FIVE-YEAR COMPARISON OF JACK PINE BARE-ROOT, ONTARIO TUBE, AND PAPERPOT SEEDLINGS

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ABSTRACT

Data are presented on jack pine (*Pinus banksiana* Lamb.) survival and height performance after three and five growing seasons, on the condition of seedlings, and on the percentage of seedlings in the *free-to-grow* class five years after outplanting. Stock types used were bare-root, the split plastic "Ontario tube", and the Japanese paperpot. Fifth-year results indicate good survival of all types except summer-planted bare-root stock. After five growing seasons, spring-planted bare-root stock was significantly taller than all other stock. Spring-planted container stock was taller than its summer-planted counterparts, but not always significantly so. In all summer-planted stock types height growth was reduced as a result of late planting. All spring- and summer-planted stock, except late-planted bare-root, was roughly equivalent in vigor.

RÉSUMÉ

L'auteur présente les résultats obtenus quant à la survie et la hauteur du pin gris (*Pinus banksiana* Lamb.) après trois et cinq saisons de croissance, quant à l'état des semis et quant au pourcentage de semis dans la classe des semis libérés (*"free-to-grow"*) cinq ans après la transplantation. Le matériel employé était à racines nues, en tubes fendus en plastique "Ontario" ou en pots japonais en papier. Les résultats après cinq ans indiquent une bonne survie pour tous les types de semis, sauf pour ceux qui ont été plantés à racines nues en été. Après cinq saisons de croissance les semis à racines nues plantés au printemps sont significativement plus grands que tous les autres. Le matériel en récipient planté au printemps est plus haut que le matériel similaire planté en été, mais pas toujours de façon significative. Chez tous les types de semis plantés en été, la plantation tardive a réduit l'accroissement en hauteur. La vigueur de tout le matériel planté au printemps et en été est à peu près équivalente, sauf pour les semis à racines nues plantés tardivement.

ACKNOWLEDGMENTS

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INTRODUCTION

Jack pine (*Pinus banksiana* Lamb.) is an important crop tree for the forest industry in Ontario, accounting for approximately 36% of the 1980 provincial softwood harvest (Anon. 1981). Successful artificial regeneration of this species, by seeding or planting, depends largely on the condition of the seedbed, with the optimum condition being exposed mineral soil on a site that is relatively free from competing weed species (Cayford et al. 1967). Seeding, in general, remains the principal means of jack pine regeneration in Ontario, with planting of either containerized or bare-root seedlings an important supplement.[1] In 1981, approximately 28 000 ha were operationally seeded to jack pine (Anon. 1981), while planting of containerized and bare-root seedlings accounted for 4 600 and 6 800 ha, respectively.[2]

The split plastic "Ontario tube" was the first container in which tree seedlings were grown operationally. Operational planting of tubelings (Ontario tubes) began in 1966 and peak production was reached in 1969 (MacKinnon 1970). For several reasons, including inadequate container size, root deformation problems, and lack of confidence in the overall system, tubelings were phased out in Ontario in the early 1970s. The Japanese paperpot was introduced as a replacement in the mid-1970s and is now (1983) the principal container used in northern Ontario (Scarratt 1982).

The percentage of containerized seedlings planted in Ontario is increasing. It is estimated that by 1985, container production in the province will reach 60 million seedlings, accounting for 70% of total nursery stock production. It is expected that approximately 60% of total container stock production will be devoted to jack pine.[2]

During 1978, plantings of operational-grade jack pine (bare-root, Ontario tubes and paperpots) were established by C.R. Mattice[3] on a well drained, coarse-textured sandy site near Kirkland Lake, Ontario. The objectives of these plantings were to compare the growth of container and bare-root stock and to assess the outplanted performance of summer-planted container stock.

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[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]Chaudhry, M., Silvicultural Information Assessment and Development Specialist, Ont. Min. Nat. Resour., For. Resour. Group, Toronto, Ont. (personal communication, 1983).

[3]Formerly Forestry Officer, Great Lakes Forest Research Centre, Dep. Environ., Sault Ste. Marie, Ont.

In this report third- and fifth-year survival and growth results are presented for both bare-root and container stock types. Two container types, tubelings and the 408-size Japanese paperpot, were used. The bare-root stock was 2+0 seedling stock. All stock types were planted during the months of June and July.

STUDY SITE

The experimental plantings are located in Bompas Township, approximately 23 km east of Kirkland Lake (lat. 48°10'N, long. 80°20'W), within the Missinaibi-Cabonga Section (B.7) of the Boreal Forest Region (Rowe 1972), and within Hills' (1959) Site Region 3E. The mean annual precipitation in this area is 80 cm and the growing season is 163 days long (Chapman and Thomas 1968). During June and July, 1978 the mean monthly temperatures were 13.5° and 17.0°C, respectively, and precipitation was 131 mm and 149 mm, respectively (Fig. 1 and 2). Mean monthly temperatures were near normal throughout the growing season. June, July and August were 136, 180 and 121%, respectively, wetter than normal, but precipitation was close to normal over the remainder of the growing season.

The experiment is located on a complex of glacial till over bedrock (McQuarrie 1975). The bedrock in this area is mainly granitic intrusive, with some basic intrusive, sedimentary, and volcanic rock as well as metamorphic rock derived from them (Boissoneau 1966). The topography in the plot area is rolling (slopes 5-10%). The plot is situated in mid-slope with a northern aspect. Soil texture ranges from loamy to medium sand, corresponding to a moderately dry moisture regime. The site is stony and the forest humus is classed as fibrimor. Tree rooting is abundant in the upper soil horizons and extends to a depth of 80 cm.

The area was clearcut in 1977 and site-prepared with Young's Teeth in October of that year. Before cutting the stand was predominantly mixedwood, and was composed of 30% poplar (*Populus* spp.), 30% white birch (*Betula papyrifera* Marsh.), 20% jack pine, 10% black spruce (*Picea mariana* [Mill.] B.S.P.), and 10% balsam fir (*Abies balsamea* [L.] Mill.).

The mechanical site preparation of this planting chance effectively removed existing vegetative competition, and retarded weed growth on treated areas. Areas in which mineral soil was exposed through scarification remain free of vegetation five years after site treatment. When observed in the summer of 1982, competing vegetation was restricted to the shoulder of the plowed furrows and within the untreated areas.

Ground cover in the summer of 1982 consisted mainly of bunchberry (*Cornus canadensis* L.), yellow clintonia (*Clintonia*

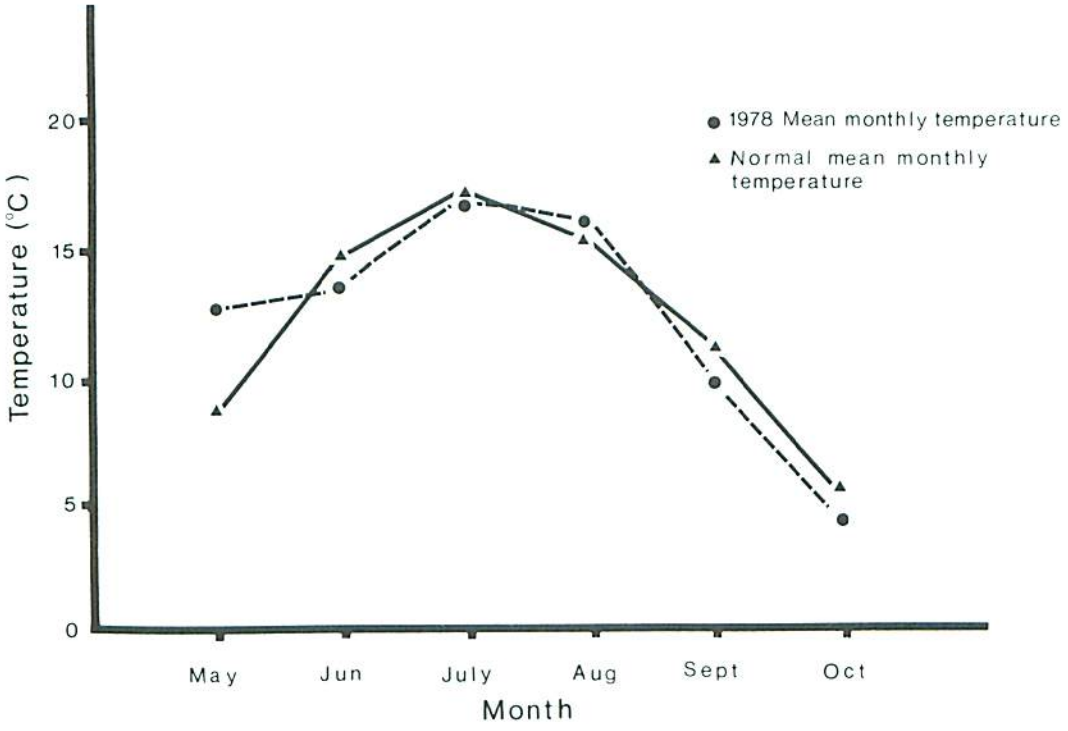

Figure 1. Normal and 1978 mean monthly (May to October) temperatures for Kirkland Lake, Ontario (Anon. 1978).

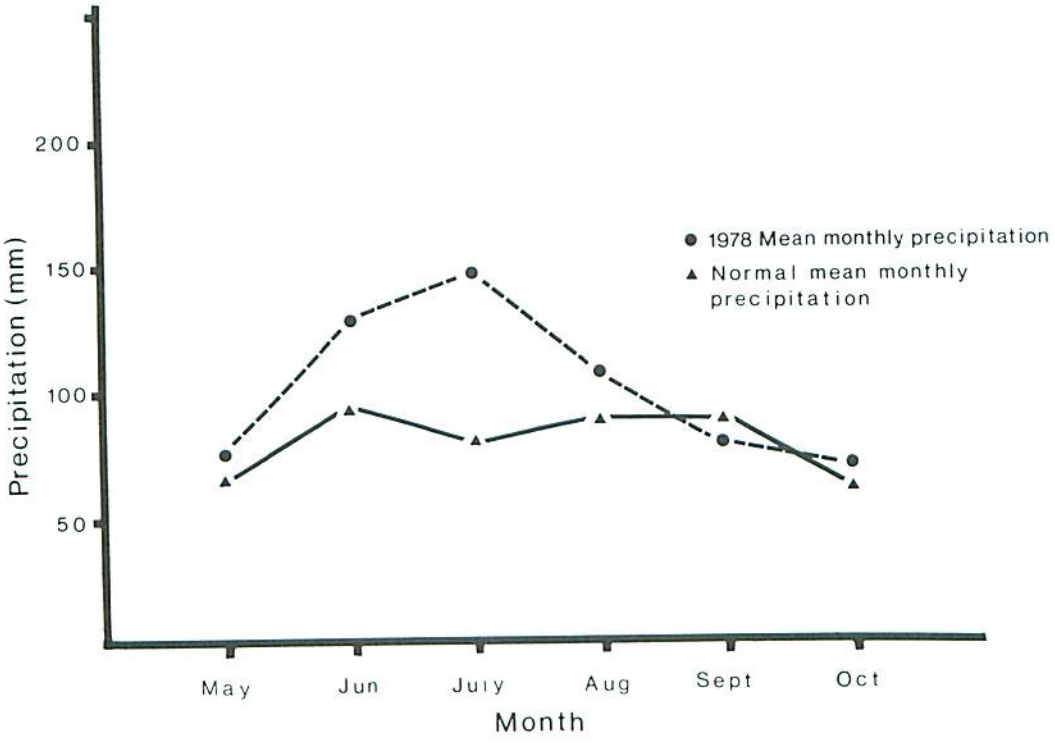

Figure 2. Normal and 1978 mean monthly (May to October) precipitation for Kirkland Lake, Ontario (Anon. 1978).

borealis [Ait.] Ref.), big leaf aster (*Aster macrophyllus* L.), and various mosses. Shrubs such as blueberry (*Vaccinium* spp.), honeysuckle (*Lonicera* spp.), and beaked hazel (*Corylus cornuta* Marsh.) were common. There was also a patchy hardwood overstory of trembling aspen (*Populus tremuloides* Michx.) and pin cherry (*Prunus pensylvanica* L.) which, along with the beaked hazel, provided the most competition for the crop trees. On the basis of a 1982 ocular estimate these three species covered 35-45% of the total plot area. In 1982, 34% of the planted seedlings were overtopped by one or more of these species.

METHODS

Three stock types (two container types and one bare-root) were used in this experiment, and there were two planting dates (2 June and 19 July) for each type. A total of six plantings (Table 1) were established. The two planting dates were selected to determine if time of planting affected survival, height growth or seedling condition. Each treatment was replicated four times for a total of 24 rows of about 35 seedlings each. Thus, about 840 trees were planted in all.

The 408 paperpot stock was grown at the Great Lakes Forest Research Centre, Sault Ste. Marie, Ontario and the tubelings and bare-root stock were grown at the Swastika Forest Station, Swastika, Ontario.

The spring-planted container stock was started in the greenhouse in May 1977 and was overwintered outdoors under a snow cover. The summer-planted stock was current-year stock started in the greenhouse in February, 1978. Spring-planted 2+0 bare-root seedlings were lifted and placed in cold storage (4°C) at the nursery several days before shipping. The summer bare-root stock was lifted from the nursery bed during its second growing season and was therefore termed 'rising' 2+0 stock. After lifting, the seedlings were placed in cold storage and the following day were shipped to the planting site.

Planters were instructed to plant within, but close to the shoulder of, plowed furrows where nutrients removed during scarification would be more available to the seedlings.

At the time of planting, samples of 25-30 seedlings were selected from each planting and the following morphological features were measured: shoot height, root collar diameter, root area index[4], shoot and root oven-dry weights, and shoot:root ratio based on oven-dry weight (Table 1). Appendix A provides size class standards and culling limits for jack pine bare-root and container shipping stock. At

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[4]After Morrison and Armson (1968).

Table 1. Morphological characteristics of planting stock.

Planting date/ stock type	Number of seedlings in sample (n)	Shoot height (cm)	Root-collar diameter (mm)	Root-area index (cm)	Total oven-dry weight (g)	Shoot: root ratio
Spring (22 June)						
408 paperpot[a] (77-2)	25	16.6a (± 4.0)	2.1c (± 0.4)	9.1b (± 3.3)	0.8d (± 0.2)	3.41a (± 1.5)
¾ in. (1.9 cm) "Ontario tube"	25	8.2b (± 1.4)	1.5d (± 0.1)	5.6b (± 1.4)	0.2c (± 0.1)	1.96cd (± 0.9)
2+0 bare-root	25	15.7a (± 3.9)	4.8a (± 1.2)	44.2a (± 21.4)	4.8a (± 2.4)	2.84ab (± 0.8)
Summer (19 July)						
408 paperpot[a] (78-1)	30	16.9a (± 2.9)	2.3c (± 0.9)	6.8b (± 2.6)	1.4b (± 0.4)	2.18bc (± 1.0)
¾ in. (1.9 cm) "Ontario" tube	30	8.1b (± 1.4)	0.8e (± 0.4)	2.9b (± 1.9)	0.1[b]	1.30d (± 0.3)
2+0 bare-root	25	16.2a (± 2.6)	3.4b (± 0.4)	5.9b (± 2.2)	1.8b (± 0.3)	3.07a (± 0.4)

[a]Paperpot crop number - (77-2) sown 27 May 1977.
- (78-1) sown 15 February 1978.

[b]Total oven-dry weight of summer tubelings obtained from nursery shipping records; individual seedling weights not available and therefore not included in range test.

Different letters indicate a significant difference within columns at the 95% level.

Figures within parentheses are standard deviations.

outplanting, the spring- and summer-planted 408 paperpots were generally heavier in total oven-dry weight and larger in root-collar diameter than recommended. The spring-planted bare-root stock had a large root-area index, but was otherwise morphologically well balanced. In contrast, the summer-planted 'rising' bare-root stock had an extremely low root-area index, only one-fourth the culling limit for 2+0 grade jack pine. It was also below the culling limit for root-collar diameter. No morphological standards were available for the tubelings.

Vegetative competition surrounding each planted seedling was assessed in 1982 by making an ocular estimate of the *free-to-grow*[5] status of the seedling. Seedling condition was assessed in the same year, with four condition classes being used: vigorous, healthy, mediocre and moribund. Seedlings in the vigorous or healthy condition classes had lush green foliage and only minor form defects. Seedlings in the mediocre or moribund condition classes had little or no height growth and suffered from serious form defects (Scarratt 1974). The classification of seedling condition and competition was largely subjective and its value therefore limited to an indication of gross trends. Summer-planted 2+0 bare-root stock is omitted from the comparison of competition and primary condition because of the low number of seedlings surviving after five years.

Morphological data and third- and fifth-year survival and height data were subjected to analysis of variance and Tukey's Mean Test (Steele and Torrie 1960).

RESULTS AND DISCUSSION

Percentage survival after five growing seasons was high for all planting-date/stock-type combinations except summer-planted rising 2+0 bare-root stock which had a survival rate of only 9.6% (Table 2). These high fifth-year survival rates were at least partially attributable to a wetter-than-normal first growing season (Fig. 2). The rate of mortality decreased in the majority of plantings after the third growing season. The poor survival performance of the summer-planted 2+0 rising bare-root was in large part the result of an inadequate root system at time of outplanting.

By the end of the fifth growing season the spring-planted 2+0 bare-root seedlings were significantly taller at 189.6 cm than the

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[5]For a seedling to be classed as *free-to-grow* its leader must be well above the surrounding brush and not likely to become threatened at any time in the foreseeable future. (Walstad, J.D. and Wagner, R.C. 1982. Crafts experimental design manual for b-level studies: release of young conifer stands from uniformly distributed brush competition. Dep. For. Sci., Sch. For., Oregon State Univ., Corvallis, 39 p. unpubl.).

Table 2. Percentage survival 3 and 5 years after planting (1978-1982).

Planting date/ stock type	Number of seedlings planted	Percentage survival	
		After 3 years	After 5 years
Spring			
408 paperpot[a] (77-2)	140	98.6a (± 1.6)	97.1a (± 0.0)
¾ in. (1.9 cm) "Ontario tube"	141	97.9a (± 1.4)	97.2a (± 2.3)
2+0 bare-root	137	97.8a (± 1.5)	96.4a (± 2.7)
Summer			
408 paperpot[a] (78-1)	138	97.1a (± 3.4)	93.5a (± 6.4)
¾ in. (1.9 cm) "Ontario tube"	140	90.0a (± 11.5)	86.4a (± 12.4)
2+0 bare-root	138	10.2b (± 7.0)	9.6b (± 6.8)

[a]Paperpot crop number - (77-2) sown 27 May 1977.
- (78-1) sown 15 February 1978.

Different letters indicate a significant difference within columns at the 95% level.

Figures within parentheses are standard deviations.

Table 3. Total height and height increment (cm) of seedlings 3 and 5 years after planting (1978-1982).

Planting date/ stock type	Number of seedlings planted	After 3 years		After 5 years	
		Total height	Current annual height increment	Total height	Current annual height increment
Spring					
408 paperpot[a] (77-2)	140	65.3b (± 4.5)	26.9b (± 2.9)	145.2b (± 12.7)	46.7a (± 4.6)
¾ in. (1.9 cm) "Ontario tube"	141	54.2bc (± 1.1)	21.3bc (± 6.0)	121.7b (± 4.1)	42.0ab (± 1.8)
2+0 bare-root	137	94.4a (± 3.4)	39.0a (± 0.5)	189.6a (± 1.2)	53.2a (± 0.8)
Summer					
408 paperpot[a] (78-1)	138	50.3c (± 4.5)	20.2bc (± 1.2)	107.6bc (± 11.7)	37.1abc (± 5.1)
¾ in. (1.9 cm) "Ontario tube"	140	29.8d (± 2.7)	15.1cd (± 2.9)	72.3cd (± 10.6)	28.1bc (± 5.2)
2+0 bare-root	138	23.8d (± 12.0)	7.4d (± 6.7)	59.0d (± 35.9)	25.0c (± 16.0)

[a]Paperpot crop number - (77-2) sown 27 May 1977.
- (78-1) sown 15 February 1978.

Different letters indicate a significant difference within columns at the 95% level.

Figures within parentheses are standard deviations.

spring-planted paperpot and tubeling stock at 145.2 and 121.7 cm, respectively (Table 3). In terms of current annual height increment, the larger bare-root stock had a total height growth advantage over the two containerized stock types.

Scarratt (1982) stated that the benefits of containerization are reflected in a higher initial growth rate than that of bare-root stock, and that the leveling off of that growth rate signals an end to this growth advantage. If the spring-planted containerized stock in this experiment did exhibit an early height growth advantage over bare-root stock, this advantage had clearly ended by the third growing season. Third-year spring results showed that the initially larger bare-root stock was growing significantly faster in height than either the paperpot or tubeling stock types (Table 3). It appears that all spring-planted stock types began height growth soon after outplanting and after the third growing season this growth was positively correlated with the initial size of planting stock. The paperpot stock was growing faster than the tubeling stock, though not significantly so.

In the summer-planted treatments after three growing seasons, the 'rising' 2+0 bare-root had the lowest total height (23.8 cm), being surpassed by the initially smaller paperpot (50.3 cm) and tubeling stock (29.8 cm) (Table 3). The poor height growth performance of the summer-planted bare-root was due in large part to the lack of an adequate root system at time of outplanting. The summer-planted paperpot stock was significantly taller and growing faster in height than the tubeling stock after three growing seasons.

After five growing seasons the summer-planted paperpots were taller than either the tubeling or 'rising' bare-root stock (Table 3). The summer-planted tubeling stock was taller than the 'rising' bare-root stock, though not significantly so. There were no significant differences in current height increment among summer-planted treatments.

Although the late planting of containerized pine produced satisfactory survival results, height growth performance after outplanting appears to have been adversely affected. This slower height growth will be critical on sites with a potential for heavy vegetative competition. On these sites it is important to have seedlings initiate growth immediately and achieve substantial height increment during the first season after outplanting in order to take advantage of the short competition-free period subsequent to scarification.

The forest manager wishing to extend the planting season by planting jack pine containerized seedlings must be willing to take greater care of the stock during the warmer summer months than he would have to during the cooler spring months. This includes regular waterings and providing shade while the stock is being held at the planting site. If shade is not available, the frequency of watering must be increased. Sutton (1983) has found that weather at time of out-

planting and for several weeks thereafter is a major factor in bare-root outplant performance. Even though containerized seedlings have the advantage of an encapsulated root system, the forest practitioner should consider suspending operations during periods of hot, dry weather rather than risking poor survival and growth.

In comparing bare-root and container stock types it is not sufficient to consider only survival and growth results. The crop trees should be healthy, have good form and be free to grow at the end of the regeneration period[6] in order to maximize future development.

The spring-planted paperpot and 2+0 bare-root plantings had the highest percentage of seedlings in vigorous and healthy condition classes (Table 4). The summer-planted containerized stock types had a lower percentage of seedlings in the better condition classes. However, no dramatic treatment differences were evident, and this indicates that all stock types were of roughly equivalent vigor.

The term *free-to-grow* is often used as a criterion of seedling growth potential. Factors controlling the percentage of seedlings in this class are crop seedling vigor, effectiveness of site preparation treatments, and site productivity. Before developing a silvicultural prescription the forest manager must consider the potential vegetation control problems and prescribe the type of post-cutting treatment and the method of regeneration that will maximize the number of crop trees. The spring-planted stock types generally had a higher percentage of seedlings in the *free-to-grow* class (Table 4), and were faster growing.

This experimental site had only a moderate amount of competition and the disparity between the percentage of *free-to-grow* seedlings in the spring and summer plantings was not large. However, on a site with heavy vegetative competition the planting of faster-growing spring stock will be necessary to ensure plantation success.

CONCLUSIONS AND RECOMMENDATIONS

1. Because 'rising' jack pine stock is generally of poor quality it is not recommended for summer planting.

2. In the spring-planted treatments total height and current annual height increment were positively correlated with initial mass of seedlings at outplanting. Therefore, if the height of spring-planted containerized seedlings is to equal that of bare-root seedlings five years after planting, a larger grade of container stock should be planted.

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[6]The time required, or decided upon, for the renewal of a stand by natural or artificial regeneration (Ford-Robertson 1971).

3. In terms of outplant survival and height growth, the grade of spring- and summer-planted paperpot stock used in this trial was adequate.

4. Summer planting of jack pine container stock seems to be a feasible regeneration option on this site type. However, the forest manager must be able to provide the extra care the planting stock requires while it is being held for outplanting.

Table 4. Percentage of seedlings in the vigorous and healthy condition classes (1+2) and *free-to-grow*[a] status five years after planting (1982).

Planting date/ stock type	Number of seedlings assessed	Condition classes 1+2 (%)	Number of seedlings or planting spots assessed (n)	*Free-to-grow* (%)
Spring				
408 paperpot[b] (77-2)	136	81	140	69
$\frac{3}{4}$ in. (1.9 cm) "Ontario tube"	137	66	141	72
2+0 bare-root	132	88	137	79
Summer				
408 paperpot[b] (78-1)	129	62	138	58
$\frac{3}{4}$ in. (1.9 cm) "Ontario tube"	121	72	140	47
2+0 bare-root (rising)	-	-	-	-

[a] *Free-to-grow* status based on living and dead seedlings. In the case of a dead seedling the average height was assumed from living seedings in the same planting row and the *free-to-grow* status was assessed.

[b] Paperpot crop number- (77-2) sown 27 May 1977.
- (78-1) sown 15 February 1978.

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APPENDIX

APPENDIX A. CULLING LIMITS FOR JACK PINE BARE-ROOT AND CONTAINER SHIPPING STOCK

1. 2+0 BARE-ROOT

A. Shipping stock

Parameter	Size Class					
	Small		Medium		Large	
	mean	range	mean	range	mean	range
Total oven-dry weight (g)	2.0	1.1-2.9	4.0	3.0-5.0	6.0	5.1+
Root collar diameter (mm)	3.0	2.8-3.2	3.6	3.3-3.9	4.2	4.0+
Root area index (cm^2)	23	20-26	30	27-33	37	34+
Shoot height (cm)	14	13-15	18	16-20	22	21+
Shoot:root ratio (ODW)	3.0	2.0-4.0	3.0	2.0-4.0	3.0	2.0-4.0

B. Cull stock

Parameter	Culling limit
Total oven-dry weight (g)	2.9 and less
Root collar diameter (mm)	3.5 and less
Root area index (cm^2)	25 and less
Shoot height (cm)	14 and less

Source: Reese and Sadreika (1979).

2. CONTAINER STOCK

A. Acceptable container stock (408 paperpots)

Parameter	
Shoot height (cm)	10-20
Root collar diameter (mm)	1- 2
Total oven-dry weight (g)	.4 - .6

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