O.D.C. 174.7 (Picea glauca)

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GROWTH OF WHITE SPRUCE FOLLOWING RELEASE FROM TREMBLING ASPEN

by

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LEGEND
location of study area
SASKATCHEWAN
MANITOBA
Northern
Coniferous
Forest
Section
Mixedwood
Aspen
Grove
Prairie
Big River
Montreal L.
Candle L.
PRINCE ALBERT
Bertwell Reserve
Riding Mtn
Lake Winnipeg
Lake Manitoba
REGINA
BRANDON
U . S . A .

ABSTRACT

Experimental release cuttings to favour white spruce in 15- to 60-year-old white spruce-trembling aspen stands have shown that diameter increment and in certain instances height increment of the spruce was doubled; merchantable volume production per acre was, on the average, increased by about 60 per cent. These findings are of special interest in the Prairie Provinces, where the spruce-aspen cover type forms the principal source of white spruce.

ACKNOWLEDGEMENTS

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CONTENTS

GROWTH OF WHITE SPRUCE FOLLOWING RELEASE FROM TREMBLING ASPEN

by

G.A. Steneker[1]

INTRODUCTION

White spruce (*Picea glauca* (Moench) Voss) normally grows in association with trembling aspen (*Populus tremuloides* Michx.) in the B18a Mixedwood Forest Section (Rowe 1959) of Manitoba and Saskatchewan. Admixtures of balsam poplar (*Populus balsamifera* L.) and black spruce (*Picea mariana* (Mill.) BSP.) may occur also on the moist sites. Aspen usually forms the upper canopy in immature stands, thereby suppressing the spruce and exposing it to mechanical injury (Kittredge and Gevorkiantz 1929). The growth rate of spruce is therefore often impaired and much of its potential volume is lost (Kagis 1952, Kabzems 1952, Cayford 1957).

Experimental improvement cuttings, to favour the white spruce component of mixedwood stands in Manitoba, were first carried out by the Department of Forestry and Rural Development in 1936 (Steneker 1963). Later, between 1951 and 1954, a series of eight experimental release cuttings were made in 15- to 60-year-old stands in Manitoba and Saskatchewan, to determine the effects of partial and complete removal of the aspen upon the development of the white spruce understorey.

This publication presents the 10-year growth results of these latter experimental release cuttings. Information is presented on the effect of various levels of aspen and white spruce stocking upon subsequent diameter, basal area and volume increment of the white spruce.

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STUDY AREAS

Location and Stand Description

The experimental areas are located within stands typical of the Mixedwood Forest Section at Riding Mountain, Manitoba, and Reserve, Bertwell, Candle Lake, Montreal Lake and Big River, Saskatchewan (Frontispiece). Data on age, diameter and height are given in Table 1. All stands originated following fire. On some of the moist sites balsam poplar and black

TABLE 1. AGE, AVERAGE DIAMETER AND HEIGHT OF WHITE SPRUCE AND ASPEN AT TIME OF TREATMENT

Study area	Date of establishment	Age*		Av. d.b.h. (inches)		Av. height (feet)	
		wS	tA	wS	tA	wS	tA
Bertwell	1951	10-25	25-30	1.2	3.6	11	44
Riding Mountain	1954	20-35	25-40	1.2	4.2	11	45
Big River Nursery	1953	15-25	20-40	2.2	3.3	15	41
Montreal Lake	1953	20-35	25-35	2.6	4.1	20	52
Candle Lake (1)	1953	15-40	45-60	2.0	5.5	15	55
Candle Lake (2)	1953	15-50	50-60	2.3	6.3	17	54
Big River	1953	35-50	55-60	3.1	5.7	28	60
Reserve	1951	25-60	50-60	4.4	6.4	28	65

*Age at 1 foot above ground.

spruce occur as component species. The profile of the stand at Bertwell (Figure 1) illustrates the typical variation in stand structure and composition in the various study areas. It shows the irregular spatial distribution of the spruce; the wide range in size classes of the spruce; and different conditions under which individual spruce trees are growing, from completely suppressed to relatively free growing.

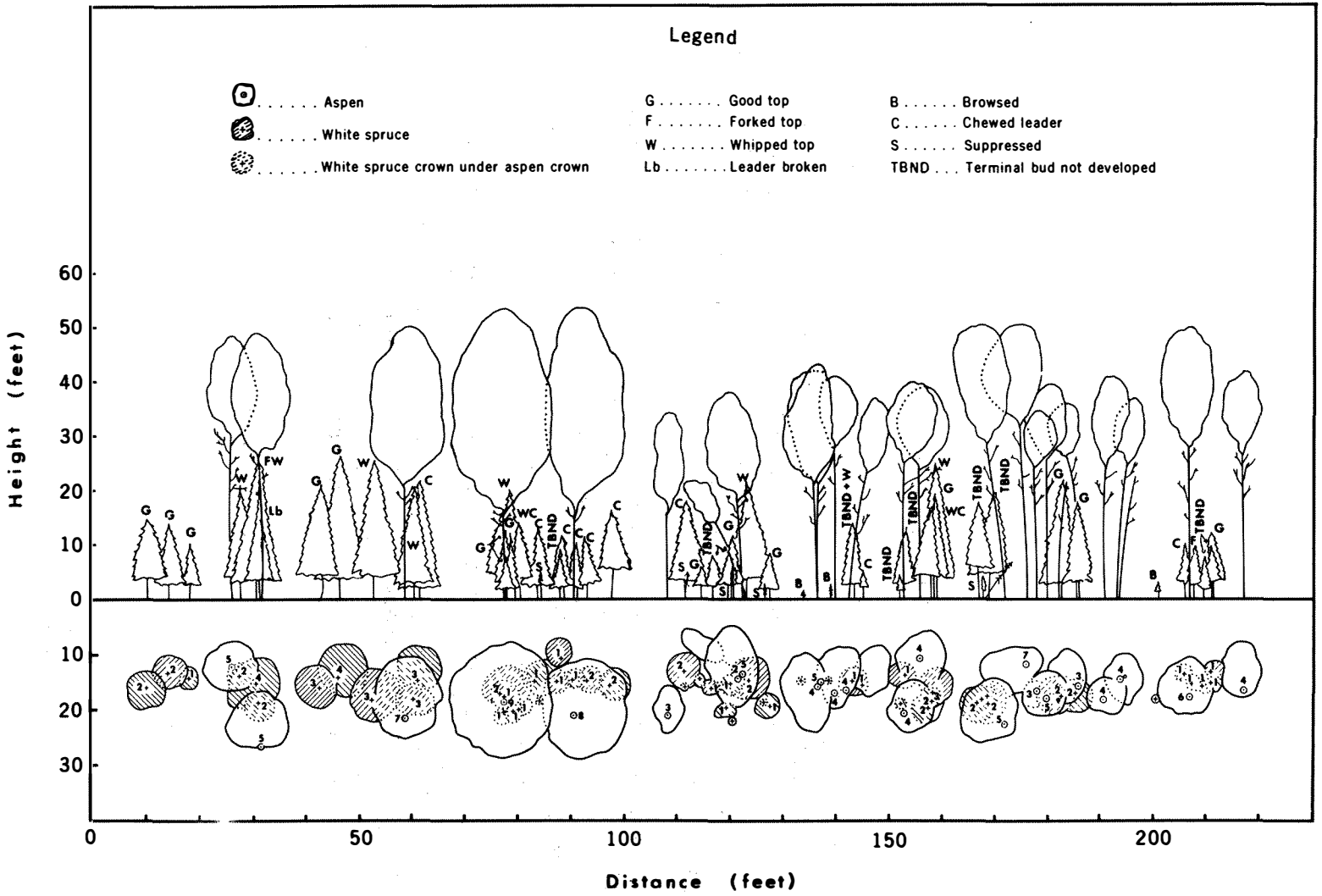

Figure 1. *Profile and plan sketch, uncut portion of stand at Bertwell Saskatchewan 1961. Number on plan view indicates diameter of tree.*

Site Information

Site conditions are similar on the various study areas. The topography is flat to gently rolling and the soils are well drained. Parent soil materials are glacial tills, and vary in texture from silty clay loams to clay loams. However at Montreal Lake soils have been influenced by water, as the profiles show bands of silt and sand over the till. Grey wooded soils have developed in all areas except Bertwell; there, degrading black or dark grey wooded soils predominate, indicating that at one time grasses were the predominant vegetation. Representative soil profile and drainage types are described in Appendix I.

METHODS

Growth data were obtained from 1/10-acre permanent sample plots. Two plots were chosen at each location as controls and two for release from which all aspen were removed from the plots and surrounds. Two additional plots were chosen at both Bertwell and Reserve for partial release from which 50 per cent of the aspen were removed by systematically cutting every other stem.

All spruces were tagged and the height and breast height diameter of all trees were measured during the year of release and 5 and 10 years after release. A number of ring counts were made to establish the range in age of the aspen and spruce in each stand (Table 1).

Plots were classified as to relative moisture status and soil texture (Hills 1952), and soil profiles were described. Increment borings at breast height were made on the spruce during the 10-year remeasurement at three study locations to analyse and compare year by year radial increment of individual spruce trees on release and on control plots.

RESULTS

Diameter Increment

Removing the aspen overstorey increased periodic diameter increment of white spruce in all diameter classes. Released trees grew between 40 (Candle Lake, area 2) and 200 per cent (Big River Nursery) faster than trees on the control plots. This wide variation in response is attributed primarily to

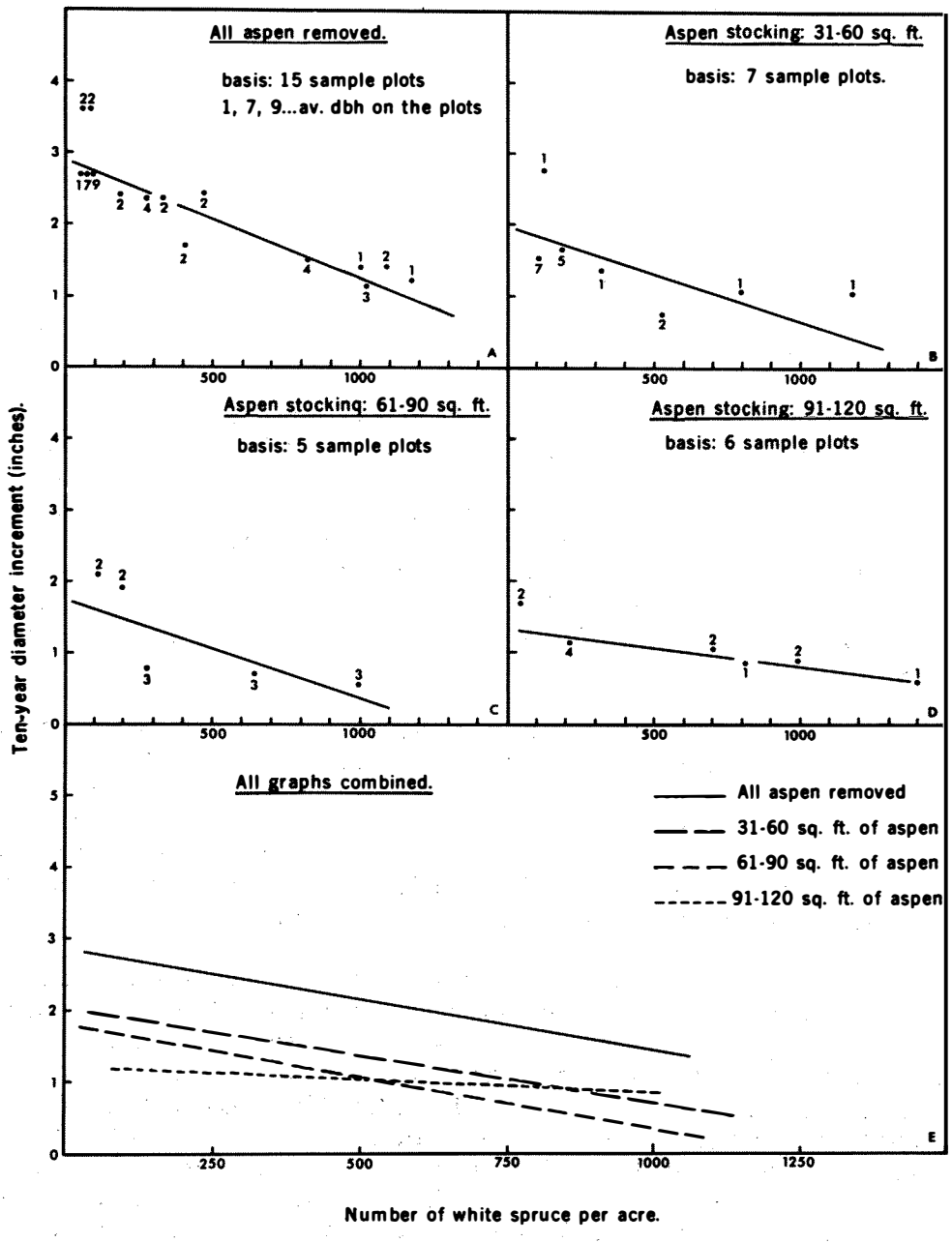

Figure 2. *Ten-year diameter increment of white spruce related to number of residual spruce per acre at four density classes of aspen.*

differences in stocking levels of spruce between release and control plots within areas (Appendix II), and to variation in the spatial distribution of spruce within plots. The effect of spatial distribution of the spruce upon its periodic diameter increment is typified by data from the Riding Mountain plots. Average 10-year diameter increment of the 1-inch unreleased spruce was 0.5 inches with individual tree increments ranging from less than 0.1 to 1.2 inches; released spruce of this size class had an average increment of 1.2 inches with individual tree increment ranging from 0.1 to 2.7 inches. Therefore, with diameter increment rounded off to the nearest 1/10 inch, the effect of release on some "released" trees could not be observed. Usually such trees were severely suppressed by neighbouring spruce.

To illustrate the effect of aspen overstorey density on white spruce growth, periodic increment data for spruce from all studies have been stratified by four levels of aspen stocking (Figure 2). This graph shows that the diameter increment of white spruce is inversely related to the overhead aspen stocking and that complete release resulted in 100 per cent increase in increment. Initial stand diameter breast height had apparently little or no influence on subsequent increment (Figure 2A).

The effect of age upon response was not determined owing to the variation in the age of spruce within individual stands (Table 1). However, as tree diameter tends to vary directly with tree age, and as initial diameter showed no relationship to response to release, it may be assumed that age, within the range examined, had little or no influence on the subsequent diameter increment of the spruce.

The year-by-year increment over a 20-year period for a number of released and unreleased spruce at Riding Mountain, Big River Nursery and Montreal Lake is shown in Figure 3. White spruce responded to treatment immediately and a maximum growth rate was reached after 3 years. During the following 6 to 7 years diameter increment declined, but remained well above the growth rate of the unreleased trees. Although a sufficient period has not elapsed to establish the complete growth pattern, indications are that the released trees will maintain a faster growth rate than the unreleased trees for some time to come.

Height Increment

The removal of the aspen overstorey resulted, on the average, in an increase in height increment of the spruce. However, in contrast to diameter increment, increases in height

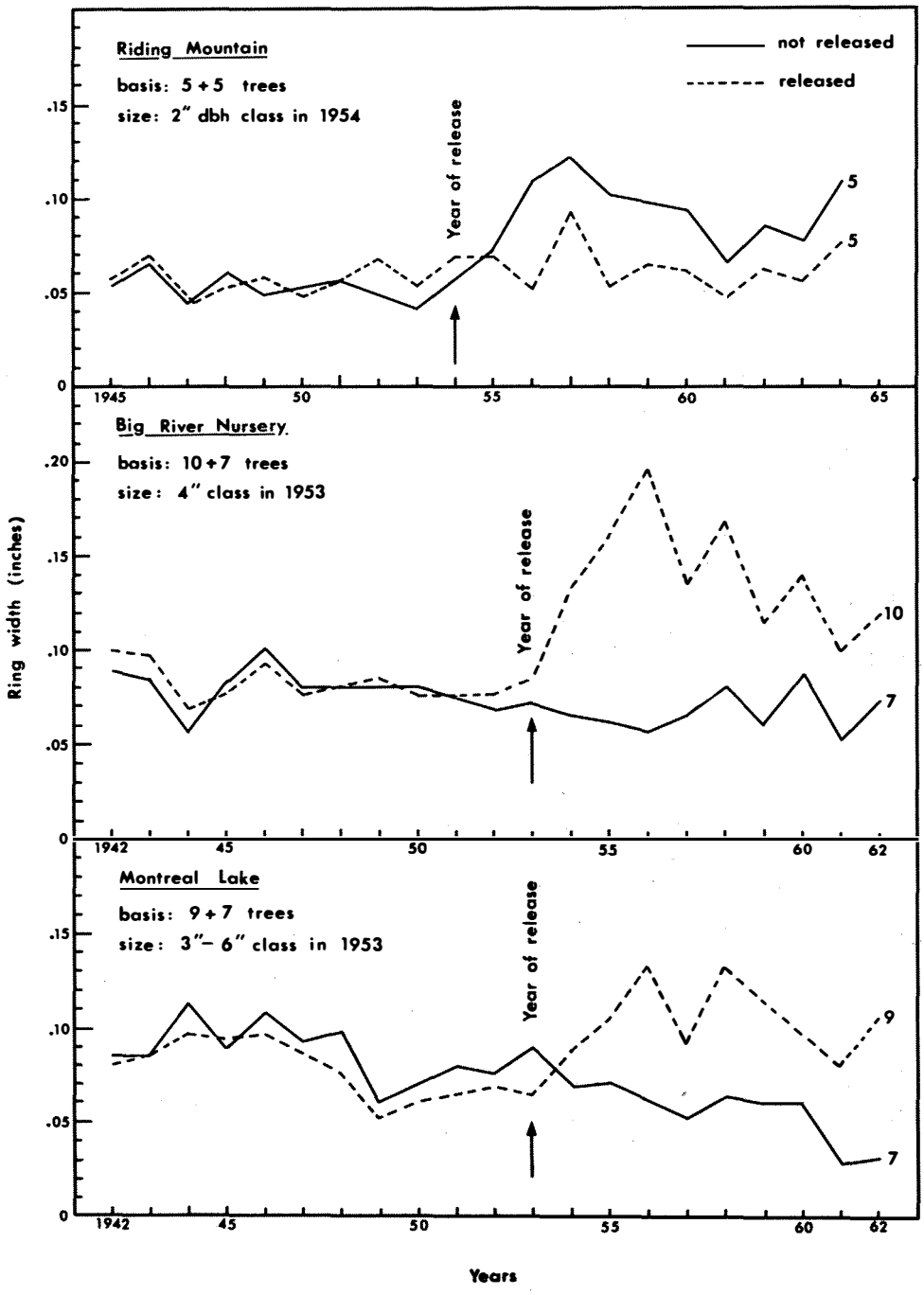

Figure 3. *Annual radial growth over a 20-year period for released and unreleased white spruce at Riding Mountain, Big River Nursery and Montreal Lake based on largest size classes of the spruce component at each area.*

increment did not occur consistently in all areas; e.g., at Riding Mountain and Candle Lake (area 2) height increment was about the same for trees on the release and control plots.

Response in height increment to release is directly related to stand structure. To illustrate this, trees on the control plots at Big River were stratified into three growth condition classes, and the increment of trees within these classes was compared to that of the white spruce on release plots. The classes are designated as suppressed (spruce which have their crowns directly underneath a crown from the upper canopy, or are suppressed by other spruce), whipped (spruce, which have their crowns within the upper canopy crowns and receive mechanical injury), and free growing (spruce although overtopped, having growing space available above their crown). The data show (Figure 4) that the height increment of the "free growing" spruce is almost as rapid as that of the completely released spruce, whereas the increment of the "suppressed" and "whipped" trees is about half that of the released spruce. The Big River data therefore indicate that the inconsistency in average height increment between the various study areas is due to the distribution of spruce trees within the suppressed whipped, and free growing classes at each location.

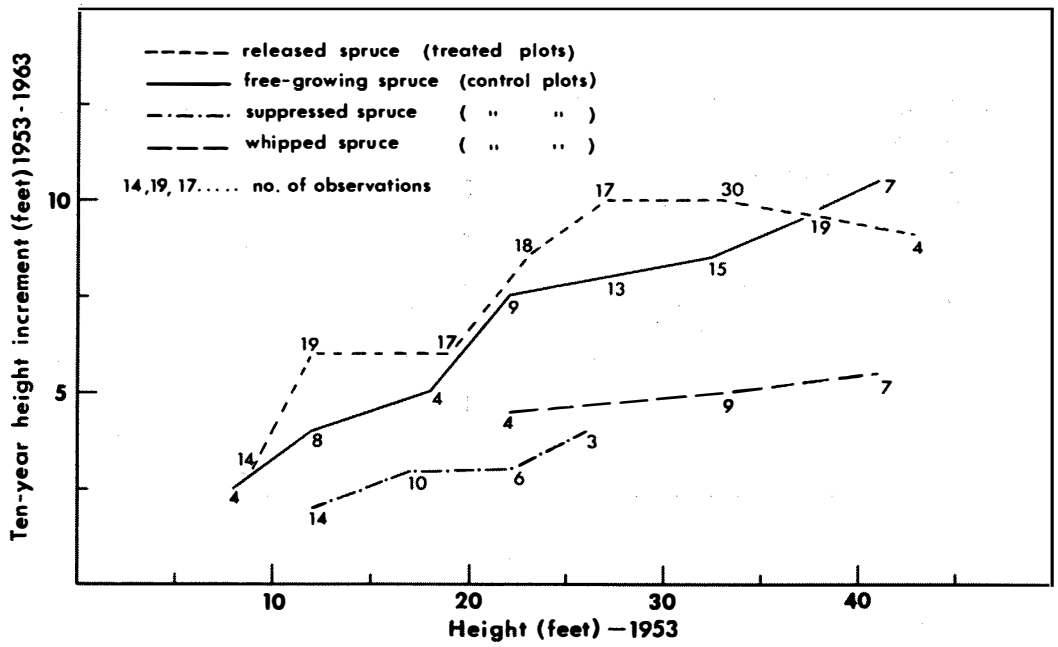

Figure 4. *Ten-year height increment by height classes for released, suppressed, whipped and free-growing spruce at Big River.*

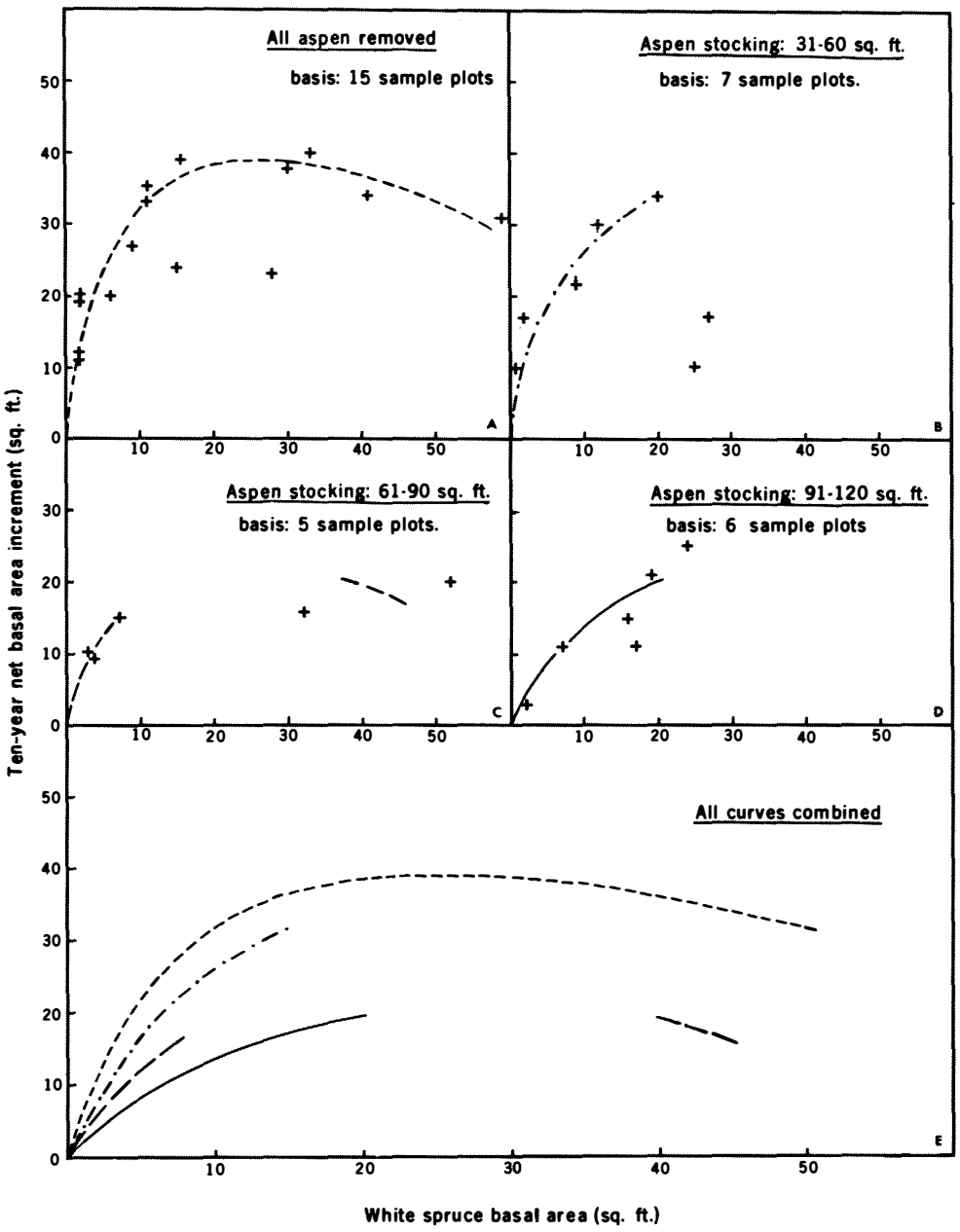

Figure 5. *Periodic net basal area increment per acre of white spruce related to residual basal area per acre of white spruce at four density classes of aspen (free hand curves).*

Basal Area and Total Volume Increment

Figure 5 shows the relationship between periodic net white spruce basal area increment and residual spruce basal area for plots with different aspen densities. Net increment of spruce was inversely related to the amount of aspen stocking. Over the 10-year period since treatment it reached a maximum of about 20 sq. ft. an acre on plots with an aspen stocking between 90 and 120 sq. ft. an acre and a maximum of about 40 sq. ft. an acre on release plots. On four sample plots (Figure 5A and B) increment was extremely low. This appears to be related to uneven spruce distribution since as much as 75 per cent of the total number of spruce trees on each plot were located on half the plot.

Total periodic volume increment of spruce showed a similar relationship as basal area increment with residual white spruce and aspen stocking. Net volume increment was as much as 50 per cent lower on the control than on the release plots because of aspen competition.

Merchantable Volume Production

The insufficient number of trees with breast height diameter of 8 inches and over on the control and release plots did not allow an assessment of the effect of release in terms of board foot volume production, so merchantable volume production has been expressed in cords only. A valid assessment of the effect of release on cordwood production can only be made if, at time of release, the tree-size or number-of-trees relationship between the control and release plots was comparable. Therefore the number of spruce trees on the release and control plots was related to the spruce basal area per acre. Figure 6 shows that at specific spruce basal area levels the tree-size or number-of-trees relationship was similar between control and release plots. Figure 6A shows the number of spruce per acre for all plots was related to spruce basal area per acre at time of release. Although within-area variation existed, on the average, basal area and number of trees per acre on the control and release plots were the same. In Figure 6B the cordwood production 10 years after release is related to white spruce basal area at time of release. The lines, significantly different at the 1 per cent level, indicate that on the average spruce cordwood production was about 60 per cent greater on the release plots than on the controls.

Mortality and Condition of Spruce after Release

Spruce mortality by number of trees during the 10-year

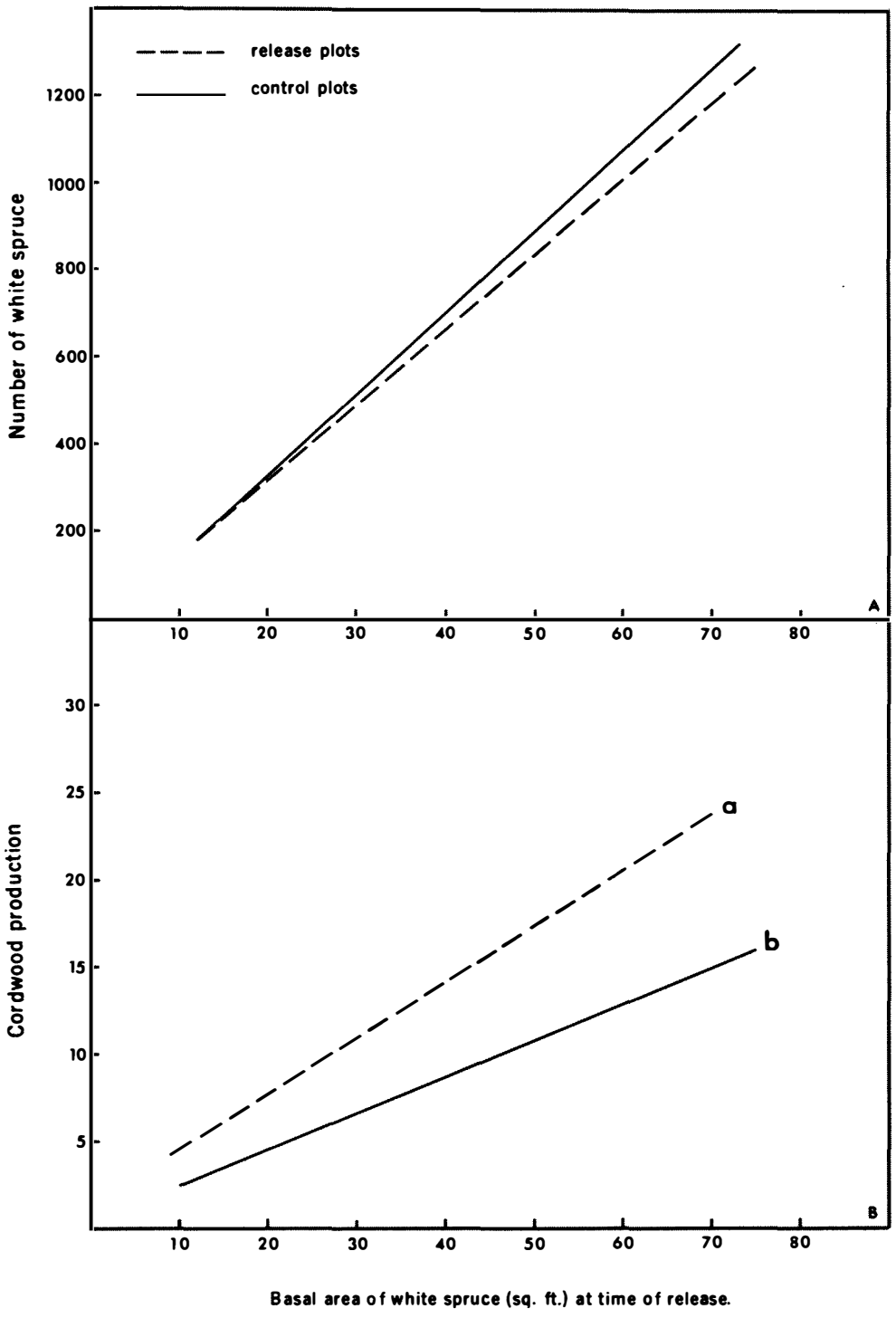

Figure 6. *Relationship between basal area and number of trees per acre of white spruce on control and release plots at time of release (A), and basal area and cordwood production 10 years after release (B). Difference between a and b significant at 1 per cent level.*

period after treatment ranged up to 12 and 30 per cent on the release and control plots respectively. In terms of total volume, percentages were 5 and 18, indicating that mortality generally occurred in the smaller diameter classes. Unexpectedly high spruce mortality at Big River was caused by porcupine girdling. The leaders of released trees at some localities showed evidence of damage by squirrels, weevils (possibly *Pissodes strobi* (Peck)) and frost; this damage was not related to release and most trees have recovered.

DISCUSSION AND CONCLUSIONS

In intermediate aged mixedwood stands, diameter increment of white spruce of all size classes can be increased up to 100 per cent by removal of the trembling aspen overstorey. Response to release in terms of height growth will be most noticeable on trees which have their crowns in direct contact with and immediately below those of aspen. In these conditions trees can be expected to double their height growth when released. The combined effect of release on diameter and height increment may result in increases in merchantable volume production of about 60 per cent an acre.

In Manitoba and Saskatchewan about 30 per cent of the B18a Forest Section consists of intermediate-aged white spruce-trembling aspen stands, which will form the principal source of white spruce in the future. The increasing demand for aspen in the two provinces should make release cutting operations more feasible. The aspen could be clearcut when it reaches commercial size at about 60 years of age, when 40 cords an acre can be expected. Where markets permit, thinning of the spruce could be carried out at the same time. Released from overhead and lateral suppression, the residual spruce is greatly stimulated and reaches sawlog size in a much shorter time than unreleased spruce. A harvest cut could be made at a rotation age of 100 to 120 years, removing spruce sawlogs and another aspen pulpwood crop, since in all probability a good stand of aspen suckers would have sprung up after the first cut. Killing aspen by aerial spraying may be considered in localities where the aspen cannot be utilized. This method has given good results in the Lake States as an economic means of disposing of undesirable hardwoods (Arend 1959).

SUMMARY

Ten-year growth results of eight experimental release

cuttings to favour white spruce in spruce-aspen stands, ranging in age from 15 to 60 years, have shown that:

a) Diameter increment of spruce can be doubled by removing the aspen canopy.

b) Height increment of spruce under immediate overhead suppression and in physical contact with the aspen crowns, can be doubled by release.

c) The combined stimulus to height and diameter increment from release can increase merchantable volume production of spruce by about 60 per cent.

The findings are discussed relative to the commonly occurring white spruce-aspen cover type in Manitoba and Saskatchewan, the principal source of white spruce, and the developing aspen-using industries in these provinces.

SOMMAIRE

L'auteur rapporte dans le présent mémoire les effets qu'ont produits huit coupes expérimentales d'éclaircies sur la croissance de l'épinette blanche au sein de peuplements mélangés d'épinette blanche et de peuplier faux-tremble dont l'âge variait de 15 à 60 ans. Les voici:

a) L'accroissement en diamètre des épinettes blanches a pu doubler par l'enlèvement du couvert des peupliers faux-trembles.

b) Du même coup, l'accroissement en hauteur des épinettes doubla lorsque celles-ci étaient auparavant étouffées ou serrées de près par les peupliers.

c) Un tel accroissement en diamètre et en hauteur peut signifier une production de volume marchand accrue d'environ 60 p. 100.

L'auteur commente les résultats obtenus au regard d'un certain type de peuplement mêlé d'épinette blanche et de peuplier faux-tremble que l'on voit communément au Manitoba et en Saskatchewan. En ces deux provinces, ce type particulier de peuplement fournit à peu près tout le bois marchand d'épinette blanche et l'on s'occupe actuellement d'augmenter l'utilisation industrielle du peuplier qui s'y trouve.

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APPENDIX I

SOIL PROFILE DESCRIPTIONS

Fresh Site	Horizon	Description
(Orthic Grey Wooded)	L - H	Horizon consisting of litter, fermenting and decomposed plant material. 1/2 - 3 inches in depth.
	A_h	Dark coloured horizon containing organic material. From a trace to 1 inch in depth. About 5.8 pH.
	A_e	Light brown eluvial (leached) horizon 3 - 6 inches in depth. pH about 5.9.
	AB	Transitional horizon between A and B. Usually only a trace in depth.
	B_t	Brown illuvial horizon, fairly hard, compact blocky structured. 12 - 24 inches in depth. About 6.8 pH.
	C	Parent material. 10 inches or more in depth. About 7.4 pH.
Moderately Fresh Site		Profile fairly well developed but shallower than the maximum on fresh sites.
Moderately Moist Site		Profile strongly developed. A_h usually present, A_e darker than on fresh sites, less colour contrast between inside and outside of aggregates of B horizon, incipient gley at bottom of the B or top of the C.
Moist Site		Profile strongly developed, A_h well developed, A_e shallow and dark in colour, no colour contrast between inside and outside of aggregates of B horizon, gley present in the B horizon.

APPENDIX II

STAND DATA PER ACRE - all plots

Treatment	Plot #	No. of trees[1] R wS	R tA	[R + 10][2] wS	[R + 10] tA	Basal area (sq.ft.) R wS	R tA	[R + 10] wS	[R + 10] tA	Total volume[3] (cu.ft.) R wS	R tA	[R + 10] wS	[R + 10] tA	Merch. volume (cords) R wS[4]	R tA[5]	[R + 10] wS	[R + 10] tA	Mortality in 10 yrs. Basal area wS	Basal area tA	Total Volume wS	Total Volume tA
Bertwell																					
Control	1	810	720	1260	500	9	60	31	78	71	1242	346	1726	0	12	0	19	0	14	0	282
Control	4	1190	830	2060	740	12	50	42	83	92	989	460	1744	0	7	0.2	16	0	2	0	21
50% hwds cut	2	330	780	1370	720	2	52	19	89	15	1038	172	2164	0	8	0	24	0	2	0	44
50% hwds cut	5	130	900	1000	760	0.7	53	11	85	4	1050	90	2057	0	8	0	22	0	5	0	95
100% hwds cut	3	70	-	770	-	0.7	-	20	-	5	-	180	-	0	-	0.4	-	0	-	0	-
100% hwds cut	6	100	-	870	-	0.5	-	21	-	3	-	186	-	0	-	0	-	0	-	0	-
Riding Mountain																					
Control	19	840	1900	950	1010	7	120	18	127	37	4110	164	3084	0	27	0	36	2	35	18	1078
Control	21	2370	1410	1820	850	16	100	31	98	144	2114	296	2187	0	19	0	24	3	20	21	308
100% hwds cut	20	1190	-	1450	-	11	-	44	-	80	-	443	-	0	-	0.8	-	0.5	-	4	-
100% hwds cut	22	1000	-	1430	-	9	-	36	-	72	-	355	-	0	-	0.4	-	0.4	-	3	-
Big River Nursery																					
Control	14	1110	1490	1320	990	24	107	50	139	194	1913	686	3696	0	21	0.8	42	0	12	0	265
100% hwds cut	13	340	-	420	-	11	-	46	-	110	-	683	-	0.2	-	6	-	0	-	0	-
Montreal Lake																					
Control	16	520	750	630	840	20	50	54	77	198	1220	1130	2028	0.8	12	10	23	0.9	5	9	119
Control	17	260	1020	360	1250	7	72	21	105	87	1783	355	2971	0.2	18	3	35	1	8	12	169
100% hwds cut	15	190	-	490	-	6	-	26	-	66	-	342	-	0.2	-	2	-	0	-	0	-
100% hwds cut	18	400	-	550	-	15	-	39	-	173	-	558	-	0.8	-	4	-	2	-	16	-
Candle Lake - area 1																					
Control	1	110	590	110	n.d.[6]	4	84	13	n.d.	41	2128	183	n.d.	0	26	2	n.d.	0.1	n.d.	1	n.d.
Control	3	170	700	170	n.d.	3	84	13	n.d.	29	2143	171	n.d.	0	26	1	n.d.	0	n.d.	0	n.d.
100% hwds cut	2	60	-	70	-	2	-	12	-	16	-	185	-	0	-	2	-	0	-	0	-
100% hwds cut	4	80	-	80	-	1	-	13	-	11	-	175	-	0	-	2	-	0	-	0	-
Candle Lake - area 2																					
Control	5	690	470	950	n.d.	19	103	40	n.d.	204	2713	555	n.d.	0.2	33	2	n.d.	2	n.d.	25	n.d.
Control	7	690	460	n.d.	n.d.	17	92	n.d.	n.d.	186	2419	n.d.	n.d.	0	29	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
100% hwds cut	6	1070	-	1290	-	33	-	73	-	387	-	977	-	0.8	-	5	-	4	-	58	-
100% hwds cut	8	460	-	530	-	16	-	55	-	167	-	658	-	0	-	7	-	0.5	-	5	-
Big River																					
Control	9	990	540	900	470	52	80	72	97	828	2253	1391	2848	4	27	11	34	2	16	17	466
Control	11	640	510	620	450	32	82	48	103	428	2319	852	3421	0.8	24	6	43	0.3	11	2	298
100% hwds cut	10	1010	-	720	-	60	-	92	-	989	-	1783	-	4	-	17	-	14	-	211	-
100% hwds cut	12	840	-	800	-	41	-	75	-	610	-	1404	-	2	-	13	-	15	-	249	-
Reserve																					
Control	1	210	410	210	370	17	105	28	115	261	3063	464	3706	1	38	4	46	0	7	0	209
Control	4	40	400	60	320	2	111	5	123	36	3244	81	4042	0.4	38	0.7	48	0	12	0	320
50% hwds cut	2	190	210	190	170	27	44	43	52	452	1244	866	1505	5	15	9	18	1	4	22	108
50% hwds cut	6	110	230	110	200	25	43	35	47	442	1172	742	1319	5	14	8	16	0.9	6	12	179
100% hwds cut	3	280	-	280	-	30	-	68	-	472	-	1323	-	4	-	14	-	0	-	0	-
100% hwds cut	5	100	-	90	-	28	-	51	-	499	-	1157	-	5	-	13	-	1	-	19	-

[1] Ingrowth has occurred in the spruce since treatment.
[2] R, [R + 10] - Time of release and 10 years after release.
[3] Interpolated Volume Tables 1941, Canada, Dept. Mines and Resources, Lands, Parks and Forests Branch. Dom. For. Serv., Misc. Series 3.
[4] Peeled - 1 ft. stump, 3-inch top ib. Formclass Volume Tables. Table 177.,1948, Canada, Dept. Mines and Resources.
[5] Peeled - 1 ft. stump, 3-inch top ib. 1934. Volume, Yield and Stand Tables for tree species in the Lake States. Univ. Minn. Tech. Bull. 39.
[6] The aspen and spruce on some plots at Candle Lake received wind damage during the 10-year period.