BLACK SPRUCE OUTPLANTINGS IN ONTARIO'S CLAY BELT. BARE-ROOT VERSUS PAPERPOT STOCK: FIVE-YEAR RESULTS

J.E. WOOD

GREAT LAKES FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

DEPARTMENT OF THE ENVIRONMENT

1984

INFORMATION REPORT O-X-356

Catalogue No. Fo46-14/356E
ISBN 0-662-12982-2
ISSN 0822-210X

Copies of this report may be obtained from:

Great Lakes Forest Research Centre
Canadian Forestry Service
Department of the Environment
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

ABSTRACT

Five years after outplanting, May-planted 1½+1½ black spruce *(Picea mariana* [Mill.] B.S.P.) and May- and July-planted 408 paperpots had significantly higher survival rates than May-planted 3+0 or July-planted rising 1½+1½ bare-root stock. May-planted 1½+1½ stock was significantly taller than either the 3+0, the paperpot, or the July-planted 1½+1½ stock throughout the five years. Current annual height increment was greater in the May- and July-planted paperpots than in other stock types two years after outplanting. Thereafter, current annual height increment was similar for all stock types, except for May-planted transplants which were growing significantly faster in the fifth year. The May-planted transplants and July-planted paperpots had the highest number of trees in good condition five years after planting.

RÉSUMÉ

Cinq ans apres la transplantation d'épinettes noires *(Picea mariana* [Mill.] B.S.P.), les taux de survie des plants repiqués 1½+1½, à racines nues, plantés en mai et de 408 plants en conteneurs de papier plantés en mai et juillet étaient significativement plus élevés que ceux du matériel à racines nues 3+0 planté en mai ou 1½+1½ planté en juillet. Durant les cinq années, la hauteur du matériel 1½+1½ planté en mai est demeurée significativement plus élevée que celle des semis 3+0, des plants en conteneurs de papier et des plants repiqués 1½+1½ plantés en juillet. Deux ans après la transplantation, l'accroissement annuel en hauteur a été plus élevé pour les plants en conteneurs de papier plantés en mai et juillet que pour les autres types de matériel. Par la suite, il a été similaire pour tous, exception faite des plants repiqués plantés en mai dont la croissance était significativement plus rapide après cinq ans. C'est chez ces derniers et chez les plants en conteneurs de papier plantés en juillet qui l'on comptait le plus grand nombre d'arbres en bon état cinq ans après la plantation.

ACKNOWLEDGMENTS

The author is indebted to C.R. Mattice for establishing this planting trial, to F.W. Curtis for technical assistance, to the forest management staff of the Ontario Ministry of Natural Resources, Kapuskasing District Office, for their cooperation and support, and to B.J. Sutherland and R.F. Sutton of the Great Lakes Forest Research Centre for their helpful comments on the draft manuscript.

INTRODUCTION

The superior pulping qualities of black spruce *(Picea mariana* [Mill.] B.S.P.) have made it one of the most valuable tree species in Ontario (Anon. 1980). In terms of land area, black spruce dominates approximately 41% of the province's productive forest land (Ketcheson and Jeglum 1972).

To date, planting has been the most successful means of regenerating black spruce (Haavisto 1980). In 1980-1981, approximately 19 million black spruce bare-root trees and just over 3 million containerized tree seedlings were produced from five Ontario provincial tree nurseries.[1] This represented a threefold increase from the 1977-1978 production level of 7.6 million trees, but fell far short of the 62.4 million trees required annually to regenerate the province's black spruce cutover adequately (ibid.).

To increase the percentage of black spruce cutover lands being successfully regenerated, the Ontario Ministry of Natural Resources (OMNR) has embarked on a major containerized tree seedling production program. Containerized planting stock offers several theoretical advantages over bare-root stock: increased planter productivity, extension of the traditional spring planting season, efficient use of available seed, and greater potential for mechanization (Haig 1982, Heeney 1982).

In this report, five-year survival and growth results from a black spruce comparative planting (bare-root vs paperpot stock) are presented. This trial was established in 1978 by C.R. Mattice[2] to compare the outplanted performance of three planting stocks: 1½+1½ transplant, 3+0 seedling, and paperpots planted in different seasons. All stock types were planted during late May and early July to assess the feasibility of extending the planting season through the use of containerized (Japanese paperpots) planting stock.

STUDY SITE

The experimental site (49°06'N, 83°03'W) is located in Opasatika Township approximately 70 km southwest of Kapuskasing within the Northern Clay Section (B.4) of the Boreal Forest Region (Rowe 1972). The area is dominated by a mixedwood upland site type which is characterized by an organic layer less than 30 cm deep over shallow-to-deep soils ranging from poorly drained to well drained (Robinson 1974).

---

[1] Smyth, J.H. and Brownwright, A.J. 1982. Forestry statistics Ontario 1982. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont., 136 p. (unpubl.).

[2] Formerly Forestry Officer, Department of the Environment, Canadian Forestry Service, Great Lakes Forest Research Centre, Sault Ste. Marie, Ont.

The planting site is in the Mixedwood-Herb Rich Operating Group (OG-7) of the Forest Ecosystem Classification developed for Ontario's Clay Belt (Jones et al. 1983).

The experimental plot is situated on the upper southwest facing slope (0-5%) of a ground moraine. The parent soil material is a silt loam, corresponding to a fresh, moderately well drained to well drained moisture regime. Tree rooting is evident to a depth of 60 cm.

The forest stand before harvesting was composed of black spruce (80%) and trembling aspen *(Populus tremuloides* Michx.) (20%). The area was cut by conventional cut and skid logging in 1975-1976 by the Spruce Falls Power and Paper Co. Ltd. Residual hardwoods were left standing in the plot area. In 1977 the site was prepared for operational planting by prescribed burning. The burn removed most of the forest humus on the plot and facilitated planting through slash reduction.

Within three years of the prescribed burn and two years of planting, the site was overgrown by trembling aspen, birch *(Betula papyrifera* Marsh.), and forbs. In July 1980, 2,4-D was applied aerially at 1.4 kg active ingredient ha^{-1} at a rate of 21.0 L of water and 2,4-D ha^{-1}. The herbicide killed the vegetation overtopping the crop trees. At the time of the last assessment (1982) trembling aspen and raspberry *(Rubus idaeus* L.) were providing the most severe competition to the outplants. These two species covered approximately 5-10% of the plot area. Ground vegetation in 1982 consisted of: big leaf aster *(Aster macrophyllus* L.), fireweed *(Epilobium angustifolium* L.), and wild strawberry *(Fragaria virginiana* Duchesne).

Mean monthly temperatures for the Kapuskasing area from May through October 1978 closely approximated the long-term monthly normals (Fig. 1). The daily minima and maxima during and subsequent to the May plant were lower than the 1978 monthly averages (Anon. 1978). During this period, daytime temperatures, recorded at the Kapuskasing weather station, reached into the low teens (°C) with night-time lows frequently dropping to near freezing. Temperatures during and subsequent to the July plant differed little from normal.

Precipitation from May through October 1978 was generally heavier than normal (Fig. 2). August was the only exception: only 54% of normal precipitation was recorded for that month (Anon. 1978). Rain fell at the experimental site during both the May and the July plants.

METHODS

Two stock types, bare-root (3+0 seedling and 1½+1½ transplant), and 408 Japanese paperpots were outplanted in both spring (30-31 May) and summer (7 July). In total, five treatments were studied (Table 1). Data from the July-planted rising 3+0 seedlings are excluded here because of doubt as to origin of the stock.

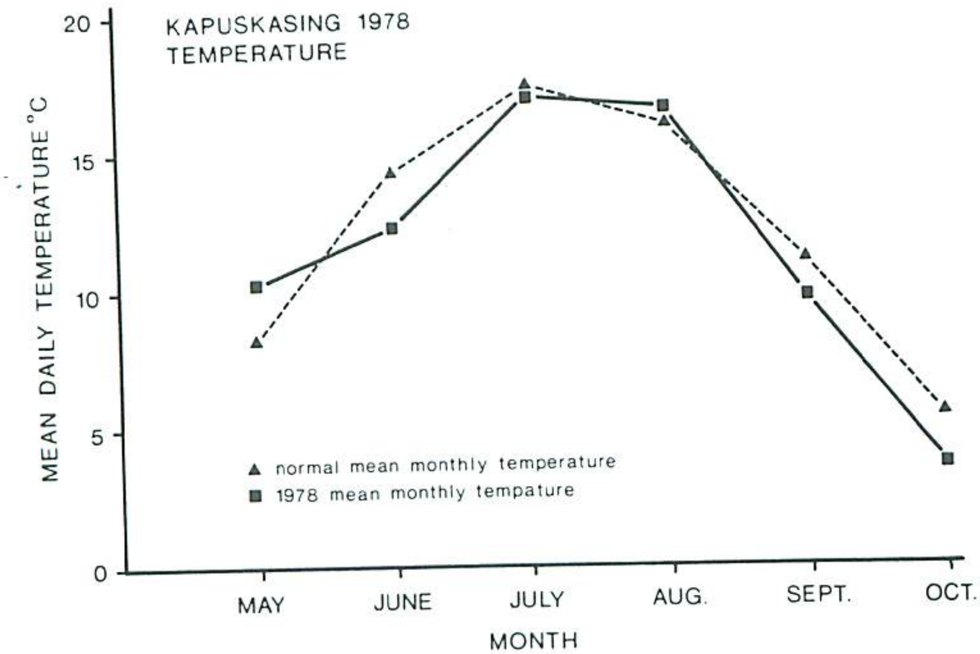

Figure 1. Normal and 1978 mean monthly (May to October) temperatures - from Can. Dep. Agric. Weather Station, Kapuskasing, Ontario.

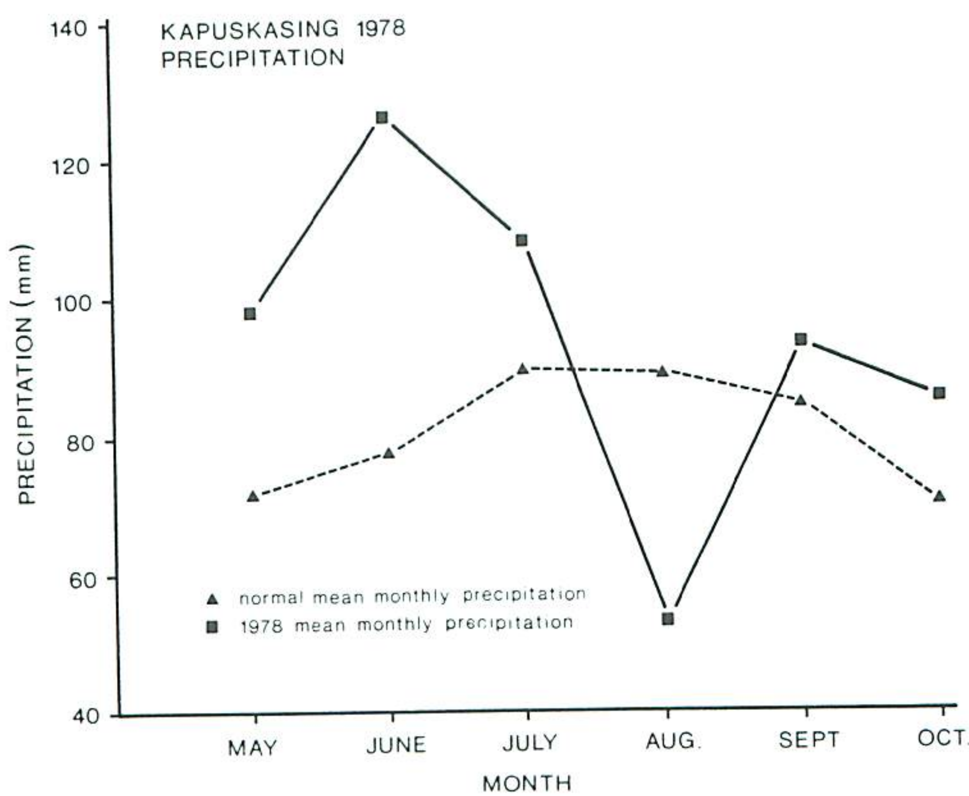

Figure 2. Normal and 1978 mean monthly (May to October) precipitation - from Can. Dep. Agric. Weather Station, Kapuskasing, Ontario.

The experimental design consisted of randomized treatment rows arranged along a straight base line. Treatments were replicated from three to five times. There were 20 treatment rows in all, each containing 35 trees for a total of 700 trees.

The bare-root stock was grown at the Swastika Forest Station (Swastika Tree Nursery), Swastika, Ontario. The paperpots were raised at the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario.

The 3+0 seedling stock was lifted from the nursery bed on 25 May, packed in polyethylene-lined kraft bags containing moistened peat, and held in cool storage (4°C) until shipped. The 1½+1½ transplant stock was lifted on 27 May and handled in the same manner as the seedling stock. Stock of both bare-root grades was shipped and was subsequently heeled in at the experimental site on 30 May. The transplants for summer planting were fresh-lifted as rising 1½+1½ stock in its third growing season. They were lifted on 5 July, packed in polyethylene-lined kraft bags, and held in cool storage at the nursery until the afternoon of 6 July when they were transported to Kapuskasing and heeled in at the planting site the following morning.

The spring-planted paperpots were sown in the greenhouse in May 1977 and overwintered outdoors under snow cover. The summer-planted paperpots were current-year stock, having been sown in the greenhouse in February 1978.

At time of planting, samples of 23-30 trees were selected from each treatment and the following morphological features were measured: shoot height, root collar diameter, root area index (Morrison and Armson 1968), shoot and root oven-dry weights, and shoot:root ratio (Table 1). According to Reese and Sadreika's (1979) size class standards for black spruce bare-root shipping stock, the spring-planted transplant stock was morphologically well balanced (Table 1). However, the 3+0 seedling stock did not meet the minimum oven-dry weights (4.0 g) and root area index (30 cm^2) culling limits (see Appendix). The summer-planted rising 1½+1½ bare-root trees were well below the culling limits in terms of root collar diameter, root area index, and total oven-dry weight. Both spring- and summer-planted paperpots were slightly shorter and heavier at outplanting than recommended.

An ocular estimate of the condition of each planted tree was made in 1982. Four condition classes were used in this assessment: vigorous, healthy, mediocre, and moribund. Vigorous trees were healthy with good form, sturdy shoots and good height growth. Healthy trees had at least moderate vigor, and only minor form defects. Trees in the mediocre or moribund condition classes lacked vigor and had abnormalities in color or form (Scarratt 1974).

Data on morphology, survival, and total height were subjected to analysis of variance and Tukey's Means Test on the basis of means of individual replications (Steele and Torrie 1960).

Table 1. Morphological characteristics of planting stock.

Planting date/ stock type	No. of seedlings in sample	Shoot ht (cm)	Root collar diam (mm)	Root area index (cm^2)	Total oven-dry wt (g)	Shoot: root ratio
Spring (30-31 May)						
1½+1½ bare-root	25	31.5a (±4.8)	5.2a (±1.4)	88.5a (±43.9)	8.76a (±3.7)	2.4b (± 0.5)
3+0 bare-root	25	26.6b (±2.5)	3.6b (±0.7)	14.5b (±8.5)	3.59b (±1.1)	3.4a (±0.5)
408 paperpots (77-2)[a]	23	9.9d (±2.1)	1.9d (±0.4)	9.9b (±3.1)	1.18c (±0.1)	1.6d (±0.3)
Summer (7 July)						
1½+1½ bare-root (rising)	25	19.8c (±3.5)	2.8c (±0.9)	17.3b (±8.4)	2.22c (±0.7)	2.6b (±0.6)
408 paperpots (78-1)	30	10.4d (±3.1)	1.6d (±0.3)	8.0b (±3.5)	1.09c (±0.2)	2.1c (±0.3)

[a]Paperpot crop number - (77-2) sown 25 May, 1977
(78-1) sown 15 February, 1978

Figures within parentheses are standard deviations.

Differing letters within each column indicate a significant difference at the P .05 level.

Table 2. Percentage survival 1, 3, and 5 years after outplanting (1978-1982).

Planting date/ stock type	No. of trees planted	Survival (%)		
		After 1 year	After 3 years	After 5 years
Spring (30-31 May)				
$1\frac{1}{2}+1\frac{1}{2}$ bare-root	175	99a (± 1.3)	99a (± 1.6)	99a (± 1.6)
3+0 bare-root	105	66c (± 6.8)	60b (± 6.4)	60b (± 6.4)
408 paperpots (77-2)	140	90ab (± 2.9)	90a (± 2.9)	90a (± 2.9)
Summer (7 July)				
$1\frac{1}{2}+1\frac{1}{2}$ bare-root (rising)	140	75bc (±19.5)	70b (± 16.9)	70b (± 16.9)
408 paperpots (78-1)	140	100a (± 0.0)	99a (± 1.7)	99a (± 2.9)

Figures within parentheses are standard deviations.

Differing letters within each column indicate a significant difference at the P .05 level.

RESULTS

Fifth-year survival of spring- and summer-planted paperpots and spring-planted $1\frac{1}{2}+1\frac{1}{2}$ transplants was excellent (Table 2). The spring-planted 3+0 and the summer-planted rising $1\frac{1}{2}+1\frac{1}{2}$ bare-root trees had significantly lower fifth-year survival rates than did stock in the other treatments: 60% and 70%, respectively (Table 2). First-year mortality was much higher than either second- or third-year mortality in the spring-planted 3+0 and summer-planted transplant bare-root trees.

Five years after outplanting, the spring-planted transplants were significantly taller (87.6 cm) than the other trees (Table 3). The spring-planted 3+0 seedling stock and summer-planted paperpots did not differ significantly in total height at the end of the five-year period. The summer-planted paperpots were significantly taller five years after outplanting than were the spring-planted paperpots. The summer-planted paperpot stock surpassed the initially taller rising $1\frac{1}{2}+1\frac{1}{2}$ bare-root product in height within three years of outplanting. At the end of the five-year period, trees in both of these treatments did not differ significantly in total height.

Table 3. Total height (cm) of trees 1, 3, and 5 years after outplanting (1978-1982).

Planting date/ stock type	Total height		
	After 1 year	After 3 years	After 5 years
Spring			
1½+1½ bare-root	33.5a (+1.1)	49.3a (+ 2.8)	87.6a (+ 5.0)
3+0 bare-root	25.9b (+1.9)	38.3b (+ 2.2)	69.8b (+ 3.5)
408 paperpots (77-2)	11.0d (+0.1)	30.1c (+1.2)	55.8d (+3.4)
Summer			
1½+1½ bare-root (rising)	17.3c (+2.1)	32.1c (+1.4)	60.3cd (+2.0)
408 paperpots (78-1)	16.6c (+0.2)	34.1bc (+1.8)	65.1bc (+2.9)

Figures within parentheses are standard deviations.
Differing letters within each column indicate a significant difference at the P .05 level.

In the second year after outplanting height increment was greater in the spring- and summer-planted paperpots than in the spring- and summer-planted bare-root trees (Table 4), this difference being significant in the spring-planted paperpots. By the third year, all trees had similar rates of height growth. By the fifth growing season, the spring-planted transplants were growing significantly faster than did the other stock types. All other trees were similar in terms of height growth.

After five growing seasons the condition of all stock types combined was similar for both spring and summer plantings (Table 5). However, the condition of both transplants and paperpots differed considerably with planting date. In both plantings, there were large differences in tree condition between stock types.

Trees in the best condition five years after planting were the summer-planted paperpots (Table 5). The spring-planted transplants had a higher number of trees in the top condition classes than did the spring-planted seedling and paperpot stock types.

Table 4. Current annual height increment (cm) of trees 2, 3, and 5 years after outplanting (1978-1982).

Planting date/ stock type	Current annual height increment		
	After 2 years	After 3 years	After 5 years
Spring			
1½+1½ bare-root	9.3bc (±2.0)	9.8a (±1.7)	20.0a (±1.8)
3+0 bare-root	6.4c (±1.4)	8.0a (±1.3)	17.0b (±0.7)
408 paperpots (77-2)	12.2a (±0.5)	10.2a (±0.5)	15.1b (±0.9)
Summer			
1½+1½ bare-root (rising)	8.3c (±0.3)	9.6a (±0.8)	16.0b (±1.2)
408 paperpots (78-1)	11.6ab (±1.5)	8.8a (±1.4)	17.0b (±0.5)

Figures within parentheses are standard deviations.

Differing letters within each column indicate a significant difference at the P .05 level.

Table 5. Percentage of originally planted trees in the healthy and vigorous condition classes 5 years after outplanting.

Stock type	Planting date	
	Spring	Summer
1½+1½ bare-root	72	47
3+0 bare-root	48	N/A
408 paperpots	58	81

DISCUSSION

The high survival rates in this trial were due in part to the wetter than normal spring and summer planting seasons (Fig. 2) and in part to the lack of competing vegetation on the planting site subsequent to the herbicide application.

The spring-planted 3+0 seedling stock had a significantly lower rate of survival after the first growing season than did the 1½+1½ transplant stock (Table 2). The only difference in the handling of these two stock types from the nursery bed through outplanting was in the lifting date and length of cool storage. The seedling stock was cool-stored for two days longer than the transplants. In all likelihood, the main cause of the high mortality in the spring-planted seedling stock was not the lifting, storage, or transportation procedures, but the inadequate biomass of the stock at time of outplanting (Table 1). Even if the 3+0 seedling stock had been morphologically well balanced at outplanting it may not have performed as well, in terms of survival and height growth, as the spring-planted transplants. The superiority of black spruce transplants to seedling stock has been well documented (Armson 1975, Fry 1975, Mullin 1980).

High mortality and reduced height growth in the summer-planted transplants were largely the result of undersized planting stock and the length of time between lifting and outplanting. Survival might have been improved by planting risen as opposed to rising stock. However, good survival results have been achieved in northern Ontario with quick planting of fresh-lifted rising transplants during July (McClain 1982). Nevertheless, in the same study McClain found that the root area of the rising stock planted in mid-July decreased, while the root area of the risen stock increased, during a 28-day period following planting. Revel (personal communication *in* Sutton 1983) stressed that summer-planting of fresh lifted bare-root stock requires careful handling and "hot" planting, with the time between lifting and planting not exceeding three days. It is preferable to do both on the same day. The physiologically active rising stock planted in this experiment was not planted until the afternoon of the third day after lifting.

Both Mattice (1982) and Scarratt (1982) have found that, for black spruce, the growth advantages of containerized stock generally disappear within the first three years of outplanting. It follows that containerized seedlings have only the first three growing seasons in which to equal the height of the larger bare-root product. Results from this experiment support these findings. In the second year after outplanting the paperpots were increasing in height faster than the bare-root trees, whereas in the third growing season, the differences in height growth between the two stock types had decreased (Table 4).

CONCLUSIONS

1. In terms of survival, either the spring- or summer-planted container stock or the spring-planted $1\frac{1}{2}+1\frac{1}{2}$ bare-root stock is acceptable for artificial regeneration treatments on this site type.

2. These data indicate that, on this site type, trees that are superior in total height three years after outplanting either maintain or increase that superiority until at least the fifth year after outplanting.

3. It appears that paperpots must match the initially larger bare-root trees in total height within the first few years after outplanting if equal height is to be achieved.

4. Because of the poor performance of the rising transplants in this trial, it is suggested that stock of dubious quality not be used in late plantings.

LITERATURE CITED

Anon. 1978. Monthly record meteorological observations in eastern Canada May-October 1978. Dep. Environ., Atmosph. Environ. Serv., Downsview, Ont. 63 (5-9). Part 3, 117 p.

Anon. 1980. Black spruce ecosystem silviculture. p. 1 *in* C.A. Plexman, *Ed.* Forestry Research Newsletter. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Fall-Winter 1980.

Armson, K.A. 1975. Establishment and early development of black spruce. p. 45-56 *in* Black Spruce Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Symp. Proc. O-P-4.

Fry, R.D. 1975. Tree planting stock quality--a view from the forest. p. 80-85 *in* Black Spruce Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Symp. Proc. O-P-4.

Haavisto, V.F. 1980. Seed requirements for regenerating black spruce in Ontario. p. 2-3 *in* C.A. Plexman, *Ed.* Forestry Research Newsletter. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Fall-Winter 1980.

Haig, R.A. 1982. Welcoming remarks by symposium sponsors. p. 3-4 *in* J.B Scarratt, C. Glerum, and C.A. Plexman, *Ed.* Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

Heeney, C.J. 1982. The status of container planting programs in Canada. p. 35-39 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed.* Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

Jones, R.K., Pierpoint, G., Wickware, G.M., Jeglum, J.K., Arnup, R.W., and Bowles, J.M. 1983. Field guide to forest ecosystem classification - clay belt, site region 3e. Ont. Min. Nat. Resour. Toronto. Ont. 122 p.

Ketcheson, D.E. and Jeglum, J.K. 1972. Estimates of black spruce and peatland areas in Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Report O-X-172. 29 p.

Mattice, C.R. 1982. Comparative field performance of paperpot and bare-root planting stock in northeastern Ontario. p. 321-330 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed*. Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

McClain, K.M. 1982. The question of extending the planting season. p. 72-83 *in* Proceedings of the Ontario Nurserymen's Meeting, Thunder Bay, Ontario, 7-11 June, 1982. Ont. Min. Nat. Resour., For. Res. Br.

Morrison, I.K. and Armson, K.A. 1968. The rhizometer, a device for measuring roots of tree seedlings. For. Chron. 44:21-23.

Mullin, R.E. 1980. Comparison of seedling and transplant performance following 15 years' growth. For. Chron. 56:231-232.

Reese, K.H. and Sadreika, V. 1979. Description of bare-root shipping and cull stock. Ont. Min. Nat. Resour. 36 p.

Robinson, F.C. 1974. A silvicultural guide to the black spruce working group. Ont. Min. Nat. Resour., Div. For., For. Manage. Br. 44 p.

Rowe, J.S. 1972. Forest regions of Canada. Dep. Environ., Can. For. Serv., Ottawa, Ont. Publ. No. 1300. 172 p.

Scarratt, J.B. 1974. Performance of tubed seedlings in Ontario. p. 310-320 *in* R.W. Tinus, W.I. Stein, and W.E. Balmer, *Ed*. Proceedings of the North American Containerized Forest Tree Seedling Symposium. Great Plains Agric. Counc. Publ. No. 65.

Scarratt, J.B. 1982. Container stock specifications for northern Ontario. p. 343-354 *in* J.B. Scarratt, C. Glerum, and C.A. Plexman, *Ed*. Proceedings of the Canadian Containerized Tree Seedling Symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-10.

Steel, R.G.D. and Torrie, H.J. 1960. Principles and procedures of statistics with special reference to the biological sciences. McGraw-Hill, New York. 481 p.

Sutton, R.F. 1983. Plantation establishment in the boreal forest: planting season extension. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-344. 129 p.

A P P E N D I X

APPENDIX

Culling Limits for Black Spruce Bare-root and Container Shipping Stock

1. Bare-root stock

Parameter	Culling limit: 1½+1½ transplant	Culling limit: 3+0 seedling
Total oven-dry weight (g)	4.9 and less	4.0 and less
Root collar diameter (mm)	3.5 and less	3.5 and less
Root area index (cm^2)	30 and less	30 and less
Shoot height (cm)	14 and less	14 and less

Source: Reese and Sadreika, 1979.

2. Container stock

Acceptable container stock (408 paperpots)

Parameter	
Shoot height (cm)	13-25
Root collar diameter (mm)	1.5-2.5
Total oven-dry weight (g)	0.5-0.8

Source: Anon. 1982. Forest management manual for crown lands. N.B. Dep. Nat. Resour., Fredericton, N.B., 176 p. (unpubl.).