Containerization – Methods and grow out period. Mechanized Potting is one field harvesting technique that is widely employed by many growers. In an effort to broaden the shipping season and improve overall root density, shade and ornamental trees are frequently field harvested and placed into a variety of "containers". As the tree regenerates root system, the tree explores the available media developing a dense mat of fibrous roots to maximize uptake of minerals and water. Expandable Containers enhance normal root development and allow the grower to ship heartier trees with dense, compact root systems. Root branching is maximized. Root Density is maximized. Feeder roots rapidly develop. All media is retained. Adventitious roots are shipped with the tree improving livability, lessening adaptation time and as importantly, avoiding secondary problems such as debilitating insect attacks. Containerization promotes root branching. Circling, girdled roots are far less common with containerized trees. Root Zone temperature is much less than trees grown in conventional round black pots. Less root injury occurs to the root system during intense photo periods. Curing field grown trees in expandable jacket media rings improves root density and allows the grower to ship a hearty Balled and Burlapped Tree with excellent potential for quick establishment

- Mechanized Potting – employ the "Four Inch Rule" (see attachment)
- Curing Field-Grown Trees in Expandable Jacket Media Rings
- Transfer from Air Pruning Devices, Root Maker, Air Pots, "Accelerators", Root "Trappers", Fabric Grow Bags, and Into Expandable Growing Medias. Shipping Root Enhanced trees grown in expandable jacket systems (air pruning or non-pruning type) offers reliability and lessens adaptation time at the job site.

Root Enhancement Devices – merits

ROOTS are finally starting to get the attention they deserve. Tree Growers that endorse root pruning and curing practices generally deliver healthier trees to their customers. In fact, most customers say they seek out "root enhanced" trees because they establish quicker and require less intensive maintenance. "**Air root-pruned" production systems and the production method of "curing" field-grown trees prior to shipping have both proven to have favorable benefits, namely: healthy trees with fibrous, "ready-to-grow" root systems**. To a knowledgeable grower, the sight of a tight root ball crammed with short, tiny roots is a thing of beauty! Bulbous-shaped terminal root tips are just loaded with carbohydrates and ready to re-establish.

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Grower Topics – Root Enhancement Methodology – Delivering Trees that Adapt

Achieving Favorable Results with Root Enhancement Practices:

Proactive growers are highly focused on the tree nursery's potential to stamp out, once and for all, the bane of circular root growth. Florida Grades and Standards (adopted in 1998) strongly addresses this issue and mandates compliance with Step 10: "cull any container-grown tree exhibiting circular root patterns" prior to sale. Few buyers know this, however, and the old standards didn't even address the question of spiraling roots that most customers overlook when they purchase container-grown trees. Examples of "Air Root-pruning" Devices :

- **The Air Pot -** European import that resembles a strip of black plastic bubble wrap. The patented "Air Pot" is a European import (Expandable Jacket System)
- **The Florida "Cool Ring"** - proprietary strips of plastic fabric, fencing hardware, and a non woven mat
- **"Accelerators" –** proprietary expandable jacket system with air pruning provisions – made of aluminum or plastic
- **Root Maker Products** - proprietary *In Ground Fabric Bags, In "Pot- Pruner" Liners, White Root "Trapper" and Root "Builder" Trade Names*. The Root "Trapper" and Root "Builder" products are above ground air-pruning containers. The Root "Builder" is an Expandable Jacket System with sophisticated Air Pruning provisions.

Preliminary evaluations of air-pruning pots by arboriculture specialist Dr. Ed Gilman at the University of Florida's environmental horticultural department report no evidence of some manufacturers' claims that air-pruning pots actually increase density. However, Gilman's tests demonstrate that the pots "almost eliminate" instances of circular rooting that can strangle maturing trees.

At last year's Great Southern Tree Conference, Gilman's department outlined its long-term field trial of several air-pruning pot systems, including the Accelerator, The Florida Cool Ring, and the Rootmaker systems. It may take another year or two before the results are in.

Consumer Education

Few customers know whether the expensive tree material they purchase is free of circular roots. Installers may – or may not – be taking the time to cut away such defects. The transplant may indeed look good from the crown up, but may never really thrive.

Such neglect only contributes to the national 10-year average for urban tree survival. The only real solution to such a poor statistic is a better-educated consumer. The benefits to Root Enhancement practices are clearly evident and measured by higher survivability, shortened adaptation time, tree health and less susceptibility to adverse planting site conditions (such as urban sites).

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Tree Growers and Tree Sales Professionals need to get the word out to the end users – the customers we're really growing trees for. Tree farms' marketing staffs are perhaps in the best position to sell consumers on the benefits of root-pruning pots. Landscape architects, for example, appear to be learning and are starting to spec out plant material that meets Florida Grades and Standards. Compliance with the revised standards is the right thing to do. Air-pruning pot systems and the practice of "Curing" field grown trees are both quality approaches to improving the grade and adaptability of trees available to consumers. There is plenty of room for improvement. Preliminary estimates indicate that only about 4% of the nation's growers are using air-pruning pots. Although most grower's air-pruning experience has focused on shade tree production methods, there may be additional potential for all woody ornamental growers.

Ongoing Efforts to Eliminate Circular Roots

Eliminating circular roots growth patterns starts early (at the seedling and liner stage). Before trees leave the mist house, the propagator must make use of liner trays with the vertical ribs protruding on the inside. Any errant seed that tries to send out a circular root will be forced to grow downwards. Many propagators first spray empty seed trays with a copper hydroxide compound (Griffin Corporation's "Spin Out") to curb the growth of ambitious roots and to promote development of more fibrous secondary roots. **Copper is toxic and not a practice that all growers endorse**. Air-pruning pots manage root growth by encouraging root initiation, branching and bulk density. From the liner stage, trees are transferred to liners such as three-gallon Lerio pots (Lerio Corp., Kissimmee, FL.). Although they resemble a standard black plastic pot, upon closer inspection, the Lerio pots have two important differences. They are lined around the sides with a geotextile fabric ("The Pot Pruner" produced by Root Control Inc., Oklahoma City) that stops root growth at the container. More dramatic than the fabric sleeves, perhaps, is the 1-inch plastic platform drilled with holes that lines the bottom of the pot. The platform prunes roots at the bottom because holes drilled into the sides around the bottom of the pot allow for ample air circulation. All tree species favorably respond to air-pruning pots. Coarse-rooted species, like live oaks, however, seem to do particularly well.

Up-front production costs are naturally higher when root enhancement practices are employed. At delivery, the pots or expandable jackets are removed for reuse. That means that the root balls must be shrink wrapped before shipping, which adds to the final production cost. The benefits are many however, namely:

- Trees attain caliper about 15% faster
- The rooting out rate is typically about 25% faster whenever material is stepped up into a bigger pot or transplanted into a landscape.
- Few Trees need to be culled. In fact, most growers can sell every one of their "Root Enhanced" trees. Many growers are even guaranteeing that none of their trees will have spiraling roots.

Container Growing – There are many drawbacks, namely: "Circling Roots". Lightweight soil-less media often produces root systems not adapted to disturbed construction site sites. Root branching within the container is minimal. The time required for root proliferation into planting site soil is much greater than planting cured field grown trees with soil balls. Intensive Container Production Grower's Management is the only reliable practice to reduce or avoid the negative results of plants becoming "root bound" due to circling roots. When a plant grows for too long in its container, it generally becomes root-bound. With no room for additional growth, roots become tangled, matted, and grow in circles. Root branching is minimal and the tree becomes quite dependent upon frequent watering cycles. Foliage color, stem caliper and overall health are compromised. Root-bound plants placed in the ground without having their roots untangled often fail to overcome their choked condition. This results in stunting the plants growth and potential to re-establish in a new planting location.

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The 4-inch Rule

Steps to Maximize Root Branching With the Whitcomb™ System

A good rule of thumb when shifting a plant to a larger container is to allow for a distance of about 4 inches between the sides of the smaller container and the larger container. As with the pruning of a branch, when a root is pruned by air, constriction, or root-tip-trapping, the branching occurs behind the pruned surface a distance of about 4 inches. With a shift to a container with a difference *greater* than 4 inches, some of the root branching opportunity will be missed. A shift to a container *less* than 4 inches will provide excellent root branching but this newly created fibrous root system will also exhaust the container volume sooner and will soon require an additional shift to maintain the root-branching and growth momentum.

RootMakers® are intensive production tools, creating a fibrous root system superior to conventional production methods. To maximize the efficiency of this system, *timing* should be given careful consideration. Often, plants in RootMakers® are not shifted soon enough. Nurserymen are accustomed to "holding" slower-growing plants in less efficient, smooth containers which create circling, stunted root systems. Achieve the full benefits of root branching in RootMakers® with every step in production. Once plants create a fibrous root system, send them on their way with a shift to the next step.

Step 1. A fibrous root system starts here, in RootMaker® II propagation containers 18-, 32-, 60-cell, or the original 4-pack.

Step 2. Illustrated here by the RootMaker® 3-gallon, but the 5-gallon and 5" or 8" cinder block bags are also options. Perhaps the most efficient use of space and time is a shift directly to a 3-gallon, which gives the ideal sidewall distance of about 4". A shift to a 1-gallon will branch well but will also run out of space sooner and require additional shifting.

Step 3. Here, represented by an 18" knit fabric in-ground container, creating a sidewall distance between the 3-gallon of about 3 _ inches, but a little over 5 inches with a 1-gallon. For field planting, the knit fabric container ranges from 12" to 24". For above ground, the new RootTrapper® 7 to 30-gallon is an additional option.

Step 4. Here, represented by the RootBuilder® expandable container. Create the container size you need to give a sidewall difference of about 4" for maximum root branching, generally over 30 gallons at this step but 150 gallons is possible. RootTrappers® also range in sizes 30 to 60-gallon.

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Linda Chalker-Scott, Associate Professor
Center for Urban Horticulture, University of Washington

The Myth of Fragile Roots
"You shouldn't disturb the rootball when transplanting trees and shrubs"

The Myth - "When you transplant, try not to disturb the roots, just take the whole pot-shaped lump of soil/roots and pop it into its new home." This and similar advice can be found on web sites and in gardening books, all which warn us of the fragile nature of roots. When we upend a container and slide out the **root** ball, it's an innate response to handle those tiny white and brown strands gingerly so as not to break them. Since the survival success of a newly installed tree or shrub is dependent upon healthy, functioning roots, it seems obvious that the more intact the **root** system the better the chances of establishment. Anything that damages this intricate web would seem to add to transplant shock.

The Reality - Though gentle handling of roots is good advice when transplanting seedlings, especially annual flowers and vegetables, woody perennials, shrubs, and trees all benefit from a more vigorous approach. There are several reasons for this, and surprisingly some of the harshest techniques result in the healthiest plants. Containerized materials, especially those in gallon sized pots, often have serious **root** problems as a result of poor potting-up techniques. Potbound plants exhibit **circling root** systems, which if not corrected become woodier and more troublesome the older they get. Eventually these **circling root** systems become girdling roots, which can lead to the early death of otherwise healthy trees and shrubs. At transplant time, a more aggressive approach to **root** preparation can discover potentially fatal **root** flaws. **Circling** roots, J-hooked roots, knotted roots, and other misshapen roots can often be corrected by careful pruning. In this manner it's possible to remove those **root** problems before they threaten the survival of your shrub or tree. It's important to realize that roots respond to pruning in much the same way as the crown: pruning induces new growth. Roots that are pruned at transplant time, especially those that are excessively long or misshapen, will respond by generating new, flexible roots that help them establish in the landscape. It is vital that these new transplants are kept well-watered during this time. A second problem with containerized materials can also be avoided during your **root** inspection. In general, the media in the container is a soilless mix with a large proportion of organic matter and pumice. If transplanted with the plant as part of the **root** ball, this material will inhibit **root** development outside the planting hole. Furthermore, the porous texture of this planting media will often lose water more rapidly than the surrounding native soil, resulting in increased water stress to your new transplant. It is much better for **root** establishment to remove as much of the container material as possible before the plant is installed. The best use for the discarded container mix is as a topdressing over the disturbed soil. When covered with wood chips or another mulch that will reduce weed colonization, the container media serves as a nice source of slow-release nutrients.

The Bottom Line - Plants with woody roots often need corrective **root** pruning before transplanting • Containerized plants are notorious for concealing fatal **root** flaws "Bare-rooting" container plants is a more successful transplanting technique as **root** flaws can be corrected and container media removed In a healthy, well-watered plant, **root** pruning at transplant time will induce vigorous new **root** growth and assist in establishment

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Grower Topics – Root Enhancement Methodology – Delivering Trees that Adapt

Creating fibrous root systems and overall healthier landscape plants and trees. Root enhancement techniques are designed to promote root branching and the production of new roots at every phase of production. By using these production and curing methods, growers and retailers create a root system that has a greater surface area than conventional container production, and therefore achieves greater efficiency in the absorption of water and nutrients, an increase in growth rate, establishment, transplant survivability, and ultimately, superior performance for their customers.

Root Enhancement Practices employ innovative, practical, and reliably proven techniques to make shade and ornamental trees more desirable.

Why is root enhancement important?

A: Root enhancement is important because it increases root mass by increasing the number of small feeder roots. These feeder roots are the lifeline of a tree since they take up necessary water and nutrients the tree needs to thrive after transplanting onto your jobsite.

Q: What is root enhancement?

A: Root enhancement is a series of steps taken to create an extraordinarily dense, vigorous and compact root system.

By employing a program to bring this about, growers and retailers can prepare their trees to be a thriving transplant. Some species naturally produce root systems that lend themselves well to harvesting and handling in the process of transplanting. Others simply do not. All trees benefit from some level of root enhancement. Field Grown Trees readily adapt to a variety of "CURING" practices

What about circling roots?

A: Circling or deformed roots are formed when a tree is grown too long in a round container. Research has shown that deformed roots can have a debilitating long-term effect on the health and stability of the transplanted tree. Circling roots in the top portion of the root ball could, as the tree and root grow, eventually girdle the tree. Products designed to control root circling such as copper compounds and air-pruning containers have proven to reduce, but not eliminate, the problem of circling roots. Field-grown trees are grown without the use of a rigid container, therefore, the root system develops a more natural form. When field grown trees are "CURED" prior to final shipping, the benefits are numerous!

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Root Enhancement Practices involve - Lateral root pruning and root stock undercutting is practiced in field production nurseries. The methods are intended to produce a compact, fibrous root system, a higher root to shoot ratio and better transplant survival. However, root pruning is not uniformly practiced in Florida. Timing, depth and distance from the trunk vary widely among nurseries which root prune, and not all nurseries and tree movers practice root pruning. Lateral roots formed in response to pruning reportedly originate close to the pruning cut. Therefore, it is hard to visualize a more compact root system developing unless roots are cut close to the trunk. Root-pruning Quercus virginiana 5 cm inside the root ball 1 year prior to harvest and then again 6 months before harvest at the edge of the harvestable root ball increased dry weight of fibrous roots inside the root ball six-fold compared to non-pruned plants. Root-pruning Picea pungens 20 cm inside the edge of the harvestable root ball 5 years before harvesting resulted in a 4-fold increase in root surface area in the root ball. Apparently, harvesting the ball beyond the point of root pruning can increase root density within the root ball. Root pruning reduces above-ground plant size and may increase time to harvest a field-grown nursery crop. However, long-term growth is either unaffected or increased.

Results from Field Studies – The number of new roots generated by root pruning varies among species. Platanus occidentalis generated an average of 32 new roots whereas Quercus virginiana and Ulmus parvifolia 'Drake' had less than 10. For five of the six species, 69% or more of the new roots originated within 2.5 cm of the cut. However, only 56% of new Acer roots originated within the zone. Acer had 27% of new roots more than 5 cm behind the cut; all other genera had 14% or less. Growth of existing lateral roots was stimulated by root pruning on five of six species tested. Southern Live Oak trees were container-grown or field-grown to a mean trunk diameter of 3.7 inches, transplanted into sandy soil, and established with frequent or periodic irrigation. Three years after transplanting, trees were harvested with a 60-inch diameter tree spade. Root number and root cross-sectional area was evaluated for all roots at the periphery of the tree-spade-dug root ball. Despite similar increases in trunk diameter, field-grown trees had greater root number and root cross-sectional area than container-grown trees. The greater root cross-sectional area occurred in roots 0.2 to 0.8 inches (5-20 mm) in diameter at soil depths of 0 to 9.8 inches (0-25 mm) and 29.5 to 39.3 inches (75-100 mm). Irrigation frequency after transplanting had no effect on root number in field-grown trees. However, root number in container-grown trees was lower without frequent irrigation.

Field Grown Live Oaks Beat Container-grown Trees

August 1996 Nursery Management & Production

Research at the University of Florida- Gainesville showed that field-grown live oaks may establish faster and be more drought resistant than those container-grown.
The study by Edward F. Gilman, associate professor of environmental horticulture, and graduate student Michael D.Marshall showed field-grown trees had more roots and greater root mass three years after transplanting than container-grown trees.

Quercus virginiana trees were grown to a 3½ -inch trunk diameter and then were transplanted into landscape situations. three years later, trees were dug with 60 inch spade and root numbers and sizes were compared.

Field grown trees had more and larger roots, especially 0-10 inches and 30-40 inches below the ground.

Gilman said field-grown trees faster establishment of deep roots likely makes them more drought resistant. He said container-grown trees may be more suited for planting next to sidewalks because they have fewer roots close to the surface, which could damage concrete.

May 1995 Nursery Management & Production (NM PRO)

If the final destination of your material will be a poorly irrigated area, you may want to sell your landscape customers root-pruned or hardened-off (cured), pre-dug material. Edward F.Gilman, associate professor of landscape horticulture at the University of Florida, has conducted studies on drought tolerance of 1 to 4 inch caliper trees separated into three categories.

1. Container-grown trees

2. Field-grown, freshly dug trees.

3. Field-grown, root-pruned trees and field-grown trees that were pre-dug and hardened-off, including balled and burlapped trees.

"If a tree were to be planted in a place with less than optimum irrigation - let's say they were watered once a week after planting -- root-pruned and hardened-off field-grown material (cured trees), would have the highest survival," he said. "Container-grown material lies somewhere in the middle and fresh-dug material would be in real trouble."

The *Scourge* of Circling Roots

Girdling roots initially grow in a circular or spiral pattern. If left unchecked they eventually cut off the sap flow from the stems and leaves. They may form in root bound container grown plants, begin when a tree is transplanted, or develop as a tree grows. Poor planting techniques, deep mulch, or compacted soil seem to encourage the development of girdling roots at the base of the trunk. As roots circle the trunk, they can slow, and eventually cut off the flow of sap in the tree. Carbohydrates produced by the leaves, through photosynthesis, are unable to move through the phloem to the roots. Weakened roots are unable to provide adequate water and nutrients to the leaves. Trees with girdling roots tend to decline over a 5-10 year period. Norway, red, and sugar maples, 'Greenspire' lindens, American beech, pines, oaks, poplars, and elms, (trees that are fast growing or tap-rooted), most often develop girdling roots.

Symptoms associated with girdling roots are caused by a weakened root system. The crown of the tree may be thin, with stunted growth. If you compare the tree crown to a clock, damage may first occur in the upper portion, between 10 and 2 o'clock. Leaves may be lighter green, scorched, show early fall color, and early leaf drop. Twig or large branch dieback can occur. When one side of the trunk is straight, with no natural flare, digging may indicate a girdling root below the soil surface. Trees with severe girdling roots may lean or completely break off. Reduced sap flow makes the tree more susceptible to insects, disease and environmental stress.

Treatment of girdling roots begins with prevention. When planting, loosen and straighten circling roots. Be sure the planting hole is wide, allowing ample room for the root system. Do not smooth or compact the sides of the planting hole, which may deflect roots and lead to girdling. The sides of the planting hole should be loose and roughened, to allow root penetration into surrounding soil. Be sure plants are planted at the proper depth and mulched lightly.

Inspect properly planted trees regularly to detect girdling roots while they are small. Small girdling roots can be removed with a sharp chisel and mallet. Remove several inches of the root where it contacts the tree trunk, to ensure the root does not reconnect. If a large girdling root has grafted with the tree trunk, it is advisable to allow it to remain undisturbed. Cutting a V shaped notch in the top half of the girdling root may help to weaken it without disrupting the vascular flow to the top of the tree. No treatment of cut roots is necessary. Seriously weakened or declining trees may need to be removed.

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FIELD-GROWN TREES

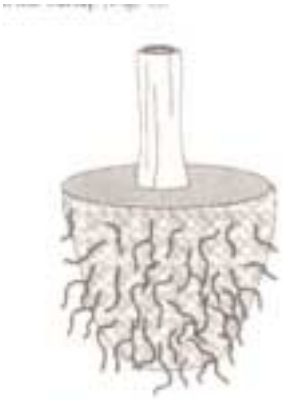
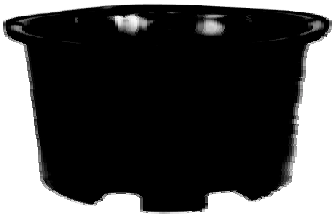


Fig. 6. Cured trees have roots growing through the burlap.

Field-grown trees that have been properly harvested and hardened off (CURED) are strong and sturdy. They are good choices for any kind of site and usually the best choice for sites where watering will be infrequent or irregular. Compared to trees grown in round containers, the root ball of a harvested field-grown tree is larger and capable of more water storage, thus making it slower to dry out. The root balls of field-grown trees are also much heavier than those of container-grown trees, making them significantly harder to handle. When field-grown trees are harvested, burlap is wrapped around the root balls and secured with nails, string or wire. The root ball of a balled-and-burlapped tree is fairly durable, but care should be exercised to avoid breaking or crushing roots in transport and handling. CURING enhances root mass prior to final shipping or planting. Shrink wrapping Balled and Burlapped Trees prior to shipping insulates fine textured roots from air drying and allows the installer to transport (and plant) an undisturbed mass of roots.

CONTAINER-GROWN TREES



Trees grown in round containers generally have smaller root balls and many times more fine roots than similarly sized field-grown trees. For a variety of reasons, container-grown trees dry out more quickly, making them more sensitive to drought injury in the period following planting. Fabric containers or fabric bags are made of a heavy flexible fabric especially designed for this growing method. Trees are planted in the fabric containers that are then planted in the ground. While their smaller size makes them easier to handle, they are also more fragile and dry out faster than the root balls of balled-and-burlapped trees.

Trees and shrubs are most commonly grown in plastic containers that are placed either above ground or, more recently, below ground and inside permanently installed containers with specially designed drainage holes. This latter method, known as pot-in-pot, insulates the root system and should produce roots that are more uniformly distributed than those found in above-ground containers.

Containers are usually filled with an artificial or soilless growing medium composed of one or more materials like bark, peat moss, compost and sand. These media are generally coarser than soil, which permits them to drain quickly and which, in turn, helps prevent root rot. To maintain optimum growth after planting, water container-grown plants at least as often as they were watered in the nursery. In the summer, it may be necessary to irrigate daily on well-drained, sandy soils for a number of weeks or months after planting, especially for trees whose trunks are over 2 inches in diameter. Taper off on watering as roots grow out into the landscape soil.

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