was almost identical—235 treated and 226 control stems were measured. The data for 10 years' growth were processed using IBM data cards and diameter and height increment of released and control trees were analysed using "t" tests[2].

Table 2A. Distribution of treated spruce sample trees by age and 2" classes—1952

Tableau 2A. Répartition d'épinettes-échantillons traitées, par classes d'âge et par classes de diamètre de 2"—1952

Age Class *Classe d'âge*	2 inch breast height diameter classes *Classes de 2 pouces de diamètre à hauteur de poitrine*								Grand total
	<0.8"	1–2	3–4	5–6	7–8	9–10	11–12	13–14	
0–10	21								
10–20	43								
20–30	71	26	5						
30–40	46	46	14						
40–50			3	4	6	6	1		
50–60			1	8	15	8	3		
60–70					2	2	1	1	
Total	181	72	23	12	23	16	5	1	333

[1] Quaite, J. 1953. The evaluation of site in the Mixedwood Section of Northern Alberta. Canada, Department of Resources and Development, Forestry Branch. Unpubl. MS.

[2] Analysis of data using appropriate "t" tests was carried out by T. G. Honer and the staff of the Data Processing Unit, Department of Forestry of Canada, Ottawa.

FIGURE 1. Spruce sample tree before release
Échantillon d'épinette, avant dégagement

FIGURE 2. Spruce sample tree after release
Échantillon d'épinette, après dégagement

Table 2B. Distribution of treated spruce sample trees by age and 2" classes—1962

Tableau 2B. Répartition d'épinettes-échantillons traitées, par classes d'âge et par classes de diamètre de 2"—1962

Age class *Classe d'âge*	2 inch breast height diameter classes *Classes de 2 pouces de diamètre à hauteur de poitrine*										Grand total
	<0.8"	1–2	3–4	5–6	7–8	9–10	11–12	13–14	15–16	17–18	
0–10.....	14	8	1								
11–20.....	18	19	3	3							
21–30.....	14	20	17	9							
31–40.....	2	17	21	14	3						
41–50.....					1	1	3	4	1		
51–60.....				1	1	5	8	11	3	1	
61–70.....					1	2	7	2			
Total.....	48	64	42	27	6	8	18	17	4	1	235

RESULTS

Curves of average annual diameter increment for treated and control stems are shown in Figure 3 for the periods 1952-56 and 1957-62. The effect of release on diameter increment has been sustained over the second five-year period. The differences between released and control stem values are significant at the 5 per cent probability level. Periodic diameter increment values for the 1962 remeasurement were plotted over the logarithm (base 10) of breast height diameter and the straight line regressions for released and control stems were developed using the weighted means for each diameter class. The regressions are presented in Figure 4. The difference between released and control stem regressions is distinct and the equations will be used in future comparisons.

Mean values of diameter increment are presented for each diameter class in Table 3 and for each age class in Table 4. The results of the "t" tests are indicated in these tables and they substantiate the trends observed in the graphical presentation. These values include all sites. In Figure 5 curves of diameter increment per cent are presented by age classes. Pressler's formula gives growth per cent based on the mid-period diameter. The greatest release occurs in the 20 to 40 year age class.

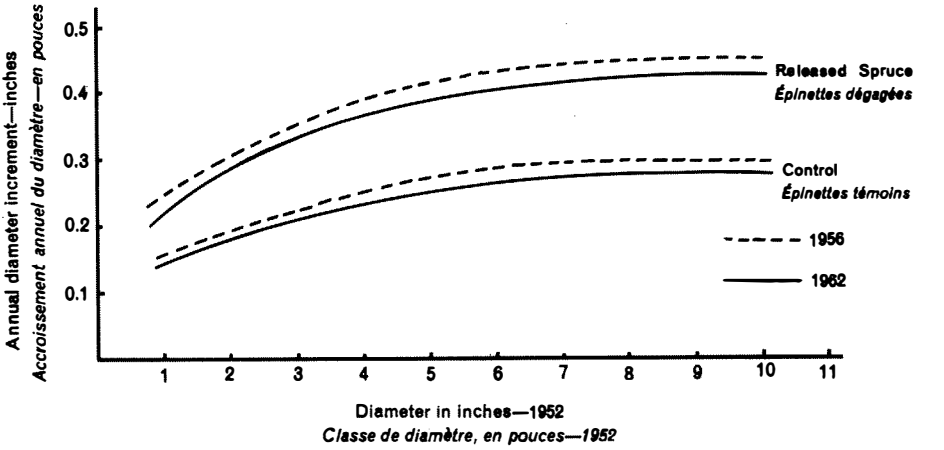

FIGURE 3. Average annual diameter increment 1952–1956 and 1957–1962 (sites and age classes combined)
Accroissement annuel moyen du diamètre, 1952–1956 et 1957–1962 (stations et classes d'âge combinées)

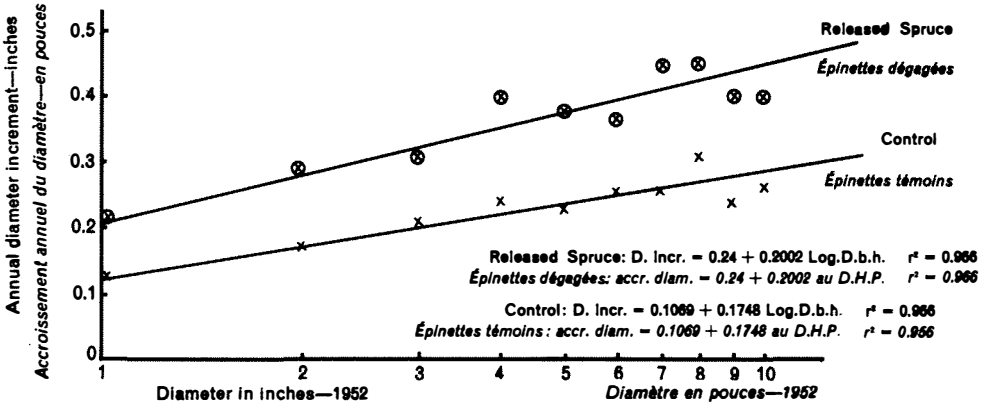

FIGURE 4. Periodic annual diameter increment 1952–1962 related to log d.b.h.
Accroissement périodique annuel du diamètre, 1952–1962, par rapport au D.H.P. de la bille

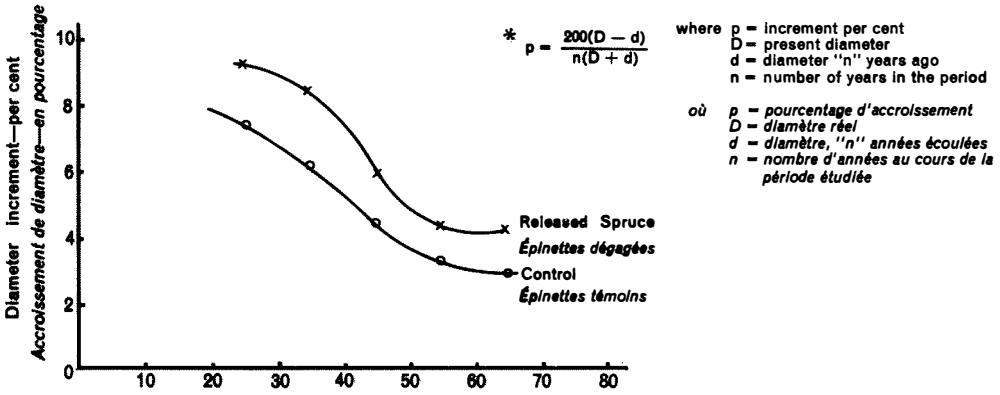

FIGURE 5. Diameter increment per cent 1962 (Pressler's Formula)*
*Pourcentage d'accroissement de diamètre, 1962 (d'après la formule Pressler)**

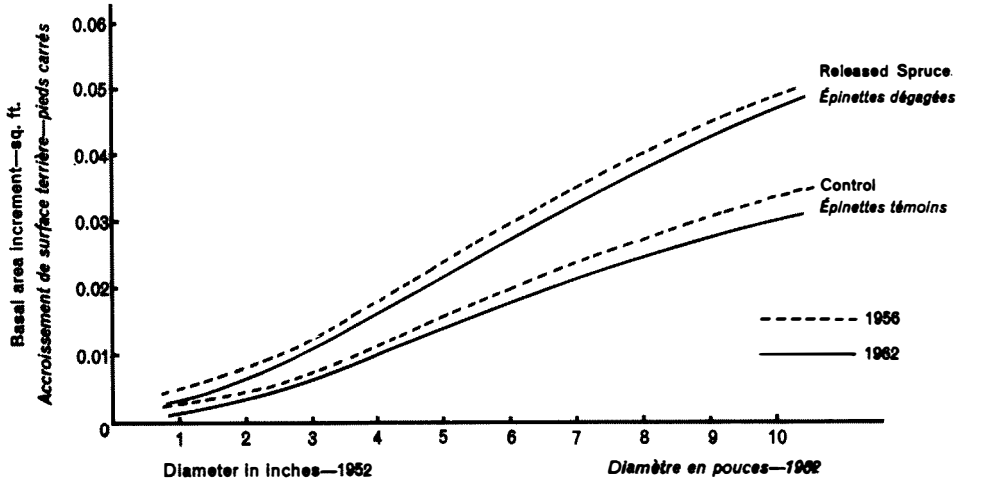

FIGURE 6. Average annual basal area increment 1952–1956 and 1957–1962
Accroissement annuel moyen de surface terrière, 1952–1956 et 1957–1962

Table 3. Mean annual diameter and height increment for treated and control stems by diameter classes

Tableau 3. Accroissement annuel moyen en diamètre et en hauteur des tiges traitées et des tiges témoins, par classes de diamètre

Diameter class *Classe de diamètre*	Diameter increment in inches Treated / Control *Accroissement de diamètre en pouces* *Tiges traitées*		*Tiges témoins*	Height increment in feet Treated / Control *Accroissement de hauteur en pieds* *Tiges traitées*		*Tiges témoins*
1	0.23	*	0.14	1.27	*	0.87
2	0.27	*	0.17	1.35	*	1.06
3	0.29	*	0.19	1.66	*	0.97
4	0.40	*	0.24	1.54	*	0.38
5	0.39	*	0.23	1.50	*	1.20
6	0.37	*	0.26	1.71	N.S.	1.08
7	0.44	*	0.26	1.56	N.S.	1.20
8	0.44	*	0.32	1.38	N.S.	0.85
9	0.40	*	0.24	1.21	N.S.	0.99
10	0.39	N.S.	0.26	1.38	*	0.80

* Difference is significant at P=0.05
La différence est significative au seuil de P=0.05

N.S. Difference is not significant at P=0.05
La différence n'est pas significative au seuil de P=0.05

Curves of average annual basal area increment by diameter classes are presented in Figure 6 for the periods 1952-56 and 1957-62. There is a slight decrease in basal area increment in the second five-year period.

Average periodic annual height increment by age classes is shown in Figure 7. Weighted mean values are shown. Greatest release occurs in the 30 to 50 year age range. Beyond 50 years of age there is greater variation within the treated and control values. Tables 3 and 4 show that height differences in the diameter range 6 to 9 inches and age class 50 to 60 years are not significant. This is the result of extensive top damage to the spruce because of whipping by competing aspen and snow and ice damage. In 1962, 18 per cent of released and 22 per cent of control stems showed top damage, and at the time of measurement a few released spruce had been bent to the ground by a recent (May) snowstorm.

Table 4. Mean annual diameter and height increment for treated and control stems by age classes

Tableau 4. Accroissement annuel moyen en diamètre et en hauteur des tiges traitées et des tiges témoins, par classes d'âge

Age class *Classe d'âge*	Diameter increment in inches Treated / Control *Accroissement de diamètre en pouces* *Tiges traitées*		*Tiges témoins*	Height increment in feet Treated / Control *Accroissement de hauteur en pieds* *Tiges traitées*		*Tiges témoins*
20–30	0.27	*	0.18	0.94	*	0.62
30–40	0.26	*	0.16	1.18	*	0.82
40–50	0.35	*	0.22	1.37	*	0.87
50–60	0.42	*	0.28	1.42	N.S.	1.24
60–70	0.39	*	0.25	1.34	*	0.84

* Difference is significant at P=0.05
La différence est significative au seuil de P=0.05

N.S. Difference is not significant at P=0.05
La différence n'est pas significative au seuil de P=0.05

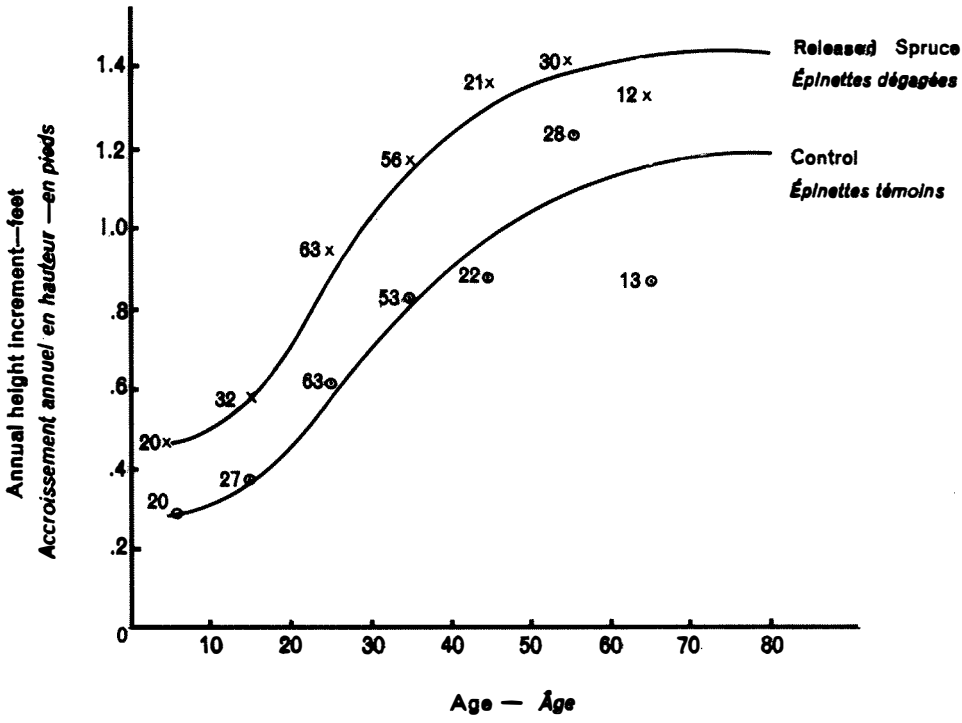

FIGURE 7. Periodic annual height increment 1952–1962
Accroissement périodique annuel en hauteur, 1952–1962

Table 5 shows mean merchantable cubic foot volume (Anon. 1962) for four of the stands in the older age classes. The merchantable volumes are presented to illustrate the value of the treatment to stems 5″ d.b.h. and over in increased productivity. Mean volumes of released stems are from 20 to 40 per cent higher than control stems.

Table 5. Mean merchantable cubic foot volume, trees over 5″ d.b.h.

Tableau 5. Volume moyen du bois marchand en pieds cubes—arbres au-dessus de 5″ D.H.P.

Age *Âge*	Stand *Peuplement*	Number of stems Released / Control *Nombre de tiges dégagées / tiges témoins*	Volume per tree (cubic feet) Released / Control *Volume (en pieds cubes) par arbre dégagé / par arbre témoin*
50	3	12 / 11	19.3 / 15.7
60	1	8 / 7	30.3 / 21.7
60	N	11 / 13	26.7 / 15.2
70	U	13 / 13	18.9 / 14.7

Ontkean and Smithers (1959) reported that no significant trends could be established by graphical analysis with age or site index. The stands were therefore reclassified on a physiographic basis recognizing 6 types as shown in Table 6.

Table 6. Physiographic site types

Tableau 6. Conditions physiographiques des stations

Physiographic site *Stations physiographiques*	Parent material* *Roche-mère***	Soil texture *Texture du sol*	Moisture status *Teneur en humidité*	Productivity class* *Classe de fertilité***	No. of released stems *Nombre de tiges dégagées*	Index height at 80 years *Hauteur habituelle à 80 ans*
1.....	Recent alluvium *Alluvions récentes*	Sands and silts *Limons et sables*	Fresh-Moist *Frais à humide*	I	20	95
2.....	Till fresh *Till frais*	Clay loams *Limons argileux*	Fresh *Frais*	I	93	90
3.....	Waterwashed till *Till lessivé*	Sandy loams *Limons sableux*	Fresh *Frais*	I	7	87
4.....	Alluvium till (variable) *Till d'alluvion (variable)*	Silts and clay loams *Limons et limons argileux*	Moist-Wet *Humide à mouillé*	I	10	84
5.....	Lucustrine *Lacustre*	Clays *Argiles*	Moist-Somewhat wet *Humide à quelque peu mouillé*	II	23	84
6.....	Till moist *Till humide*	Clays *Argiles*	Moist *Humide*	II	84	84

* Classification follows Duffy (1965). A Forest Land Classification for the Mixedwood Section of Alberta. Dept. Forestry Can. Publication No. 1128

** *Classification d'après Duffy (1965).* A Forest Land Classification for the Mixedwood Section of Alberta. *Min. des Forêts, Can. Publication nº 1128*

Separate empirical diameter growth curves were developed for each type. Unfortunately not all diameter classes were represented on all sites. However it was quite clear that for trees of given size there was no significant difference in diameter growth between the sites sampled. There are no extremes included in the sample and index height at 80 years for spruce ranges from 84 to 95 feet. Soil textures do not vary a great deal among the stands sampled and are mainly clay loams and clays. More than half of the sites in the region occur on glacial tills and most of the remainder occur on lacustrine deposits of the ancient Lesser Slave Lake basin. The site data were not analysed further.

Aspen Poisoning

Ammonium sulphamate was applied in V-notches in the cut aspen stumps, in crystalline form, around the treated stems. Quaite (1953) reported that this was effective in inhibiting aspen sprouting and suckering within the treated circle and in killing additional standing stems on the circle perimeter. The treated areas re-examined in 1962 were still remarkably clear of aspen suckers although a stand of smaller stems 3 to 4 years old seemed to be quite vigorous and healthy. Among the small spruce of less than one inch in diameter this was sufficient to provide serious competition. It is doubtful if release of such small spruce stems is worthwhile unless repeated treatments could be given.

DISCUSSION

The results of this study indicate that release of individual spruce stems from aspen competition will be successful on all the sites which were sampled and that the treatment will be widely applicable in the study region.

The treatment which was used suggests a method of thinning which emphasizes crown space and the relative crown position of the spruce and aspen stand components. Variation between individual stems within sample stands illustrates the need for treatment of single spruce crop trees rather than whole stands since each tree requires individual and different treatment based on crown characteristics. During the period when the spruce grows up through the hardwood overstorey, top damage from whipping is extensive. Height growth is checked and several years height growth may be lost.

The 10-year remeasurement shows that the effect of treatment is still favourable. However, in 1962 the crowns of many of the spruce crop trees were in contact with those of competing aspen and further release is warranted within the next five-year period.

At present the very small spruce stems up to 3 feet high which were treated are suffering from heavy and repeated browsing and from ground vegetation competition. These should not be treated in future thinnings unless more frequent release can be given.

The release of the oldest stems in this study bears out the experience of other workers (Cayford 1957, Steneker 1963) who note the ability of mature spruce to respond to release. Thinning in stands more than 70 years old is not recommended. However partial cutting from a commercial standpoint will lead to a valuable increase in growth of residual stems and an increase in merchantable volume production from the stands. These findings agree with results from associated studies of harvest cutting methods where partial cutting resulted in increased growth of residual spruce (Lees, 1963, 1964). The most valuable age and diameter range for release of spruce from aspen competition indicated by this study is 20 to 40 years and 3 to 5 inch d.b.h. classes.

It is recommended that stump poisoning of the cut aspen competition be carried out at the time of release treatment.

Economics did not feature in the current study. The decision to carry out the suggested treatment which may be biologically sound must depend on what is economically feasible. It may be possible to thin these stands twice to obtain best development; once in the range 20 to 40 years and again in the 40 to 60 age range. This would greatly increase the yield of quality spruce lumber and would prevent the crucial period of competition when the spruce is co-dominant with the aspen. However, thinning of the aspen cannot be considered an economic hardwood improvement treatment as long as the vast areas of pure aspen in the region remain unexploited. Nevertheless, it will always be worthwhile to remove as many poor and diseased aspen stems as possible in the release of spruce. It may be economical to poison or girdle the aspen if it is unmerchantable.

The results of this study closely parallel those in Saskatchewan. Growth rates are higher in Alberta but the effect of release may be more pronounced in the Saskatchewan studies. All studies indicate that the aspen overstorey in immature spruce-aspen stands inhibits the height and diameter growth and lowers the quality of the spruce. It is agreed that the release of the spruce is justified before it becomes co-dominant with aspen.

SUMMARY

Removal of competing aspen within twice the crown width of spruce crop trees in spruce-aspen stands resulted in a marked increase in height and diameter growth of the spruce. Poisoning of the cut aspen stumps with ammonium sulphamate (ammate) prevented suckering and sprouting of the aspen for several years. Release was effective over a wide range of ages and diameters on all sites sampled. These represent the most extensive and commonly occurring fresh to moist sites with predominantly clay loam and clay soil textures. Results agree with those of parallel release studies in Manitoba and Saskatchewan within the same forest section. It is recommended that release of spruce be carried out before spruce and aspen crowns are co-dominant.

SOMMAIRE

Cette publication porte sur le dégagement de l'épinette blanche, au milieu de peupliers faux-trembles concurrentiels, dans un peuplement mélangé d'épinette et de peuplier faux-tremble de l'Alberta. Dans un peuplement mélangé d'épinette et de peuplier faux-tremble, on a effectué une coupe de nettoiement des peupliers faux-trembles concurrentiels dans un espace correspondant à deux fois la largeur de la cime des épinettes de récolte; cette coupe a amené une augmentation sensible de la croissance des épinettes, en hauteur et en diamètre. L'empoisonnement des souches des peupliers faux-trembles, au moyen de sulfamate d'ammonium (ou ammate), a empêché le drageonnement et le bourgeonnement des peupliers faux-trembles pendant plusieurs années. Ce dégagement s'est révélé efficace pour un grand nombre d'épinettes d'âge et de diamètre variés dans toutes les stations échantillonnées; ces dernières comprenaient toute la gamme des types forestiers, de frais à humides, les plus répandus et les plus communs, et dont le sol était en majeure partie composé de limon argileux ou d'argile. Les résultats de cette expérience concordent avec ceux qu'on a obtenus au cours d'expériences analogues pratiquées au Manitoba et en Saskatchewan dans la même zone forestière. L'auteur recommande de pratiquer de telles coupes avant que les cimes d'épinette et de peuplier faux-tremble deviennent co-dominantes.

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