SIZE OF CONTAINER-GROWN SEEDLINGS SHOULD BE MATCHED TO SITE CONDITIONS

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Abstract.--Trials with container-grown white spruce *(Picea glauca* [Moench] Voss) under different site conditions in the Sub-Boreal Spruce Zone of British Columbia showed that stock size and site condition significantly affected survival and growth and that stock size can and should be matched to site conditions. Large stock without site treatment may be a feasible alternative to small stock plus site treatment. The use of a seedling size appropriate to the density of competing vegetation should result in cost savings. Container-grown stock must reach size and quality standards consistent with the size of container used if performance is to meet expectations.

Résumé.--À la suite d'essais faits avec des plants d'épinette blanche en mottes emballées *(Picea glauca* [Moench] Voss), dans le centre-nord de la Colombie-Britannique, on a constaté qu'il y avait un rapport entre la grosseur du matériel de reproduction et l'état de l'emplacement. Les petits plants se développaient mal sauf si l'emplacement avait été traité de façon à empêcher la végétation de leur faire concurrence. Les gros plants se développaient bien dans les emplacements qui n'avaient pas été traités. On a constaté expérimentalement qu'on pouvait faire correspondre la grosseur des plants à l'état de l'emplacement.

INTRODUCTION

Successful plantation establishment depends primarily on type and condition of planting stock, planting quality, condition of site and weather at time of, and shortly after, planting. This paper, which is based on results from trials with 1-0 styroplug white spruce *(Picea glauca* [Moench] Voss) in the Sub-Boreal Spruce Zone (Krajina 1965) of the north central interior of British Columbia, discusses interactions between stock size and site condition.

Trials were established east of Prince George between 1972 and 1979 in randomized blocks, with the same spruce seed lot being used in any one trial. Measurements made at intervals since planting were analyzed by the Newman-Student-Keuls multiple range test and have been presented in various preliminary reports (Dobbs 1976, McMinn and Homoky 1977, McMinn and Van Eerden 1977, McMinn 1978, 1980).

SURVIVAL AND GROWTH OF CONTAINER-GROWN STOCK

White spruce seedlings which have been grown in small containers (styroplug-2)[2] usually perform poorly following outplanting on untreated sites with high potential for dense competing vegetation. They are readily smothered when snow presses vegetation down at the end of the growing season and growth of surviving seedlings is usually slow. Survival and growth can be improved by bull-

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[2]Styroplug-2, -4 and -8 containers have nominal volumes of 40, 80 and 125 ml (2, 4 and 8 in^3), respectively.

dozer-blade scarification (Table 1). Blade scarification controls competing vegetation (Fig. 1) by removing plant roots, together with surface organic matter and the uppermost mineral soil. Reduction of shading vegetation and exposure of mineral soil by removing surface organic matter enhance soil temperature (Fig. 2) within the range favorable for tree seedling growth (Fig. 3).

Table 1. Performance of styroplug-2 white spruce seedlings after 10 growing seasons in untreated and blade-scarified plots[a].

Treatment	Survival[b] (%)	Height (cm)	Stem volume[c] (ml)
Untreated	76	181	528
Scarified	87	199	653

[a]Values in each column differ significantly ($p = 0.05$).
[b]Values based on 120 seedlings planted.
[c]Height times one-third area of base.

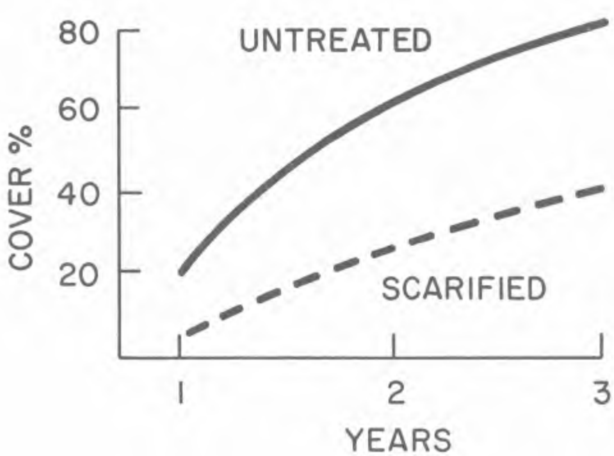

Figure 1. Change in density (% cover) of competing vegetation on untreated and bulldozer-blade scarified sites with time since clearcutting or treatment.

The type of site treatment can influence performance of container-grown stock, especially in fine-textured soils. Although blade scarification enhances soil temperature, surface organic matter is pushed aside so that its inherent fertility is beyond the immediate reach of planted seedlings. This fertility can be retained by mixing competing vegetation and surface organic matter with the underlying mineral soil to form a new organic-matter-enriched surface horizon. Styroplug-2 seedlings planted in sites prepared by such a mixing treatment grew better than seedlings planted in scalped sites left by blade scarification (Table 2). Roots of competing vegetation were sufficiently comminuted by the mixing treatment to control vegetation effectively.

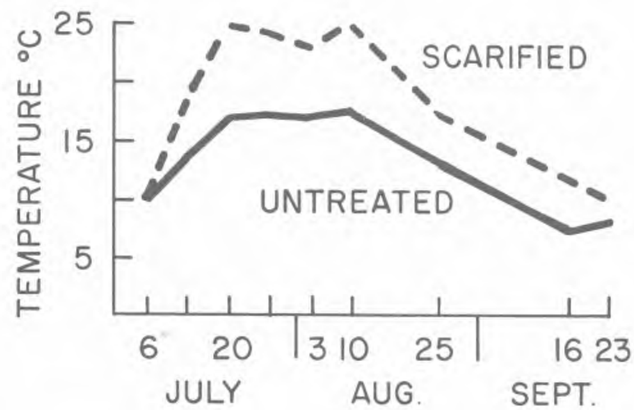

Figure 2. Seasonal change in afternoon (1500 to 1700 hr) soil temperature at 5 cm depth on untreated and bulldozer-blade scarified sites (Dobbs and McMinn 1973).

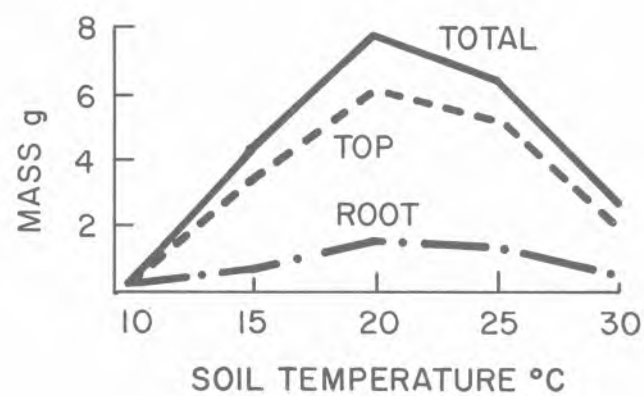

Figure 3. Dry mass of white spruce seedlings grown at various root temperatures for 17 weeks (Dobbs and McMinn 1977).

Trial results indicated that large stock can be an alternative to small stock plus site treatment (Table 3). Styroplug-8 white spruce seedlings grew better in untreated plots with heavy competition potential than did styroplug-2 stock in plots where vegetation was controlled by blade scarification. In this experiment, conducted in a fine-

Table 2. Performance of styroplug-2 white spruce seedlings after seven growing seasons in untreated, blade-scarified and mixing-treatment plots on a fine-textured soil[a].

Treatment	Survival[b] (%)	Height (cm)	Stem volume[c] (ml)
Untreated	93a	122a	152a
Scarified	97a	110a	113a
Mixing	99a	141b	208b

[a]Values in each column followed by same letter do not differ significantly ($p = 0.05$).
[b]Values based on 150 seedlings planted.
[c]Height times one-third area of base.

textured soil, blade scarification did not improve performance of the larger stock. Although styroplug-8 seedlings responded well to the mixing treatment, economic analysis based on long-term performance would be needed to show whether the extra cost of the larger stock plus mixing treatment would be justified. Large stock without site treatment or small stock with mixing treatment provided gains in total mass of 50 to 100% at the end of five growing seasons over small stock that had no treatment or blade scarification (Table 3).

In comparison with stock planted immediately following clearcutting (Table 4: i. Recently cut site), each of the three sizes of container-grown stock tested exhibited reduced growth when planting was delayed for two years following clearcutting (Table 4: ii. Backlog site). The density of competing vegetation at time of planting on the backlog site was considerably greater than that on the recently cut site. The styroplug-4 stock performed about as well on the recently cut site as did the styroplug-8 stock on the backlog site. This performance comparison shows that planting untreated sites immediately after clearcutting could result in cost saving because styroplug-4 stock is cheaper to produce than styroplug-8 stock. The use of styroplug-4 stock on backlog sites which are already occupied by dense competing vegetation would seem economically questionable, however, because performance of styroplug-4 stock could well be poor. The low stem volume of the styroplug-2 stock on both sites (Table 4) suggests that planting styroplug-2 white spruce seedlings without site preparation on sites with potential for dense com-

Table 3. Oven-dry mass of styroplug-2 and -8 white spruce seedlings at planting and after five growing seasons in variously treated, fine-textured soils[a].

Stock Treatment	At planting[b] Root mass (g)	At planting[b] Total mass (g)	At 5 years[b] Root mass (g)	At 5 years[b] Total mass (g)
Styroplug-2				
Untreated	)	)	12.4a	98a
Scarified	)0.7a	)1.6a	16.6a	83a
Mixing	)	)	20.0b	146b
Styroplug-8				
Untreated	)	)	23.9bc	168c
Scarified	)1.6b	)3.2b	16.6a	104d
Mixing	)	)	29.3c	212e

[a]Values in each column followed by same letter do not differ significantly ($p = 0.05$).
[b]Values based on 30-seedling sample.

Table 4. Parameters for styroplug-2, -4 and -8 white spruce seedlings at planting and after two growing seasons in untreated, recently cut and backlog (cut 2 years previously) sites[a].

Stock	At time of planting[b] Height (cm)	Root mass (g)	Total mass (g)
Styro-2	16a	0.2a	0.8a
Styro-4	20b	0.4b	1.5b
Styro-8	22c	0.6c	2.1c

Stock	After two growing seasons[c] Survival (%)	Height (cm)	Stem volume[d] (ml)
i. Recently cut site			
Styro-2	91a	28a	1.6a
Styro-4	96a	35b	2.7b
Styro-8	99b	40c	4.7c
ii. Backlog site			
Styro-2	94a	25d	0.8d
Styro-4	92a	31e	1.7a
Styro-8	93a	37f	2.9b

[a]Values in each column followed by same letter do not differ significantly ($p = 0.05$)
[b]Values based on 50-seedling sample.
[c]Values based on 250 seedlings planted.
[d]Height times one-third area of base.

peting vegetation would be false economy even though styroplug-2 stock has the lowest production cost of any of the styroplug stocks tested.

Data appear to be lacking for the Sub-Boreal Spruce Zone to indicate whether large or small seedlings from the same styroblock might perform differently following outplanting. However, results from a trial with different sizes of 2-1 bare-root transplants lifted from the same nursery bed suggest that different performances can be expected (Table 5). Transplants from shipping boxes filled from the same nursery bed following routine culling procedures were regraded into small and large on the basis of mass. After three growing seasons, it was evident that small transplants had performed so poorly that they were of dubious value for reforestation. Performance differences between large and small transplants might have been predicted from differences in root growth capacity at time of planting. These results suggest that discrimination in culling standards to discard poor seedlings

Table 5. Parameters for 2-1 bare-root white spruce transplants regraded into large and small at planting and after three growing seasons in untreated, recently cut and backlog sites[a].

Stock	At time of planting[b]: Height (cm)	Root mass (g)	Total mass (g)	R.G.C. Class[c]
Small	20	3.8	9.8	1.75
Large	33	6.5	22.3	3.18

Stock	After three growing seasons[d]: Survival (%)	Height (cm)	Stem volume[e] (ml)
i. Recently cut site			
Small	65	37	7.6
Large	86	57	21.7
ii. Backlog site			
Small	30	33	3.6
Large	60	52	13.2

[a]All values in each column significantly different (p = 0.05).
[b]Values based on 50-seedling sample.
[c]Root growth capacity class (Burdett 1979).
[d]Values based on 250 seedlings planted.
[e]Height times one-third area of base.

in styroblocks might be advisable. Differences in size among seedlings in the same styroblock may be at least partially under genetic control because growing conditions in any given size of styroblock are relatively uniform.

The use of large containers to obtain improved survival and growth presupposes that the seedlings will have reached size standards which justify the cost of using such containers. White spruce seedlings which had not fully utilized styroplug-4 containers performed no better than styroplug-2 stock in either untreated or mixing-treatment planting spots (Table 6). Stock of both sizes performed better in mixing-treatment planting spots than in untreated plots. Relative performance of substandard-sized[3] styroplug-2 stock with respect to 2-1 "reclaims"[4] did, however, differ according to site treatment. The larger initial mass of the 2-1 reclaims

Table 6. Parameters for "substandard" styroplug and "reclaim" bare-root white spruce stock, at planting, and after five growing seasons in mixing treatment and untreated, backlog sites[a].

Stock	At planting[b]: Height (cm)	Mass (g)	At 5 years[c]: Survival (%)	Height (cm)	Stem volume (ml)
i. Untreated site					
Styro-2	7a	1.09a	67a	35a	4.6a
Styro-4	9b	1.34a	70a	35a	4.8a
Bare-root	13c	3.37b	64a	40b	6.6b
ii. Mixing treatment site					
Styro-2	7a	1.09a	97b	55c	20.4c
Styro-4	9a	1.34a	96b	55c	18.2cd
Bare-root	13c	3.37b	92b	50d	15.7d

[a]Values in each column followed by same letter do not differ significantly (p = 0.05).
[b]Values based on 50-seedling sample.
[c]Values based on 190 seedlings planted.
[d]Height times one-third area of base.

[3]Smaller than expected for the container size used.
[4]Reclaims are transplants which are too small for outplanting at the 2-0 stage so are transplanted in the expectation that they will be large enough for outplanting a year later.

seems to have been advantageous under the competitive conditions of the untreated site, but not in the mixing treatment site where even substandard-sized styroplugs performed better than 2-1 bare-root reclaims. These results suggest that the practice of reclaiming small 2-0 stock at the end of the growing season might be viewed critically lest a significant amount of genetically inferior stock be introduced into planting sites.

Table 7 compares the performance of various sizes of styroplug white spruce seedlings with 2-0 and 2-1 (not reclaims) bare-root stock on an untreated, recently cut site with heavy competition potential. The height of styroplug-2 and -4 stock after two growing seasons was comparable with that of 2-0 and 2-1 bare-root stock, respectively. The stem volume of styroplug-4 seedlings was comparable with that of the 2-0 bare-root seedlings, which is impressive because the bare-root seedlings had twice the mass of the styroplug-4 seedlings at the time of planting. Although stem volume of the styroplug-8 seedlings after two growing seasons was less than that of the 2-1 transplants (which had much greater mass at time of planting), height was greater. These data suggest that styroplug-8 seedlings, which take only one year to grow, may be interchangeable with 2-1 transplants where larger stock is required.

Table 7. Parameters for styroplug and bare-root white spruce stock, at planting, and after two growing seasons, in an untreated, recently cut site[a].

	At planting[b]		After 2 years[c]		
Stock	Height (cm)	Mass (g)	Survival (%)	Height (cm)	Stem volume[d] (ml)
Styro-2	16a	0.76a	91a	28a	1.6a
Styro-4	20b	1.46b	96a	35b	2.7b
Styro-8	22c	2.11c	99b	40c	4.7c
2-0	20b	3.07d	88a	29a	2.7b
2-1	21c	10.60e	90a	33b	5.8d

[a]Values in each column followed by same letter do not differ significantly ($p = 0.05$).
[b]Values based on 50-seedling sample.
[c]Values based on 250 seedlings planted.
[d]Height times one-third basal area.

CONCLUSIONS

Results from trials with container-grown white spruce seedlings in the Sub-Boreal Spruce Zone of British Columbia showed that survival and growth are affected by both size of stock and condition of site. The following points were demonstrated.

1. Seedlings raised in small containers may perform poorly following outplanting on sites with potential for dense competing vegetation unless such vegetation is controlled by site treatment.

2. Performance of container-grown seedlings in fine-textured soils prepared by biologically favorable site treatments which retain the fertility inherent in surface organic matter available to seedlings can be superior to that of seedlings in soils prepared by scalping site treatments.

3. Container-grown seedlings raised in large containers may be substituted for site treatment where or when site treatment is not feasible.

4. Container-grown seedlings raised in large containers may be an alternative to 2-1 bare-root transplants where large stock is needed.

5. Performance of container-grown seedlings will be poorer than expected if seedling size is substandard for the size of container used or if seedling quality (e.g., root growth capacity) is poor.

6. Cost savings may be possible by the use of seedlings grown in containers of a size commensurate with that needed to perform satisfactorily at the density of competing vegetation to be expected on a given site.

7. If planting is delayed following clearcutting, larger container-grown stock is needed because the density of competing vegetation increases with increasing time since clearcutting.

8. Since growing conditions in styroblocks are relatively uniform, size differences among container-grown seedlings raised in a given size of styroblock may be at least partially under genetic control; the small-sized seedlings in a styroblock consequently may be unsuitable for outplanting.

The relationships found show that size of container-grown stock can and should be matched to site conditions.

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