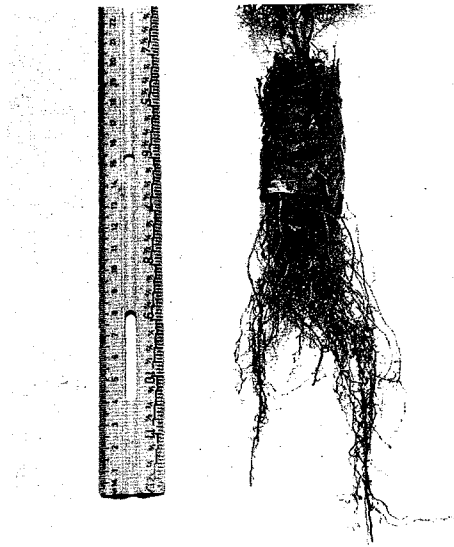


SUGGESTED MINIMUM STANDARDS FOR CONTAINERIZED SEEDLINGS  
IN NOVA SCOTIA

by

Kalman J. Roller



Maritimes Forest Research Centre

Fredericton, New Brunswick

Information Report M-X-69

Canadian Forestry Service

Department of Fisheries and the Environment

1977

Cover photo: Root extension below pot base of a 24-month-old black spruce in 408 paperpot, grown in nursery bed, transplanted at 8 months.

## ABSTRACT

At present, container seedlings are not graded in the Maritimes but increased use of this type of seedling for reforestation makes it necessary to establish standards of quality for planting stock. The morphological features of seedlings of four native conifer species reared in different containers for use in reforestation in southwestern Nova Scotia are described using two criteria; sturdiness, the quotient of top height to collar diameter, and quality index, the combined quotient of total oven-dry weight, top height, and collar diameter. The specifications are based on the results of measurements of 1600 seedlings selected from about 50,000 container seedling and 1200 bare-root seedlings from nursery beds at two locations. Field survival of the container seedlings was assessed after two growing seasons from seeding. Field performance of bare-root seedlings was not assessed; suitability of the different age classes was taken from earlier documentations. The data are presented in tables and charts.

## RESUME

Aux Maritimes, actuellement, les semis en potets (contenants) ne sont pas classés mais l'utilisation accrue de ce type de semis dans le reboisement rend le classement nécessaire à l'établissement de normes de qualité des plants. Les caractéristiques morphologiques des semis de quatre essences de résineux, cultivés dans des contenants divers et destinés au reboisement dans le sud de la Nouvelle-Ecosse sont décrites par l'utilisation de deux critères: la robustesse, le quotient de la hauteur de la cime au diamètre du collet et l'indice de qualité, ou quotient combiné du poids anhydre total, de la hauteur de la cime et du diamètre du collet. Les spécifications se fondent sur le résultat du mesurage de 1 600 semis, choisis parmi environ 50 000 semis en potets et 1 200 semis à racines nues provenant de planches de semis de deux pépinières. La survie des semis en potets sur le terrain fut évaluée deux saisons de croissance après l'ensemencement. On n'a pas évalué le rendement des semis à racines nues sur le terrain; des documents préalables ont servi à déterminer la convenance de diverses catégories d'âges. Les données sont sous forme de tableaux.

## INTRODUCTION

The Forest Industry of Nova Scotia is currently planting about 0.7 - 1 million container seedlings a year but expects to double this number. Poor performance in the field is a major problem. Bailey\* reported that up to 1974, the average survival of seedlings grown in various containers was only 54%, mainly because of poor-quality stock.

To increase survival rate in future plantings, greater consideration must be given to stock quality than has been in the past. In assessing planting stock, nurserymen need an objective measure that will enable them to predict performance in the field (Dickson et al. 1960). Quality appraisal of bare-root seedling has been documented by many authors using various measurements (Dickson et al. 1960, Armson and Williams 1960, Aldhous 1972, Armson and Sadreika 1974, etc.) but grading of container seedlings has been presented by only a few who measured stem length and oven-dry weight of stem and roots (Ferdinand 1972, Walker and Johnson 1974, Scarrat 1972, Scarrat and Reese 1976, etc.).

Nursery stock can be graded on either physiological or morphological characteristics. The determination of physiological characteristics requires laboratory analysis, therefore, it is easier and more practical to use morphological features. For bare-root seedlings, Dickson et al. (1960) used a quality index based on the oven-dry weight of stem and roots and on the measurements of stem length and collar diameter. Aldhous (1972) applied the term "seedling sturdiness" to define seedling quality which was based on the ratio of height to collar diameter.

---

\* Minutes of meeting on container planting. Steering Committee of Nova Scotia Department of Lands and Forests, Truro, October 24, 1974.

In this study, both criteria, quality index and sturdiness, were used to identify the more important morphological features of both container and bare-root seedlings. As a result, a preliminary grading system was defined, outlining the minimum requirements for planting stock suitable in cutovers in southwestern Nova Scotia. The data are presented in charts and tabular form. The container seedlings were produced in the greenhouse at the Acadia Forest Experiment Station under the management of the Canadian Forestry Service. The bare-root seedlings were from J.D. Irving Ltd. Juniper Tree Nursery, and the nursery-bed at the Acadia Forest Experiment Station.

#### MATERIALS AND METHODS

From 1972 to 1976, about 50,000 container seedlings of white spruce (Picea glauca (Moench) Voss), red spruce (P. rubens Sarg.), and black spruce (P. mariana (Mill.) B.S.P.), and red pine (Pinus resinosa Ait.) were used for reforestation and planted in designed experiments in southwestern Nova Scotia. The seedlings were reared in various types of containers (Table 1).

Table 1. Types and dimensions of containers

Type	Top diameter cm	Depth cm	Gross Volume cm <sup>3</sup>	No. of cavities/m <sup>2</sup>
Styroblock 8	3.9	15.2	125	441
Styroblock 4	3.0	12.7	65	765
Styroblock 2	2.5	11.4	40	1064
Spencer - Lamaire	2.5x0.75	10.2	48	1410
Swedish Multipot	3.3	8.0	45	882
Paperpot 408	3.8	7.5	70	1076

The seeds were sown each January in containers filled with heat-sterilized moist peat moss. The seeded cavities were covered with a thin layer of coarse sand and the containers were then placed on 1-meter-high benches in a plastic greenhouse. In early June after danger of late frost, the containers were set out under shade for hardening. In addition to the yearly production of container seedlings for field experiments, a demonstration trial was established in 1975-76 with black spruce in various containers in the greenhouse to check the container effect on growth. Also 800, 8-month-old seedlings grown in paperpots were outplanted in nursery beds, for assessment of 24-month-old container grown seedlings.

Plantings were established twice each year, late June and September, and were assessed for survival after two growing seasons from seeding, i.e. sown in January and assessed at the end of August of the following year.

To assess growth at 4, 6, and 8 months, 100 seedlings of each species and each container were randomly sampled. At 24 months, a total of 100 transplanted container seedlings of white, red, and black spruce was sampled from the nurserybed. The peat or soil was washed from the roots of each seedling. Top length, from the base of the terminal bud to the root collar, and root length, from the root collar to the end of the longest root (usually on the extension of the tap root) were measured to the nearest millimeter. The root collar diameter was measured with a microcaliper to the nearest 0.05 mm. The shoots and roots were then dried at 70°C, and the bulk sample of 100 seedlings was weighed to the

nearest 0.5 g (average individual weight of seedlings was calculated from the bulk weight).

The ratio of top height to collar diameter was calculated to determine an arbitrary quotient of sturdiness (Aldhous 1972) that separated the spindly and sturdy seedlings. An evaluation of the frequency distribution suggested that the top height/collar diameter quotient indicates the suitability of container seedlings for field plantings, in general, but did not provide a defined classification for seedling quality and size, i.e. all morphological features which also characterize the physiological make up. Therefore, a quality index ( $Q_{ix}$ ) recommended by Dickson *et al* (1960) for bare-root seedlings was applied to find the appropriate weight of seedlings for each quotient of sturdiness. Quotients of oven-dry weight, top height, and collar diameter were calculated for both container seedlings and bare-root seedlings.

The formula used to determine quality index is as follows:

$$Q_{ix} = \frac{\text{Seedling dry weight (g)}}{\frac{\text{Top height (cm)}}{\text{Diameter (mm)}} + \frac{\text{Top dry weight (g)}}{\text{Root dry weight (g)}}}$$

## RESULTS

Quantitative morphological features can be used to indicate the suitability of seedlings for outplanting. Seedlings produced in containers should be well suited for the dimensional requirements of the planting site. The appearance of the seedlings is subsidiary in judging

fitness, compared to the quantitative characteristics. Color of needles, sound terminal and lateral buds, and well-developed tissue complex of stem (differentiated phelloderm and cortex) are indications of healthy plantable stock. Seedling survival depends principally on the ability to produce new roots immediately after outplanting to prevent fatal water deficit, particularly when planted in late spring. In this study, the following dimensional features of container seedlings were investigated to determine the criteria of plantable stock.

Survival. Throughout the investigation, it was recognized that the field performance of the seedlings, both survival and height growth, varied with container types and local environmental conditions. The overall survival was 74%, exceeding the 54% reported by Bailey which was an unsatisfactory performance for 11 or 14 months after planting. Survival of seedlings are presented in Table 2.

Height. Height growth of container seedlings cannot be measured for at least four years after planting because of the slow initial growth rate and the high variability in growth. For all species, a proportionate increase in height which does not depend on root length can be expected up to 8 months. Under identical greenhouse conditions, black and red spruce in containers will grow faster throughout the 8-month period than white spruce, and much faster than red pine. Growth of all organisms is influenced by heredity and even under optimum growing conditions white spruce and red pine will not continue height growth beyond a certain size. Growth rate of white spruce was highly variable; red pine



Table 2. Percentage field survival of container seedlings, 19 months after seeding

	Swedish multipot	Caseless R.C.A. peat	Styroblock			Paperpot 408	Spencer Lamaire	Overall average
			8	4*	2			
Spruces white, red, and black	92	89	69	65	65	80	52	73
Red pine		74	83	70		74	70	74
Average	92	82	76	68	65	77	61	74

Assessment of field performance is based on approximately 50,000 outplanted seedlings from 1973 until 1976. Seedlings were planted in June and September, each year. Survey was carried out at the end of August the following year.

\* Styroblock 4 was used in 1976. Survival assessment was carried out in September after one growing season from seeding, for those seedlings which were set out in early July.

was highly uniform. Armson and Williams (1960), however, found that compacted soil versus loose structured media, such as a mixture of calcareous soils with sand, significantly reduced growth of 3-month-old red pine grown in glass tubes. The peat moss used in the containers probably became compacted in the greenhouse from shaking, intensive watering, etc. Black and white spruce and red pine responded more favorably to outplanting than did red spruce.

Root length. The root length of container seedling while growing in the greenhouse was determined by the depth of the cavity. The development of fibrous roots was not constrained within the cavity wall and the root systems differed in number of hair roots, density, bulk, and conditions within the different containers. The ratio of root/shoot by length was irrelevant to seedling quality throughout the greenhouse treatment because of the restricted growth of root length.

Seedlings outplanted in paperpot 408 containers developed disproportionate root length at 24 months (Fig. 1). Observations on outplanted seedlings showed that the plugs, set out without cases, did not change shape and remained compacted for years (3 years was the longest period checked). Also, at 24 months, the paperpot 408 had not disintegrated completely and the egress of lateral roots was limited. A test was made on the biodegradability of the paper tissue by Dr. Sebastian\*. He found that when the paperpots 408, manufactured by Paper Pot and Products Inc., Japan, were soaked in cold water, the bond between the individual tubes dissolved but the paper tissue did not disintegrate

---

\* Professor in Wood-technology, Forestry Faculty, U.N.B., Fredericton, N.B.

after soaking for 7 days. Solubility tests in organic solvents showed no weakening of the bond between the cavities and the paper case. The paper material was composed of a wide variety of recycled fibers of wood, cotton, grass, and bamboo. These fibers need more than 2 years to disintegrate sufficiently to allow the thorough egress of side roots.

Root collar diameter. Figures 1, 2, and 3 show that root collar diameter apparently correlates with shoot and root weight. This correlation was also documented by Armson and Smith (1966). Root collar diameter is a useful visible dimensional characteristic. Black spruce had the largest diameter at 8 months, but by 24 months, red pine had the largest. Black spruce grown in Styroblock 8 container had the greatest diameter (Fig. 2); those in paperpots 408, the smallest diameter. There are 441 styroblock 8 cavities/m<sup>2</sup> vs. 1076 paperpots 408/m<sup>2</sup>; the smaller cavity of the paperpot 408 container had an adverse effect on diameter enlargement. Conversely, the height growth of seedlings in paperpots was greater than in the containers with larger cavities.

Sturdiness. In general, sturdiness indicates the suitability of seedlings for outplanting and varies with the different species and the different containers. A low quotient indicates a sturdy seedling rather than a tall spindly one. Suggested sturdiness quotients at planting, are as follows:

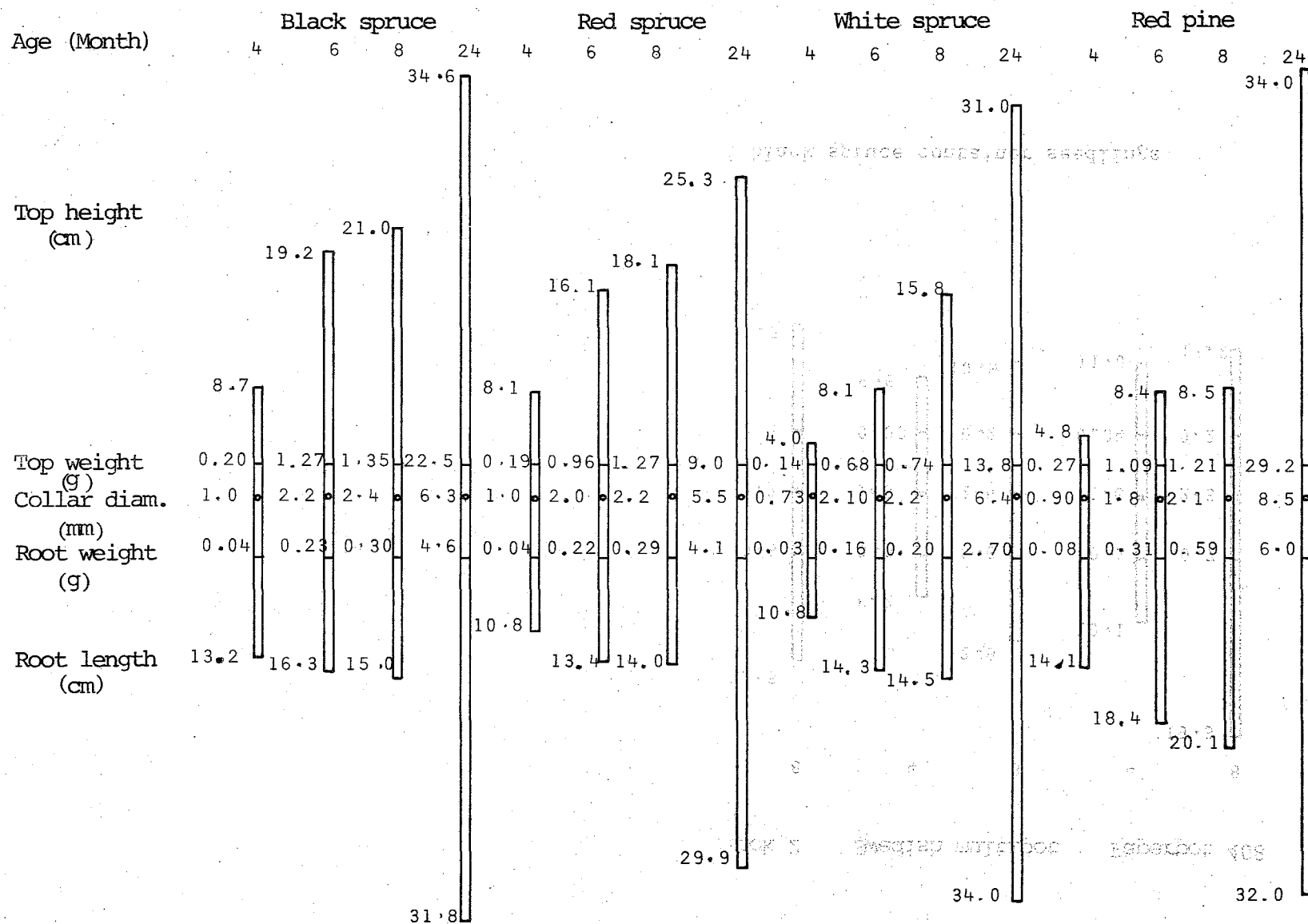


Figure 1. Measurements of container seedlings  
Means of 1600 seedlings grown in different containers.

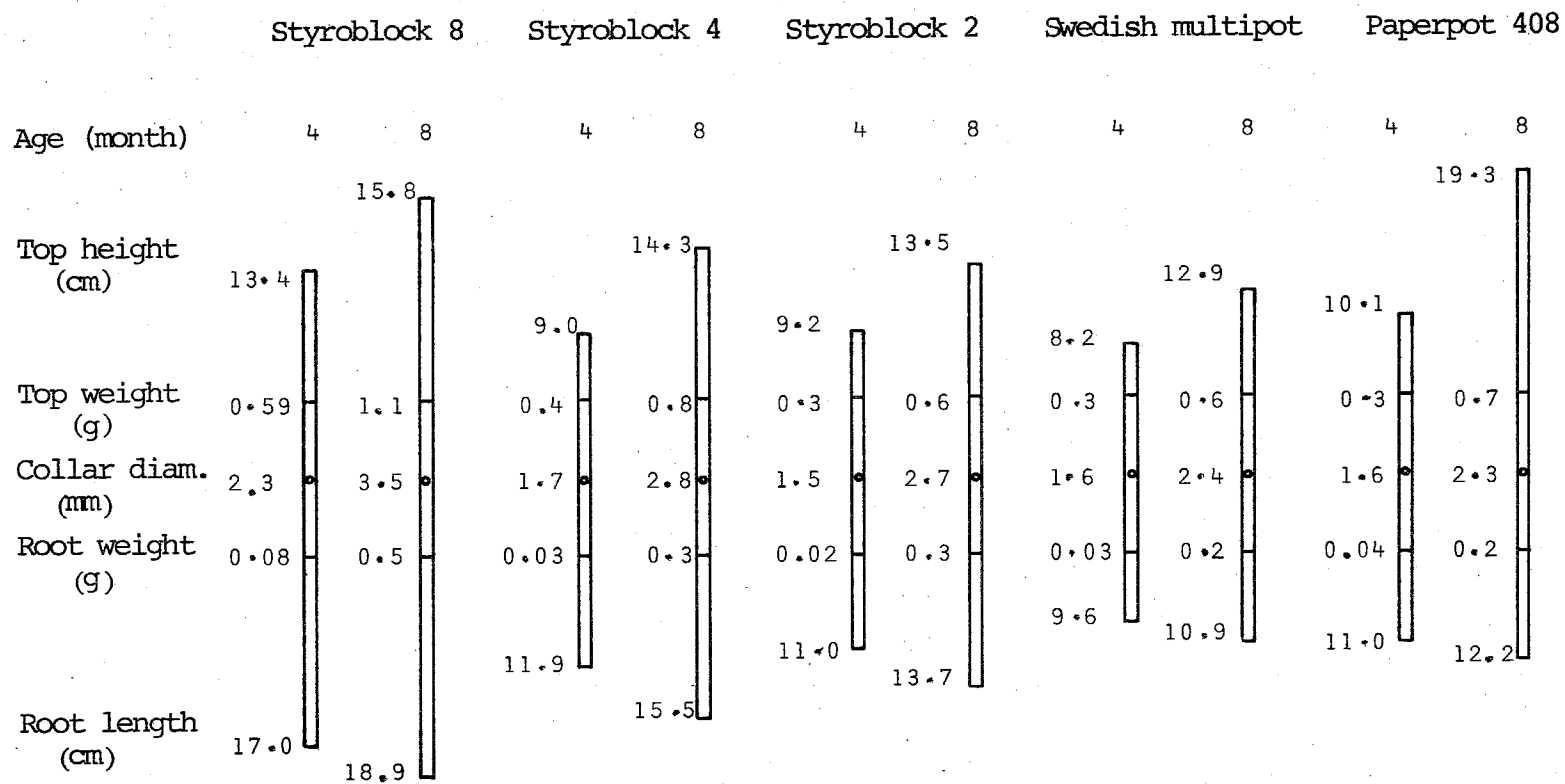


Figure 2. Measurements of black spruce container seedlings.

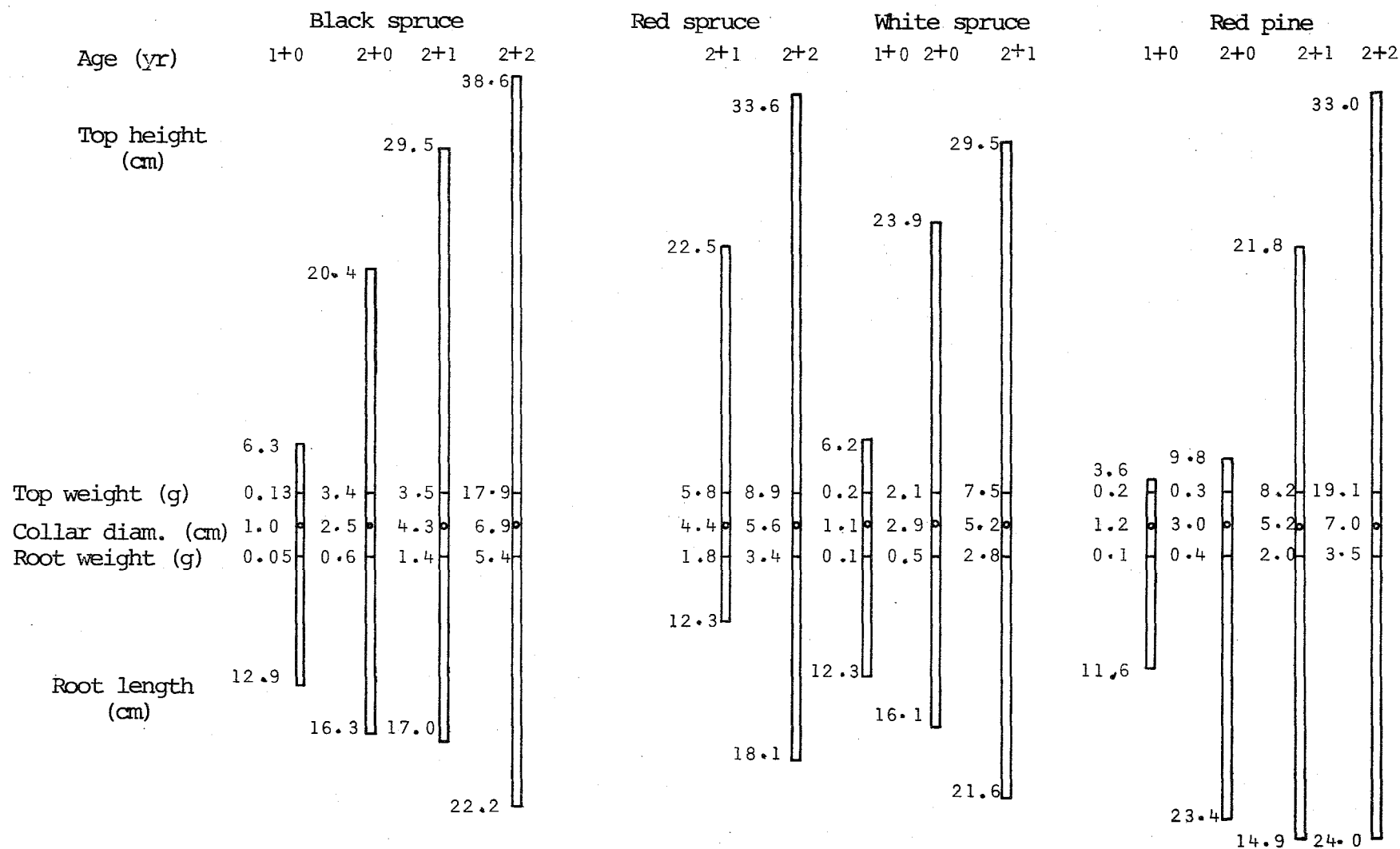


Figure 3. Measurements of bare-root seedlings.

Container seedlings: Red and black spruce . . . . .	6.0
White spruce . . . . .	5.0
Red pine . . . . .	4.0
Styroblock 8 and 4 . . . . .	5.0
Swedish multipot . . . . .	5.0
Styroblock 2 . . . . .	6.0
Paperpot 408 . . . . .	6.0
Bare-root seedlings: For all ages . . . . .	6.0

Container seedlings with higher quotients were found to be spindly and had low survival because of the disproportionate stem length and collar diameter. A steady decrease in sturdiness was recorded from Styroblock 8 to paperpot 408. The spindly seedlings were not hardy and were seriously damaged when exposed to wind, drought, and frost. Older seedlings are generally sturdier than young seedlings and red pine and white spruce are sturdier than black and red spruce.

Quality index. Field performance has shown that older container seedlings survive better than younger ones. The older seedlings exhibited advanced morphological features and physiological make up. The formula of quality index gave consistently good results to differentiate between the older and younger seedlings and thus, the plantable from the unsuitable seedlings. In the first column of Table 3, quality indices less than 0.09 are listed; those seedlings were not plantable. They grew spindly and had poorly differentiated stem tissue. The table also shows that the suitability of container seedlings increases with increasing quality index.

For bare-root seedlings of white spruce, Dickson et al. (1960) determined the mean values of quality indices as 0.0623 for poor, 0.2367 for fair, and 0.4160 for good seedlings. These quality indices suggest that 1+0 transplants measured in this study are poor, the 2+0 black spruce are fair, and 2+1 are good quality seedlings, suitable for outplanting. The optimum age-class of transplants used under the conditions of southwestern Nova Scotia has been documented by Roller (1976a, b).

Table 3. Quality index of container and bare-root seedlings

Species	Age							
	Months in container*				Transplants in years**			
	4	6	8	24	1+0	2+0	2+1	2+2
White spruce	0.0221	0.1036	0.1159	1.657	0.0232	0.2113	1.2333	
Red spruce	0.0142	0.0955	0.1120	1.928			0.9205	1.4273
Black spruce	0.0175	0.1053	0.1243	2.611	0.0202	0.2813	0.5262	2.6153
Red pine	0.0590	0.1711	0.1888	3.969	0.0625	0.1728	1.2375	2.2274

\* Index mean of seedlings reared in Styroblock 8 and 4, Paperpot 408, and Spencer Lamaire containers.

\*\* Index mean of bare-root seedlings from Acadia Forest Experiment Station and Juniper Tree Nursery.



## DISCUSSION

Grading of bare-root seedlings is mechanized in most nurseries in the United States and different machines and methods are used to determine the quantitative quality of plantable seedlings. Grading methods for container seedlings have not yet been implemented in the Maritimes and rapid expansion of container reforestation has preceded research on the quality of container seedlings.

Survival one growing season after outplanting appears to be the criteria to indicate the relative seedling quality at planting, that is, if the planting stock features qualities and dimensions that "render it suitable for use, in terms of handling, adaptation to the planting site, and most importantly survival and ultimate growth" (Armson and Sadreika 1974). A "spot-check" of 100 seedlings from each container type and each species would provide sufficient information on seedling quality before planting to enable the nurserymen to take advantage of the uniform growth of even-age seedlings reared in identical containers. In the field, the range of values for each quality category will vary with species and local environmental conditions. Environmental factors will have more effect on survival and height growth in the later years after planting than in the first year. The initial advantage of the high suitability of container seedlings is demonstrated when they outlast the adverse effects of overwinter loss, late spring freezing, inadequate soil quality, and weed and brush competition. Sutton (1974) states that survival and growth will be affected by the condition of the seedling when it goes into the ground. Arnott (1975) points out that

larger seedlings such as advanced-age bare-roots give better overall performance than container stock. The above statements document the generally accepted fact that it is advantageous to use sturdy seedlings. Roller (1976b) observed and documented that container seedlings with greater than 0.09 quality index would overcome the initial difficulties after planting under proper site conditions easier than the larger bare-root seedlings. The fertile and moist media of the plug in which the small seedling thrived, have favorable effects on subsequent vigor of the stem and root system. Overnourished, overwatered, rapidly grown, spindly seedlings will suffer after planting because they are succulent and sensitive to frost, drought, and wind. Well-prepared planting sites, light structured soils, undisturbed ground surface of cutovers, eliminated weed competition, and favorable microsites provide favorable conditions for plantations of container seedlings.

Top-heavy or oversized spindly seedlings need continuous nursery treatment, hardening, and winterization. They should be rejected if this treatment does not produce the required quality, i.e. if the seedlings remain discolored, have dry needles and branchlets on the lower part of the stem, or lack a fibrous root system. Four-month-old seedlings will be adequate for outplanting only if they meet the desired quality index, i.e. higher than  $0.09 Q_{ix}$ . On the other hand, 8-month-old seedlings that are qualified lower than  $0.09 Q_{ix}$  will not successfully outplant in September or October because they are spindly and have poor tissue development. They will not go dormant before early frost.

It is expected that the minimum dimensional measurements presented in this study as a result of the determination of quality index and sturdiness will serve as screening methods for nurserymen when selecting seedlings best suited for a given site. The measurement data can be supplemented with observations on seedling features that are known by tree seedling producers. The Canadian Forestry Service will continue investigations on seedling quality that will provide standards based on the foregoing quotients to indicate the morphological features and physiological make up of the container seedlings suitable for outplanting under different site conditions.

#### ACKNOWLEDGMENTS

The author wishes to express his thanks and appreciation to Dr. L. Sebastian, Professor in Wood Technology, U.N.B., for his investigation on the biodegradability of the paperpot film tissue; to Mr. R.S. Bezzant, Superintendent, J.D. Irving Ltd., Juniper Tree Nursery, for providing the bare-root seedlings; to Messrs. S.E. Hunter and L.R. Butcher, forestry technicians, Maritimes Forest Research Centre, Fredericton, for their assistance in measuring all seedlings used in the study.

## LITERATURE CITED

- Aldhous, J.R. 1972. Nursery Practice. U.K. For. Comm. Bull. No. 43, HMSO, London.
- Armson, K.A. and V. Sadreika. 1974. Forest Tree Nursery Soil Management and Related Practices. Ont. Min. Nat. Res. Tech. Bull.
- Armson, K.A. and V.A. Smith. 1966. Dry Weight-diameter Relationships for Jack Pine Seedlings. For. Sci. 12: 365-366.
- Armson, K.A. and J.R.M. Williams. 1960. The Root Development of Red Pine (Pinus resinosa Ait.) Seedlings in Relation to Various Soil Conditions. For. Chron. 36: 14-17.
- Arnott, J.T. 1975. Field Performance of Container-grown and Bare-Root Trees in Coastal British Columbia. Can. J. For. Res. 5: 186-194.
- Dickson, A., A.L. Leaf, and J.F. Hosner. 1960. Quality Appraisal of White Spruce and White Pine Seedling Stock in Nurseries. For. Chron. 36: 10-13.
- Ferdinand, I.S. 1972. Container Planting Program at North Western Pulp and Paper Ltd. In: Proc. Workshop on Container Planting in Canada. Can. For. Serv., Dept. Environ., Inf. Rep. DPC-X-2. pp 21-25.
- Roller, K.J., and S. Hunter. 1976a. Field Survey of Plantations in the Stanley Management Unit, Hants County, Nova Scotia. Can. For. Serv., Dept. Environ., Inf. Rep. M-X-63.

- Roller, K.J. 1976b. Field Performance of Container-grown Norway and Black Spruce Seedlings. Can. For. Serv., Dept. Environ., Inf. Rep. M-X-64.
- Scarrat, J.B. 1972. Effect of Tube Diameter and Spacing on the Size of Tubed Seedlings Planting Stock. Can. For. Serv., Dept. Environ., Inf. Rep. O-X-170.
- Scarrat, J.B. and K.H. Reese. 1976. Objectives and Criteria for Planting Stock Production in Ontario. In: Proc. Meeting of Reforestation Problems. Kirkland Lake, Ontario. Ont. Min. Nat. Res. - Great Lakes For. Cen.
- Sutton, R.F. 1974. Problems and Approaches in Biological Research Related to Mechanized Reforestation. For. Chron. 50: 22-26.
- Walker, N.R. and H.J. Johnson. 1974. Field Performance of Pine and Spruce Reared in the BC/CFS Styroblock, Alberta. Can. For. Serv., Dept. Environ., Inf. Rep. Nor-X-84.