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Performance of container and bare-root stock on prescribed burns in Saskatchewan

W.J. Ball and V.S. Kolabinski

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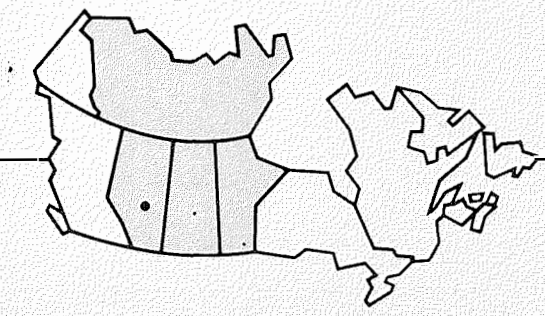

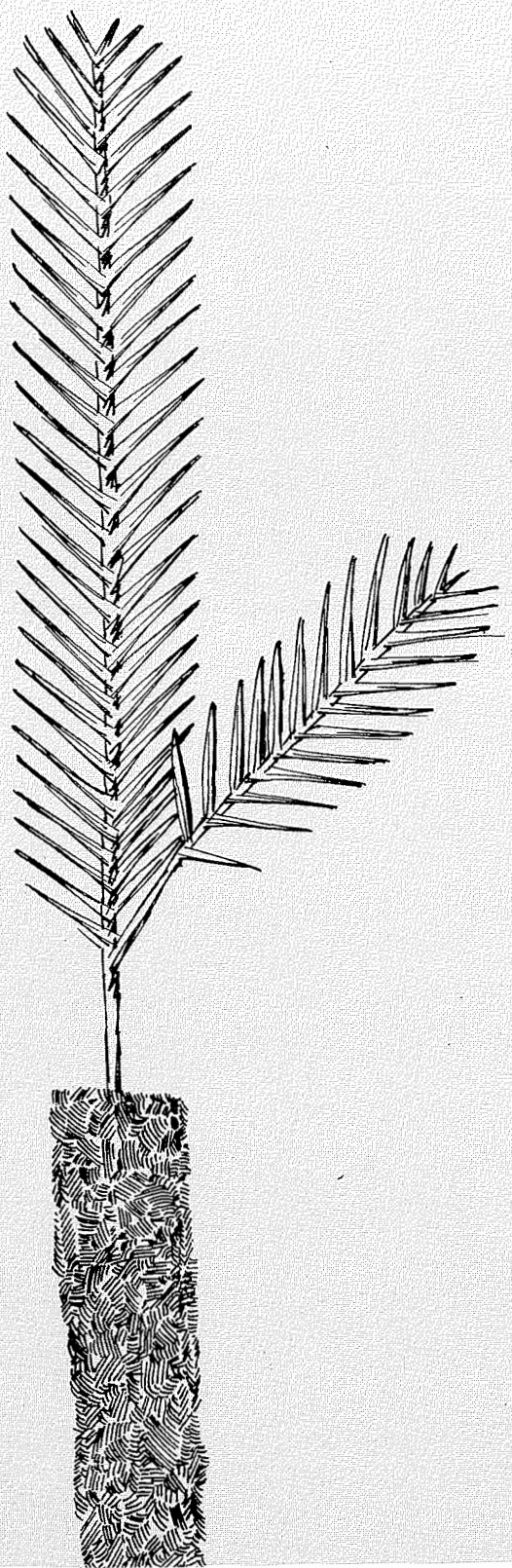

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PERFORMANCE OF CONTAINER AND BARE-ROOT STOCK ON PRESCRIBED BURNS IN SASKATCHEWAN

W.J. Ball[1] *and V.S. Kolabinski*[1]

INFORMATION REPORT NOR-X-283

NORTHERN FORESTRY CENTRE
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ABSTRACT

Fall and spring-planted jack pine (*Pinus banksiana* Lamb.) and white spruce (*Picea glauca* (Moench) Voss) bare-root and container seedlings outplanted on burned jack pine clear-cuts in central Saskatchewan were evaluated in terms of survival, height, and height increment for 5 years. At 5 years, survival was 88% for pine and 96% for spruce. Height of spruce was 50% greater for 2 + 2 bare-root stock than for Styroblock 2 seedlings; with pine the difference was more than 20%. For both species, season of planting did not affect fifth-year height of bare-root stock, but heights of fall-planted Styroblock 2 seedlings were greater than those that were spring planted. Fifth-year height increments for both pine and spruce were greater for 2 + 2 bare-root stock than for container seedlings.

RESUME

On a évalué dans le centre de la Saskatchewan sur des parterres de coupe rase incendiés, anciennement boisés en pin gris, la survie, la hauteur et l'accroissement en hauteur pendant cinq ans de plants de pin gris (*Pinus banksiana* Lamb.) et d'épinette blanche (*Picea glauca* (Moench) Voss) ayant été plantés à racines nues ou en récipients, à l'automne ou au printemps. A cinq ans, le pourcentage de survie était de 88% pour le pin et de 96% pour l'épinette. La hauteur des plants à racines nues 2 + 2 était de 50% supérieure à celle des semis sur Styroblock 2; dans le cas du pin, la différence était de plus de 20%. La saison de plantation n'a pas influé sur la hauteur à la cinquième année des plants à racines nues des deux espèces, mais pour les semis sur Styroblock, la hauteur de ceux qui avaient été plantés à l'automne était supérieure. L'accroissement en hauteur de la cinquième année tant pour le pin que pour l'épinette a été plus élevé pour les plants à racines nues que pour ceux en récipients.

CONTENTS

FIGURES

TABLES

NOTE

The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by the Canadian Forestry Service.

INTRODUCTION

Seventeen percent of Canada's cutover area is currently reforested by planting (Brace and Golec 1982), and in the prairie provinces nearly half of the planted area consists of container seedling stock (Ball and Brace 1981). In general, field performance comparisons between container and transplanted bare-root stock types are scarce; current stock prescriptions frequently reflect opinions rather than past experience (Van Eerden 1981).

Because inadequate site preparation has been a significant factor in high prairie plantation mortality (Froning 1972) and controlled burning to prepare sites for planting and seeding had been demonstrated operationally in 1971 (Chrosciewicz 1978a, b), the Canadian Forestry Service (CFS) during 1971–74 conducted a series of planting trials in central Saskatchewan on jack pine (*Pinus banksiana* Lamb.) cutovers that had been control-burned in July and August 1971[1]. The study was designed to compare field performance of 2 + 2 bare-root stock and 40-cm^3 Styroblock 2 container seedlings of jack pine and white spruce (*Picea glauca* (Moench) Voss) in fall and spring planting for 3 years on four burned areas (Fig. 1).

STUDY AREAS

The three areas used in this study were located approximately 30 km northeast of Candle Lake, Saskatchewan, in the Mixedwood Section (B.18a) of the Boreal Forest Region (Rowe 1972). The areas were burned between July 21 and August 5, 1971; the mean duff depth (which ranged from 6.4 to 7.9 cm before burning) was reduced to 2.0–3.8 cm (Chrosciewicz 1978a).

Descriptions of the burns conducted on the three study areas (Fig. 1) were provided by Chrosciewicz (1978a). Using Hills' (1955) classification, the predominant soil moisture regimes on Area Centre East were rated fresh (2) and on Areas North and South were rated fresh to moderately moist (2–3). The jack pine stands were over 80 years old and had pulpwood yields of approximately 190–270 m^3/ha (20–30 cords per acre) when they were clear-cut between 1968 and 1971.

TREATMENTS

The 2 + 2 pine and spruce conventional bare-root stock used in each year of these planting trials were obtained from the Prince Albert Nursery of the Saskatchewan Department of Natural Resources (DNR). Sufficient stock was fall-lifted for both fall and spring planting, with the latter being overwintered in cold storage at the Prince Albert Nursery.

The container stock was reared in late winter (from the same DNR seedlots as the 2 + 2 stock) by the CFS in Edmonton, Alberta. BC/CFS Styroblock 2 containers with 40 cm^3 cavities were used, except in the fall of 1972 when 70 cm^3 Japanese FH 408 paper pots were substituted. Greenhouse rearing times of 13–14 weeks were followed by approximately 3 weeks of shade frame hardening; at this time the seedlings were transferred to shade frames at the Prince Albert Nursery. Half of the shipment was then spring planted and the remainder held in shade frames at the nursery.

The conventional 2 + 2 stock was bar-planted using three insertions of the planting bar (one to open the hole for the seedling and one on each side of the seedling to close the hole firmly). The Styroblock 2 plugs were planted more easily using a solid dibble; the one fall planting of paper pots was done with a pottiputki planting tool. Planting details and outplanting heights are given in Appendix 1.

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[1] Kolabinski, V.S. 1974. Fall and spring planting of conventional and container grown seedlings in controlled burn cutovers near Candle Lake, Saskatchewan. North. For. Res. Cent., Edmonton, Alberta. Unpubl. file rep.

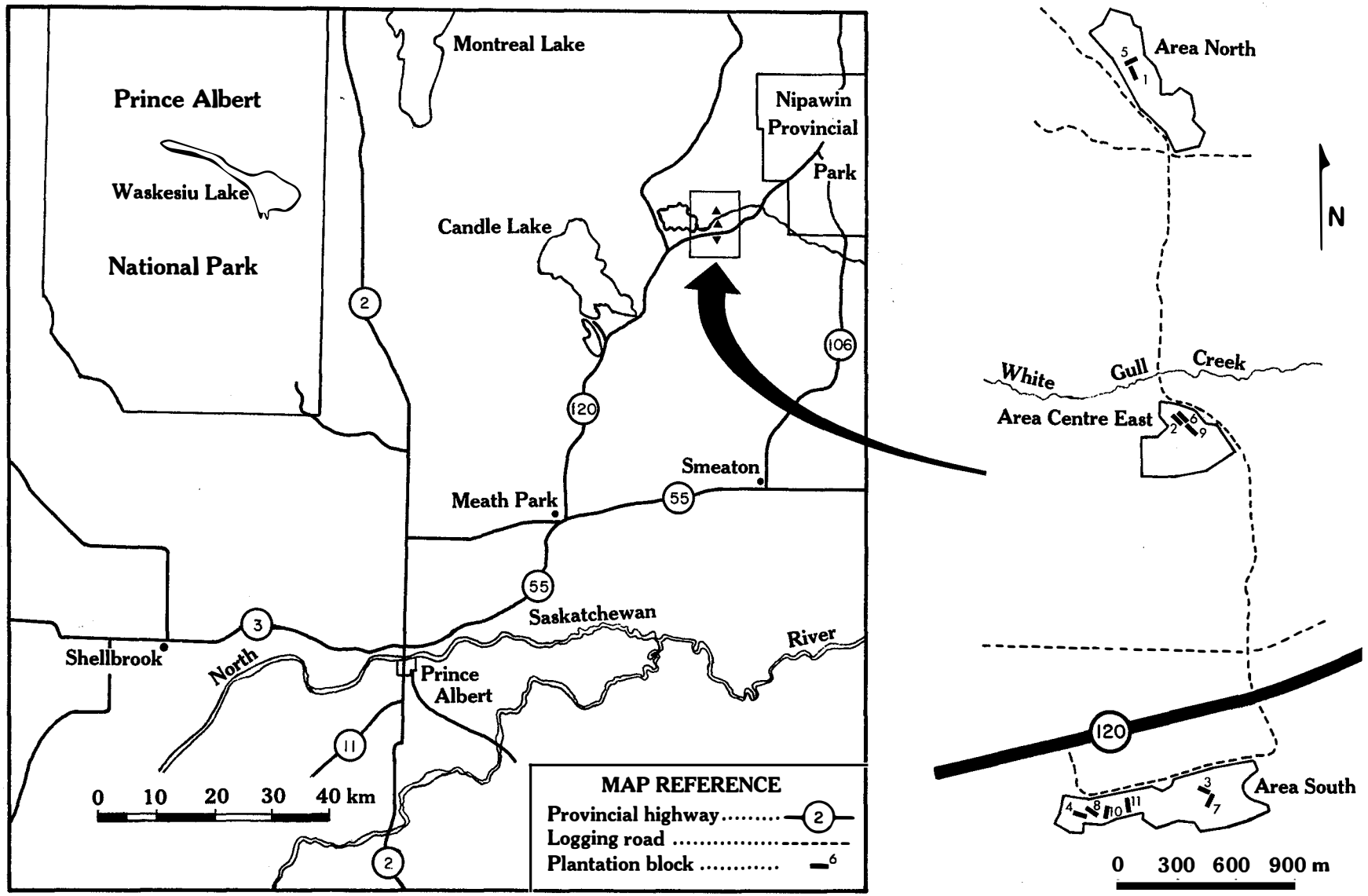


Figure 1. The study areas.

EXPERIMENTAL DESIGN

The experimental design consisted of a randomized block design with four replications of eight treatments per block, replicated over four areas per year for 3 years. Each treatment consisted of 30 seedlings spaced 120 cm apart in three rows of 10 seedlings (Fig. 2). Every third seedling was identified with a wire pin and measured for height and survival. Individual tree data were thus obtained on four replications of each of 10 trees, or 40 trees per treatment per block.

Blocks 1–4 were established for fall 1971 and spring 1972 planting, blocks 5-8 for the second fall and spring, and blocks 9-11 for the last fall and spring replications (Table 1). (Area Centre East was partially burned in 1974, destroying blocks 2 and 6.)

ANALYSIS

Five-year survival percentages of all bare-root and Styroblock 2 seedlings based on 24-36 plots of 10 trees each (Table 2) were transformed using an angular transformation ($\text{Sin}^{-1}\sqrt{x}$) (Jeffers 1960) and analyzed with an analysis of variance test at the 95% probability level. Five-year heights were analyzed with Duncan's test to compare means at the 95% level (Vann 1972). To illustrate the relationship between seedling size and height growth performance, linear regressions of fifth-year leader growth on fourth-year height were calculated on all undamaged seedlings for all treatments over all blocks. Equations were plotted for all treatments.

RESULTS

Survival

Overall 5-year survival for the jack pine treatments was 88% (Table 2). Fall- and spring-planted Styroblock 2 plugs and spring-planted 2 + 2 transplants had high 5-year survival percentages of 99.4, 98.9, and 95.1, respectively. These three treatments were significantly better ($p = 0.05$) than the survival rate of fall bare-root stock (60%). In fact, most of the pine mortality was experienced by one replication of fall-planted bare-root stock; 97% of the 1972 fall-planted 2 + 2 stock was dead by the summer of 1973. Overall 5-year survival of all white spruce treatments combined was 96% (Table 2). Spring-planted 2 + 2 stock had a high (99.4%) 5-year survival rate.

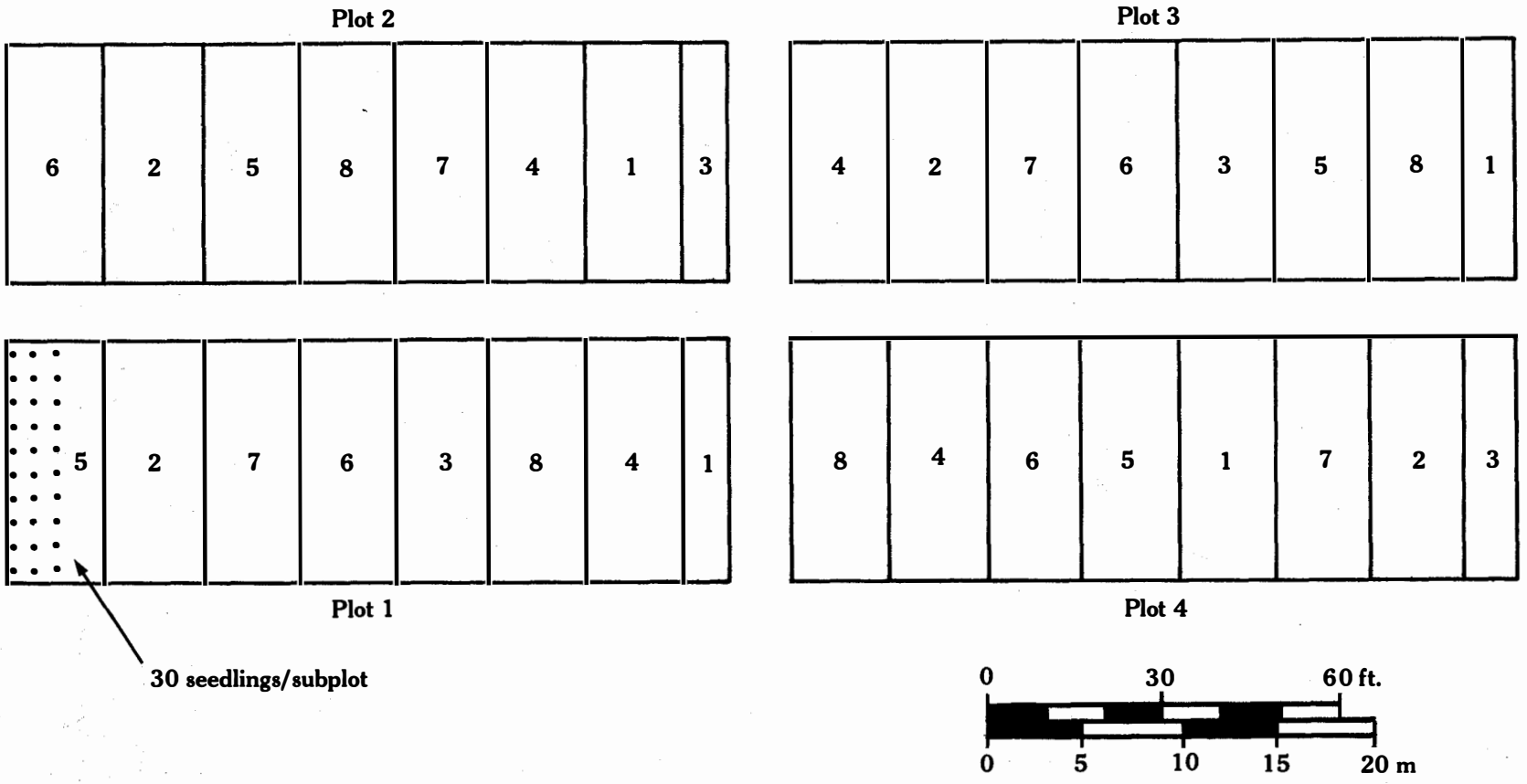
Height

At 5 years both fall- and spring-planted transplant stock of jack pine were significantly taller than their container counterparts (Table 3). Heights of fall- and spring-planted 2 + 2 stock were 11.5% and 31.2% greater than those of their respective fall- and spring-planted Styroblock 2 counterparts. There was no significant difference between fall- and spring-planted 2 + 2 stock, but spring-planted Styroblock 2 plugs were 14% shorter than the fall-planted plugs that had been reared for 3 months longer over the summer in cold frames.

At 5 years both fall- and spring-planted transplant stock of white spruce were significantly greater in height than their container counterparts (Table 3). Heights of all fall- and spring-planted 2 + 2 stock were 42.1% and 61.9% greater than their respective fall and spring-planted Styroblock 2 counterparts. There was no significant difference between fall and spring-planted 2 + 2 stock, but spring-planted Styroblock 2 plugs were 11.4% shorter than (older) fall-planted plugs that were reared over the summer in cold frames.

Height differences among the five stock types for both species are illustrated by area and year of planting in Figure 3, in which considerable variation in 5-year-height among blocks due to site and year of planting is evident. For example, compare Block 9 (planted in the third year on Area Centre East) with Block 4 (planted in the first year in Area South); heights among the eight treatments did not vary appreciably. On both blocks, fall-planted 2 + 2 pine were tallest, followed in descending order by spring-planted 2 + 2 pine, fall-planted Styroblock 2 pine, spring-planted Styroblock 2 pine, spring-planted 2 + 2 spruce, fall-planted 2 + 2 spruce, fall-planted Styroblock 2 spruce, and spring-planted Styroblock 2 spruce, despite the nearly 50-cm greater height of the fall-planted Styroblock 2 spruce on Block 4.

The one (1972) fall replication of FH 408 paper pots (on blocks 5, 7, and 8) had the poorest 5-year height of all the fall 1972—spring 1973 treatments for both spruce and pine (Fig. 3).



Treatment code

1	Jack pine 2 + 2 bare-root stock, fall planting	5	White spruce 2 + 2 bare-root stock, fall planting
2*	Jack pine Styroblock 2 seedlings, fall planting	6*	White spruce Styroblock 2 seedlings, fall planting
3	Jack pine 2 + 2 bare-root stock, spring planting	7	White spruce 2 + 2 bare-root stock, spring planting
4	Jack pine Styroblock 2 seedlings, spring planting	8	White spruce Styroblock 2 seedlings, spring planting

*FH 408 paper pots were substituted for Styroblock 2 containers in fall 1972.

Figure 2. The block design.

Table 1. Distribution of stock type by year of planting and block

Stock type	Fall 1971—spring 1972 (Blocks)	Fall 1972—spring 1973 (Blocks)	Fall 1973—spring 1974 (Blocks)	Total plots
Fall 2 + 2 bare-root	1, 3, 4	5, 7, 8	9, 10, 11	36
Fall Styroblock 2	1, 3, 4	—	9, 10, 11	24
Spring 2 + 2 bare-root	1, 3, 4	5, 7, 8	9, 10, 11	36
Spring Styroblock 2	1, 3, 4	5, 7, 8	9, 10, 11	36
Fall FH 408 paper pot	—	5, 7, 8	—	12

Table 2. Mean fifth-year percentage survival

Species and stock type	No. of 10-tree plots	Standard deviation	Mean
Jack pine			
Fall 2 + 2 bare-root	36	34.8	60.0
Fall Styroblock 2	24	2.0	99.4[a]
Spring 2 + 2 bare-root	36	5.0	95.1
Spring Styroblock 2	36	2.7	98.9
White spruce			
Fall 2 + 2 bare-root	36	7.8	95.5
Fall Styroblock 2	24	7.4	92.6
Spring 2 + 2 bare-root	36	2.8	99.4
Spring Styroblock 2	36	4.4	96.3

[a] Within species, values joined by a line do not differ at $p = 0.05$.

Table 3. Mean fifth-year height (cm) by year of planting

Year of planting and block	Jack pine				White spruce			
	Styroblock 2		2 + 2 bare-root		Styroblock 2		2 + 2 bare-root	
	Spring	Fall	Spring	Fall	Spring	Fall	Fall	Spring
Fall 1971—spring 1972								
1	108.6	119.5	124.1	130.1[a]	40.1	40.0	63.7	68.6
3	111.8	144.0	146.8	129.7	58.4	61.3	88.8	85.6
4	117.1	140.5	153.4	161.3	49.9	58.7	93.3	95.0
Fall 1972—spring 1973								
5	90.0	—	103.6	—	26.3	—	42.7	37.6
7	112.8	—	166.5	—	48.6	—	62.3	64.7
8	115.7	—	183.3	—	38.4	—	71.1	80.4
Fall 1973—spring 1974								
9	74.3	82.2	100.8	113.5	19.8	35.4	35.0	38.0
10	107.1	114.0	126.4	127.6	30.8	31.5	43.7	45.3
11	105.6	117.4	125.5	138.6	41.6	43.4	54.2	55.1
Fall 1971—spring 1974								
All	104.8	119.5	137.5	133.3	39.4	43.9	62.4	63.8

[a] Within species, values underscored with the same line do not differ significantly ($p = 0.05$).

For both spruce and pine, the larger and older conventional transplant stock outperformed (in terms of fifth-year height) the small-volume container material on all areas, over all seasons, and for all years of replication (Fig. 3, Table 3). It is also evident that for both species, the (older) fall-planted Styroblock 2 plugs outperformed spring-planted Styroblock 2 plugs on all areas over all years of replication. All heights, with the exception of the 1972 spring-planted 2 + 2 pine stock, declined significantly and progressively by year of planting (Table 4).

Growth Rate

In general, the jack pine container stock attained and surpassed the outplanting height of the 2 + 2 stock (20–25 cm) in the third growing season (Fig. 4). For all treatments, a weak but significant ($p = 0.001$) relationship existed between fourth-year height and fifth-year height increment (Table 5). Seedling size at 4 years accounted for 17% (fall Styroblock 2 containers) to 48% (fall paper pots) of the fifth-year increment. It is clear, however, that both the fall- and spring-planted conventional stock were growing about 4 cm per year more quickly than all other container stock (Fig. 5, Table 5).

As with the pine, the white spruce container seedlings did not attain the outplanting height (20–25 cm) of the spruce transplant stock until the third growing season (Fig. 6). For all treatments, a weak but significant ($p = 0.001$) relationship existed between fourth-year height and fifth-year height increment (Fig. 7). Seedling size at 4 years accounted for 22% (spring Styroblock 2 containers) to 57% (fall 2 + 2 stock) of the fifth-year increment (Table 5). Treatments that produced the largest seedlings at 4 years showed the greatest fifth-year height increment: spring-planted 2 + 2 stock averaged 59.7 cm in height at 4 years and had a leader growth of 12.6 cm, and fall-planted FH 408 paper pot stock averaged 20.4 cm at 4 years and had a fifth-year increment of 6.1 cm (Table 5). Also, within each treatment larger trees grew faster than smaller ones (Fig. 7). For example, a spring-planted 2 + 2 seedling, 50 cm high at 4 years, averaged about 10 cm in fifth-year height growth, whereas a spring-planted 2 + 2 seedling, 70 cm high, averaged nearly 16 cm in fifth-year leader growth.

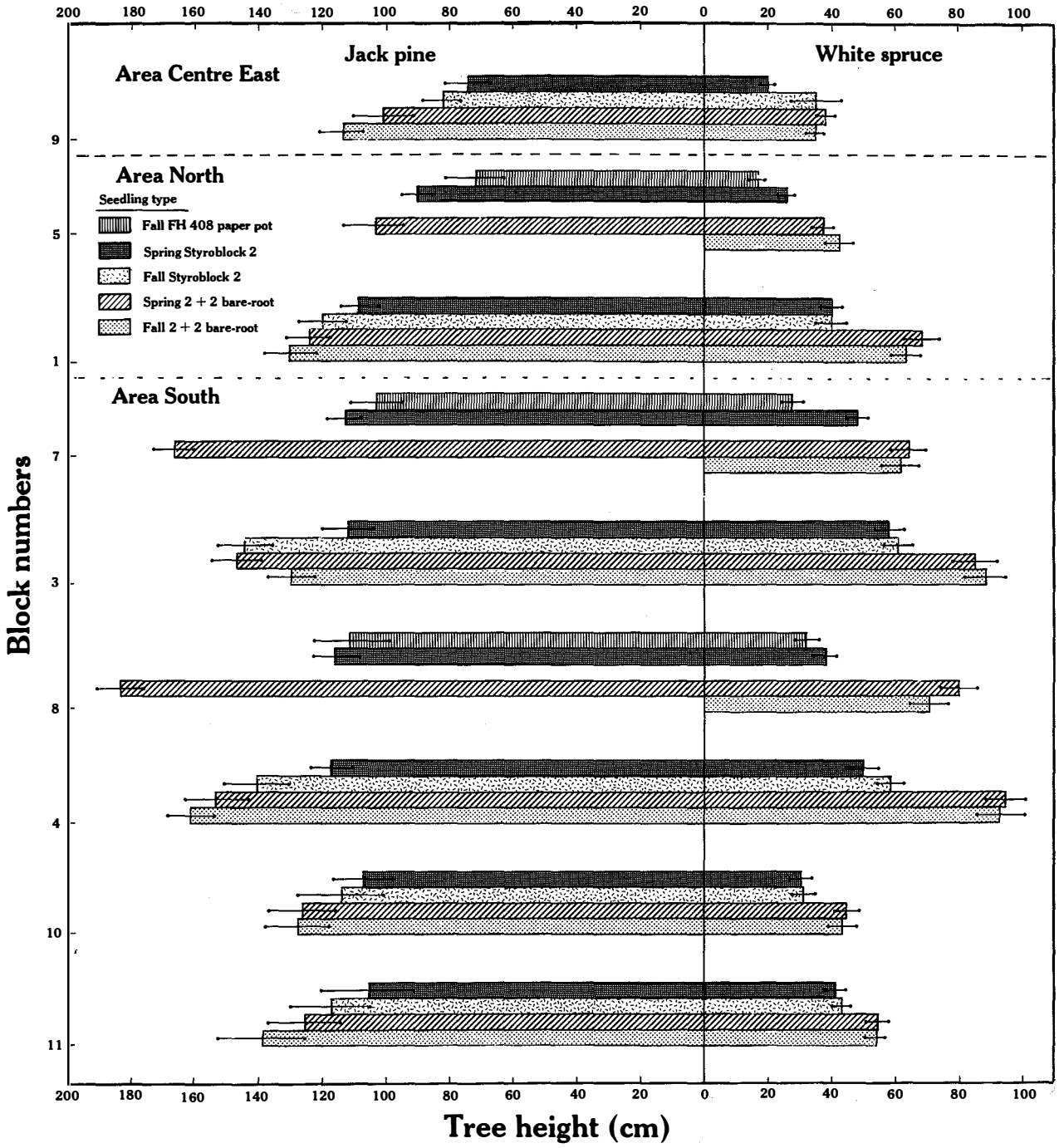


Figure 3. Five-year height by block. The lines extending from each end of the bars represent one standard error of the mean.

Table 4. Fifth-year height by species and year of planting origin[a]

Species and stock type	Height at 5 years (cm)		
	Fall 1971—spring 1972	Fall 1972—spring 1973	Fall 1973—spring 1974
Jack pine			
Fall 2 + 2 bare-root	140.6	—	126.2
Fall Styroblock 2	134.8	—	104.4
Spring 2 + 2 bare-root	141.6	151.7	118.8
Spring Styroblock 2	112.5	106.0	95.6
Fall FH 408 paper pot	—	95.3	—
White spruce			
Fall 2 + 2 bare-root	82.3	60.9	44.3
Fall Styroblock 2	53.1	—	36.8
Spring 2 + 2 bare-root	83.0	62.0	46.1
Spring Styroblock 2	49.5	37.9	30.8
Fall FH 408 paper pot	—	25.6	—

[a] All values within each row are significantly different ($p = 0.05$).

Table 5. The effect of seedling height on height increment

Species and stock type	No. of seedlings	Coefficient of determination (R^2)	4-year height (cm)	5th-year height increment (cm)
Jack pine				
Fall 2 + 2 bare-root	194	0.26	99.9 (1.6)[a]	37.4 (1.6)
Fall Styroblock 2	210	0.17	90.8 (1.9)	34.5 (0.8)
Spring 2 + 2 bare-root	302	0.38	103.8 (1.5)	38.3 (0.7)
Spring Styroblock 2	326	0.30	74.6 (1.1)	32.9 (0.6)
Fall FH 408 paper pot	90	0.48	62.6 (2.4)	33.4 (1.3)
White spruce				
Fall 2 + 2 bare-root	174	0.57	58.5 (1.5)	11.7 (0.5)
Fall Styroblock 2	110	0.39	39.5 (1.3)	10.4 (0.6)
Spring 2 + 2 bare-root	202	0.49	59.7 (1.4)	12.6 (0.5)
Spring Styroblock 2	182	0.22	36.3 (0.9)	9.0 (0.3)
Fall FH 408 paper pot	49	0.35	20.4 (1.3)	6.1 (0.4)

[a] Number in brackets is standard error.

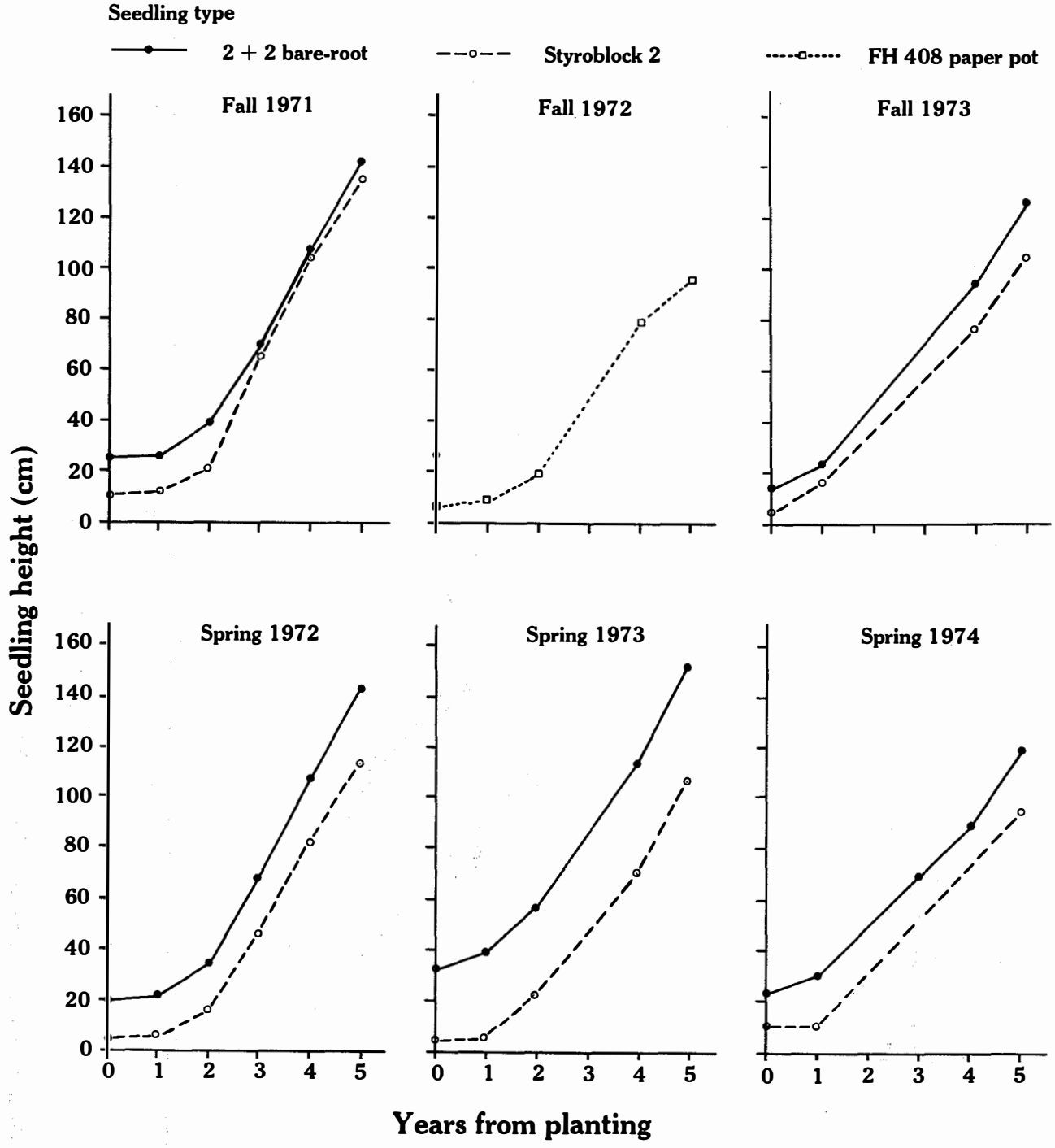


Figure 4. Height growth of jack pine by year of planting.

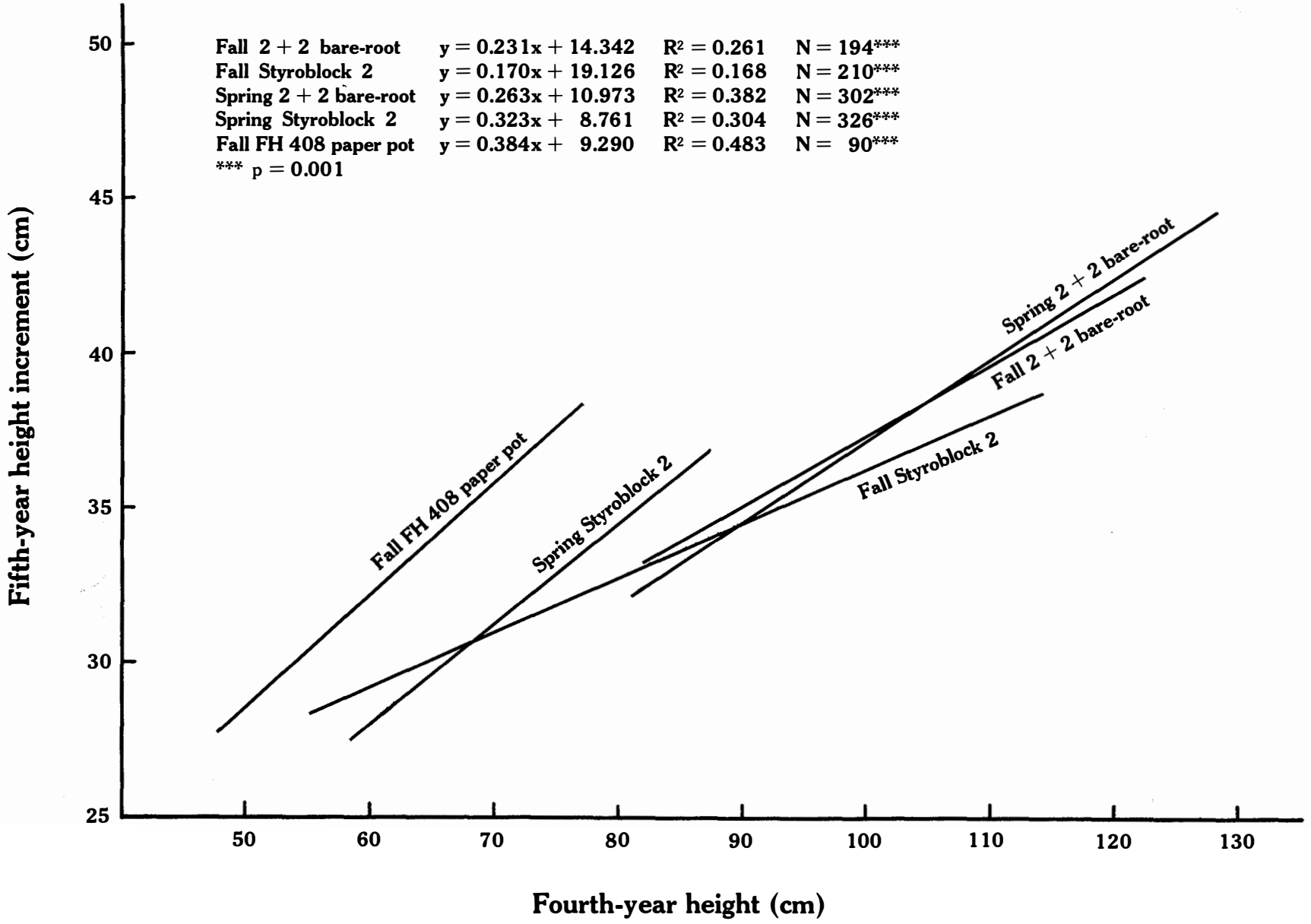


Figure 5. Relationship between fourth-year height and fifth-year height increment of jack pine.

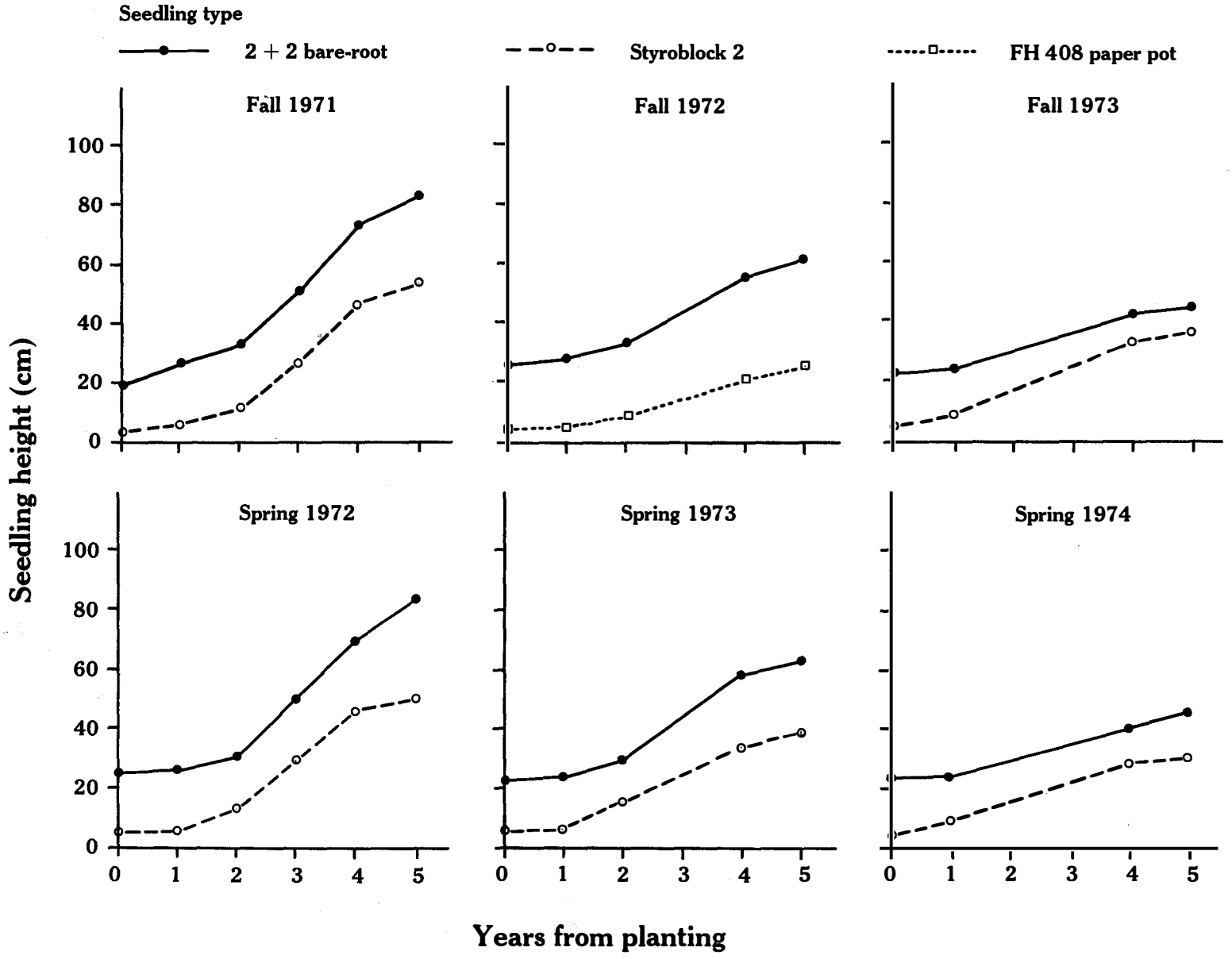


Figure 6. Height growth of white spruce by year from planting.

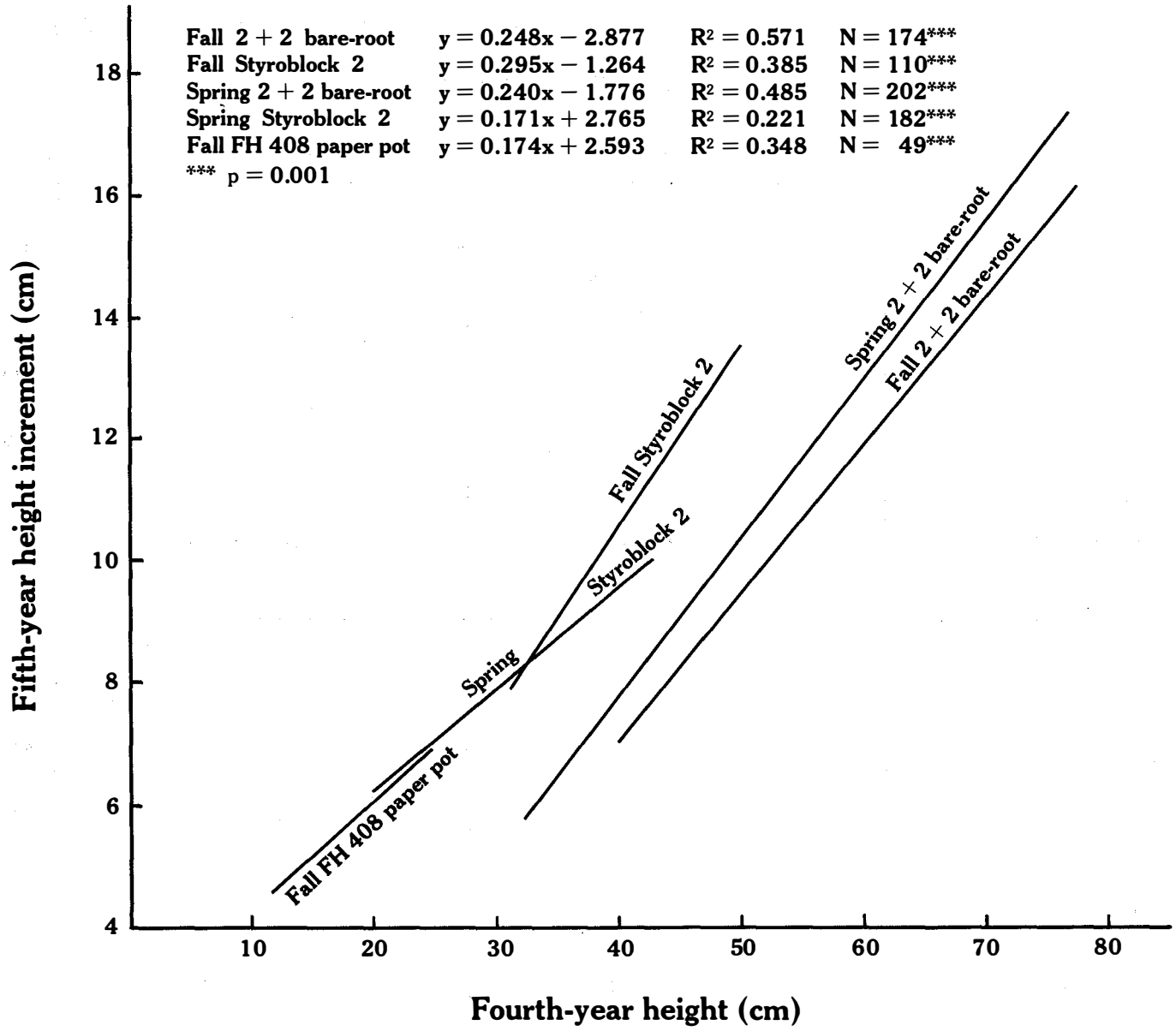


Figure 7. Relationship between fourth-year height and fifth-year height increment of white spruce.

Damage

Moderate-to-severe damage from the lodgepole terminal weevil (*Pissodes terminalis* Hopping) and the pitch nodule maker (*Petrova albicapitana* (Busck)) has resulted in substantial numbers of multileadered jack pine with poor form and likely some reduction in total tree height. As mentioned above, however, all heights of pinned survivors were included in the analysis of mean height; trees with damaged leaders were excluded from the analysis of leader growth.

Some snowshoe hare (*Lepus americanus*) browsing occurred on 1971 fall-planted jack pine 2 + 2 stock on one block (Block 3) in 1972. Of the 34 survivors, 31 had sustained chewing damage; therefore, outplanting heights were predicated on 120 seedlings in the other three blocks. These browsed seedlings grew well (14.4 cm) in 1973 and showed little adverse effect.

As with the pine, heights of all pinned survivors of white spruce were included in the determination of tree heights; however, substantial reductions in height due to loss of apical dominance and subsequent "cabbaging" were common and increasing (Table 6). All seedlings were single-stemmed when planted, but at 5 years 44.4% of all spruce were multileadered, some with as many as 11 leaders. Although moderate frost injury was common on the two areas north of the highway, causes of this bush form of both container and bare-root white spruce, resembling that reported by Gross (1979), are not known.

Table 6. Incidence of multileaders in 5-year-old white spruce

Blocks and year measured	% trees with multileaders	
	Bare-root	Container
1, 3, 4 (1976)	26.9	48.0
5, 7, 8 (1977)	44.6	40.2
9, 10, 11 (1978)	57.5	50.0
Average	42.7	46.3

DISCUSSION

These results show high initial (5-year) survival rates for jack pine and white spruce container and bare-root seedlings planted on burned cutovers, although differences in survival and growth may be blurred due to better handling and planting of bare-root stock by research staff (Pierpoint et al. 1981). Also, any adverse effects of summer planting would tend to affect container stock less than bare-root stock (Walker and Johnson 1980) and would lower the performance of bare-root stock (Ackerman and Johnson 1962; Mullin and Reffle 1980; Sutton 1982a).

The reasons for the one disaster in three with fall planting of jack pine bare-root stock are not clear; however, the phenomenon of variable survival with fall planting of pine is not uncommon and is well discussed by Sutton (1982a, b). Current practice in this region is to avoid fall planting of jack pine bare-root stock.

Results presented here show that growth differences between larger 2 + 2 bare-root and smaller Styroblock 2 white spruce and jack pine can be substantial and much greater than differences in survival. In general, large natural spruce seedlings (and saplings) grow faster than small ones (Hellum 1967; Johnstone 1978), and large transplant seedlings grow faster than small ones (Fowells 1953; Brace 1964; Smith and Walters 1965; Zaerr and Lavender 1976; Wynia and McClain 1981; Mullin and Christl 1981). King et al. (1965) found that larger selected 2 + 2 spruce stock had significantly greater height growth than average stock; this super spruce also showed less damage from late spring frost. Eighteen years after planting, super spruce were 30% taller than controls (Nienstaedt 1981).

Large container seedlings at outplanting have also been shown to have greater growth potential than small ones (Scarratt 1974; Tinus 1974). This has been found with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) bullets and bullet plugs (Arnott 1972). Other investigators working with white spruce, lodgepole pine (*Pinus contorta* Dougl.) and jack pine have shown that older and larger container seedlings (from paper pots, Spencer-

Lemaire Rootrainers, Styroblocks, and ARC (Alberta Research Council) sausages) grow faster than smaller ones (Scarratt 1972; Endean and Hocking 1973; Hocking and Endean 1974; Pollard 1978; Walker 1978; Walker and Johnson 1980; McMinn 1981, 1982; Ball and Walker 1981; Walker and Ball 1981).

It follows that differences in height growth between container and bare-root seedlings would be diminished by increasing container seedling size or by using small bare-root stock. When Vyse (1981b) compared growth of 8-cm Styroblock 2 spruce (60% larger than that used in this study) with small 14-cm bare-root stock (50% smaller than that reported here), he found that container stock grew as well as bare-root seedlings. When container and bare-root stock of the same size were compared, Vyse (1981a) found that growth of container stock exceeded that of bare-root stock. Alm (1983), using very large black spruce (*Picea mariana* (Mill.) B.S.P.) and white spruce from Styroblock 2 containers and size 315 paper pots (several times larger than those used here) or bare-root seedlings from prairie nurseries, found height growth of container seedlings to be as good as the conventional bare-root seedlings.

Two to three crops of container seedlings are commonly produced annually in prairie nurseries with considerable variability (Edwards and Huber 1981). Unlike bench crops such as chrysanthemums, containerized tree seedlings have to grow quickly after outplanting; many advantages of the container seedlings (such as ease of planting and better microsite selection) may be lost if current trends toward production of small stock relegate the container seedlings to poorer sites with less competition.

CONCLUSIONS AND RECOMMENDATIONS

In general, high 5-year survival rates were obtained with both white spruce and jack pine container and bare-root stock on burned jack pine cutovers in central Saskatchewan; however, fall-planted bare-root pine had variable survival and is not recommended.

The substantial difference in outplanting size between bare-root and container seedlings (the bare-root stock were 3–4 times taller at outplanting) resulted in 5-year height differences between the two treatments of 50% for spruce and 20% for pine. It is therefore recommended that the size of spruce container stock be increased to at least twice that used in this study.

The one fall planting of FH 408 paper pot container seedlings had poorer survival and growth than the five other seasonal plantings of Styroblock 2 pine and spruce. This paper pot did not degrade during the first 5 years on these jack pine sites and (similar to other unsatisfactory containers such as the Ontario tube and the ARC sausage planted with the container intact around the root plug) performed poorly by restricting root development. The FH 408 paper pot container seedlings, particularly white spruce, are therefore not recommended for outplanting on upland sites.

Five-year heights declined progressively by year of replication. Notwithstanding technical problems associated with planting fresh burns, it is recommended that planting be carried out as soon as possible following burning (or any site preparation) to reduce the negative impact of vegetative competition, particularly aspen. It is also likely that seedlings planted shortly after burning would gain more from the positive effects of burning, particularly the capture of released nutrients, than would seedlings planted 2 or 3 years later.

Rather surprisingly, differences in 5-year height between bare-root and container seedlings planted in the second and third years diminished under more competitive conditions, particularly with spruce. Large stock, as suggested by Dobbs (1976), is therefore not recommended as a substitute for vegetation control or for planting on unprepared sites.

In this study, larger trees (particularly spruce) at 4 years grew at a faster rate than smaller ones. To reduce the extremely hazardous period of plantation establishment (as well as to shorten the intended rotation), it is recommended that measures be taken to ensure early rapid growth of individual tree seedlings following outplanting. Gains can be achieved by planting large, high-quality stock on freshly prepared sites and following up with vegetation control.

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REFERENCES

Ackerman, R.F.; Johnson, H.J. 1962. Continuous planting of white spruce throughout the frost-free period. Can. Dep. For., Ottawa, Ont. Tech. Note 117.

Alm, A.A. 1983. Black and white spruce plantings in Minnesota: container vs. bare-root stock and fall vs. spring planting. For. Chron. 59(4):189–191.

Arnott, J.T. 1972. Influences affecting container seedling performance on Vancouver Island, British Columbia. Pages 89–91 *in* R.M. Waldron, editor. Proceedings of a workshop on container planting in Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Inf. Rep. DPC-X-2.

Ball, W.J.; Brace, L.G. 1981. Production, use and field performance of container seedlings in the prairie provinces. Pages 313–320 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, editors. Proceedings of the Canadian containerized forest tree seedling symposium, Toronto, 1981. Can.-Ont. Joint For. Res. Comm. Proc. O-P-10.

Ball, W.J.; Walker, N.R. 1981. Increasing shoot-root ratio and seedling size improves 1st-year performance. Page 7 *in* R. Waldron and J. Samoil, editors. Silviculture. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. For. Rep. 24.

Brace, L.G. 1964. Early development of white spruce as related to planting method and planting stock height. Can. Dep. For., Ottawa, Ont. Publ. 1049.

Brace, L.G.; Golec, P.J. 1982. Silviculture statistics for Canada, 1975–80. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-245.

Chrosciewicz, Z. 1978a. Large-scale operational burns for slash disposal and conifer reproduction in central Saskatchewan. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-201.

Chrosciewicz, Z. 1978b. Slash and duff reduction by burning on clear-cut jack pine sites in central Saskatchewan. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-200.

Dobbs, R.C. 1976. Effect of initial mass of white spruce and lodgepole pine planting stock on field performance in the British Columbia interior. Can. Dep. Environ., Can. For. Serv., Pac. For. Res. Cent., Victoria, B.C. Inf. Rep. BC-X-149.

Edwards, I.K.; Huber, R.F. 1981. Contrasting approaches to containerized seedling production. The prairie provinces. Pages 123–127 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, editors. Proceedings of the Canadian containerized forest tree seedling symposium, Toronto, 1981. Can.-Ont. Joint. For. Res. Comm. Proc. O-P-10.

Endean, F; Hocking, D. 1973. Performance after planting of four types of container-grown lodgepole pine seedlings. Can. J. For. Res. 3:185–195.

Fowells, H.A. 1953. The effect of seed and stock sizes on survival and early growth of ponderosa and Jeffrey pine. J. For. 51:504–507.

Froning, K. 1972. An appraisal of recent plantations in forests of the prairie provinces. Dep. Fish. Environ., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-31.

Gross, H.L. 1979. Studies initiated to determine cause of multileadered nursery seedlings. Can. Dep. Environ., Can. For. Serv., Great Lakes For. Res. Cent., Sault Ste. Marie, Ont. For. Res. Newsl. Fall-Winter 1979.

Hellum, A.K. 1967. Periodicity of height growth in white spruce reproduction. For. Chron. 43(4):365–371.

Hills, G.A. 1955. Field methods for investigating site. Ont. Dep. Lands For., Res. Div. Site Res. Man. 4.

Hocking, D.; Endean, F. 1974. Performance after planting of four types of container-grown white spruce seedlings. Can. J. For. Res. 4:238–245.

Jeffers, J.N.R. 1960. Experimental design and analysis in forest research. Almquist and Wiksell, Stockholm, Sweden.

Johnstone, W.D. 1978. Growth of fire and spruce advance growth and logging residuals in west-central Alberta. Fish. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-203.

King, J.P.; Nienstaedt, H.; Macon, J. 1965. Super-spruce seedlings show continued superiority. U.S. Dep. Agric., For. Serv., St. Paul, Minn. Note LS-66.

McMinn, R.G. 1981. Size of container-grown seedlings should be matched to site conditions. Pages 307–312 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, editors. Proceedings of the Canadian containerized forest tree seedling symposium, Toronto, 1981. Can.-Ont. Joint For. Res. Comm. Symp. Proc. O-P-10.

McMinn, R.G. 1982. Ecology of site preparation to improve performance of planted white spruce in northern latitudes. Pages 25–32 *in* M. Mayo, editor. Forest regeneration at high latitudes: experiences from British Columbia. Sch. Agric. Land Resour. Manage., Fairbanks, Alaska, and U.S. Dep. Agric., For. Serv., Pac. Northwest For. Range Exp. Stn. Misc. Rep. 82-1.

Mullin, R.E.; Christl, C. 1981. Morphological grading of white spruce nursery stock. For. Chron. 57:3.

Mullin, R.E.; Reffle, R.J. 1980. Effects of dates of lifting and planting on success of frozen spring storage at Swastika nursery. Ont. Minist. Nat. Resour., For. Res. Branch, Maple, Ont. Nursery Notes 29.

Nienstaedt, H. 1981. "Super" spruce seedlings continue superior growth for 18 years. U.S. Dep. Agric., For. Serv., St. Paul, Minn. NC-265.

Pierpoint, G.; Paterson, J.M.; Boufford, J.G.; Glerum, C. 1981. Irregular growth of outplanted red pine. The influence of handling and planting on fifth-year performance. Ont. Minist. Nat. Resour., For. Res. Branch., Maple, Ont. For. Res. Note 29.

Pollard, D.F.W. 1978. Relationship between duration of initial growing period and subsequent growth of greenhouse-reared white spruce seedlings. Bi-month. Res. Notes 34(4):24.

Rowe, J.S. 1972. Forest regions of Canada. Environ. Can., Can. For. Serv., Ottawa, Ont. Publ. 1300.

Scarratt, J.B. 1972. Relationship between size at planting and growth of white spruce tubed seedlings. Environ. Can., Can. For. Serv., Great Lakes For. Res. Cent., Sault Ste. Marie, Ont. Inf. Rep. O-X-58.

Scarratt, J.B. 1974. Performance of tubed seedlings in Ontario. Pages 310–320 *in* R.W. Tinus, W.I. Stein, and W.E. Balmer, editors. Proceedings of the North American containerized forest tree seedling Symposium. Great Plains Agric. Counc., Denver, Colo. Publ. 68.

Smith, J.H.G.; Walters, J. 1965. Influence of seedling size on growth, survival and cost of growing Douglas fir. Univ. B.C., Fac. For., Vancouver, B.C. Res. Note 50.

Sutton, R.F. 1982a. Plantation establishment in the boreal forest: planting season extension. Environ. Can., Can. For. Serv., Great Lakes For. Res. Cent., Sault Ste. Marie, Ont. Inf. Rep. O-X-344. Revised edition.

Sutton, R.F. 1982b. Plantation establishment with bare-root stock; some critical factors. Pages 304–321 *in* G.D. Mroz and J.F. Bernier, compilers. Proceedings. Artificial regeneration of conifers in the upper Great Lakes region, Green Bay, 1982. Michigan Tech. Univ., Houghton, Michigan.

Tinus, R.W. 1974. Large trees for the Rockies and plains. Pages 112–117 *in* Tinus, W.I. Stein, and W.E. Balmer, editors. Proceedings of the North American containerized forest tree seedling symposium. Great Plains Agric. Counc., Denver, Colo. Publ. 68.

Vann, E. 1972. Fundamentals of biostatistics. D.C. Heath and Company, Toronto, Ont.

Van Eerden, E. 1981. The fundamentals of container seedling production. Pages 83–90 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, editors. Proceedings of the Canadian containerized tree seedling symposium, Toronto, 1981. Can.-Ont. Joint. For. Res. Comm. Symp. Proc. O-P-10.

Vyse, A. 1981a. Field performance of small-volume container-grown seedlings in the central interior of British Columbia. Pages 291–297 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, editors. Proceedings of the Canadian containerized forest tree seedling symposium, Toronto, 1981. Can.-Ont. Joint. For. Res. Comm. Symp. Proc. O-P-10.

Vyse, A. 1981b. Growth of young spruce plantations in interior British Columbia. For. Chron. 57:174–180.

Walker, N.R. 1978. Field performance of Spencer-Lemaire container seedlings in west-central Alberta. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-207.

Walker, N.R.; Ball, W.J. 1981. Larger cavity size and longer rearing time improve container seedling field performance. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. For. Manage. Note 6.

Walker, N.R.; Johnson, H.J. 1980. Containerized conifer seedling field performance in Alberta and the Northwest Territories. Environ. Can., Can. For. Serv., North. For. Res. Cent., Edmonton, Alberta. Inf. Rep. NOR-X-218.

Wynia, A.; McClain, K.M. 1981. How seedbed density can affect nursery stock costs. For. Chron. 57:6.

Zaerr, J.B.; Lavender, D.P. 1976. Size and survival of 2-0 Douglas fir seedlings. Oregon State Univ., Sch. For., For. Res. Lab., Corvallis, Oregon. Res. Pap. 32.

APPENDIX 1

PLANTING STOCK, TIME, AND WEATHER

APPENDIX 1

Planting stock, time, and weather

Year of planting and blocks	Planting stock			Planting time		Planting weather
	Stock type	Species	Outplanting height (cm)	Season and year	Dates	
Year 1						
(Blocks 1–4)	2 + 2 bare-root	Jack pine	21.0	Fall 1971	Oct. 4–9	Overcast, rain (Oct. 6–7)
	2 + 2 bare-root	White spruce	19.3	Fall 1971	Oct. 4–9	Overcast, rain (Oct. 6–7)
	Styroblock 2	Jack pine	4.6	Fall 1971	Oct. 4–9	Overcast, rain (Oct. 6–7)
	Styroblock 2	White spruce	3.6	Fall 1971	Oct. 4–9	Overcast, rain (Oct. 6–7)
	2 + 2 bare-root	Jack pine	13.5	Spring 1972	June 1–2	Sunny and warm
	2 + 2 bare-root	White spruce	20.3	Spring 1972	June 1–2	Sunny and warm
	Styroblock 2	Jack pine	6.0	Spring 1972	June 27–28	Sunny and warm
	Styroblock 2	White spruce	5.2	Spring 1972	June 27–28	Sunny and warm
Year 2						
(Blocks 5–8)	2 + 2 bare-root	Jack pine	26.7	Fall 1972	Sept. 19–21	Cool, snow flurries
	2 + 2 bare-root	White spruce	23.4	Fall 1972	Sept. 19–21	Cool, snow flurries
	FH 408 paper pot	Jack pine	4.8	Fall 1972	Sept. 19–21	Cool, snow flurries
	FH 408 paper pot	White spruce	3.8	Fall 1972	Sept. 19–21	Cool, snow flurries
	2 + 2 bare-root	Jack pine	32.0	Spring 1973	May 7–8	Warm and humid
	2 + 2 bare-root	White spruce	21.0	Spring 1973	May 7–8	Warm and humid
	Styroblock 2	Jack pine	4.9	Spring 1973	June 27–28	Showers
	Styroblock 2	White spruce	6.2	Spring 1973	June 27–28	Showers
Year 3						
(Blocks 9–11)	2 + 2 bare-root	Jack pine	13.7	Fall 1973	Oct. 2–4	Cool, showers
	2 + 2 bare-root	White spruce	20.0	Fall 1973	Oct. 2–4	Cool, showers
	Styroblock 2	Jack pine	4.6	Fall 1973	Oct. 2–4	Cool, showers
	Styroblock 2	White spruce	5.9	Fall 1973	Oct. 2–4	Cool, showers
	2 + 2 bare-root	Jack pine	23.4	Spring 1974	May 23	Cool and sunny
	2 + 2 bare-root	White spruce	18.5	Spring 1974	May 23	Cool and sunny
	Styroblock 2	Jack pine	3.9	Spring 1974	June 17	Sunny and warm
	Styroblock 2	White spruce	3.7	Spring 1974	June 17	Sunny and warm