Native plant containers for restoration projects

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ABSTRACT

The choice of container is one of the most important considerations when growing or ordering native plants for a restoration project. Container characteristics affect not only growth and production efficiencies in the nursery, they can also have important consequences after outplanting. The challenging conditions on restoration sites require containers with characteristics that are significantly different from standard containers used for horticultural crops. Unfortunately, plant specifications for many restoration projects are written using traditional horticultural pot dimensions, and we feel that this oversight is adversely affecting survival and growth after outplanting.

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NOMENCLATURE
USDA NRCS (2010)

The harsh conditions on restoration projects require specialized containers that are different from standard horticultural pots in several ways. All too often, however, plant specifications for restoration outplantings are made by people who are not aware of these requirements. Our objective, therefore, is to point out these physical and operational differences and discuss why they are important for outplanting success. The decision-making process for selecting the appropriate container should be based on 7 important considerations.

1. SIZE AND SHAPE

Native plants grown for restoration projects must survive and grow on inhospitable sites without the irrigation and care that ornamental plants receive after outplanting. The benefit of a deep root system has been a traditional characteristic of bare-root nursery stock for reforestation, so container depth was a key aspect into the design of the first containers for reforestation. In a comparison of 18 different container types, pine (*Pinus* L. [Pinaceae]) seedlings in containers that were 15 cm (6 in) or less in length had excessively high mortality rates on a harsh outplanting site (Miller and Budy 1974). Because soil moisture is typically the most limiting factor on restoration sites, we recommend containers that are relatively long and narrow so that plants can more readily access soil moisture at deeper levels in the soil. For example, the Ray Leach "Cone-tainer"™ Super Cell (Stuewe and Sons Inc, Tangent, Oregon) has been a favorite of native plant growers for many years; it measures 164 ml (10 in^3) in volume with a 3.8 cm (1.5 in) diameter and a 21 cm (8.25 in) depth. One of the most popular containers for native plant restoration is the Tall One Treepot™ (Stuewe and Sons Inc), which is 10 cm (4 in) in diameter, 36 cm (14 in) deep, and has a volume of 2.8 l (0.75 gal). A standard round nursery pot of similar volume is much shorter and wider: 16 cm (6.4 in) in diameter and 18 cm (7.0 in) deep (Figure 1A and B). Deep containers are particularly important in riparian restoration where water-loving plants need immediate access to the capillary fringe of ground water (Dreesen and Fenchel 2010).

2. ROOT CONTROL FEATURES

The most critical innovations in the design of native plant containers have been to reduce root deformations. Thirty years ago, experiences in reforestation nurseries showed that growing woody plants, and pines in particular, in smooth-walled round containers caused the roots to spiral around the outside of the container and especially around the bottom (Figure 1C). When this stock was outplanted, the roots were never able to grow out of this spiral growth and often grew around each other, creating mechanical instability (Figure 1D). The spiral root problem generated considerable concern from reforestation specialists and caused some to recommend against using container stock at all (Hiatt and Tinus 1974). The problem was considered so severe that it was the subject of an entire symposium (Hulten 1982). A number of research studies were instituted to address the root spiraling phenomenon. Although it can occur in almost any container type, root spiraling is most serious in round, smooth-walled plastic containers. Girouard (1982) grew 4 species of conifer seedlings in 3 different types of containers and found that the only one in which root spiraling occurred was the round container. A study in British Columbia found that root deformities due to spiraling prevent reforestation nursery stock from becoming properly established in the surrounding soil and resulted in frost-heaving, toppling, or even strangulation (Burdett 1979). In response to the serious problem of root spiraling in round containers, new containers with vertically oriented ridges, ribs, or grooves on the inside that protrude into the growing medium were created (Figure 1B). These ribs intercept roots and force new root growth downward to the drainage holes rather than allowing the new roots to spiral. Once these deflected roots reach the drainage holes, the low humidity causes them to stop growth, a process known as "air-pruning." Several container manufacturers have even incorporated the anti-spiraling feature into their brand name, for example "Rootrainer"™ (Beaver Plastics Ltd, Acheson, Alberta) and Rootmaker® (Lacebark Inc, Stillwater, Oklahoma).

To curtail root spiraling and develop a more fibrous root system, roots can also be "pruned" with chemicals. Chemical pruning involves coating the interior container walls with copper chemicals that inhibit root growth (Figure 2A). Copper-coated containers are available commercially (for example, the Copperblock™ [Beaver Plastics Ltd]), and some nurseries apply the copper chemicals by spraying or dipping. Spinout® (SePro, Carmel, Indiana) is a commercially available root growth regulator that contains copper hydroxide and can be applied to nursery containers or landscape fabrics to chemically prune plant roots (SePro 2010). Although some concerns were expressed about potential phytotoxicity and the leaching of copper into the groundwater (Arnold and others 1997), copper toxicity does not appear to be a problem for most native species, and rigorous testing proved that leaching of copper into the environment was negligible (Crawford 2003).

Another structural innovation to prevent root spiraling and improve fibrosity is the use of air slits along the sides of the containers (Figure 2B). The basic principle behind the "sideslit" container is simple. Just as when plant roots air prune when they reach the bottom drainage hole, roots stop growing and form suberized tips when they reach the lateral slits in sideslit containers. The air-pruning technology has also been incorporated into some round nursery containers such as the Accelerator® (Nursery Supplies, Orange, California) and the RootMaker®, which was the original air-pruning container.

A final option to control root spiraling is to avoid the smooth plastic container altogether. Jiffy® Pellets (Jiffy Products, North Bay, Ontario) consist of compressed peat moss surrounded by a thin plastic mesh, and they are popular for reforestation projects. The pellets are arranged in a plastic tray and one of the challenges of Jiffy pellet system was to prevent roots from growing between the pellets. This problem has been solved with an innovative mechanical root pruning machine that cuts roots between the pellets in both directions. Similarly, the Vapo system consists of a block of compressed peat moss with holes drilled in the top at regular spacing for seed placement. The peat block is placed in a plastic tray with slots on all four sides to allow mechanical root pruning. In an outplanting trial with white spruce (*Picea glauca* (Moench) Voss [Pinaceae]) container stock (Krasowski and Owens 2000), box-pruned Vapo seedlings were compared with stock grown in Styroblock™ and Copperblock™ containers (Beaver Plastics Ltd). Not only did the mechancially pruned Vapo plants have significantly greater shoot height and stem diameter but, more important, had greater root egress than the Styroblock™ and Copperblock™ (Figure 2C).

One disadvantage that prevents more widespread use of these specialized containers is cost. The Copperblock™ costs almost 40% more than a nontreated container (that is, the Superblock™ [Stuewe and Sons 2010]). Another concern is that nursery cultural procedures, especially irrigation, need to be adjusted. Reforestation nurseries have found that sideslit containers produce a plant with an improved root system but require increased amounts and frequency of irrigation due to evaporation losses through the slits.

3. PROPAGATION EFFICIENCY

Unlike most ornamental and horticultural crops, native plant seeds can have complex dormancy requirements that make propagation challenging. Seeds of most native plants must undergo some sort of treatment to overcome their inherent dormancy and to promote germination before they are sown. By comparison, seeds of most ornamental and horticultural crops have been selectively bred to overcome dormancy so they germinate relatively quickly and uniformly. Because native plant seeds often tend to germinate over a period of weeks or even months, independent, single cell containers assembled in trays or racks, such as the Ray Leach "Cone-tainer"™ and Deepot™ (Stuewe and Sons Inc), are popular. As mentioned earlier, the Ray Leach Super Cell has become a standard of the native plant nursery industry because the individual "cells" (tubes) can be "consolidated"—empty cells can be removed from the holding racks and replaced with a cell with a plant, which ensures that

Figure 1. Containers for growing native plants are narrower in diameter and are longer than standard nursery pots of equal volume (A). Most nursery pots do not have any "anti-spiraling" features, such as vertical grooves in the sidewalls (B), which reduce root deformation on the sides and bottom of the containers (C). These root deformations can cause poor growth and mechanical instability after outplanting (D). Photos A, B by Eric Stuewe; C, D by Tom Landis

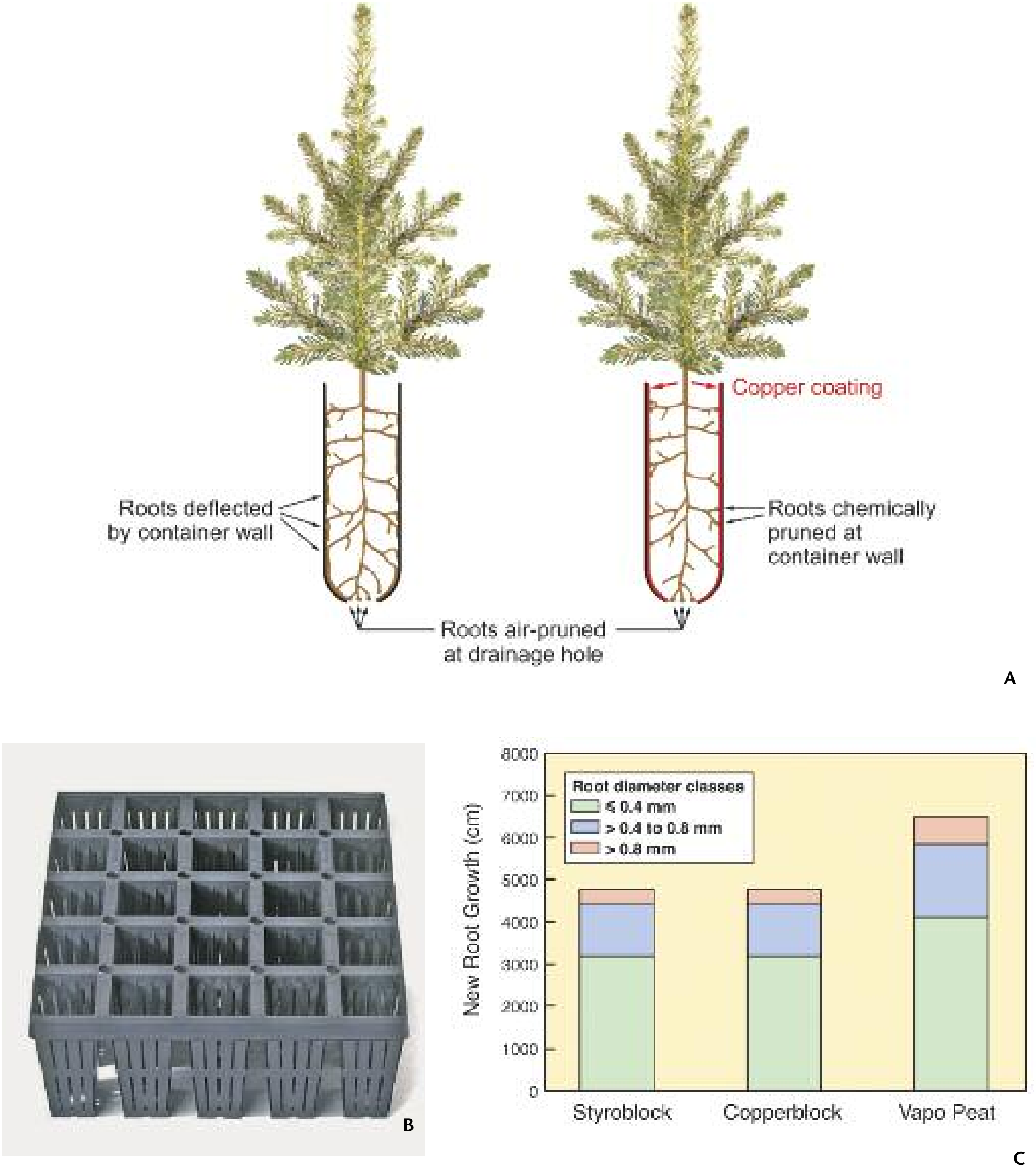

Figure 2. The latest technological innovations to control root deformation include coating the insides of containers with a copper compound to chemically prune roots (A), and "sideslit" containers that air prune roots along the sides (B). Plants grown in Vapo compressed peat and root pruned had greater root egress after outplanting compared with hard wall containers (C). Illustration A by Jim Marin; Photo B by Eric Stuewe; Illustration C modified from Krasowski and Owens (2000)

TABLE 1

Wholesale price (US$) of different stocktypes of native plants from Plants of the Wild Nursery (2010).

Container volume	Price per plant*
66 ml (4 in^3)	0.35
164 ml (10 in^3)	1.00
328 ml (20 in^3)	1.70
656 ml (40 in^3)	2.50
3.8 l (1 gal)	4.00
7.6 l (2 gal)	8.00
11.4 l (3 gal)	10.00
18.9 l (5 gal)	18.00

* Minimum order of 500 to 999 plants

valuable nursery bench space is used efficiently (Landis and others 1990).

One cultural procedure that many native plant growers use to conserve valuable seeds is to germinate them in as small a container as possible and to then transplant the resulting seedlings to larger containers for additional growth before outplanting (Landis and others 1999). Again, using small "mini-plugs" maximizes growing space in the nursery, which promotes economic efficiency. As the crop grows, the plants are often transplanted into larger containers several times until they are ready for sale or outplanting.

4. TREND TO LARGER STOCKTYPES

The average container volume has been steadily increasing during the past several decades, and this is especially true for native plants grown for restoration projects. The trend started in forestry. Back in the early 1970s, when forest and conservation plants were first grown in greenhouses, most containers were in the 40 to 64 ml (2.5 to 10 in^3) range. In the late 1980s, the largest container listed in Agriculture Handbook 674, Volume 2 (Landis and others 1990) was 490 ml (30 in^3). Since then, the trend has been to grow plants in increasingly larger container volumes (Figure 3A and B). The interest in large containers is based on the generally accepted premise that larger nursery stock survives and grows better after outplanting, especially on stressful sites. Containers with a large volume of growing media have more roots as well as a reserve of moisture and mineral nutrients to support new plant growth until they become established.

Figure 3. Large volume containers are especially popular for restoration projects because the large root plug provides a reserve of moisture and mineral nutrients (A). Large container stocktypes of Salicaceae (willow [*Salix* L.] and cottonwood [*Populus* L.]) are effective for riparian restoration projects but sturdy racks are required for handling in the nursery and for shipping to the outplanting site (B). Photos by Tom Landis

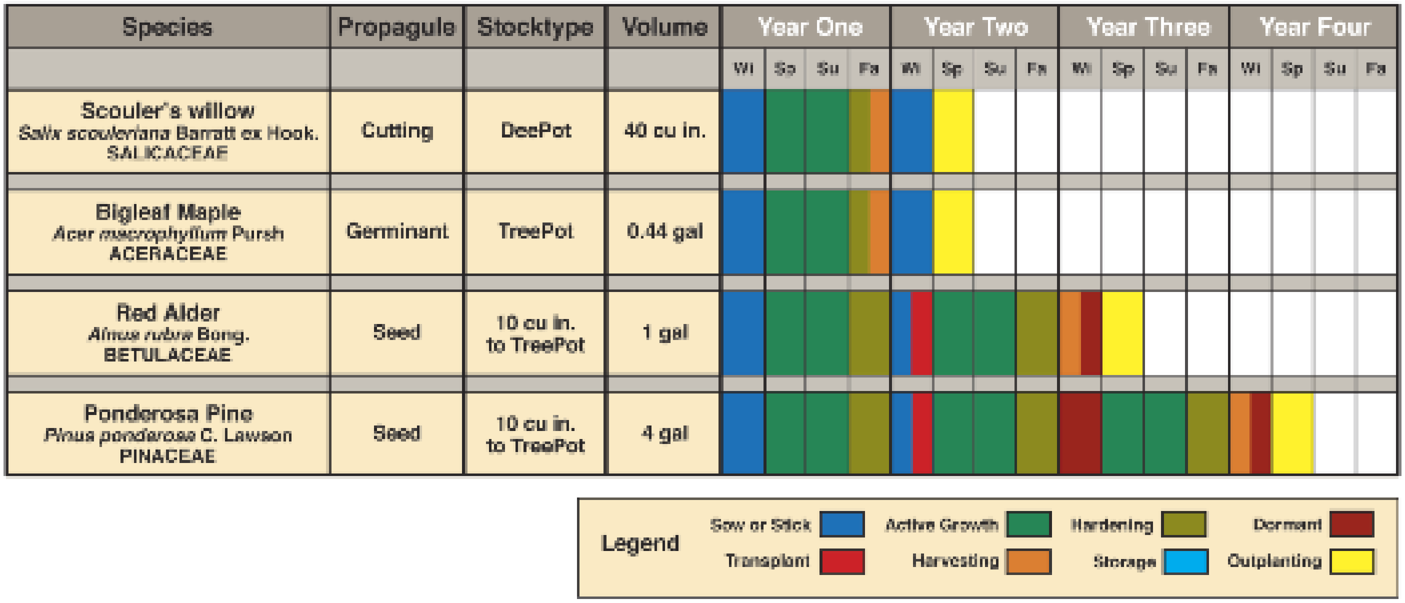

Figure 4. Growing schedules for a variety of native plants from the USDA JH Stone Nursery show that it takes 2 to 4 y to produce larger stocktypes.
Illustration by Jim Marin

5. GROWING SCHEDULES

Larger plants take longer to grow in the nursery. Although it varies by species, propagation technique, and cultural practices, large stocktypes of many native plants typically require at least 2 to 4 y of production time (Luna and others 2009). Although some native species can be direct-sown in large containers, others must first be grown in small containers and then transplanted into larger containers. The decision to direct sow or transplant is a function of species characteristics and the type of propagule. Plants that readily root from cuttings can often be direct struck in large containers, but transplanting is a better option for slower growing plants and for seedlings destined to be larger stock types. Transplanting allows many plants to be started in a small area (often in expensive greenhouse space) and ensures that every large container (often in less expensive outdoor growing compounds) has a live plant. Growing schedules are the best way to show customers the time that it will take to produce the desired target plant, and also show the various phases of nursery production. Figure 4 shows growing schedules for 4 species of native woody plants grown in different large containers. Note that the red alder and ponderosa pine are grown in 164-ml (10-in^3) containers for the first year before they are transplanted.

6. COST

Although the costs of containers, growing media, and other supplies are important, the selling price of container stock is basically a function of nursery production space. A unit area of greenhouse bench space or outdoor growing compound costs a fixed amount to operate, so the prices of the various container sizes increase as their cell densities decrease. For example, for an order of 500 to 999 conifer seedlings, the price per plant increases from US$ 0.35 to US$ 1.00 as the volume of the container increases (Table 1). Selling prices for each container size will vary by market factors, especially demand and effects of competition (Landis and others 2010).

7. SUPPORT AND HANDLING

Large containers can be expensive and labor intensive to handle at the nursery, ship to the outplanting site, and to properly plant. A good container handling system should support individual tall containers against toppling and also allow easy movement of many containers at once. Containers in trays or racks (for example, the Styroblock™ and DeePot™) are self-supporting, whereas tall individual containers (for example, Treepots™) require a support structure to keep the containers upright during wind and handling. These support structures can be constructed out of wooden pallets and heavy wire fencing; stock panels work particularly well. Because the containers, plants, and support structure can be very heavy, the support structures should be strong enough to withstand being moved by a forklift or pallet jack (Figure 3B).

Large containers are more expensive to handle and to outplant. Not only are they heavier and bulkier so that planters can carry fewer plants (or other special transportation is required) but also very large stocktypes require special planting tools. Planting shovels with long narrow blades work well for individual plants. Augers are effective planting tools because one skilled operator can create planting holes in advance of the planting crew that places the plants and backfills the holes with soil by hand. Well-organized auger teams can reach production rates ranging from 30 to 70 plants per person per hour (Kloetzel 2004). Tractor-mounted augers can create holes large enough for the largest container stock (Landis and others 2010). Innovative outplanting equipment includes the pot planter, developed especially for riparian restoration projects (Hoag 2006). The pot planter makes use of water under high pressure to create planting holes for large container stock. Water from a lake, stream, or tank is pumped into a compressor and then forced through the tip of a high-pressure nozzle. The pot planter has 7.6-cm (3-in) vanes attached to the sides of the nozzle, which create holes large enough for containers up to 3.8 l (1 gal). The hole that is created by the pot planter is backfilled with a soil slurry that is displaced when the root plug of the container plant is inserted to the desired planting depth. After the water drains from the slurry into the surrounding soil, the soil settles in around the root plug, assuring good soil-to-root contact. The water also thoroughly wets the root plugs and seeps into the surrounding soil. Operational trials have shown that large container stock can be planted at a rate of approximately 60 plants per hour (Hoag 2006).

RECOMMENDATION

Native plants grown for restoration projects require containers that are significantly different from those used for horticultural crops. Typical horticultural containers are shorter and wider and lack root control features, characteristics that are less important when plants are outplanted into landscapes where after-care maintenance (such as irrigation, weeding, fertilization, and mulching) are usually supplied. In comparison, narrow, deeper containers with root control features are essential to survival and growth of native plants outplanted on harsh restoration sites where little, if any, after-planting maintenance is expected. Although they are more expensive to produce and outplant, large container stocktypes have many advantages under the harsh conditions found on most outplanting sites. Our hope is that this information will help educate those in charge of purchasing plants or writing specifications for restoration projects, which will ultimately increase survival and growth of plants.

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