Target Seedling Symposium

Chapter 2
Target Seedling Specifications: Are Stocktype Designations Useful?

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ABSTRACT

A stocktype designation identifies a seedling's age and the basic method by which it was produced. The designation inexactly implies seedlings' relative size and conveys very little information about their critically important physiological condition. Although designations for the primary types of seedlings have not changed much over the years, size and quality of most types have been improved signify-cantly. Comparisons of field performance in the Pacific Northwest indicate that survival is often not greatly different whether a seedling was produced in a container, in a bareroot seedbed, or had been transplanted. On the other hand, seedling height after three to five years in the field tends to be somewhat greater for stocktypes that usually consist of larger seedlings; increased growth probably relates more to initial seedling size than to seedling age and production method. For most sites and situations, foresters should prescribe seedlings of the size and physiological condition that are most appropriate ecologically and economically. Nursery managers should use the cultural and economic options available to them to meet those client needs. Choosing the type of seedling to produce is just one of the decisions to be made in accomplishing that goal.

2.1 Introduction

A seedling's "stocktype" tells us its age and by what general method it was produced (e.g., bareroot, container-grown, transplant, or a combination of methods). Stocktype designation, per se, relates only inexactly to seedling size and even less to physiological condition. Production of different stocktypes, however, was the first attempt at growing seedlings targeted for specific sites. Foresters of earlier generations knew the species and size of seedlings they wanted for the sites on which they were planting them.

Furthermore, they knew from experience approximately what size of seedling they would get by specifying species and stocktype. Times have changed. More stocktypes are available; seedling sizes for a given type have increased markedly as technology has improved; and economic realities demand refinements to achieve even better seedling performance than obtained in the past. Most of the other papers in this symposium indicate, at least by inference, that specifying stocktype is not sufficient to target seedlings for specific sites, and I agree. Furthermore, I believe that results of empirical field comparisons of stocktypes are primarily applicable to the particular combinations of nurseries, stock, and sites tested.

I believe, however, that stocktype designation is useful—it is a good communication tool; the basic types have some general characteristics that affect use and performance; and comparisons in the field are useful for specific, localized situations.

2.2 Terminology

Development of new stocktypes in recent years has resulted in confusing terminology. Thus, for this paper, I will define the basic terms that I will be using:

Seedling—a very young tree regardless of where and how it is growing.

Nursery stock and planting stock—synonymous terms denoting seedlings being grown or having been grown for outplanting on forest sites.

Stocktype—a class of nursery stock produced by one or more of the basic production methods –bareroot, container, transplant, and so forth—for a particular length of time. Special treatments used in production are not considered part of the designation. For example, seedlings inoculated with mycorrhizal fungi are not a separate stocktype. Nor is species considered part of the designation.

Bareroot seedlings—seedlings grown in soil in traditional outdoor nursery beds and lifted from the beds for packing and shipping with their roots essentially bare of soil. I consider a transplant to be a type of bareroot seedling.

Container seedlings—those grown in individual pots and usually, but not necessarily, in greenhouse or shadehouse nurseries.

Plug seedlings—container seedlings that are extracted from their containers and planted with a plug of roots and potting mixture. Since this is, by far, the most common technique, the terms "container" and "plug" seedling are often used synonymously.

Transplants—seedlings that were started from seed in either a bed of soil or in some type of container and then transplanted into an outdoor bed for subsequent lifting as a bareroot plant.

Miniplugs—seedlings grown in very small containers (about one cubic-inch volume) of several configurations (cubical or tubular). They are usually grown in the container for only three to six months and are produced solely for transplanting into a nursery bed and later lifting as bareroot plants. Thus, they warrant a designation separate from standard plugs.

Stocktype is usually expressed as a two-part code, with the parts separated by a plus sign (e.g., 1+0, 2+0, P+1, MP+1) or a dash (e.g., 1-0, 2-0, P-1 MP-1). If the first part is a digit, the stock was grown in a traditional outdoor seedbed; the digit represents the number of years (i.e., growing seasons) it grew in the bed in which its seed was sown. The second digit represents years in a transplant bed. Thus, a tree to be outplanted as a two-year-old bareroot seedling directly from its original seedbed is termed a 2+0 seedling; a seedling transplanted for the second year is a 1+1. If the first part of the stocktype designation is a letter, the stock was started in a container. Since standard container seedlings are normally grown for one year (season), I designate them as P+0's (P for plug with a one year growing time understood). A seedling grown one year in a container and then put into a transplant bed for a second year is termed a P+1. Miniplug transplants are designated as MP+1.

One suggestion I have for the industry is not to devise a new stocktype designation for every variation of similar practices-at least not for industry-wide use. Detailed designations are fine for individual organizations, but a complicated system probably will not be widely accepted.

One proposal for designation by type of production, size, and intended season of planting was proposed at the Western Forest Nursery Meeting over 15 years ago (Nicholson 1974). It seemed like an efficient, useful system; but it has never been widely used.

Let's keep basic stocktype designation as a simple communication tool for all of us to use and readily understand.

2.3 Stocktype Characteristics and Uses

2.3.1 Common stocktypes

Stocktypes can be conveniently grouped into bareroot, container, combination, and minor types. The most commonly used stocktypes are relatively few in number, and their production and use tend to vary by region (Table 2.1).

Stocktypes also have some differences in basic characteristics that influence where they are used (Table 2.2). Although these differences relate to targeting in a general sense, I want to restate my introductory comment that stocktype does not define a target seedling with the accuracy and detail that current practices require.

Table 2.1*—Common stocktypes.*

STOCK TYPE	REGION(S) OF PRIMARY PRODUCTION AND USE
Bareroot	
1+0	temperate zones, mostly warmer parts
2+0	temperate zones, mostly cooler parts
3+0	temperate zones, mostly cooler parts
1+1	temperate zones, mostly cooler parts
2+1	temperate zones, mostly cooler parts
2+2	temperate zones, mostly cooler parts
Container	
P+0, large container	tropics
P+0, small container	temperate and boreal zones
Combination	
P+1	temperate zones, cooler parts
MP+ 1	temperate zones (exclusively for transplanting)

Table 2.2*—Relative stocktype characteristics.*

Stocktype	Bareroot	Size	Plantability	Cost
1+0	Yes	Small	Easy	Low
2+0	Yes	Average	Average	Average
1+1	Yes	Av. to	Av. to Difficult	High
2+1	Yes	Large	Difficult	High
P+0	No	Large Small	Easy	Av.to High
P+1	Yes	Large	Difficult	Highest

2.3.1.1 Bareroot stocktypes

Sizes of any plants are influenced strongly by the length of time and amount of space in which they grow. Limitations in a nursery are primarily economic—individual seedlings for the large-scale plantings characteristic of reforestation programs cannot be so large that nurseries do not have room to grow required numbers or that handling and planting are too costly for economic realities. The “reforestation culture” in much of the temperate world has been built around the production and planting of 1+0 seedlings in warm areas and 2+0 seedlings in relatively cool temperate regions. Resulting seedling sizes fit reasonably well with the logistic capabilities and economic realities of most reforestation programs. Furthermore, they have been reasonably good performers on typical reforestation sites. Other stocktypes are invariably spoken of in terms of how they compare with non-transplanted, bareroot seedlings.

The most obvious characteristic of bareroot stocktypes is their lack of root contact with the soil between the time they are lifted and planted. Such exposure makes it imperative that the seedlings be dormant when they are lifted from the seedbed, handled, stored, and planted. Succulent, growing tissues are easily killed by desiccation or damaged by mechanical forces and, thus, cannot withstand the exposure and handling that occur in normal operations.

Another characteristic of bareroot seedlings is that part of their root systems are cut off in the lifting process and may be further trimmed to facilitate planting. This mechanically increases the ratio of tops to roots when it would be better for survival if the ratio were decreased!

In the western United States, 2+0’s are commonly grown at densities of 215 to 325 per square meter (20 to 30 per sq. ft.) and to sizes of 15to 46 cm (6to 18 in.) in height and about 4 to 7 millimeters (0.2-0.3 in.) in stem diameter at the root collar. Their root systems are usually trimmed in the nursery at 20 to 30 cm (8 to 12 in.) below the root collar to facilitate planting.

For harsh sites, foresters prefer using 1 +1, 2+1, or even 2+2 transplants that have sturdier stems and more fibrous root systems than 2+0’s. To produce these stocktypes, 1- or 2-year-old bareroot seedlings are lifted from their seedbeds and transplanted into beds at less dense spacing—commonly 130 to 170 per square meter (12 to 16 per sq. ft.). In addition to the morphological advantages of sturdier stems and more fibrous root systems, cull factors for transplants can be lower than for 2+0 seedlings grown at higher densities.

Thus, transplanting can make economic sense when using very costly seed, despite higher production costs. A trend towards production of larger stock was noted in the early ‘80s (Iverson 1984), and relatively large stock is commonly used now. Informal discussions with nursery managers and reforestation specialists in the Pacific Northwest indicate that the 1+1 transplant has been rapidly gaining favor.

In warmer parts of the temperate zones, where species such as loblolly pine *(Pinus taeda* L.) in the southern United States grow at faster rates than species in cooler regions, 1 +0 seedlings are commonly planted. Seedling sizes approach or even exceed those of 2+0 seedlings grown in cooler climates. In cooler part of temperate zones, improved nursery practices in the past 15 to 20 years have led to increasing use of 1+0 stock of faster growing species—ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) grown in California and southwestern Oregon nurseries is a prime example. Sizes of this stock also approach or exceed that of 2+0 seedlings grown further north or in the interior West.

Use of 1+0 stock is attractive because of its short production cycle and lower costs. Thus, it has been tested and used even when the stock is smaller than average 2+0 seedlings (Jenkinson and Nelson 1983). Successful use of these smaller 1+0's is usually restricted to sites that are only low to moderately stressful or to situations where the stock can be given protection from environmental stresses of drought, competition, ravel, high radiation, animal damage, and so forth. As nursery technology keeps improving, the use of 1+0's will probably move northward as this stocktype more closely resembles current-day 2+0's and performs similarly.

2.3.1.2 Container stocktypes
In the tropics, where seedlings do not experience true dormancy, use of P+0 stock grown in large containers such as polyethylene bags has been common practice for many years. The lack of disturbance to the root systems allows planting of such stock while trees are not dormant. More recently, technology was brought to bear on development of small container systems for use in temperate and boreal regions (Tinus and Owston 1984). In these regions, containers with volumes of 65 to 165 cubic cm (4 to 10 cu. in.) are commonly used for one-year production schedules in greenhouses.

Use of relatively small seedling containers in the western United States began in earnest in the early 1970s. The main impetus was the attraction, for some, of a more automated and economical system of reforestation. For others, the attraction was the perceived biological advantage of an undisturbed root system. It was also believed possible that, because of production in a relatively controlled environment, container seedlings could be lifted on demand. This would allow for a somewhat extended planting season compared to bareroot stock.

One characteristic of this seedlings, when grown in containers of realistic size for large-scale programs, is that they tend to be smaller than 2+0 bareroot stock. Thus, they often need more protection from environmental factors such as solar radiation and animal damage than larger seedlings.

Although the plugs of potting mixture and roots make container-grown seedlings somewhat bulky to ship and handle, the relatively small size of the individual seedlings and their compact root systems make them easier to plant than bareroot stocktypes. This characteristic is particularly useful for planting where the soil is rocky or shallow or when planters are inexperienced.

Minor species, which are usually grown in relatively small quantities and often grow more slowly than the major tree species, are well-suited to container production. Small seedlots can be readily handled in greenhouses, and the controlled environment usually results in more rapid growth than in outdoor beds. This is particularly true in the western United States for species such as western hemlock *(Tsuga heterophylla* (Raf.) Sarg.) and true firs (Abies spp.), which tend to benefit from extended photoperiods and long growing seasons that are possible in many greenhouses. The controlled environment of greenhouses also allows such specialized production as, for example, growing trees in Oregon, Washington, or Idaho for planting in Alaska (Zasada and Owston 1990).

2.3.1.3 Combination stocktypes
Development of the P+1 stocktype was an effort to take advantage of the high growth potential of plug seedlings when placed in good growing environments (Hahn 1984). Transplanting of plug seedlings creates the largest reasonable seedlings with the most fibrous root mass possible in two growing seasons97presumably for the very toughest sites. Plug transplants are particularly useful to organizations or regions that have developed a plug-oriented nursery and planting system but find it necessary to have larger stock for some sites. British Columbia is a good example (Van Eerden and Gates 1990).

The miniplug-transplant technology takes the concept further by producing smaller but readily plantable stock in one year (Hahn, this volume; Hee et al. 1988; and Tanaka et al. 1988). Production in one year reduces costs and increases flexibility in reforestation planning (Tanaka 1988). Another alternative is to produce stock comparable in size to 2+192s in about 1.5 years (Hee et al. 1988).

2.3.1.4 Minor stocktypes
Other stocktypes that have not been used enough to be given common designations are:

Bedhouse seedlings—those grown in outdoor seedbeds under a greenhouse cover (Hansen 1983).

Seedlings grown in raised beds—e.g., the Dunneman process of using litter or duff (Maurer et al. 1986).

Wildlings—young, naturally regenerated seedlings dug from roadsides or forest sites.

Cuttings—either rooted (also termed stecklings (Russell and Ferguson 1 990)) or, as in the case of *Populus spp.,* unrooted.

Someday, it may be common to use TC+1's; i.e., transplants from tissue cultures (Ritchie and Long 1 986).

2.4 Cost Comparisons

The cost of nursery stock is only a small part of reforestation economics. Data from the Siuslaw National Forest in the Oregon Coast Range, for example, show that planting stock comprises only 10 percent of their total reforestation cost per hectare (Owston and Turpin, in press). Nevertheless, cost of stock should not be overlooked in planning a planting project. Table 2.2 indicates relative costs by stocktype, and Table 2.3 contains some specific values as an example of the widely varying costs of different stocktypes.

Reforestation planners have to use production costs along with estimated costs of handling, planting, protection, necessay replanting, and so forth to arrive at actual reforestation costs. A specific procedure for comparing alternatives has been developed for British Columbia; it takes into account costs, survival, and anticipated wood production (Tunner 1982).

Table 2.3—*Examples of seedling costs by stocktype.*

Selling costs per thousand bareroot seedlings, USDA Forest Service nurseries in Oregon and Washington, 1990:

Stocktvpe	Ave. Cost per M
1+0	$125
2+0	152
1+1	233
2+1	304

Prices paid for container seedlings by some national forests in Oregon and Washington, 1990:

4-cu. in. cells	$120 -130
10-cu. in. cells	228

2.5 Comparisons of Field Performance

Many comparisons of stocktype field performance are reported in the literature. There is even evidence that differences between types are discernible more than 20 years after planting (Krumlik and Bergerud 1985). However, after examining most of the reports, I have concluded that stocktype, by itself, makes very little difference—size and condition are the important factors. Hobbs (1984) reached a similar conclusion after reviewing the literature; i.e., he found no clear consensus favoring a particular stocktype. You will see plenty of evidence to support that conclusion in the rest of this volume.

At one time, I believed that the less-disturbed root systems and the opportunity for careful culturing of container seedlings would give them a clear performance advantage. But I have not seen that demonstrated consistently in the Pacific Northwest. What I have found instead, both from studies in which I have been personally involved and others reported in the literature, is that survival tends to be relatively similar among stocktypes and that the larger bareroot seedlings tend to maintain their initial advantage in stem height.

I recently summarized the results from almost 80 field comparisons of container-grown vs. bareroot seedlings

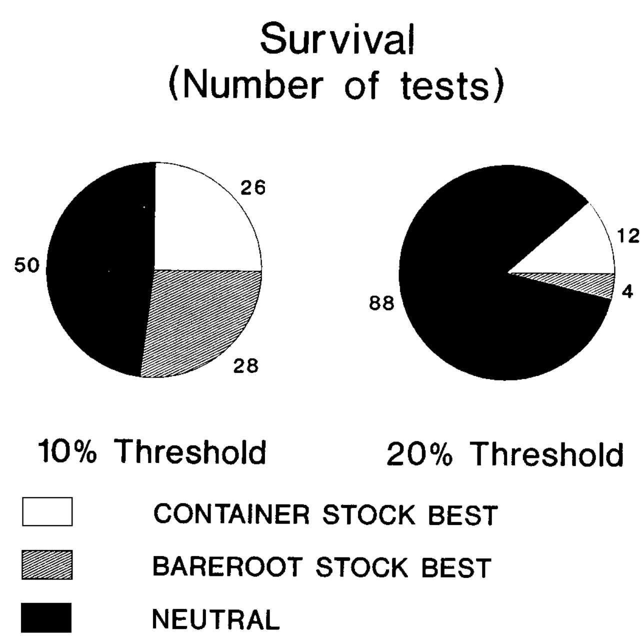

Figure 2.1—*Number of individual tests in southwestern Oregon, northern California, and coastal Oregon and Washington in which survival between bareroot and container stocktypes did or did not differ by more than 10 or 20 percentage points. All tests were 2 to 10 years old.*

(mostly 2+0's) that were installed in southwestern Oregon and northern California in the 1970s and 1 980s and 28 plots that were planted in the Oregon and Washington Coast Ranges in the 1970s. Sources used for this summary were Duddles and Owston (this volume), Helgerson et al. (1990, unpublished data), McDonald (1990, unpublished data), Owston (1990, unpublished data), and Walters (1990). All data were for trees at least two years old, and most of them were five to ten years old. Actual survival percentages varied widely for each stocktype. To see how they compared on the same sites, I developed frequency diagrams for survival and height that compared the number of individual tests in which one of the stocktypes did better, worse, or about the same as the other.

For survival, types were considered to have performed the same if their average survivals did not differ by more than 10 percentage points in one scenario or 20 percentage points in another (Figure 2.1). In about half the trials, average survivals for container and bareroot stock were within 10 percentage points of each other—very small differences given the wide variability of seedlings and microsites. Furthermore, one stocktype came out ahead just about as many times as did the other. When 20 percentage points were used as the threshold difference for survival, most of the comparisons showed no difference.

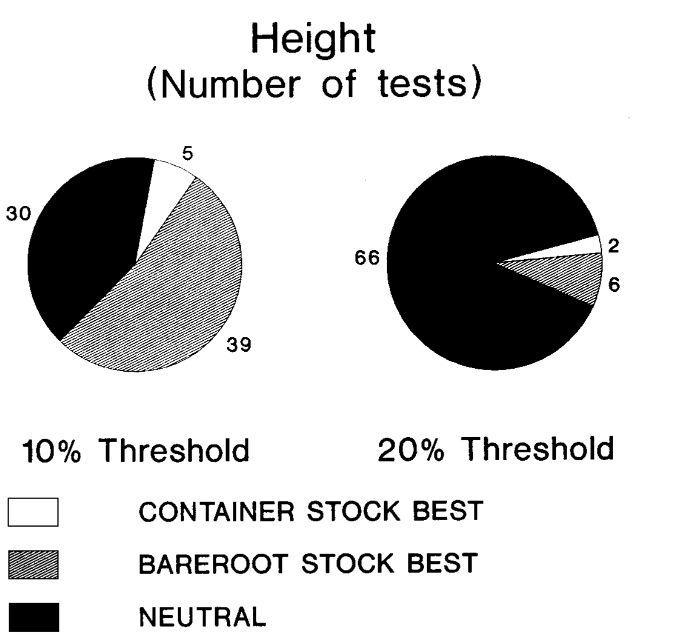

Figure 2.2—*Number of individual tests in southwestern Oregon, northern California, and coastal Oregon and Washington in which total height between bareroot and container stocktypes did or did not differ by more than 10 or 20 percent. All trials were 3 to 10 years old.*

Although there appears to have been a slight tendency for container seedlings to perform better based on this threshold, I do not feel that the data are convincing enough to draw any conclusions.

For height, the threshold values used were 10- and 20-percent differences between the stocktypes (Figure 2.2). Height data from tests that were at least 3 years old were available from all of the coastal tests and 46 of those in southwestern Oregon and northern California. Forty-one percent of the tests showed less than ten-percent difference between stocktypes, but bareroot seedlings were taller in many more instances than were container seedlings. At the 20-percent level, where differences probably are important, less than 10 percent of the comparisons were different.

For those interested in a brief description of container vs. bareroot trials over a wider geographical area, see Sloan et al. (1987). For a wide range of sites, I believe that most of the current types will perform acceptably if they are sturdy plants that are in good physiological condition and are handled and planted with care. That includes being given protective treatments appropriate for the site onto which they are being planted. The only exception I can think of is the better plantability of small container stock in very rocky or shallow soils.

2.6 Are Stocktype Comparisons Useful?

That depends. I think the evidence is sufficient to conclude that all current stocktypes can perform well if they are grown and used properly. Thus, I see no further need for the broad-scale comparisons that were needed when container technology was in its infancy. Morphology and physiology vary so much within stocktypes that it makes little sense to make management decisions based on broad comparisons or to extrapolate from narrow ones.

I do feel, however, that empirical comparisons have their place. I believe they are appropriate for specific combinations of planting stock and nurseries and for specific types of sites or reforestation situations. But if practices or management change, do not assume that the stocktypes will perform the same as before.

One statement published long ago comes very close to matching current conventional wisdom: "The results of the experiments with western yellow and western white pine showed that, other factors being equal, large stock survived better than small stock, that transplants are usually preferable to seedlings, that stock with roots eight inches long or longer succeed better than stock with shorter roots, and that a low top-root ratio indicates better planting stock than a high ratio." (Wahlenberg 1928). Examination of Wahlenberg's data shows, however, that his stock was much smaller and the results much poorer than would be acceptable by current standards. It is the quantitative rather than relative results that determine success or failure of reforestation programs.

Whatever comparisons are made, the morphology and physiology of the test stock should be characterized. It is those characteristics and their interaction with the environment, rather than the stocktype, per se, that will largely determine how the stock performs.

2.7 Why Bother With Stocktype Designation?

Use of stocktype won't put you in the bull's-eye, but it might point you in the general direction of the target. Here are some suggested guidelines for those responsible for plantation establishment:

1. There is no substitute for a well-planned prescription that takes numerous factors of site, logistics, and costs into account.

2. Once the seedling parameters have been established, arrange for production of that stock with a nursery that you know from experience or reputation will provide a consistently good product at a reasonable price. The stocktype will influence factors such as protection required, lead time needed for ordering, and so forth. But, unless you are under constraints such as lack of time or some specific condition mentioned below, the stocktype probably will not greatly influence performance as long as the seedlings meet size and condition specifications.

3. There are a few situations where particular stocktypes fit better than others:

   a. P+0's are the easiest stocktype to plant. Use them when the soil is too rocky or shallow to do a good job of planting bareroot stock.

   b. Consider 1 +0's for use on sites where stress factors are low.

   c. If stress factors are critical (competition, ravel, temperature extremes, animals, and so forth), only use small stocktypes (P+0's or 1+0's) if the factor(s) can be mitigated.

   d. Do not plant plugs in the fall on sites prone to frost heaving. Until their roots grow into surrounding soil, plugs are more easily pushed out of the ground than bareroot seedlings.

   e. Use a large stocktype (as long as the tops and roots are well-balanced) on sites where stress factors cannot be sufficiently mitigated.

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