Target Seedling Strategies for Intensively Managed Douglas-fir Plantations in the Oregon Coast Range

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Wall M. 2011. Target seedling strategies for intensively managed Douglas-fir plantations in the Oregon Coast Range. In: Riley LE, Haase DL, Pinto JR, technical coordinators. National Proceedings: Forest and Conservation Nursery Associations—2010. Proc. RMRS-P-65. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station: 150-156. Available at: http://www.fs.fed.us/rm/pubs/rmrs_p065.html

Abstract: The target Douglas-fir seedling for outplanting on Roseburg Resources Company timberlands is a least-cost, large [stem] caliper 1- to 2-year old bareroot (>8 mm) or container (>6 mm) seedling with good form, high root growth potential, and the ability to withstand browse without the use of browse deterrents. This target is achieved through the use of large cell transplant plugs and low density spring or fall transplanting, or large cell low density container seedlings for outplanting.

Keywords: container seedlings, bareroot seedlings, target specifications, browse resistance

Roseburg Resources Company Timberlands

Roseburg Resources Company (RRC) timberlands are located between Eugene, OR, and Roseburg, OR, and extend west to the coast. The company has been privately owned for more than 75 years, and sustainably manages approximately 190,00 ha (470,000 ac) of high quality timberlands in Oregon. The 50-year site indices on these lands range from 27 to 43 m (90 to 140 ft), with an average site index of 36 m (120 ft). Douglas-fir (*Pseudotsuga menziesii*) is the dominant tree harvested and planted on company lands. The emphasis of this discussion is on seedling strategies RRC employs on its higher site lands (>33 m [>110 ft]). These lands comprise the majority of RRC ownership. Different strategies are employed on the lower site timberlands that are touched on but not addressed in detail in this discussion.

Target Seedlings

RRC considers the target Douglas-fir seedling for outplanting to be a least-cost, large [stem] caliper 1- to 2-year old bareroot or 1- to 2-year old container seedling with good form, that is, good branch architecture, well-balanced fibrous roots with high root growth potential, and the ability to withstand browse without the use of browse deterrents.

Large Bareroot Seedlings

The target specifications for bareroot seedlings include calipers that are greater than 10 mm (0.4 in), with a minimum of 8 mm (0.3 in), and heights of 60 to 90 cm (24 to 36 in). On lower site index lands, the maximum seedling heights are usually reduced to 50 to 60 cm (20 to 24 in) with slightly lower minimum calipers.

Base Stock

1+0 Bareroot Seedlings—Although bareroot seedling culture is considered "old technology" by many foresters, it continues to have several advantages for use as stock designated for transplanting. Currently, bareroot 1+0 seedlings are relatively inexpensive to produce, costing approximately US$ 110/thousand seedlings. In addition, field sowing usually results in

overruns, which can be advantageous when needs change on short notice and extra seedlings can be transplanted to supplement existing orders. Finally, the ordering process is simple because you are dealing with one nursery and one contract for all phases of seedling production.

Using 1+0 bareroot seedlings for base stock can confer some disadvantages. Direct sowing into seedbeds is often an inefficient use of seeds, since sowing calculations factor in higher losses than those found in greenhouse container culture. The resulting seedlings have a wide variety of both shoot and root sizes, so it is often difficult to achieve consistently large sized 1+0 seedlings from seedbed production. As well, seedlings in the seedbeds are susceptible to early frosts in the fall, and the lifting schedule is totally dependent on the weather. This last issue is becoming more of a concern with the widespread deployment of high gain orchard seeds that seem to be less tolerant of early freeze events in the fall.

Container Seedlings—Growing container seedlings destined for transplanting allows for very efficient use of seeds, with single and fractional sowing becoming more prevalent for the highest gain and most valuable orchard seeds. Efficient seed use not only lowers the overall cost per seedling, but also allows for broader deployment of valuable seeds. Growing transplant seedlings in containers can also result in a more uniform product that can be custom grown to a variety of target specifications, thereby providing the basis for larger more uniform transplant stock. If container seedlings are targeted for spring transplanting, they can easily be frost protected in the fall by remaining in, or being moved back into, greenhouses. In addition, lifting of these seedlings is not subject to weather delays.

Container transplant seedlings, however, are more expensive than bareroot transplant seedlings, ranging from US$ 150 to 180/thousand seedlings. Logistical considerations can also be an issue if the base stock is grown at one nursery and designated for transplanting at another nursery. One of the big disadvantages to container stock in the US Pacific Northwest has been the limited opportunity for growing the stock in the region. Ten years ago, stock had to be ordered from container nurseries in Canada. The situation has changed in recent years, with more container production now occurring in the US Pacific Northwest.

Container transplant seedlings have become the preferred RRC base stock for outplanting—they currently account for almost 95% of base stock production. One primary reason is the consistency in producing large P+1 bareroot seedlings. Another reason is the flexibility in seasonal transplanting. Although most seedlings are transplanted in the spring, fall transplanting is also used for larger stock needs. In this case, the use of container seedlings for base stock makes fall transplanting more feasible with better yields over comparable 1+0 transplants. The preference for container transplants is not only due to the size but also because the bareroot nurseries that were best capable of producing a large fall 1+1 transplant seedling have gone out of business; additionally, the remaining nurseries struggle to produce 1+0 seedlings of the size required for large bareroot stock.

The justification for the use of more expensive container stock can be based almost solely on the cost of seeds (Table 1).

Table 1. Justification for cost of container versus bareroot base stock for transplant production. (All costs are in US $; 1 lb = 0.45 kg.)

	Improved Seeds		
Stocktype	**Styroblock™ 410A**	**Styroblock™ 411A**	**1+0**
Order Amount	100,000	100,000	100,000
Cost of Seeds ($/lb)	1500	1500	1500
Germination Rate	90%	90%	90%
Seeds/lb	36,000	36,000	36,000
Oversow Factor	1.15	1.15	2.2
Seeds/Cavity	1.2	1.2	n/a
Pounds of Seeds Required	3.8	3.8	6.1
Base Stock Cost/thousand ($)	180	150	110
Total Cost ($)	23,750	20,750	20,167
Cost/thousand ($)	238	208	202
P+1/1+1 Final Yield	95%	95%	100%
Net Cost ($)	250	218	202
	Woods Run Seeds		
Stocktype	**Styroblock™ 410A**	**Styroblock™ 411A**	**1+0**
Order Amount	100,000	100,000	100,000
Cost of Seeds ($/lb)	60	60	60
Germination Rate	80%	80%	80%
Seeds/lb	36,000	36,000	36,000
Oversow Factor	1.25	1.25	2.3
Seeds/Cavity	1.5	1.5	n/a
Pounds of Seeds Required	5.2	5.2	6.4
Base Stock Cost/thousand ($)	180	150	110
Total Cost ($)	18,313	15,313	11,383
Cost/thousand ($)	183	153	114
P+1/1+1 Final Yield	95%	95%	100%
Net Cost ($)	193	161	114

When woods-run seeds were used at a cost of approximately US$ 133/kg (US$ 60/lb), the nurseries could use all they needed for production. But with the cost of improved seeds exceeding US$ 3300/kg (US$ 1500/lb), efficient use of seeds becomes a critical part of the cost consideration when trying to figure out where to grow seedlings and at what cost. It is essential that foresters incorporate seed cost into their evaluation of seedling costs, and not just simply compare one stocktype price to another. The opportunity cost of not being able to deploy your highest gain seeds over more acres due to differences in efficiency is an additional consideration that can be quantified, if necessary, without too much effort.

RRC base container stock is grown in several nurseries located in both the US Pacific Northwest and British Columbia, Canada. RRC initially started with Styroblock® 311A and 313B containers (45 cm^3 [2.6 in^3] and 65 cm^3 [3.9 in^3]), but has, over time, migrated to Styroblock® 410A (Figure 1) and, more recently, to 411B containers (80 cm^3 [4.9 in^3]). The increasing costs of producing 410A containers (US$ 180+/thousand seedlings) has led RRC to start to transition to 411B containers (US$ 150+/thousand seedlings). They have the same volume as the 410A, but contain more cavities per block (144 versus 112), therefore, lowering greenhouse costs. The initial seedling orders we have gotten with this new stocktype meet comparable target specifications of the 410A stocktype with only minor reductions in caliper and no change in height specifications. While current production includes an even mix of both cavity types, RRC expects to migrate more production to the 411B stocktype over time.

Low Density Transplanting—RRC was interested in the effects of low density transplanting on seedlings and what the trade-offs in cost were as a result. Traditional transplant densities range from 24 to 32 trees/bed foot using 5 to 6 row transplanters. Research conducted by RRC quantified the caliper increases as a result of dropping transplant densities to as low as 12 trees/bed foot. As expected, there were diminishing returns as density was reduced. RRC concluded that when 410A/411B containers were used for base stock, a transplant density of 14 to 17 trees/bed foot provided the optimum density, and best value, target bareroot seedling.

Lower densities do increase seedling costs due to the increase in the amount of bed space needed. For example, a transplant cost of US$ 200/thousand seedlings for 24 seedlings/bed foot would cost in excess of US$ 340/thousand seedlings for 14 seedlings/bed foot. A transplant density of 14 to 17 seedlings/bed foot results in a final cost of US$ 0.45 to 0.50/seedling depending on where the base stock is grown and which transplant nursery is used.

Root Pruning—The standard industry specification for root pruning of base stock is 20 cm (8 in). Because the root-to-shoot ratio needs to be considered, larger stock requires more roots. RRC, therefore, requires a 25 cm (10 in), or even 30 cm (12 in), root prune. One key point in ordering base stock, or any seedlings, is to be certain whether the measurement is taken at the root collar or at the first limb. The root collar can be an ambiguous point on the seedling; this is why RRC prefers to use the first live limb as the point of measurement.

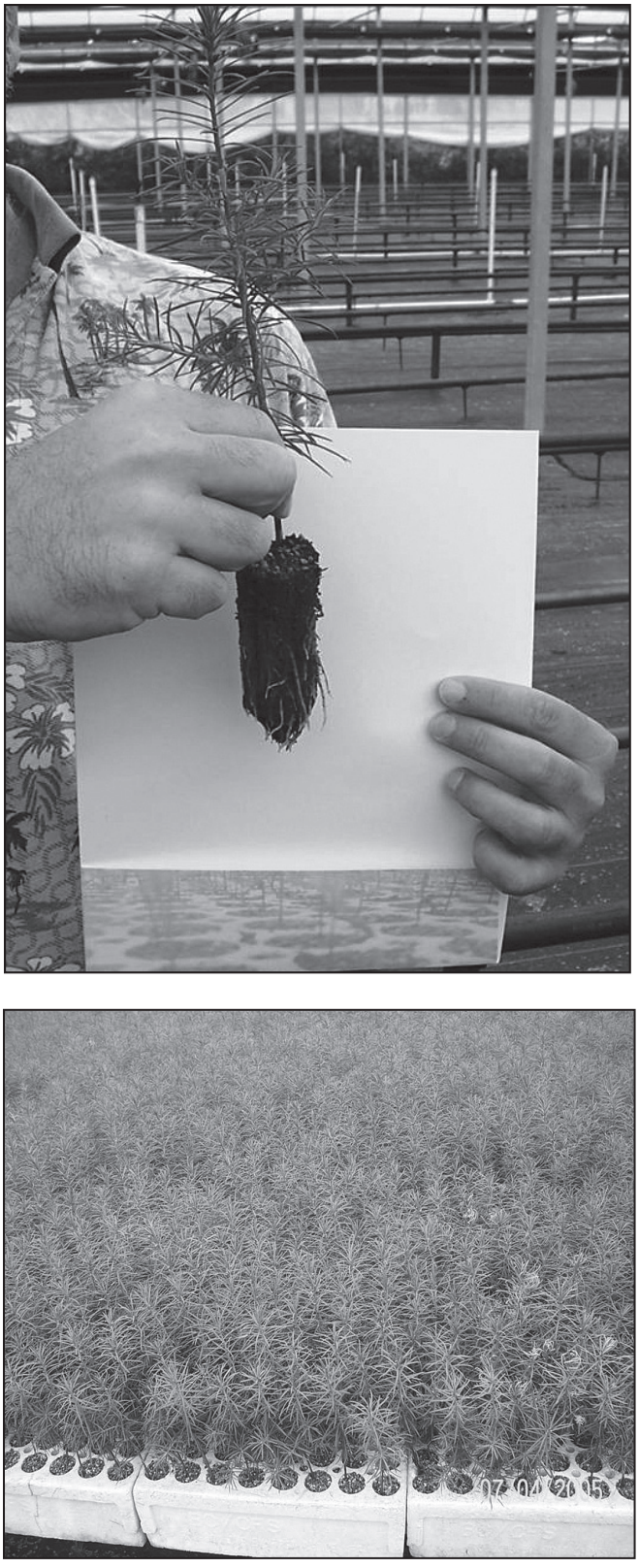

Figure 1. Styroblock™ 410A large-cell container stock. Target specifications for this transplant base stock are 3.5 mm caliper and 20 to 25 cm (8 to 10 in) height.

Quantified Results for Large Bareroot Seedlings—A trial based on initial caliper class at the time of outplanting was initiated in 1999. A total of 2000 seedlings were outplanted in 4 replications. The first of 4 replicates (500 seedlings) have recently been measured. Seedling performance was measured by calculating final tree volume and plotted it against initial caliper class (Figure 2). Our initial analysis shows that larger caliper class seedlings increased in volume at a faster rate than smaller seedlings, which supports our strategy of outplanting larger stock. The remaining replicates will be measured in the winter of 2011.

Large Container Stock for Outplanting

In 1999, RRC started experimenting with ouplanting large container stock, that is Styroblock® 515A (250 cm^3 [15.3 in^3]). Both root growth and field performance of these larger seedlings were encouraging, but browse resistance was a big concern. The initial assessment indicated there was not enough wood present to withstand ungulate browsing, and that seedling caliper was too small to survive mountain beavers. Working with several Canadian nurseries, the full range of large-sized plugs, from 615A (336 cm^3 [20.5 in^3]) through 1015A (1000 cm^3 [61 in^3]), were tested (Figure 3). As with bareroot seedlings, there are diminishing returns as the densities in the blocks were lowered from the 515A (60 seedlings/block) to the 1015A (15 seedlings/block). If cost were not an issue, the 1015A plug would be preferred, but because seedlings cost US$ 1.00+ each and transport logistics are difficult, use of these seedlings operationally is not realistic. Our current target specifications for higher site index, Douglas-fir container seedlings are a 5 mm minimum caliper (greater than 7 mm preferred) and height between 40 to 60 cm (16 to 24 in).

As with the bareroot stocktype, a container stocktype trial using initial caliper class at the time of outplanting was initiated in 1999. Seedling performance was measured by calculating final tree volume and plotting it against initial caliper class (Figure 4). Not surprisingly, the trend shows larger caliper class seedlings increasing in volume faster than the smaller seedlings.

Browse Resistance—The amount of browse resistance afforded by larger-sized plugs was surprising. In 2006, a trial to examine the effects of container size on browse resistance was established in an area known for heavy deer and elk browsing. Seedling volume (in cm^3) was calculated at the end of the second growing season (Figure 5). Our data indicated larger plugs were more resistant to browse and were comparable to the 1+1 fall transplant seedlings from Humboldt Nursery that were used as a control.

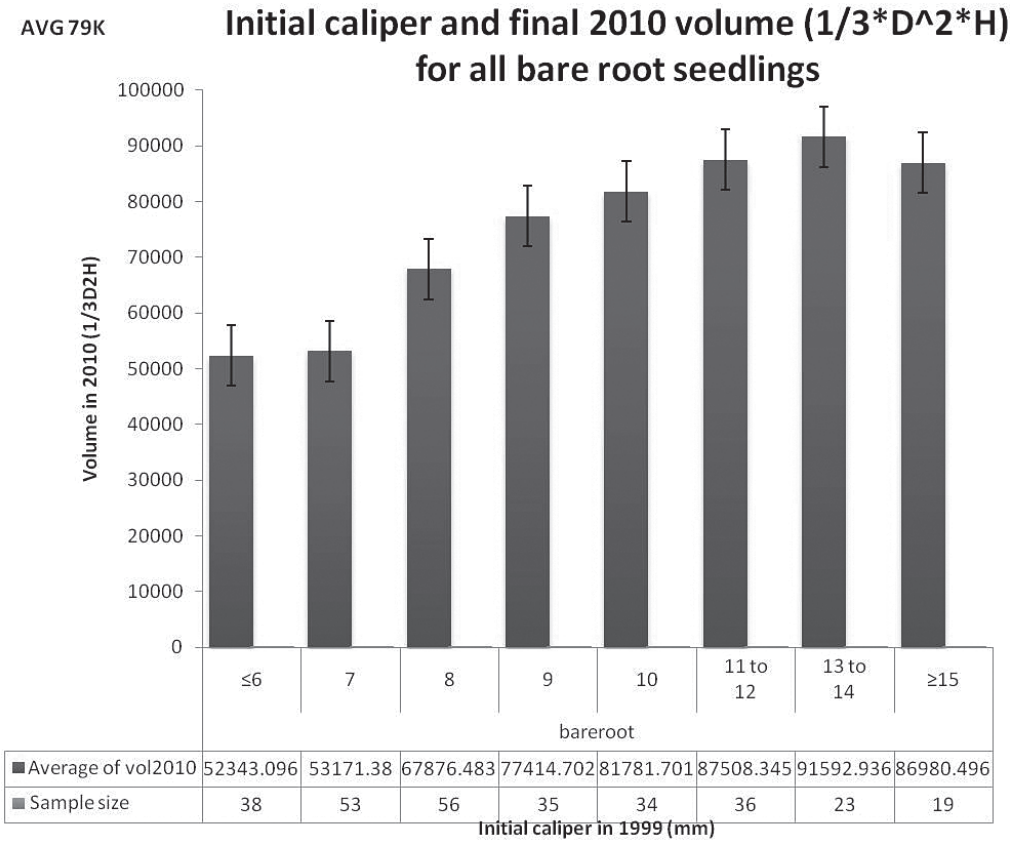

Figure 2. Initial results from 1999 bareroot seedling outplanting study.

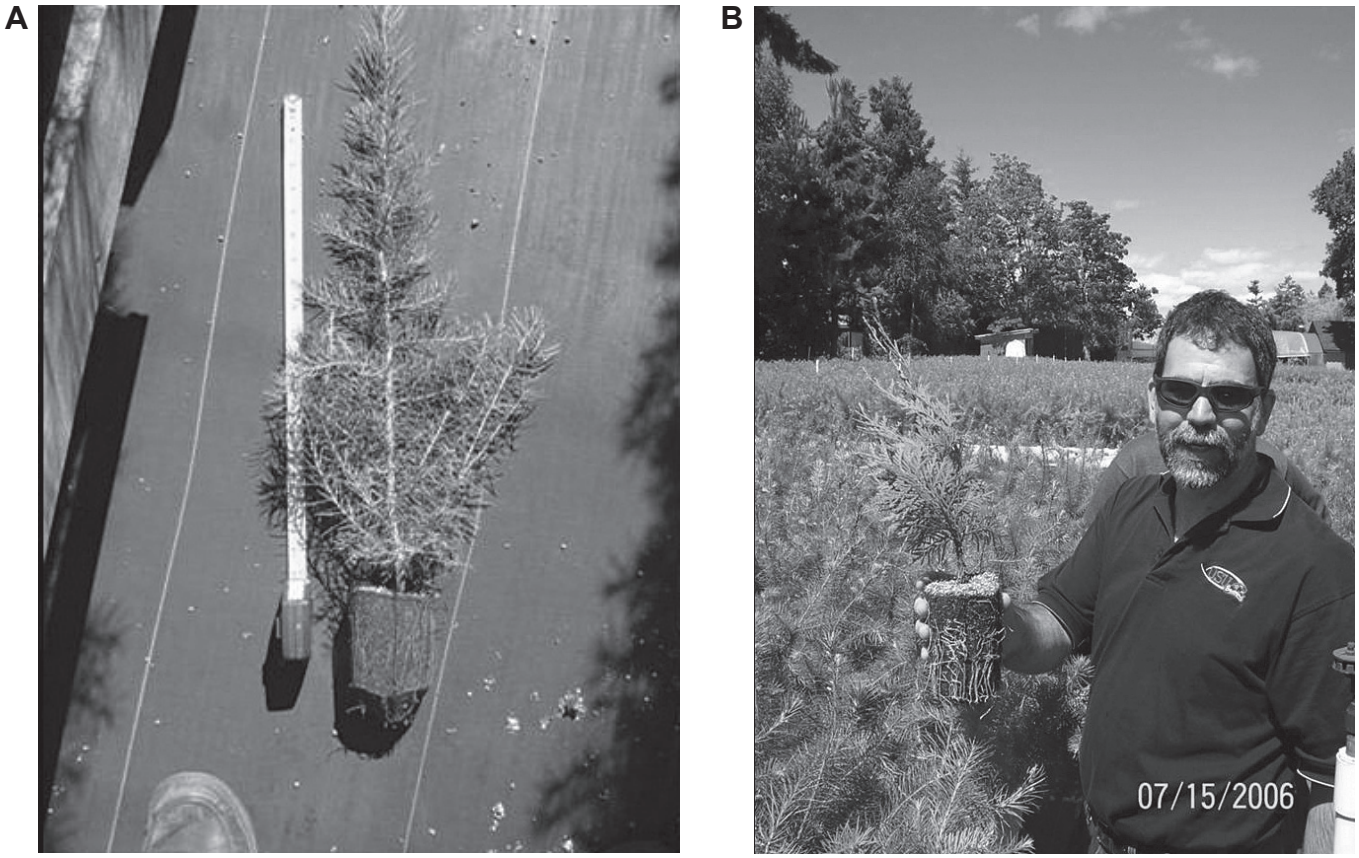

Figure 3. A) Douglas-fir seedling grown in a Styroblock™ 815A; B) western redcedar (*Thuja plicata*) grown in a Styroblock™ 1015A.

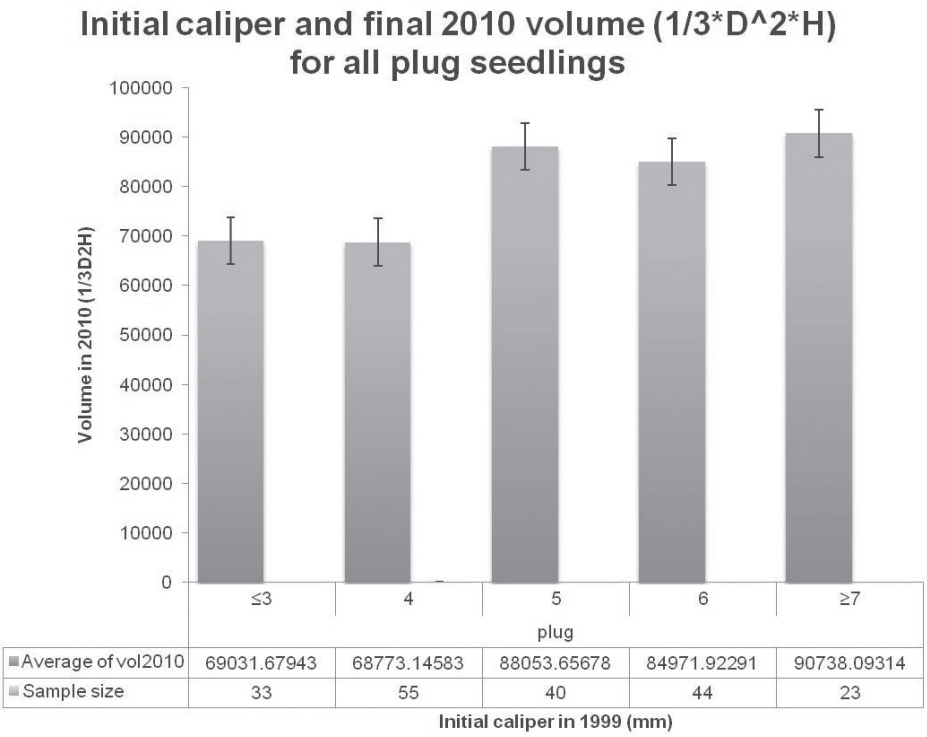

Figure 4. Initial results from 1999 container seedling outplanting study.

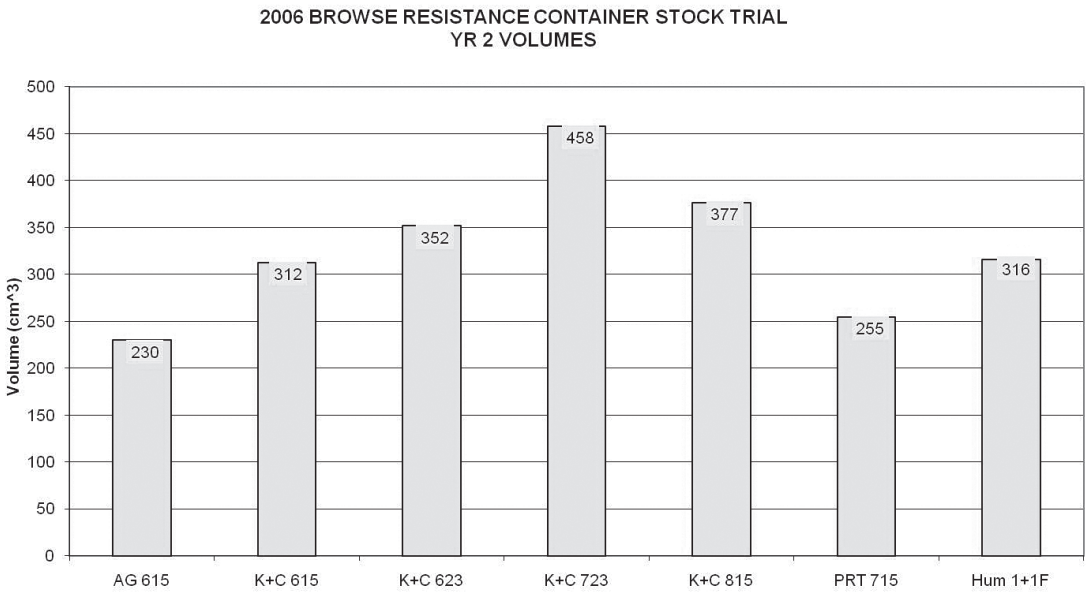

Figure 5. Results from 2006 browse resistance outplanting study.

Current Strategies—Bareroot nursery capacity in the Pacific Northwest has been severely constrained due to nursery closures and impending regulations on the use of fumigants. The fumigation issue will increase bareroot costs due to the higher cost of alternatives, increased hand weeding, reduced yields, and reduced nursery capacity. The price differential and performance between large bareroot seedlings and comparable container stock is now closing quickly.

The use of large container stock for outplanting has both positive and negative economic considerations. On the positive side, green-up and adjacency requirements for harvesting are more easily met (Table 2); the need for browse deterrents is reduced; rotations can be shortened; and improved survival leads to fewer trees per acre planted and fewer acres that need to be replanted. One of the biggest negative economic impacts, however, involves logistical challenges. These challenges include: 1) coordination between nurseries with trucking schedules, handling schedules, and payment; 2) increased cooler space needs, with most cooler capacities based on 120+ seedlings/bag, and large stock packed at 40 to 80 seedlings/box; 3) field delivery considerations, including use of trailers and load capacity of delivery pickup trucks; and 4) planting tool considerations and getting trees onto the site. All of these logistical issues can result in increased seedling costs, planting costs, and transportation costs.

Table 2. The economic advantages of outplanting large container stock include meeting green-up and adjacency requirements for harvesting and shortened timber rotations with greater ease. (All costs are in US $; 1 ac = 0.4 ha.)

	Adjacency consideration scenario #1	Adjacency consideration scenario #2
Adjacent Stand Acres	120	40
Volume/acre	3030	
Stumpage Value ($/m)	350	350
Total Value ($)	**1,260.00**	**420,000.00**
Cost of Money	6%	6%
Cost of Holding 1 More Year ($)	**75,600**	**25,200**
Plantation Acres	120	120
Small Stock Regime Cost/ac ($)	551	551
Large Stock Regime Cost/ac ($)	609	609
Difference ($)	58	58
Total Cost Difference ($)	6960	6960
Savings ($)	**68,640**	**18,240**
Break-even Cost/Seedling Cost ($)	**1730**	**680**

While RRC continues to experiment with larger container stock, the current focus is 1- and 2-year old seedlings grown in Styroblock® 615A systems ((336 cm^3 [20.5 in^3] at 45 cavities/block), and 2-year old seedlings grown in Styroblock® 815C systems ((440 cm^3 [26.9 in^3] at 35 cavities/block). RRC will order bareroot seedlings (1+1 or P+1) to meet 70% to 75% of anticipated needs 2 years out, then supplement this initial order with container seedling orders 12 to 18 months out as overall seedling needs become more apparent. This strategy also provides the opportunity to target the highest gain seedlots into container stocktypes to maximize seed efficiency and deployment acres.

The current practice of growing large 2+0P container stock has resulted in better sun versus shade needle development, better bud development, improved seedling hardiness earlier in the growing season, better caliper, improved root system, and more lignified stems and laterals to provide better browse resistance.

Summary

The lessons learned by RRC during the last decade have enabled the company to dramatically improve seedling outplanting survival and growth on its high site timberlands. The synergy of large stock, genetically improved seeds, and intensive site prep has thus far been impressive. The downstream cost savings of large planting stock more than overcome the initial extra costs and should be included in any discussion about seedling costs. Consider, for example, how much you might spend on browse protection per acre because you are planting a small tree and how much more you could spend on a larger seedling if you eliminated the browse protection and invested those dollars in a larger seedling that can withstand the browse.

The take-home lesson is to get to know your seedling growers and be involved in the crop development. In other words, learn to custom grow seedlings to meet your needs. Do not necessarily settle for the status quo, experiment with your current practices, continually strive for improvement throughout the entire process.