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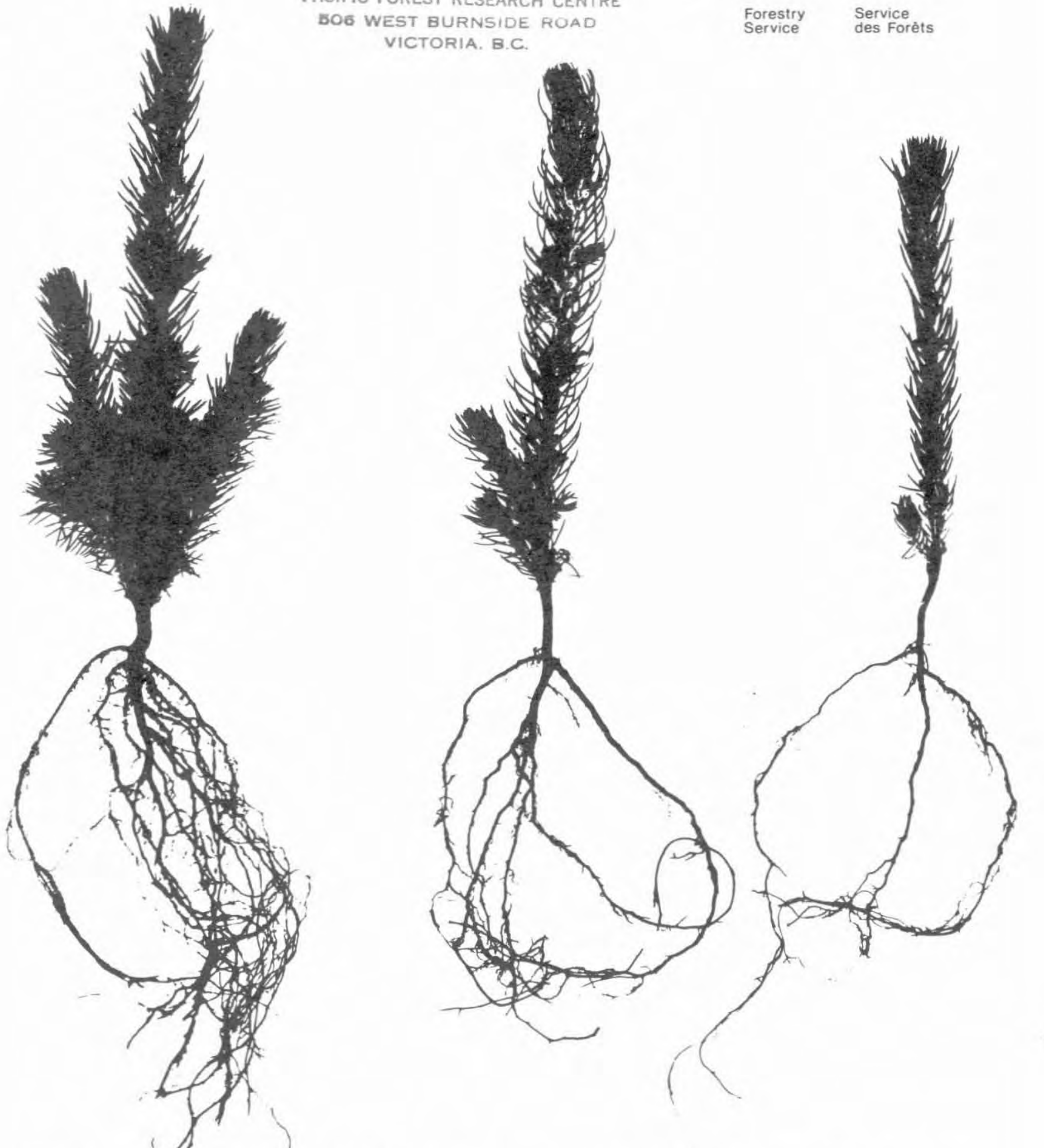

Effect of Initial Mass of White Spruce and Lodgepole Pine Planting Stock on Field Performance in the British Columbia Interior

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Résumé

On a classé par ordre de grosseur deux types de jeunes Epinettes blanches et de Pins tordus (semis 2 + 0 et plants 2 + 1), selon leur poids à l'état frais, et, avec des plantes appartenant aux mêmes espèces, "empotées" dans des "styroplugs-2", on les a plantés ou repiqués à l'extérieur sur des parcelles scarifiées avec des lames, ou non traitées. On a défini trois classes de grosseur (les gros, les moyens et les petits) pour les semis 2 + 0 et deux classes (gros et petits) pour les plants 2 + 1; les plantes dans les styroplugs-2 étant relativement uniformes, ne furent pas classées.

A la fin de trois saisons de croissance, la survie, la hauteur totale, l'accroissement en hauteur, le diamètre de la tige et le poids anhydre furent mesurés et comparés aux classes initiales de grosseur au sein de chaque espèce et type de plantes.

Généralement, les "gros" semis ou les plants produisirent mieux que les "petits", et ceux qu'on plante en parcelles scarifiées réagirent mieux que ceux des parcelles non traitées. Un fait d'importance particulière, les gros plants des parcelles non traitées ont mieux réussi que les petits plants des parcelles scarifiées, indiquant une possibilité d'"échanges" entre la grosseur des plants et l'aménagement des stations, échanges qui, au moyen du classement des plants, pourraient être exploités par le sylviculteur.

Le Pin a mieux produit que l'Epinette; à vrai dire, les semis de Pin ont généralement aussi bien réussi que les plants d'Epinette. A l'intérieur d'une même espèce, les gros semis se comparaient favorablement aux petits plants et les styroplugs-2 se comparaient favorablement aux semis et aux plants dont la taille d'origine était beaucoup plus grosse.

Cover - Typical large, medium and small 2+0 white spruce seedlings.

Abstract

Two types (2+0 seedlings and 2+1 transplants) of white spruce and lodgepole pine planting stock were graded into size classes on the basis of fresh mass and, together with styroplug-2 stock of the same species, were outplanted on blade scarified and untreated plots. Three size classes (large, medium and small) were defined for 2+0 seedlings and two classes (large and small) were defined for 2+1 transplants; styroplug-2 stock was relatively uniform in size and was not graded.

At the end of three growing seasons, survival, total height, height increment, stem diameter and dry mass were assessed and related to initial size class within each species and stock type.

Generally, "large" seedlings or transplants outperformed "small" ones, and those on scarified plots outperformed those on untreated plots. Of particular importance, large stock on untreated plots outperformed small stock on scarified plots, indicating a potential "trade-off" between stock size and site preparation which, through stock grading, may be exploited by the silviculturist.

Pine outperformed spruce; indeed, pine seedlings generally did as well as spruce transplants. Within a species, large seedlings compared favorably with small transplants. Styro-2 plugs compared favorably with seedlings and transplants of greater initial size.

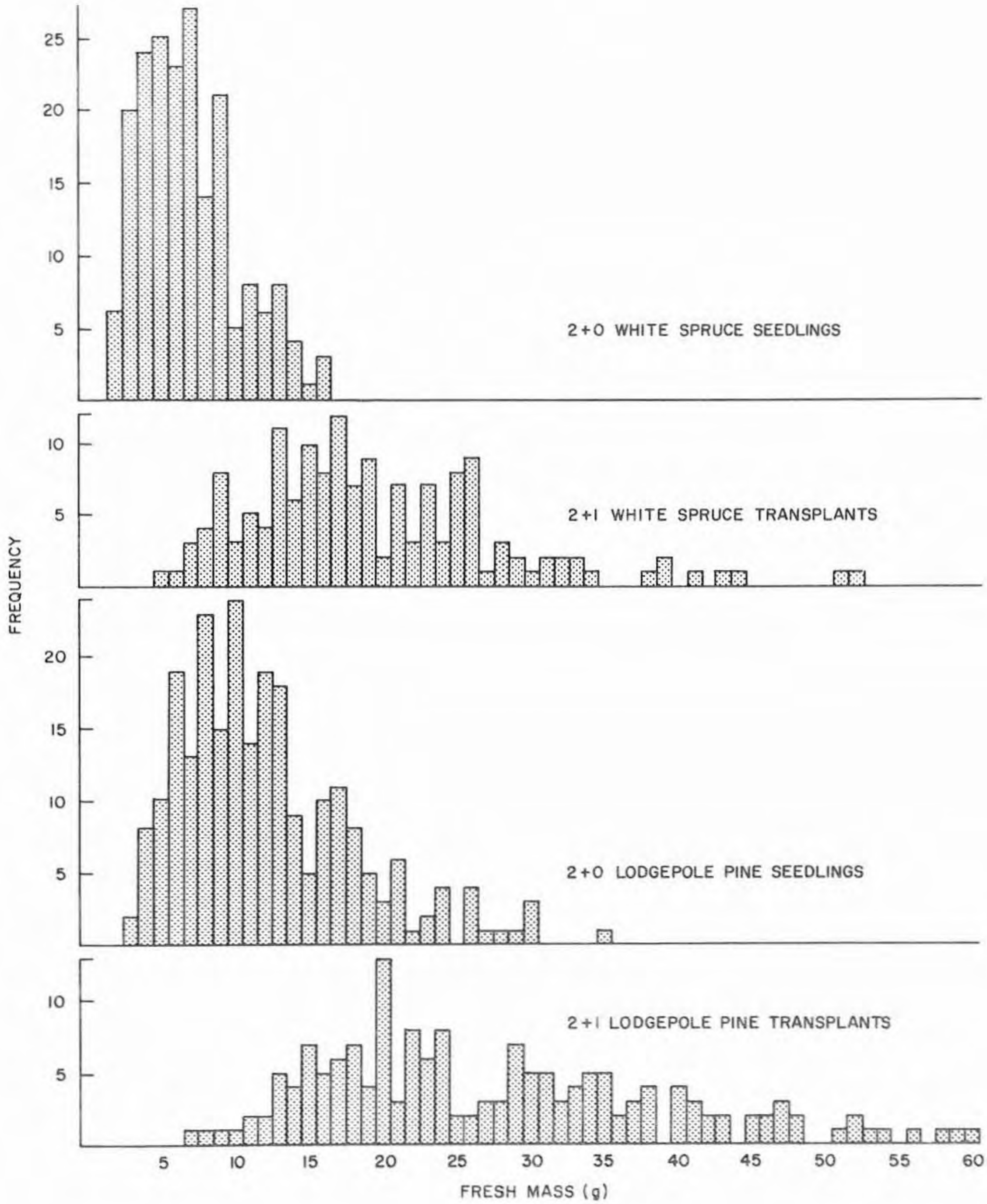

Figure 1. Distributions of fresh masses of spruce and pine 2+0 seedlings and 2+1 transplants after routine culling.

Introduction

Competition from native vegetation is a major impediment to reforesting spruce/alpine fir cutovers. In the British Columbia Interior, blade scarification is frequently prescribed to eliminate this obstacle. However, this practice is costly and may reduce fertility by removing nutrient-rich duff and topsoil from the proximity of planted stock (McMinn 1974). Preparation of planting sites should be no more severe than necessary and should be avoided when it is not needed.

Bare-root planting stock from a given seedlot usually varies widely in size and, therefore, in ability to compete with vegetation. To ensure maximum survival, the silviculturist must prescribe site preparation geared to the needs of those outplants least able to compete. Consequently, preparation of the site often exceeds the survival requirements of much of the stock to be planted on an area. If stock of relatively uniform size were available for planting, the degree of site preparation could be more closely attuned to stock requirements, and inadequate or excessive site preparation could be more easily avoided. Separation of planting stock into size classes has been termed morphological grading (Walters and Kozak 1965).

Measurements preliminary to the present study indicated that the mass* of bare-root white spruce (*Picea glauca* (Moench) Voss) and lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) stock may vary markedly, even after routine culling in the nursery grading shed. To explore the benefits that might accrue from planting stock of relatively uniform size, 2+0 seedlings and 2+1 transplants of both species were divided into size classes on the basis of fresh mass and, together with styro-2 "plug" seedlings, were planted on blade scarified and untreated plots.

* Although "weight" will be a more familiar term to most readers, the more technically correct term "mass" is used throughout this paper to conform to the International System of Units.

Methods

To establish limits for the several grades of stock to be tested, fresh mass was determined for representative white spruce and lodgepole pine stock produced at the British Columbia Forest Service's Red Rock Nursery; data were based on 200-250 individuals of each species and stock type (seedlings and transplants) randomly selected from stock that had been routinely culled and packaged for shipping. Although loose soil was shaken from the roots before weighing, stock was not washed as this probably would have impaired performance after outplanting and invalidated the results. On the basis of the resulting distributions of mass (Figure 1), three size classes were defined for seedlings of each species and two for transplants, as shown in the first two columns of Table 1. Sampled stock and stock subsequently graded and planted were from the same seedlots; spruce derived from BCFS seedlot No. 1553 (Bowron River source) and pine from seedlot No. 1460 (Parsnip source).

Representatives of each defined size class were then segregated by weighing from stock that had been routinely culled, packaged and stored in May 1972. Masses were determined on a top-loading Mettler P1200 balance. Further culling, especially of forked seedling, was also done at this time. During this procedure, care was taken to avoid root drying by returning graded seedlings to boxes and to storage coolers as soon as possible.

The styro-plugs 2, to be planted for comparison with bare-root stock, were raised at the Pacific Forest Research Centre in Victoria during the previous summer (1971). This stock (from the same seedlots as the bare-root) was grown in a greenhouse for 28 weeks, then transferred to a shade house to overwinter. In early March 1972, the container stock was transferred to a 4C cold room to forestall premature flushing and, in early May, it was transported to Red Rock Nursery*

* Pine stock was transported with permission of BCFS Protection Division.

Table 1. Pre-planting size parameters by stock class

Stock Class	Nominal fresh mass range	Mean Height	Mean basal Diameter	Mean oven-dry mass		
				Shoot	Roots	Total
	grams	centimetres	centimetres	grams	grams	grams
Spruce						
2 + 0 (large)	> 9	20.4 ± 1.2 [1/]	.386 ± .0015	2.656 ± .257	.748 ± .078	3.406 ± .285
(medium)	4.5-9	16.9 ± 1.0	.351 ± .0020	1.510 ± .125	.374 ± .030	1.884 ± .143
(small)	2-4.5	13.3 ± 0.8	.226 ± .0010	0.675 ± .054	.222 ± .014	.898 ± .058
2 + 1 (large)	> 18	19.8 ± 1.2	.627 ± .0030	5.167 ± .522	2.784 ± .364	7.382 ± .798
(small)	7-18	16.5 ± 0.7	.457 ± .0020	2.711 ± .217	1.428 ± .110	4.139 ± .271
Styro-2 plugs	—	11.7 ± 0.1	.193 ± .0010	0.438 ± .006	.512 ± .006	.950 ± .010
Pine						
2+0 (large)	> 17	15.6 ± 0.8	.478 ± .0020	4.996 ± .486	1.533 ± .121	6.558 ± .537
(medium)	7.5-17	14.0 ± 0.7	.462 ± .0020	2.625 ± .191	.708 ± .062	3.333 ± .205
(small)	2-7.5	12.5 ± 0.5	.323 ± .0020	1.580 ± .219	.548 ± .113	2.141 ± .302
2 + 1 (large)	> 25	21.2 ± 1.1	.668 ± .0025	8.886 ± .790	3.213 ± .245	12.057 ± .922
(small)	11-25	18.1 ± 0.7	.539 ± .0020	4.797 ± .436	1.867 ± .102	6.593 ± .311
Styro-2 plugs	—	15.7 ± 0.1	.252 ± .0010	0.750 ± .012	.734 ± .010	1.485 ± .016

1/ 95% confidence intervals

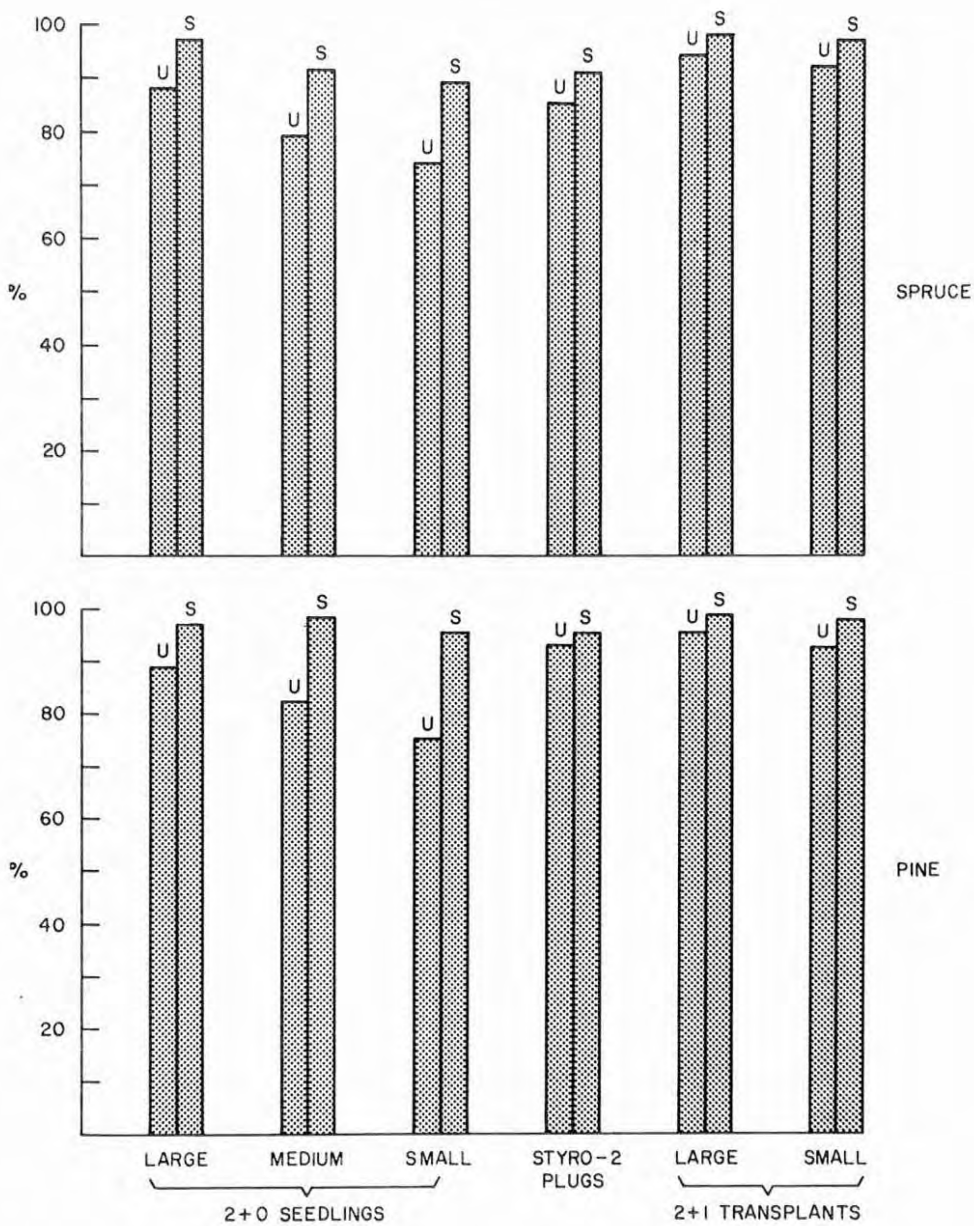

Figure 2. Survival after three growing seasons in the field. (U indicates untreated plots; S indicates scarified plots.)

and held in the nursery cooler until planting commenced in early June.

Prior to planting, 50 seedlings (or transplants) were randomly selected from each stock class for determination of size parameters -- i.e., height, basal stem diameter and mass of oven-dried tops and roots.

The study was conducted on Tree Farm License 30 (Cutting Permit 23), near Upper Fraser, B.C. The area selected was an 8 hectare clearcut that previously supported a mixed white spruce/alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) stand. Site type is Oplopanax (Illingworth and Arlidge 1960); predominant soil texture is a silty clay-loam. Logging took

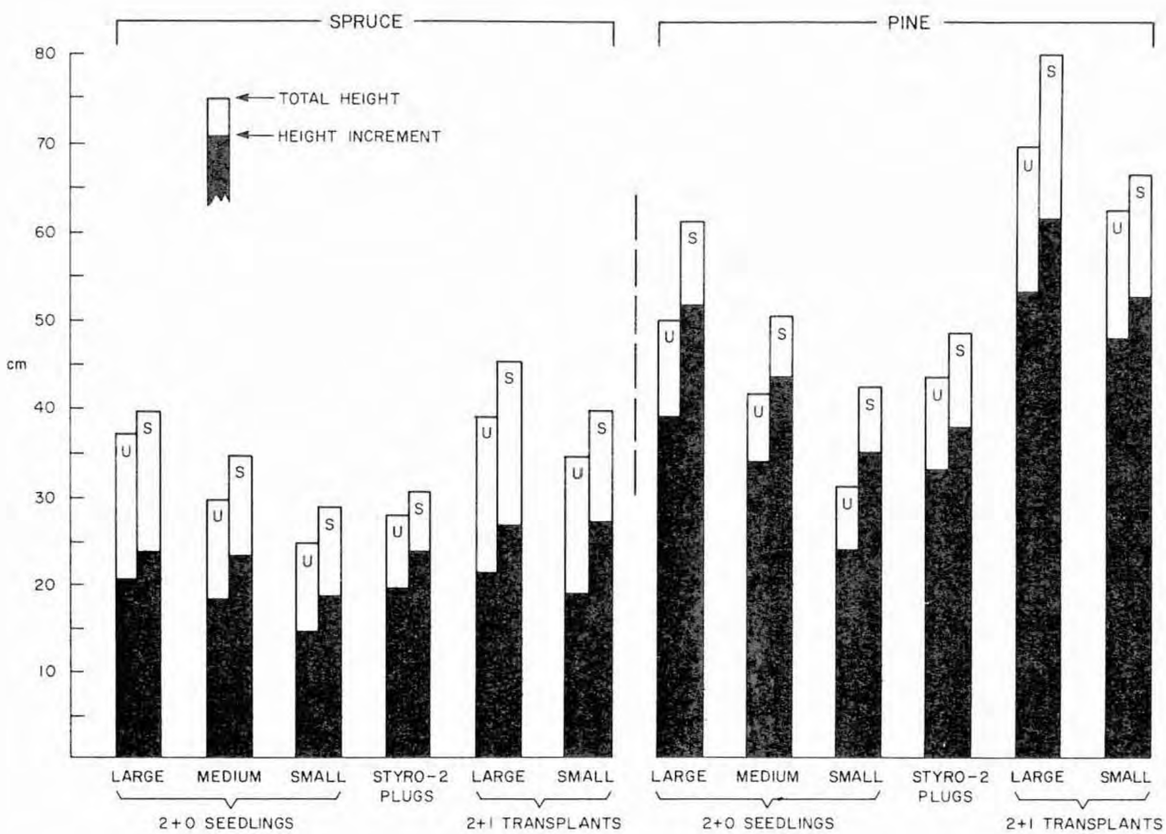

Figure 3. Total heights and height increments after three growing seasons in the field. (Based on all surviving trees.)

place in the winter of 1970-71 and the area was blade-scarified in the fall of 1971. Scarification followed standard operational procedures, except that the proportion of area treated was restricted to provide adequate area for establishing untreated plots; scarified strips were uniformly distributed over the study area.

Plots were established on scarified and untreated areas in a randomized block design. Each of eight blocks contained six scarified plots (one for each stock class) and six untreated plots. Thirty seedlings (or transplants) of each species were planted on each plot at a spacing of approximately 1 metre, and marked by numbered stakes. Planting was carried out in early June 1972, during cool, moist weather. Bare-root stock was mattock planted and styro-plugs were planted with dibbles.

Survival was assessed after the first, second and third growing seasons and after the first and second winters. At the time of the 3-year survival assessment (fall 1974), height increment and total height of all surviving stock was recorded. Also, one spruce and one pine were excavated from each plot for determination of basal stem diameter and dry mass of tops and roots. Excavated trees were selected as representative of those growing in the plot. All 3-year survival and growth data were subjected to analysis of variance and a Duncan's multiple range test.

Table 2a - Survival and growth means for white spruce

	Survival	Tot. Ht.	Ht. Incr.	Stem Diam.	Dry Mass Shoot	Dry Mass Root	Dry Mass Total
	%	cm	cm	cm	g	g	g
Treatment (T)	**	**	**	*	**	**	**
Untreated	86.7	32.9	19.6	0.58	14.6	6.1	20.7
Scarified	94.5	36.8	23.7	0.64	19.2	8.7	27.9
Stature (S)	**	**	**	**	**	**	**
2+0 Large	92.9ab	38.3ab	22.0a	0.65a	18.9a	7.0ab	25.9a
2+0 Medium	85.0a c	32.0 c	20.6ab	0.59a	10.0ab	3.1a	13.1a
2+0 Small	81.5 c	26.4	16.5 b	0.38 b	8.1 b	2.9a	11.0
2+1 Large	96.2 b	42.2a	24.0a	0.86	29.8	12.2 c	42.0
2+1 Small	94.4 b	37.2 b	22.0a	0.67a	19.5a	8.0 bc	27.5
styro-2	88.3abc	29.1 c	21.6a	0.43 b	9.9ab	5.5ab	15.4a
Interaction (TXS)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
U:2+0 Large	88.3	37.2	20.5	0.61	17.2	5.7	22.9
S:2+0 Large	97.5	39.4	23.5	0.69	20.6	8.4	29.0
U:2+0 Medium	78.8	29.5	18.2	0.57	8.0	2.4	10.4
S:2+0 Medium	91.2	34.5	23.0	0.61	12.0	3.7	15.7
U:2+0 Small	73.8	24.3	14.5	0.34	6.6	2.2	8.8
S:2+0 Small	89.2	28.4	18.5	0.42	9.6	3.5	13.1
U:2+1 Large	94.2	39.1	21.3	0.81	25.7	8.9	34.6
S:2+1 Large	98.3	45.3	26.8	0.92	33.9	15.4	49.3
U:2+1 Small	91.7	34.6	18.7	0.61	14.2	6.1	20.3
S:2+1 Small	97.1	39.7	25.2	0.73	24.8	9.9	34.7
U:styro-2	85.4	27.6	19.6	0.40	8.8	4.6	13.4
S:styro-2	91.2	30.5	23.6	0.47	11.0	6.3	17.3

** means significantly different at 1%. * means significantly different at 5%. n.s. means not significantly different.
For a particular parameter, means designated by the same letter are not significantly different at 5%.

Table 2b - Survival and growth means for lodgepole pine

	Survival	Tot. Ht.	Ht. Incr.	Stem Diam.	Dry Mass		
					Shoot	Root	Total
	%	cm	cm	cm	g	g	g
Treatment (T)	**	**	**	**	**	**	**
Untreated	88.0	50.4	38.8	1.04	49.9	14.5	64.4
Scarified	96.5	57.4	46.0	1.25	77.1	21.4	98.5
Stature (S)	**	**	**	**	**	**	**
2+0 Large	92.7ab	55.6	45.5a	1.27ab	66.9ab	20.3a	87.2ab
2+0 Medium	89.8ab	46.1a	38.8 b	0.88 c	22.9 c	6.9 b	29.8 c
2+0 Small	84.6 b	36.9	29.4 c	0.71 c	21.7 c	6.5 b	28.2 c
2+1 Large	96.5a	74.6	57.3	1.67	143.5	34.9	178.4
2+1 Small	94.2ab	64.5	50.1a	1.30 b	85.5a	22.6a	108.1a
styro-2	94.0ab	46.0a	35.4 bc	0.95a c	43.8 bc	14.0ab	57.8 bc
Interaction (TXS)	**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
U:2+0 Large	88.8	50.5	39.2	1.19	45.8	14.1	59.9
S:2+0 Large	96.7	61.1	51.8	1.35	88.0	26.5	114.5
U:2+0 Medium	81.7	41.7	34.1	0.85	21.4	6.9	28.3
S:2+0 Medium	97.9	50.4	43.5	0.92	24.4	7.0	31.4
U:2+0 Small	74.6	31.3	23.8	0.60	13.9	4.5	18.4
S:2+0 Small	94.6	42.5	35.0	0.82	29.6	8.4	38.0
U:2+1 Large	94.6	69.4	53.3	1.49	113.0	29.4	142.4
S:2+1 Large	98.3	79.8	61.3	1.85	174.0	40.4	214.4
U:2+1 Small	91.7	62.6	47.8	1.12	67.3	17.3	84.6
S:2+1 Small	96.7	66.3	52.5	1.48	103.7	27.8	131.5
U:styro-2	92.9	43.6	33.0	0.83	32.0	12.2	44.2
S:styro-2	95.0	48.4	37.8	1.07	55.5	15.8	71.3

** means significantly different at 1%. * means significantly different at 5%. n.s. means not significantly different.
For a particular parameter, means designated by the same letter are not significantly different at 5%.

Results

Despite the errors inherent in basing size on the fresh mass of unwashed stock, the classes differed markedly in terms of all parameters measured (Table 1) and no evidence was found that stock was wrongly categorized by this method. Prior to planting, large bare-root seedlings of both species averaged three times the dry mass of seedlings in the small class; large transplants averaged nearly twice the dry mass of small transplants.

Site treatment and stock class had statistically significant effects on survival and on all growth parameters measured in both species at the end of three growing seasons (Table 2a,b).

Scarification improved survival for all stock classes of both species, but only marginally for plugs and transplants (Table 2a, b; Figure 2). Among size classes of 2+0 seedlings, the benefit of scarification was greatest for small stock and least for large stock; survival of large stock on untreated plots approached that of medium and small stock on scarified plots, especially for spruce. Mortality after the first year was negligible for all stock classes.

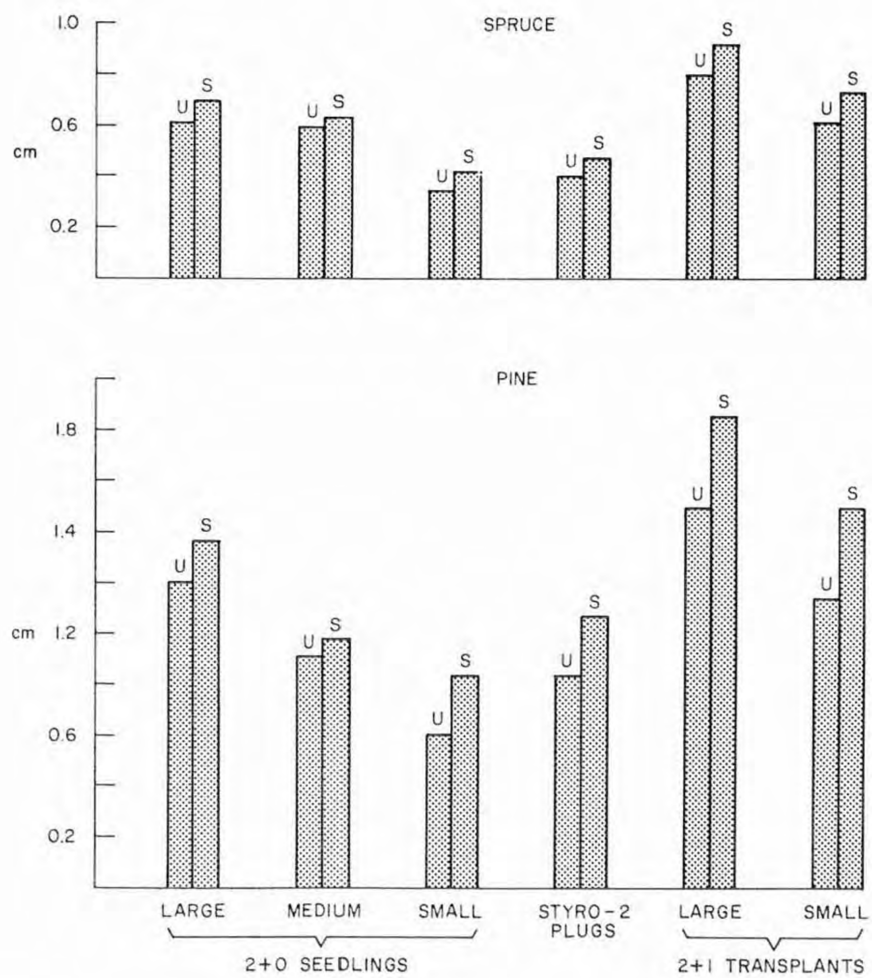

Figure 4. Basal stem diameters after three growing seasons in the field. (Each bar is based on eight representative trees.)

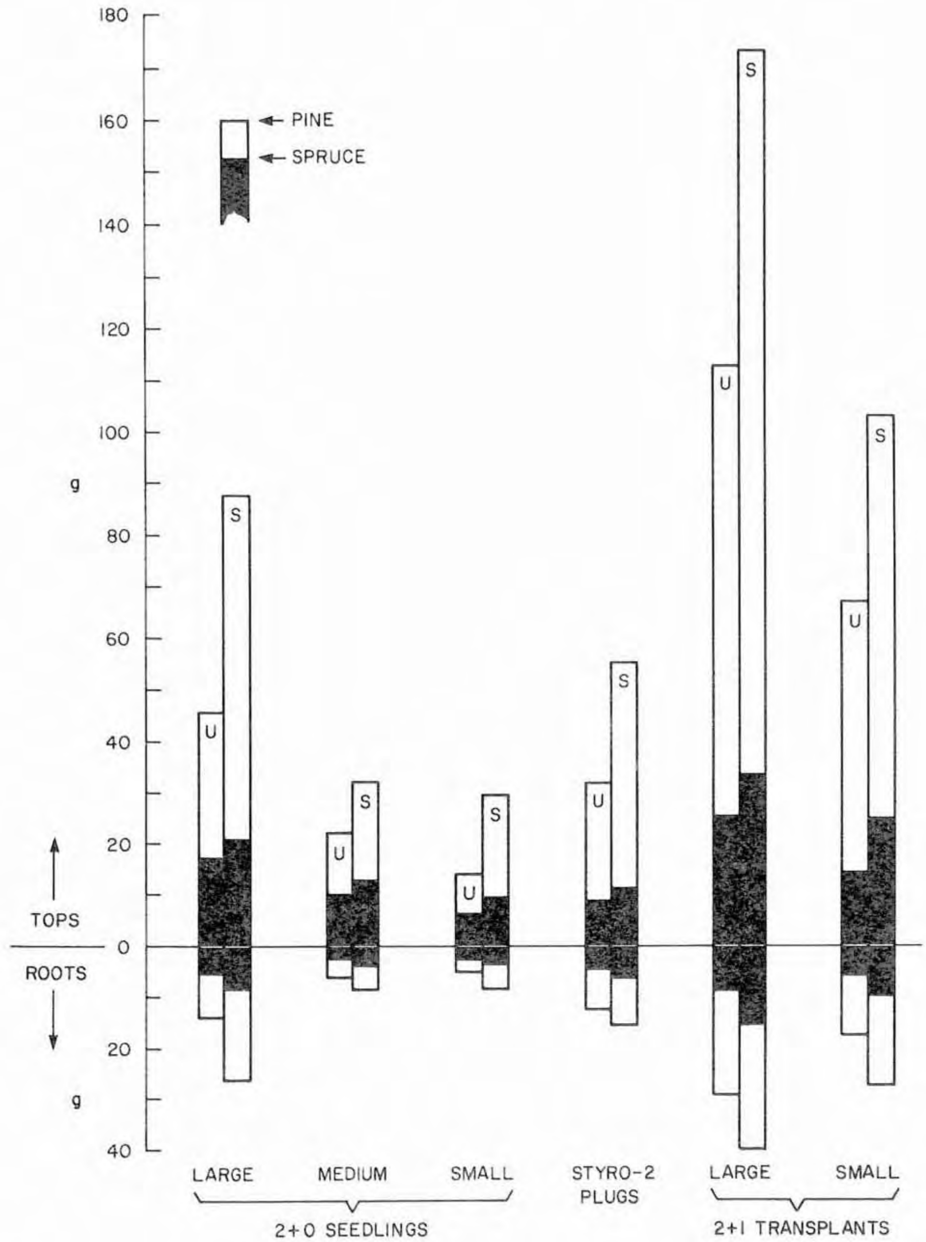

Figure 5. Dry masses of tops and roots after three growing seasons in the field. (Each bar is based on eight representative trees.)

Growth of all stock classes of both species was enhanced by scarification, but in many instances, size class had a more pronounced effect (Table 2a, b; Figures 3, 4 and 5). For both species, large 2+0 stock on untreated plots outperformed small stock on scarified plots in terms of height increment, basal stem diameter and dry mass of tops and roots after 3 years. Generally, large 2+1 transplants on untreated plots also matched or exceeded the growth of small transplants on scarified plots. The performance of large seedlings compared favorably to that of small transplants and plugs performed about as well as 2+0 medium seedlings. Growth of pines was much greater than that of spruce; in fact, pine seedlings (2+0) generally outperformed spruce transpants (2+1).

Discussion

Size is by no means the only index of stock quality - nor is it necessarily the best index. Morphological grading, whereby stock is separated on the basis of one or more size characteristics, has obvious pitfalls in that other determinants of stock quality may override size. Consequently, physiological grading has been advocated by many workers (Walters and Kozak 1965). This is based on direct indicators of a seedling's chances for survival; for example, the number of new root tips it possesses just before planting (Stone et al. 1963).

Planting quality is important; indeed, well-planted small seedlings often have better prospects than large seedlings that have been planted poorly. However, notwithstanding the limitations of morphological grading, there is substantial evidence that large seedlings from a given nursery generally survive better and grow faster than smaller seedlings from the same nursery (Burns and Brendemuehl 1971; Walters and Kozak 1965).

Results of the present study confirm this general observation. Although based on one seedlot each for spruce and pine and a single planting area, this study indicates that, among seedlings or transplants from the same seed source which have received essentially the same cultural treatment, large stock initially outperforms small stock. The more intense the competition from surrounding vegetation, the greater the advantage of using large stock. Survival and growth was also enhanced by blade scarification. Moreover, the results demonstrate a potential trade-off between stock quality (as reflected by initial size) and site preparation by showing that a given level of survival and growth can be achieved by planting smaller stock on blade scarified areas or by planting larger stock on untreated areas. This trade-off is, however, demonstrated only in principle. Possible economic advantages of upgrading seedling quality or of grading seedlings as a means of reducing site preparation requirements must be verified by an economic analysis that takes full account of all variables in plantation establishment.

The performance of 2+1 transplants was only marginally better than that of the large 2+0 seedlings. This suggests that grading 2+0 seedlings could negate the need for producing transplants to regenerate brushy or untreated sites. Pine stock of all grades grew substantially better than spruce of the corresponding grade; in fact, the smallest pine seedlings compared favorably with the largest spruce transplants. On untreated plots, survival of styro-2 pine plugs was better than that of all bare-root stock grades, except large 2+1 transplants; spruce plugs on untreated plots survived almost as well as large bare-root seedlings. Survival of plugs and transplants of both species was only modestly increased by blade scarification. Height increment of spruce plugs did not equal that of medium 2+0 seedlings. Styro-2 plugs performed favorably, even though, initially, they were of similar or smaller size than the small grades of seedlings.

Even the largest grades of stock benefitted from site preparation, especially in terms of dry matter production. On the basis of 3-year survival and growth data, blade scarification did not appear to reduce fertility in the study area -- i.e., any deleterious nutritional relocations (McMinn 1974) were presumably compensated for by benefits such as reduced vegetative competition. However, growth increases brought about by scarification probably will not persist after vegetation returns to full vigor.

The wide range in sizes of bare-root seedlings and transplants was probably due in part to variation in growth conditions in the nursery. That the effect of genetic variability can be reduced is indicated by the relative uniformity of plugs derived from the same seedlot; an indication of this uniformity is revealed by the comparative small confidence intervals for styro-2 plug size parameters in Table 1. Although no observations were made on the experimental stock prior to lifting, much of the difference in size may have been due to irregular nursery bed densities.

While the production of relatively uniform stock of high quality remains a nurseryman's goal, wide variability in stock size cannot always be avoided. Morphological grading is one means of providing the silviculturist with stock of more uniform potential, thus allowing him to match stock grades to reforestation sites and to prescribe site preparation treatments with greater precision.

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