Achieving Establishment Success the First Time

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Abstract

Planning a planting project to achieve a high probability of success the first time, though it may cost a little more up front, will pay off in dollars, effort, and time to the final product—all of which mean higher investment returns. A set of principles are reviewed that are central to a successful planting project, focusing in particular on choosing the right planting stock, handling them properly from the nursery to the planting hole, and tending the trees after planting.

Introduction

Every grower's goals and conditions are unique, but the importance of *successful establishment the first time* (figure 1) characterizes every planting project. A key component of success the first time is choosing healthy, vigorous planting stock of the right size and condition for your needs. This article will help you understand your planting stock options and share with you some "insider information" about key indicators of planting stock vigor and success factors that might not be evident from a quick glance at the seedlings.

Figure 1. A Douglas-fir seedling after 5 yr in the field, illustrating "Success the First Time." (Courtesy of Weyerhaeuser Company photo archives)

Success means growing the product your customers want, in the shortest possible time, at the lowest cost required. Getting a good start on your project—getting it right *the first time*—not only increases your returns but can save you money over the life of your project, even though it might cost a little more up front.

First, as you define success, remember: time is money. You could have put the money spent to buy seedlings, prepare and plant your field, and tend your trees into an alternative investment with a certain rate of return—or you could have borrowed the money at a certain interest rate and need to think about how much return you need to pay the interest. The longer you have to wait to harvest your crop and take the payback, the higher the carrying cost of that compounding interest or the alternative rate of return. To make even 6 percent on your planting investment, you need to make $1.80 at year 10 for every $1 you invested up front. To make 10 percent, you need to bring in $2.60 at year 10 for every dollar you invest up front. By the same logic, if you could make that $2.60 in 8 years instead of 10 years, your return would be 13 percent instead of 10! Time really does mean money.

Given all the costs of starting a new plantation, and the long waiting period before a timber harvest, it's often tempting to try to economize. In the case of establishment success, the temptation to start cheap can cost you more over the total project, especially considering the carrying cost of money. Consider the following examples.

In the "Right the First Time" case, shown in table 1A, we invest in 2 yr of weed control around the trees, good-sized healthy seedlings, and a quality planting job. These costs can add up—in this case, nearly $350 per acre. (Of course your own regime and costs may be different.) To make even 6 percent on our investment over a 50-yr timber rotation, we would have to net $6,401 per acre.

In the "cheap way," shown in table 1B, we "economized" with only 1 yr of weed control and smaller, less expensive planting stock. Sure enough, in this case we can get away with $70 per acre less cost up front. *However*…the lower quality stock and extra weed competition is likely to

Table 1A. An example of cost and revenue for a planting project done "right the first time."

"Right the First Time"	
2 yr intensive vegetation control	$100
Plant 350 trees	$248*
Total cost, Yr 1-2	**$348**
Revenue needed to make a 6% rate of return in 50 years	***$6,401***

*$0.30 cost for each seedling, $0.20 per tree for planting.

Table 1B. An example of cost and revenue for a planting project done "the cheap way."

The "Cheap" Way	
Spot weed control	$50
Plant 300 trees	$135*
Total Yr 1	$185
But then, 1 yr later….	
Replant 200 TPA	$140**
Respray	$75
REAL total Yr 1-2	$400
Revenue needed to make a 6% rate of return in 52 yr	$8,027
Extra cost of money at 6%	***$1,626***

*$0.25 cost for each seedling, $0.20 per tree for planting.

**$0.35 cost for each seedling, $0.35 per tree for replanting.

result in considerably more mortality, requiring a replant to utilize the field fully and another spray to ensure that the additional trees will survive. Over the same 2 yr, we would end up spending $50/acre MORE than we would have to do it right the first time—and we've lost 2 yr on the production cycle, so now we have to carry our investment for 52 yr instead of 50. Now we'll have to earn over $8,000 per acre instead of $6,400 to make the same 6 percent on our investment.

What Is Required To "Do it Right the First Time"?

Four elements are required to "do it right the first time":

- Good ground preparation: site selection, drainage, nutrition;
- Vigorous planting stock: the right size and type for your objectives;
- Proper seedling storage, handling, and planting; and
- Full control of competing vegetation before and for at least 2 yr after planting.

Think of your seedlings as a biological "bank account." The size of the first deposit depends on the size, balance, and physiological condition of the seedlings you select. Beginning with lifting the trees at the nursery, we start to make "withdrawals." The nursery helps to minimize withdrawals by lifting at the right time, culling the poor trees, handling the seedlings carefully, minimizing exposure, and using proper storage conditions. You can add to the bank account by selecting the right site; using good ground preparation, including drainage as needed; controlling weeds; and adding fertilizer if a soil test calls for it. You can minimize withdrawals by carefully managing storage and handling of the trees, doing a quality job of planting, and protecting them from deer browse and weeds.

What Are Your Choices for Planting Stock?

What are your choices when it comes to planting stock for the best up front "deposit" in your stand's biological bank account? You need to consider external features of your stock—things like seedling size, stock type, and grade—as well as internal features relating to the seedlings' physiological condition, which influence cold and stress tolerance and the vigor of roots and shoots (ready to grow at the right time after planting).

The Ready-to-Grow Seedling. Let's start with some "first principles" of a healthy, vigorous, ready-to-grow seedling.

1. *Root system morphology*. Survival after planting depends on the roots being able to take up more water than the top transpires. Development of a lot of fine-root mass (moppy roots) is the key. We look for a root system like this because new, fine roots have more surface area and better water uptake than older woody roots after planting (figure 2).

2. *Root-shoot balance.* The larger the top, the more transpiration demand is placed on the roots. If roots can't take up enough water, photosynthesis stops and trees begin to lose needles and die back from the tops. Conversely, if roots *can* absorb water quickly and efficiently the tops can photosynthesize more, producing more energy to fuel growth of new roots and tops (figure 3).

3. *Seedling caliper (diameter at root line).* A conifer stem is made up of tracheids—hollow pipes that transport water from root to top. Water is pulled up the pipes—into the roots, up the stems and out through the stomates or leaf pores—in very narrow columns by the tension that is generated by the demand from the atmosphere. In dry, hot conditions, the tension can be so high that water columns break, which leaves pipes unusable, at least for a time. The stouter the stem, the more redundant plumbing the seedling has to carry water from the roots to support the top under stressful conditions. Larger caliper seedlings also tend to have more foliage and energy reserves, and so typically grow more at the start than smaller seedlings (as long as water availability through the roots is able to keep up).

Figure 2. A seedling root system showing moppy form, with plenty of branching and fine roots.

Your Choices in Stock Types. When you go to purchase seedlings, you'll be faced with an array of "stock types." "Stock type" refers to the growing regime of the tree and drives the morphology and performance you can expect. The most common choices are bareroot stock and containerized stock.

Bareroot stock. The tree was grown for 1–3 yr in an outdoor bed and delivered dormant with the soil gently shaken from the roots (figure 4).

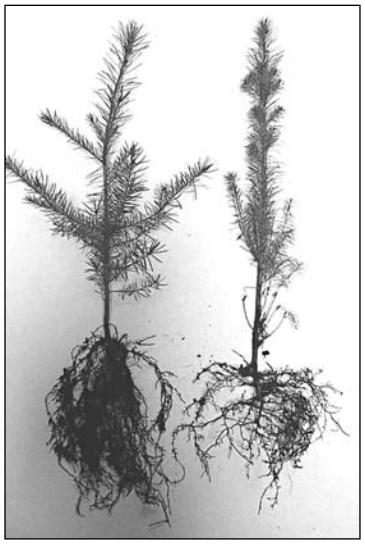

Figure 3. Two bareroot seedlings grown with different regimes and providing different root-shoot balance. Note the coarser and less branched roots in the 2+0 seedbed seedling to the right, compared with the well-balanced 1+1 transplant seedling on the left.

Figure 4. A 2-yr-old bareroot transplant Douglas-fir seedling.

- Seedbed only—sown and grown to lifting in place in the bed, usually at a fairly high density.

- Transplant—sown and grown for 1 yr in seedbed, then lifted and transplanted for 1–2 additional yr at lower density in a transplant bed.

Terminology:

1+0 or 2+0 refers to seedbed stock grown 1or 2 yr before lifting and delivery. 1+1 or 2+1 refers to stock grown 1 yr or 2 yr in a seedbed, then lifted, graded, and transplanted for 1 yr, usually at lower density, in a transplant bed (figure 5).

Advantages:

- Typical bareroot transplants are often larger and woodier than container seedlings, with more lateral branching, which can make them more tolerant of sites with heavy brush or animal browse.

- Because of their initial height and caliper advantage over containers, they can offer excellent performance for the cost if they can link up quickly and survive to the fall root-growth period. *Maximum volume of moppy, healthy roots and good root-shoot balance out of the nursery are critical in a bareroot seedling.*

- Size for size, bareroot seedlings cost less than container stock to buy, store, and ship because they don't carry soil on their roots.

Disadvantages:

- Bareroot trees must depend on existing roots to hold them over until new roots can develop, and they tend to be slower to initiate new roots in cold soils. The older roots are not as efficient in water uptake, so for a time these trees will be at higher risk of mortality on sites with heavier soils; warmer, drier, or windier conditions; or infrequent rain.

- The normal process of lifting, sorting, and planting bareroot stock can cause accumulated low-level damage to tissues. As a result, this stock will often show "planting shock"—a lag period when roots must recover and grow before the top will emerge and grow vigorously. This can be the entire first growing season if conditions are less than favorable.

Figure 5. 1+1 bareroot seedlings in an outdoor nursery bed, nearing the end of their second growing season.

Containerized stock. These seedlings are grown indoors in containers, extracted, and shipped with the soil "plug" intact around the roots (figure 6).

Terminology:

Unfortunately, multiple naming systems have arisen for container seedlings. Containers may be described by the number of cells in the growing tray (112, 160, 198—the larger the number, the smaller the seedling), by the volume of the plug in cubic inches (styro 8, styro 15—the larger the number, the bigger the seedling), or by the diameter and length of the plug in centimeters (412, 515—the larger the number, the bigger the seedling) (figure 7).

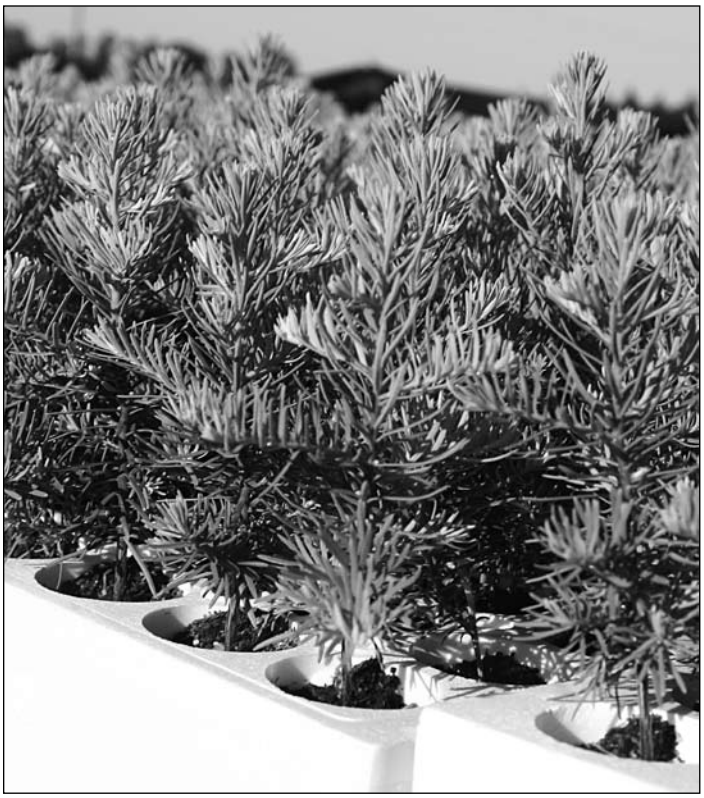

Figure 6. Containerized noble fir seedlings before lifting and packaging from their styro blocks.

Advantages:

- Because the seedling's roots are protected from drying and root damage during packing, they tend to proliferate more quickly even in cold soil (plenty of ready-to-grow root tips).
- The soil-root contact and greater number of fine roots that come with the plug give containers a better start when water stress is high (figure 8).
- Because of the intact root plug, they can be planted properly with less effort on shallow, rocky, or heavy soils.
- They can be made to set bud early with "dark-out" to support late summer or fall planting.

Figure 7. A containerized western redcedar seedling in a Styro-15 plug.

Figure 8. A containerized seedling a few weeks after planting—note the proliferation and rapid elongation of new, efficient roots.

- Some slow-growing or small-seeded species can only be grown to large size economically if started in a container. The more stressful the site and the more important early growth is, the greater is the advantage of container stock.

Disadvantages:

- Size for size, container stock is considerably more expensive than bareroot, and transporting the weight and mass of the soil plug also adds cost.
- Most containerized stock types are shorter and less robust than bareroot, with fewer buds and less lateral branching, making them more vulnerable to clipping by rodents or browsing by deer or elk.

Other Considerations. Several other factors should be considered in selecting seedlings.

Culling standards. Most planting stock is graded against specific standards for height, caliper, and balance and pruned to a specified root-length standard when it is packed. Ask your nursery to describe the culling standards they used and inspect the stock in several bags to ensure they consistently meet the standard. A small or unhealthy tree will mean more rework!

Seedling conditioning. Seedling vigor after planting is strongly impacted by dormancy, stress resistance, and cold hardiness—a suite of traits that together can be referred to as "conditioning." Dormancy peaks in late autumn, but cold hardiness and stress resistance are at their highest in midwinter. What do these terms really mean and how do they matter?

Dormancy is a measure of bud condition and readiness to flush. When buds are fully dormant, they will not flush for weeks, even when placed into spring-like conditions. Once buds begin to flush, the energy produced through photosynthesis is diverted from roots into the new growing shoot, temporarily shutting down root growth. At optimum dormancy, the buds will remain at rest for a time after planting, allowing roots to emerge and link the tree with the soil before the buds flush. Dormancy is released as trees are exposed to warm temperatures through the winter and early spring. A seedling lifted and delivered too early or too late may flush immediately, putting too great a demand on the root system and leading to mortality as the weather gets warm and dry.

Cold hardiness and stress resistance result from changes in the plant's cells after the seedling stops growing, sets a bud, and is exposed to chilling through the fall. The changes, which typically peak in early winter, leave the plant able to withstand cold temperatures and handling stress much better than it could earlier or later (figure 9).

These elements of seedling conditioning are driven by a complex sequence of events—some controlled by the nursery grower and some by you. Luckily for the seedling buyer, knowledge and techniques to maximize seedling conditioning have advanced dramatically in the past 10 yr.

Stock is well conditioned when it has received the right signals for dormancy to develop, tissues have developed good cold and stress hardiness, and dormancy release has not progressed too far. The timing of lifting in the nursery really matters. Late lifting or early lifting can mean low stress tolerance, vulnerability to cold damage, and buds that will flush too soon, preventing normal early-spring root growth. Storage also plays a role. Seedlings lifted early can be chilled more in cooler storage, thus bringing them to the optimum hardiness and dormancy. Seedlings lifted at the optimum time can be held in the cooler for 4–6 wk until the best time for planting, though they will slowly decline in conditioning. Techniques have also been developed to hold stock "in stasis" in the freezer at 25–28 °F (-2 to -4 °C).

Some knowledge of storage and lifting guidelines can make you a more knowledgeable seedling buyer and can make a real contribution to planting success. Ask how your stock was conditioned before lifting—how and when was it shut down, and whether sufficient time and chilling was allowed for. Ask when your stock was lifted and how long it was stored. Inspect your stock for well-developed buds, stiff woody stems, dark green waxy needles—all evidence of a good conditioning regime. And don't forget to look for the "moppy" roots!

Protection from frost and disease. Nurseries are farms and, as such, can be subject to damaging temperatures and soil diseases. Seedling nurseries can protect their stock, like many other crops, from damaging cold through the fall by sprinkling the trees with water through the cold periods. The constantly freezing film of water maintains the stems and foliage at undamaging temperatures. Also, ask your nursery about their disease prevention and treatment program. If they don't have one, your trees are at risk. If not managed carefully, fungi can build up and kill fine roots, leading to poor survival and growth. Inspect your seedlings by stripping several roots—if the bark peels off easily, leaving brown tissue, they are dead; if the inner tissue is white they are alive.

Don't accept seedlings that have storage mold growing on the lower needles when you open the bag. The needles will not be healthy and stem tissue may have been killed.

Stock Handling and Planting

Remember that seedlings, even dormant bareroot ones, are alive! Even well-conditioned trees are vulnerable to damage and exposure during handling and planting. The way you handle your seedlings after you pick them up from the nursery is vital in their survival and early vigorous growth (figure 10).

Figure 9. This well-conditioned seedling has a stout stem, well-developed buds, and dark green needles with well-developed waxy cuticle, able to tolerate the stress of handling and planting on tough forest sites.

Figure 10. Hand planting of bareroot seedlings on a forest site. (Courtesy of Weyerhaeuser Company photo archives)

First, exposure to warmth and breeze can dry out roots to the point where survival and growth can suffer. Once you receive your trees, keep them moist (*not* wet), out of the sun and heat. Don't store your stock in water—that will kill roots. Also, very wet, muddy conditions during storage can promote disease buildup. Rough handling can reduce vigor of roots and shoots, so treat your seedlings gently, even in the bags. Seedling bags should be kept below 35 °F (2 °C) during storage and transport and stored no longer than 4–6 wk. If you need to keep them longer, they can be frozen at 26–28 °F (-2 to -4 °C). In all cases, get them in the ground as soon as you can—but don't try to plant when it's warm, windy, or very dry. Even a few minutes out of the bag under these conditions can kill or cripple a seedling.

Next, make sure you plant your trees with care. Be sure that the tree is planted to the root collar; exposed roots can wick water right out of the seedling. Close the planting hole so that there are no air pockets around the roots, but without heavily compacting the soil around the trees. Wadded or J-roots can lead to poor or asymmetrical root growth, which can lead to poor tree growth and instability later. Handle the trees gently—that means no beating roots on stumps, no ripping roots apart, and no holding them out in the air for an extended time during planting. Closely oversee your planting crews during the planting, and spend the time up front to make sure they understand your quality expectations (figure 11).

Finally, keep the grass and weeds away from your seedlings. Their thick roots will suck up the water that your seedlings need during the crucial early years. The best results will come from a broadcast weed control application, tilling out the weeds before planting and hoeing or spraying all the vegetation for at least 2 yr after planting. If the weeds and grass aren't too thick, you may be able to get away with spraying or pulling the weeds in a spot 3–4 ft (approx 1 m) in diameter around each tree. If you use herbicides, choose the product carefully. Some herbicides can be sprayed over young seedlings if they're dormant, but some can cause serious damage; some also need to be kept strictly away from wells and streams. And, of course, read and follow all label requirements for mixing, application, and cleanup for that specific product.

These basic steps, if consistently followed, will take you well down the road to a vigorous, effective plantation *the first time* (figure 12). Good luck, and happy growing!

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Figure 11. Planting shovel and properly planted seedling. A proper tool is critical to a good planting job.

Figure 12. Vigorous, well-conditioned seedlings, properly planted with good weed control, now starting their second year of growth. Success the First Time!