Survival and Growth of Selected White Spruce Container Stock Types in Interior Alaska

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Survival and growth of white spruce (Picea glauca *(Moench) Voss) seedlings raised as 4 different-sized container stock types were followed on 5 harvested sites in the Cache Creek drainage of interior Alaska. Stock types evaluated were 1-0 Ray Leach Pine Cells® (65 cm^3, 4 in^3) and 1-0 Styroblock® sizes 313B (65 cm3, 4 in3), 415B (98 cm3, 6 in3), and 415D (164 cm^3, 10 in^3). After 5 y, survival and height growth were mixed. Ray Leach Pine Cells had a significantly higher rate of survival than seedlings grown in Styroblock 313B containers, but there were no differences among the survival of Ray Leach and the other 2 Styroblock sizes, nor among the Styroblock sizes themselves. Survival of all 4 stock types varied dramatically among sites. Although this experiment was not designed to evaluate site factors, lowest survival rates (25% to 40%) may have been related to the bluejoint grass* (Calamagrostis canadensis *(Michx.) Beauv.) and fireweed* (Epilobium angustifolium *L.) cover found in 2 of the sites, and highest survival (90%) may have been related to the slight topographic elevation of 1 site. Seedlings grown in Styroblock containers were substantially taller at planting than those grown in Ray Leach containers; this difference was maintained after 5 y. Stem diameter did not differ significantly among stock types, either at planting or after 5 y. Our results reiterate that seedling out planting performance is a complex f unction of many factors, including stock type, competing vegetation, and microsite, and suggest that more research on the performance of different stock types in Alaska is needed before standard stock types can be identified for various site conditions.* Tree Planters' Notes 50(1): 44-49; 2003.

Over the last 10 y, the timber harvest on State lands of interior Alaska has averaged approximately 400 ha (Clautice, personal communication, see "Notes"), with some additional harvesting occurring on Alaska Native Corporation and other private lands. Clearcutting is the most common harvest method used for white spruce *(Picea glauca* (Moench) Voss) in this region. Because seed production in white spruce varies greatly from year to year (Zasada and Viereck 1970; Rupp 1998), prompt natural regeneration requires that forest management activities be timed to coincide with good seed years (Zasada 1980). Although spot seeding and natural regeneration have been used successfully (Densmore and others 1999), planting seedlings has become a common regeneration method. In recent years, an average of 350,000 white spruce seedlings has been planted annually on 300 ha (about 750 acres) in the Fairbanks area (Lee, personal communication, see "Notes").

The 1st white spruce plantations in Alaska were established in the late 1970s with all planting stock produced at a single nursery. In the early 1990s, some Alaskan forest managers began to purchase seedlings outside Alaska from nurseries with an increased selection of containers. The applicability of stock type trials from other regions was uncertain and information on outplanting performance under Alaskan conditions was needed. Cole and others (1999) found that plug+1 white spruce seedlings had slightly higher survival and were taller than container-grown seedlings 5 y after outplanting in south-central Alaska. Our study was conducted in interior Alaska using seedlings produced in different container sizes: Ray Leach Pine Cells® and 3 Styroblock® sizes.

Methods

White spruce seedlings from a single, local seed source were produced at 2 nurseries from spring through summer 1992 (table 1). The State forest nursery at Eagle River, AK, used Ray Leach Pine Cells (Landis and others 1990), and Pelton Reforestation at Maple Ridge, British Columbia, used Styroblock 313B, 415B, and 415D containers (Scagel and others 1993). Seedlings were shipped from the nurseries and held in a shade house for less than 2 w prior to planting.

Study plots were located on 5 different operational cutting sites, all located within 2 km (1.24 mi) of each other in the Cache Creek drainage (lat 64°50'N, long 148°17'W), about 24 km (15 mi) west of Fairbanks. Sites all occurred on a gentle south- to southwest-facing slope or on the bench on top of the slope; they varied in size and shape. The mean annual temperature at Fairbanks, the nearest recording station, is -3.2 °C (26.2 °F) and mean annual precipitation is 26.5 cm (10.4 in). Before harvesting, the sites supported a mature, productive "closed white spruce forest" (Viereck and others 1992) with paper birch *(Betula papyrifera* Marsh) and occasional quaking aspen *(Populus tremuloides* Michx.). Common understory plants were mountain alder *(Alnus crispa* (Ait.) Pursh), lingonberry *(Vaccinium vitis-idaea L.),* fire-

Table 1—*Container specifications and size of white spruce (*Picea glauca *(Moench) Voss) seedling stock types at planting*

	Container depth		Container volume		Cell spacing		Shoot height $\bar{x} \pm s_{\bar{x}}$		Stem diameter	Root:shoot
Stock type[a]	(cm)	(in)	(cm^3)	(in^3)	(cm)	(in)	(cm)	(in)	$\bar{x} \pm s_{\bar{x}}$ (mm)	ratio
Ray Leach Pine	16	6.3	65	4	3.0	1.18	14.1 (0.5)	5.6 (0.20)	2.2 (0.05)	0.66
Styro. 313B	13	5.1	65	4	3.4	1.34	16.6 (0.6)	6.5 (0.24)	3.1 (0.1)	0.90
Styro. 415B	14	5.5	98	6	4.2	1.65	15.5 (0.8)	6.1 (0.32)	3.5 (0.1)	0.52
Styro. 415D	15	5.9	164	10	5.0	1.97	18.5 (0.9)	7.3 (0.35)	3.6 (0.08)	0.62

[a]Ray Leach Pine Cells®; Styroblock® 313B, 415B, 415D.

weed *(Epilobium angustifolium L.),* bluejoint grass *(Calamagrostis canadensis* (Michx.) Beauv.), squashberry, *(Viburnum edule* (Michx.) Raf.), and prickly rose *(Rosa acicularis* Lindl.) (USDA NRCS 2001). Soils in this area are moderately deep, well-drained, silty loams, with a parent material of micaceous loess underlain by Birch Creek schist (Rieger and others 1963).

The sites had been clearcut less than a year before planting and had received single-disk trencher scarification treatment approximately a month before planting. The seedlings were hand-planted on sides of trenches beginning in late July 1992. The layout was a randomized block design with different cutting sites as blocks; 60 seedlings per stock type were planted per block. The height and diameter of a separate sample of seedlings was measured at planting; then these seedlings were oven-dried, clipped at the root collar, and weighed to determine root:shoot ratio. All planted seedlings were measured for height and groundline diameter after 2, 3, and 5 growing seasons. Seedling survival was tallied at each measurement.

Mean heights, diameters, and survival percentages were subjected to analysis of variance, and means were separated using Tukey's procedure. Survival percentages were normalized prior to analysis with the arcsine transformation (Zar 1984).

During the 3rd growing season of the study, the vegetation associated with the planted seedlings was assessed. Three seedlings of each stock type were randomly selected in each site, for a total of 60 seedlings. Circular 1-m^2 (10.76-ft^2) plots were established around the stem of each seedling, and the percent cover of each plant species was visually estimated.

Results

After 5 years, considerable mortality had occurred (table 2). Larger initial seedling or container size did not increase field survival. Rather, survival of the stock type that was smallest at planting, seedlings from Ray Leach Pine Cells, was highest but not significantly greater than the largest seedlings grown in 415D Styroblocks. In the most striking result of the study, survival of all 4 stock types varied dramatically by study site (figure 1). For example, survival of 415D seedlings varied from 25% to 85% and that of Ray Leach varied from 43% to 90%, depending on study unit (table 2).

At planting, seedling diameter more closely reflected container volume and cell spacing than did seedling height (table 1). After 5 y, there were no significant differences in diameter among any of the stock types examined in this study. The Ray Leach Pine Cell seedlings were shortest at planting and remained significantly shorter than the 313B and 415B Styroblock types after 5 y (table 3). However, height did not differ significantly among the 3 Styroblock stock types (figure 2).

Eighteen species or groups of associated vegetation were tallied in the 5 study sites (table 4). Of those, fireweed and bluejoint grass were the most frequently encountered; these 2 species also accounted for the most cover. Although all 5 sites supported similar amounts of total cover (all species combined), the 2 sites in the western end of the study area (Sites 1 and 2) had the most fireweed and bluejoint grass (table 5). After 5 y, seedling survival in Sites 1 and 2 was clearly the lowest (figure 1).

Table 2—*Percent survival of white spruce (*Picea glauca *(Moench) Voss stock types 5 y after outplanting near Fairbanks, AK*

	Stock type[a]			
Site	RLPine	313B	415B	415D
1	43	27	25	25
2	54	29	42	32
3	65	36	60	76
4	65	52	67	61
5	90	69	78	85
All sites[b]	70 (8.4) a	47 (8.7) b	62 (8.8) ab	62 (12.9) ab

[a]RLPine = Ray Leach Pine Cells®; others are Styroblock®
[b]Means, $\bar{x} \pm s_{\bar{x}}$, followed by the same letter are not significantly different (Tukey's test, $P \leq 0.05$).

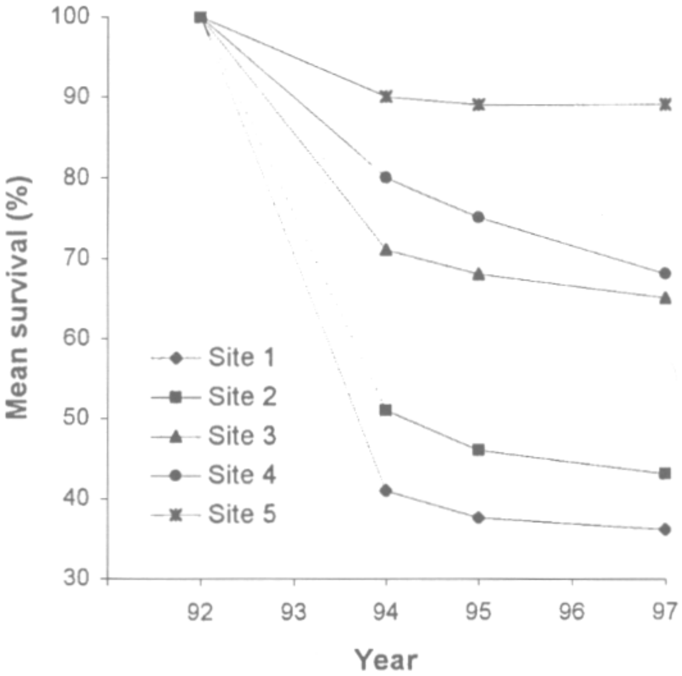

Figure 1—Mean survival of all white spruce (Picea glauca (Moench) Voss) seedlings on 5 planting sites near Fairbanks, AK

Discussion

Whether summarized by stock type or by site, seedling survival in the present study was low compared to that of other plantations in interior Alaska. Styroblock 415D seedlings planted in 1993 on an upland ,site near the Cache Creek drainage had 5-y survival ranging from 80% to 88% (Wurtz 2000), while Ray Leach Pine Cell seedlings planted on a nearby floodplain site in 1983 had 5-y survival greater than 96% (Youngblood and Zasada 1991). In south-central Alaska, Cole and others (1999) reported the average survival of a number of white spruce stock types to be greater than 74% under a variety of site preparation treatments.

The 5-y height of Ray Leach Pine Cell seedlings in the present study is comparable to similar seedlings planted on other Alaska sites (Youngblood and Zasada 1991; Cole and others 1999). However, Styroblock 415D seedling size (table 3) is somewhat less than reported by Wurtz (2000) for 5-y size of Styroblock 415D seedlings on a nearby site (94 to 96 cm, 37.0 to 37.8 in, average height; 14 to 16 mm, 0.55 to 0.63 in, average diameter). In northwestern Alberta, the height of container-grown white spruce seedlings at 5 y ranged from 25 to 46 cm (9.8 to 18.1 in) (Walker 1987). In northern British Columbia the seedlings ranged from 35 to 122 cm (13.8 to 48.0 in) (Van Eerden 1978; McMinn 1982). In general, the growth rate of planted white spruce seedlings in the

Table 3—*Height and diameter, $\bar{x} \pm s_{\bar{x}}$, of white spruce (Picea glauca (Moench) Voss) stock types 5 y after outplanting near Fairbanks, AK*

	Stock type											
	Ray Leach Pine Cells®			Styroblock® 313B			Styroblock 415B			Styroblock 415D		
	Height		Diameter	Height		Diameter	Height		Diameter	Height		Diameter
Site	(cm)	(in)	(mm)	(cm)	(in)	(mm)	(cm)	(in)	(mm)	(cm)	(in)	(mm)
1	55.3 (3.8	21.8 (1.5)	8.2 (0.6)	77.4 (6.3)	30.5 (2.5)	12.8 (1.1)	73.5 (4.3)	28.9 (1.7)	11.1 (0.6)	60.1 (6.6)	23.7 (2.6)	9.3 (1.1)
2	44.2 (3.3)	17.4 (1.3)	7.8 (0.5)	65.5 (5.7)	25.8 (2.2)	10.4 (1.1)	59.1 (4.3)	23.3 (1.7)	8.6 (0.6)	50.8 (4.4)	20.0 (1.7)	7.7 (0.5)
3	55.1 (3.0)	21.7 (1.2)	7.6 (0.3)	67.8 (5.2)	26.7 (2.1)	9.6 (0.7)	83.4 (4.2)	32.8 (1.7)	11.7 (0.5)	79.7 (4.1)	31.4 (1.6)	15.0 (3.7)
4	62.1 (3.8)	24.4 (1.5)	9.6 (0.5)	75.5 (6.0)	29.7 (2.4)	11.3 (0.9)	76.1 (3.0)	30.0 (1.2)	10.7 (0.5)	69.4 (3.8)	27.3 (1.5)	10.2 (0.6)
5	61.5 (2.6)	24.2 (1.0)	8.9 (0.3)	68.7 (3.4)	27.0 (1.3)	10.3 (0.3)	64.4 (3.0)	25.4 (1.2)	9.7 (0.4)	82.3 (3.7)	32.4 (1.5)	11.2 (0.5)
All sites[a]	55.6 (3.2)a	21.9 (1.3)	8.4 (0.3)y	71.0 (2.3)b	28.0 (0.9)	10.9 (0.5)y	71.3 (4.3)b	28.1 (1.7)	10.3 (0.5)y	68.4 (5.9)ab	26.9 (2.3)	10.7 (1.2)y

[a]Values followed by different letters (height, a, b; diameter, y, z) are significantly different (Tukey's test, $P \le 0.05$).

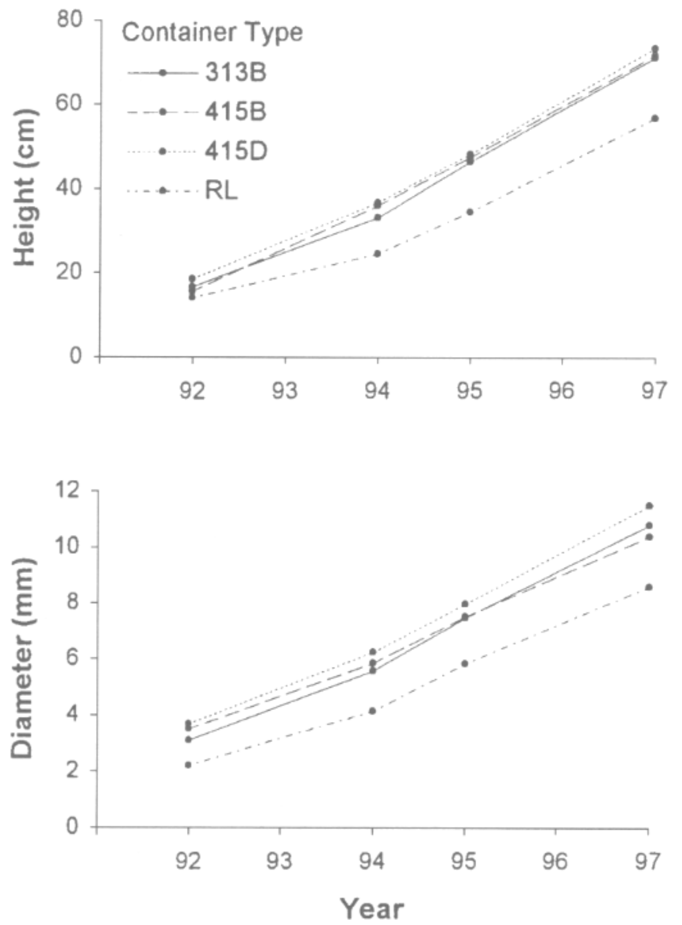

*Figure 2—Mean height and diameter of different stock types of white spruce (*Picea glauca *(Moench) Voss) over the 1st 5 y after planting near Fairbanks, AK (RL=Ray Leach Pine Cells®; others are Styroblock®).*

Table 4—*Species found associated with planted white spruce (*Picea glauca *(Moench) Voss) on each of 5 sites near Fairbanks, AK, 3 y after clearcut harvesting (USDA NRCS 2001)*

Common name	Scientific name
mountain alder	*Alnus crispa* (Ait.) *Pursh*
bluejoint grass	*Calamagrostis canadensis* (Michx.) *Beauv.*
bunchberry dogwood	*Cornus canadensis* L.
fireweed	*Epilobium angustifolium* L.
field horsetail	*Equisetum arvense* L.
northern bedstraw	*Galium boreale* L.
twinflower	*Linnaea borealis* L.
tall bluebells	*Mertensia paniculata* (Ait.) G. Don
white spruce	*Picea glauca* (Moench) Voss
quaking aspen	*Populus tremuloides* (Michx.)
prickly rose	*Rosa acicularis* Lindl.
red raspberry	*Rubus idaeus L. var. strigosus* (Michx.) Maxim
willow	*Salix* spp.
russet buffaloberry	*Shepherdia canadensis* (L.) Nutt.
common dandelion	*Taraxacum officinale* G. H. Weber ex Wiggers
lingonberry	*Vaccinium vitis-idaea* L.
squashberry	*Viburnum edule* (Michx.) Raf.
violet	*Viola* spp.

Table 5—*Percent cover ($\bar{x} \pm s_{\bar{x}}$) of fireweed (*Epilobium angustifolium *L.), bluejoint grass (*Calamagrostis canadensis *Michx.), and total of all species 3 y after clearcut harvesting in 5 sites near Fairbanks, AK*

	Cover (%)		
Site	fireweed	bluejoint	Total
1	42.0 (7.3)	22.6 (6.2)	76.6 (5.4)
2	26.3 (6.7)	34.1 (9.9)	75.4 (5.9)
3	11.2 (5.8)	5.8 (3.1)	75.8 (4.6)
4	15.4 (0.9)	0.9 (0.5)	62.9 (5.7)
5	18.0 (4.0)	7.4 (3.3)	69.1 (6.9)

Cache Creek drainage appears typical despite the somewhat low survival.

Comparisons of white spruce stock types have been conducted across Canada, with most reports comparing bareroot with container-grown seedlings (Dobbs 1976; Vyse 1981; Burdett and others 1984; Ball and Kolabinski 1986). The results of these studies have been mixed, possibly due to differences in planting sites and stock type condition at the time of planting. Comparisons among container-grown seedlings have been more consistent. In general, seedlings grown in larger containers have been larger at planting and have survived and grown better than seedlings from smaller containers (Van Eerden 1978; McMinn 1982; Walker 1987; Sutherland and Day 1988; Thompson and McMinn 1989; Simpson 1991).

Although this study was not designed to compare site factors statistically, we believe that observed differences may be associated with site factors, and seedling survival seemed to be more closely related to site factors than to stock type. Although the 5 study sites were located along a single, continuous hillside, and were harvested, scarified, and planted at the same time, they varied in the composition of their associated vegetation. Sites I and 2 had far more cover of fireweed and bluejoint grass, 2 species that compete aggressively with newly planted seedlings (Lieffers and Stadt 1994). The study sites did not receive any brush control; competition and overtopping were present. Seedling survival was much lower in those 2 sites than in the other sites used in this study, regardless of stock type. No one stock type demonstrated any particular ability to survive competition from those 2 species. Interestingly, relative survival was largely consistent across the range of conditions presented, with Ray Leach seedlings surviving best on sites with heavy bluejoint grass as well as in sites with little competition.

Seedling survival of all 4 stock types was markedly higher in Site 5 than in the other 4 sites. Because there were no differences in associated vegetation among Sites 3, 4, and 5, the high survival in Site 5 cannot be attributed solely to a lack of competition from bluejoint and fireweed. Because we did not collect soil or microclimatic data, we can only speculate that the difference may have been due to elevation. Site 5 was about 30 m higher in elevation than the other study sites, located on a bench on top of the slope. This position likely allowed more solar radiation, and had warmer soils than the other study sites (Slaughter and Viereck *1986).*

For white spruce seedlings, increasing container volume and cell spacing have resulted in increased field growth (Van Eerden *1978;* McMinn *1982;* Walker *1987;* Sutherland and Day *1988;* Thompson and McMinn *1989).* However, in this study, seedling height at 5 y was not significantly different among the Styroblocks, despite an apparent height advantage for the 415D Styroblock seedlings at planting. Similarly, Simpson *(1991)* found that height growth in the field was not strongly affected by nursery spacing. As with survival, 5-y height and height growth were significantly affected by site (PS 0.05).

In Canada, white spruce survival generally improves with larger container size (Sutherland and Day *1988),* but larger size did not enhance survival in the present study. Geographic differences in survival may be related to climate; interior Alaska typically has an early summer drought when soil frost depth is still shallow (Slaughter and Viereck *1986).* Smaller stock types may tolerate these conditions better than larger stock types.

The practical implication of our results is that one cannot reliably predict what the response of a stock type will be on any given site. Yet, stock type selection involves many factors, including cost and predicted planting site competition (Scagel and others *1993).* Larger seedlings generally cost more than smaller seedlings (Landis and others *1990),* but nursery pricing may be determined by more than greenhouse space alone. In the present study, larger stock types maintained superior height but not superior diameter nor survival. If planting density remains unchanged, then plantation establishment costs would likely be increased by using larger stock. The economic gain from improved growth by planting larger stock types was not evaluated. However, based on these limited data, the use of midsize or smaller stock types in interior Alaska appears justified.

Our results reiterate that seedling outplanting performance is a complex function of many factors, including stock type, competing vegetation, and microsite, and suggest that more research on the performance of different stock types in Alaska is needed.

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Notes: Personal communications with the following individuals are cited and unreferenced.

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