

THE ROOT  
OF THE  
PROBLEM



**FOR NOW, ONLY YOU  
CAN KEEP TREES WITH  
ILL-FORMED ROOTS  
FROM LEAVING  
THE NURSERY.**

BY JAMES R. URBAN, FASLA

In the mid-1990s, practitioners and researchers were noticing a disturbing trend. Trees were increasingly declining as they reached maturity. The problem was not limited to one species but affected many nursery-grown trees.

Gary Johnson, a scientist at the University of Minnesota Extension Service, looks at hundreds of dead or dying trees each year. He would inspect the trees' leaves and bark for signs of disease or insect damage, but, at some point, he began to look at the bases of the trees as well. He saw many trees that were slowly strangling themselves with their own

roots. Their root flares—where the trees' roots and trunks meet—were buried unusually low beneath the ground, and their roots had wrapped around the buried part of the trunk, making it difficult for nutrients and water to flow upward.

In Chicago, the landscape architect Bernard Jacobs, FASLA, and the urban forester Robert Benjamin were noticing similar issues with the mostly field-grown balled and burlapped trees in their local landscape. Meanwhile, the researchers Richard Harris, Brian Kempf, and Ed Gilman found similar problems in container-grown plants in California

**TOP**  
A tree is being strangled by its own roots.

**INSET**  
Trees with girdling roots snapped off during a storm.



and Florida. Clearly, the problem could not be tied to one single type of production method.

Johnson and his colleague Rich Hauer wrote a technical booklet on the subject in 2000, titled *A Practitioner's Guide to Stem Girdling Roots of Trees*. And in 2003, at the American Society of Landscape Architects Annual Meeting in New Orleans, various experts met to discuss the issue. The problem appeared real, though there was no agreement about its extent, source, or solution. Some blamed landscape contractors' planting trees too deep. Others blamed nurseries.

Because any solution by the nursery industry was going to be expensive and time-consuming, the nursery industry wanted more research be-

fore it would change production methods. An industry-wide working group formed, led by Gary Watson of the Morton Arboretum. Two years later, researchers presented 13 papers at a conference called "Trees and Planting: Getting the Roots Right." Those papers indicate that there are measurable effects on trees from girdling roots and roots too deep in the root ball. They document that the problems are widespread, and they often originate in the nursery.

Most trees begin their lives in large nurseries that specialize in growing "liners"—trees about one inch in caliper that are then sold to regional nurseries. Before the 1970s, these trees were typically raised in fields and transplanted with bare roots, so the grower could easily inspect the roots and plant the tree properly—

with the main roots and developing trunk flare close to the surface of the soil.

Today, containers are often used at various stages of the growing process. Even field-grown trees may be started in containers. When a tree root reaches the wall of a typical container, it bends in a new direction to keep growing. Usually this bend forces the root to grow in a circle along the container wall.

Ribbed containers, meant to stop roots from circling, may cause roots to kink up or down, which can also be problematic. "Straight roots growing from the trunk form a strong, wide root plate," writes Gilman of the University of Florida in *Strategies for Growing a High-Quality Root System, Trunk, and Crown in a Container*

**LEFT**  
A young tree is becoming girdled by roots formed in a one-gallon nursery pot.

**RIGHT**  
A circling root is forming on a field-grown tree.

**INSET**  
A seedling tree pulled from the initial propagation container shows the start of circling and kinked roots.



*Nursery.* “When main woody roots are deflected and not straight, there may be no root plate and the tree can become unstable.”

Unless the roots are pruned when the tree moves to a larger container, the root system will retain the imprint of the smaller container. And in the larger container, the process can start all over again. With trees often repotted three times before they are sold, a tree may have three sets of roots circling around the trunk.

Containers aren’t to blame for all of the circling roots. Deep structural roots and buried trunk flares are another potential problem of both field-grown and container-grown trees. When the trunk flare is deep under the soil, circling roots may grow close to the surface near the tree trunk.

A study published by Chad Giblin and four others observed 180 little-leaf lindens (*Tilia cordata*) to see how planting them deeply would affect them. The lindens were planted with their first lateral root zero, five, or 10 inches below grade. After six years, more than 60 percent of the lindens planted five and 10 inches below the surface had stem-encircling roots, compared with just 17 percent of those planted zero inches below the surface.

As the tree grows, roots that grow tangential to the trunk above the main structural roots may compress the trunk and cut the flow of sap between the canopy and roots. Compression can also weaken the trunk at that point. As the amount of trunk circumference affected by the root increases, the impact on tree health increases.

The result, observed by Johnson and others, is slower-growing trees with portions of the canopy that do not develop well or decline.

Tyson Woods, an arborist with Moore Tree Care in Dallas, found girdling roots so common among declining trees that he added an entire crew to address the problem. He reports that once the roots were removed, tree health generally improved.

Several production issues contribute to the structural roots that lie too deep in the root ball. Watson and his colleague Angela Hewitt have observed that in the process of transplanting tree liners, the primary root of the tree growing downward is often pruned. A new set of roots will grow out from the cut and may become the main roots of the tree.

**LEFT**  
Soil has been removed from a balled and burlapped tree with five inches of soil above the developing trunk flare.

**RIGHT**  
Eight to nine inches of soil is over the top of the trunk flare. The tree was dead at the time of excavation.



Lateral roots growing above this point may then fail to develop.

At this point the tree's planting depth has already been established. Keith Warren at J. Frank Schmidt & Son, a large liner producer in Oregon, reports that maintaining this deeper planting depth actually aids in plant establishment in well-drained and tilled field soils. But this depth may cause problems when the tree is placed into a less-well-drained soil in the landscape.

Another reason trees are planted too deep is to hide an ugly graft. Grafting tends to create a slight crook at the graft point, and many growers found that purchasers preferred it when the graft was hidden. With field-grown trees, mechanical cultivation equipment used to

till the soil around the tree tends to push soil up against the trunk. With container trees, roots may be buried when the root ball from the previous container is set too low and potting mix is added to top off the container.

The industry group led by Watson developed a best management practice recommending "at least two structural roots should be within one to three inches of the soil surface, measured three to four inches from the trunk." I have observed the primary lateral roots as deep as 11 inches below the root ball surface, and roots five and eight inches deep are not uncommon. A survey of trees dug for resale in broker yards in Ohio by Richard Rathjens and T. Davis Sydnor in 2004 found that the average depth to the main roots

was 3.4 inches. Most of the trees they examined would not have met the standard proposed by Watson.

They might not meet the American Standard for Nursery Stock, ANSI Z 60.1-2004, either. It specifies standards for root ball depth and states that the "depth of the ball is measured from the top of the ball, which in all cases shall begin at the root flare." A considerable amount of soil would need to be removed from the top of these root balls for the measurement to be done, shrinking the size of the root balls.

At the 2012 International Society of Arboriculture Annual Meeting in Portland, Oregon, there was a symposium on understanding the nursery practice problem. All speakers supported root pruning trees at

**LEFT**  
A container-grown tree has a dense root mat and circling roots over the top of the root ball from the previous smaller container.

**CENTER**  
A typical container tree.

**RIGHT**  
The same tree after root inspection and removal of numerous large girdling roots above the root flare. This tree survived once planted.



each step in the production process or using container types that prevent circling roots. Gilman's work showed that root pruning does not appear to lengthen the time to produce a healthy liner.

It is unreasonable to specify a perfect tree, Warren cautioned. Growers have difficulty in maintaining the elevation of the developing trunk flare and keeping the first set of main roots close to the soil.

Gilman and Daniel Struve, an associate professor at the Ohio State University, are developing a new generation of containers that are "root safe." These include paper containers, spun poly fabric containers, and open-mesh air-pruning containers that have open voids on up to 80 percent of the sur-

face area. None as yet has been adopted by the industry. Everyone agreed that bare-root planting resolves most of these problems (see "The Bare Root Cause," *LAM*, June 2011).

In extreme cases of girdling roots, the tree may snap off at the point of the constriction. This happened during a windstorm last spring to some littleleaf lindens I examined in Iowa—30 years of growing them was lost. To prevent similar calamities, landscape architects should demand better planting and nursery practices. Their planting details should show the entire top of the root ball above the ground and its outer edge flush with the adjacent soil line. They should direct the contractor to remove any soil above the trunk flare and main roots and any girdling roots before planting.

A separate detail is needed to address container trees' specific issues. In addition to visible girdling roots, container trees often have a thick mat of fine roots above the main roots, which can become girdling roots over time—these roots should be removed. The drawing should also show the contractor how to cut off or shave all the roots on the outer edge of the root ball so that all cuts leave root stubs in a radial relationship to the trunk. Pruning these outer edge roots may appear to damage the tree, but Gilman's research indicates that trees are not harmed by this severe pruning if they are irrigated immediately, and the new roots growing out from the shaved roots grow in a radial fashion away from the trunk, producing a stabler, healthier tree.

**LEFT**  
Container trees before and after being shaved as recommended to remove outer girdling roots.

**RIGHT**  
Mesh containers are being tested as a potential solution to the root problem.

**INSET**  
A container tree has had approximately 25 percent of the root ball removed to eliminate root mat above the flare. This tree also needs additional shaving of the perimeter roots.

## CHANGE YOUR SPECIFICATION

The following is a suggested specification to deal with the root system of trees currently available in the market.

### PLANT QUALITY AT OR BELOW THE SOIL LINE:

- A. A minimum of three structural roots reasonably distributed around the trunk shall be found in each plant. Plants with structural roots on only one side of the trunk (J roots) shall be rejected.
  - B. The root crown must not be more than two inches below the soil line. The top two structural roots shall be no more than three inches below the soil line when measured four inches radial to the trunk. The top of the other structural root shall be no greater than five inches below the soil line when measured four inches radial to the trunk. The grower may request a modification to this requirement for species with roots that rapidly descend, provided that the grower removes all circling roots above the structural roots across the top of the structural roots.
  - C. The root system shall be reasonably free of root defects including potentially stem-girdling roots above the root collar and main structural roots, vertical roots, and/or kinked roots from nursery production practices, including roots on the interior of the root ball.
1. Reasonable and reasonably—when used in this specification relative to plant quality—are intended to mean that the conditions cited will not affect the establishment or long-term stability, health, or growth of the plant. This specification recognizes that it is not possible to produce plants free of all defects and that some decisions cannot be totally based on measured findings, so professional judgment is required. In cases of differing opinion, the landscape architect shall determine when conditions within the plant are judged as reasonable.
  2. The final plant grower shall be responsible for certifying that the plants have been root pruned at each step in the plant production process to remove stem-girdling roots and kinked roots, or shall ensure that the previous liner production system used other practices that produce a root system throughout the root ball that meets these specifications. Regardless of the work of previous growers, the plant's root system shall be modified at the final production stage to produce the required plant root quality. The final grower shall certify in writing that all plants are reasonably free of root defects as defined in this specification and that the tree has been grown and harvested to produce a plant that meets these specifications.
- D. All plants may be inspected at the supplier's nursery. The landscape architect may make invasive inspection of the root ball as needed to verify that plants meet the requirements. Inspections of container trees may require random cutting into the interior root ball of up to 2 percent but not fewer than two trees of each type of tree in a container at each source nursery. Such cutting and inspection may render the container tree unsuitable for planting. Findings of the root inspections shall be considered as representative of all trees of that type from that source.
  - E. Container-grown plants, in addition to the above requirement, should comply with the following:
    1. Container-grown plants may be permitted only when indicated on the drawing or this specification.
    2. Container-grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its potting medium together but not so long as to have developed roots that are matted or circling around the edge or interior of the root mass. Plants shall have been root pruned at each change in container size.
    3. Plants that fail to meet any of the above requirements shall be modified to correct deficiencies if approved by the landscape architect. Modification shall include the following:
      - a. Shaving all circling roots on the exterior of the root mass deep enough so that all cut roots' ends are roughly radial to the trunk.
      - b. Removal of all roots above the top of the main structural roots and trunk flare including any roots that are imprints from previous smaller containers. (The above modifications shall not be cause to alter the warranty provisions of this specification.)

—JAMES R. URBAN, FASLA

The container tree detail should also require the removal of circling roots from previous smaller containers in the interior of the root ball that are above the main structural roots. However, it's much harder to deal with roots buried deep within the root ball. Also, there is no research indicating how many of these roots can be removed before the tree health is compromised. So it might be better to reject such trees altogether. This provision should eventually be added to planting specifications, but it will be hard to meet initially.

In case the contractor complains about the cost of the additional work or that the root cutting will compromise the guarantee, the specifications should be clear that such modifications are required and what

will happen if the contractor buys defective plants. A definition of defective plants will need to be added to the specification. ANSI Z 60 may not be sufficient to allow rejection of plants. ANSI does require that the soil line be "at or near the top of the root flare," but it does this in the context of how the tree is measured, and there is no discussion of circling roots for field-grown trees. ANSI Z 60 requires that container trees do not have "excessive" encircling roots on the inside of the container, but "excessive" is not defined. There is no standard that specifically addresses encircling roots caused by smaller containers.

Progress is being made in field-grown trees. Given that the grower is already processing the root ball at the time of sale, it is fairly plausible

to resolve issues with buried trunk flares and to remove girdling roots at that time. In Florida and Illinois, tree growers, contractors, and landscape architects came together to develop better field-grown root ball standards. The Illinois Green Industry Association website ([www.ina-online.org/treespecs.html](http://www.ina-online.org/treespecs.html)) provides good root ball guidelines for field-grown trees, including defining the relationship of the roots to the root ball starting with the liner planting. These guidelines could be adopted nationwide.

Finding solutions to container tree production issues appears to be more difficult. Most growers are currently not doing any processing of the root package at the time of sale. Modifying the root balls of container-grown trees on the construction site or at

## PLANTING DETAIL BALLED AND BURLAPPED TREE

Remove soil and all circling roots above the structural roots from top of root ball prior to harvesting in nursery

Top two structural roots:  
< 3 inches below top of root ball

Lowest structural root  
< 5 inches below top of root ball

Soil saucer  
> 3 inches high

10 inches

Cut and fold  
wire basket  
away from  
top of root ball

4 inches

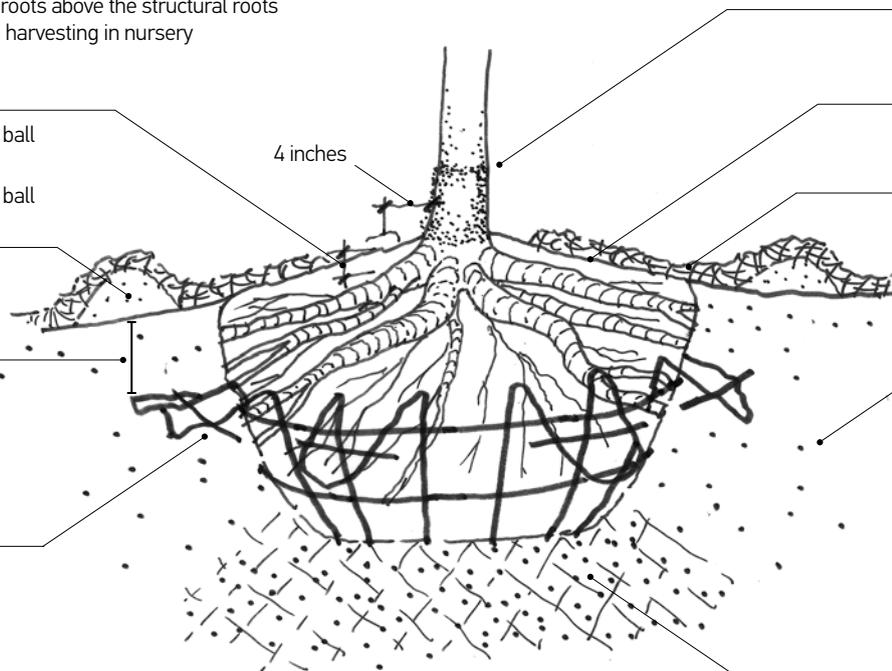
Graft visible above soil line

Soil line of the top of root ball  
after removing excess soil

1 to 2 inches mulch

For soil treatment around  
root ball, see soil plans  
and details

Compact soil under root ball  
to 90 percent proctor



the time of shipping can be expensive. Research at the University of Florida showed that it takes approximately 12 minutes per tree to shave the outer edges of a 45-gallon tree. More time is required to fix internal root problems.

Container growers and contractors are more likely to be persuaded to change their long-term production techniques than to modify the root balls of existing stock. Therefore changing the container industry will take longer and require landscape architects, contractors, and growers to join together to find workable solutions. In California, the Urban Tree Foundation, led by Brian Kempf, has worked with Gilman to develop a nursery root pruning guide and specifications for container trees ([www.urbantree.org/nurserytreequality.shtml](http://www.urbantree.org/nurserytreequality.shtml)).

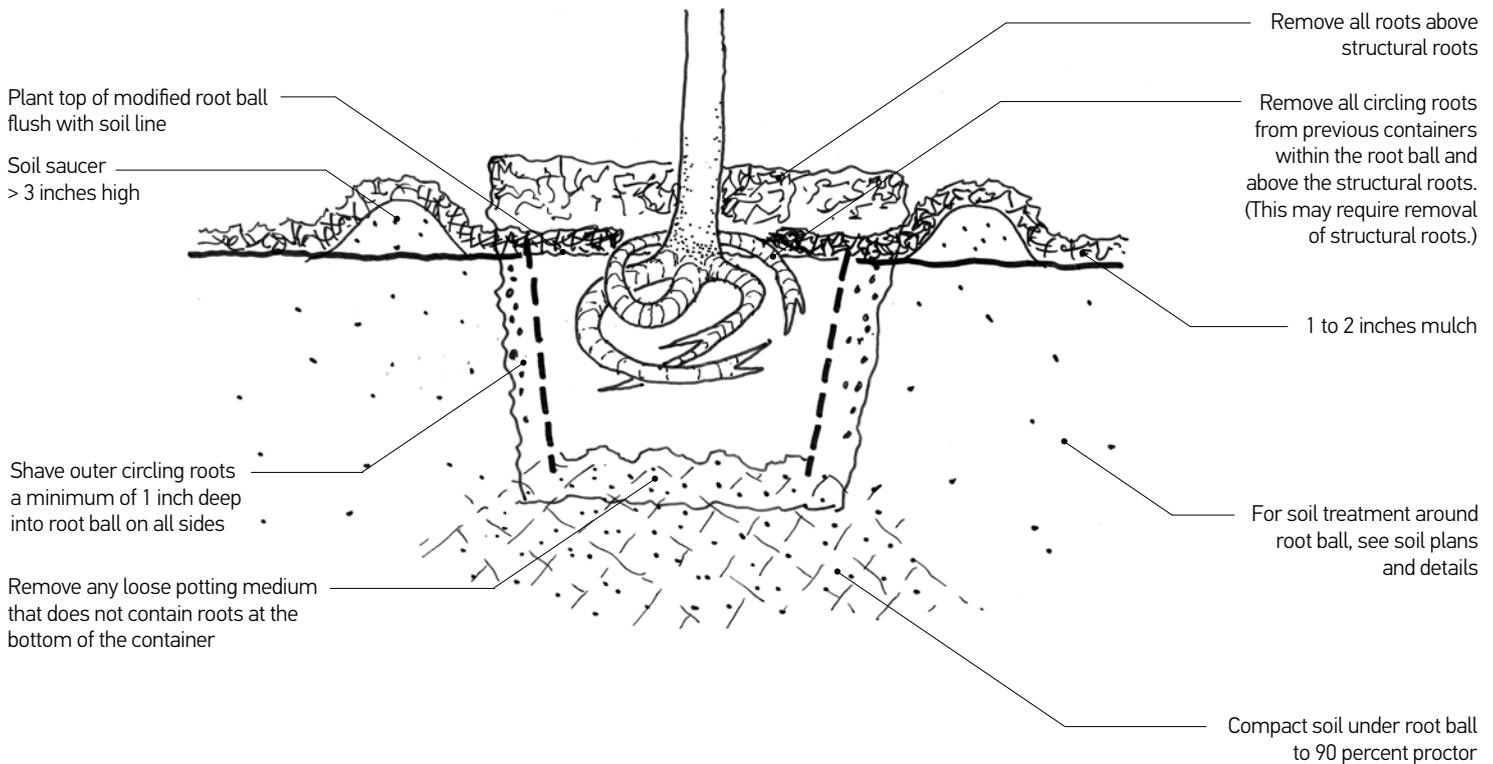
Modifying root systems in container trees will be perceived as impractical by some. However, the alternative is to either plant trees that have known defects and short life expectations or reject trees with these problems entirely. Neither of these alternatives is practical, especially the latter in the South and West, where trees are primarily grown in containers.

The nursery industry does not generally enforce its own standards, so landscape architects are going to have to become more involved in approving their planting stock. They will need to outline the inspection process and the bases for approval or rejection in the contract documents and account for construction administration to monitor plant quality. Inspection at the nursery is critical, as costs and delays of returning trees

from project sites make it hard to reject trees unless the problems are extreme. Many clients will not support delays for a problem that they cannot see, is not easy to explain, and may only affect the long-term health of the project long after the warranty has expired and the development team has moved on to other work or even retired. Rejecting trees at the grower's nursery gives the grower the opportunity to make modifications to the root ball. Or the contractor may be able to find a better source.

When you inspect a field-grown tree, your goal will be to find the depth and distribution of a few main roots. Inspections can be accomplished with hand gardening tools that the landscape architect brings to the nursery. A typical inspection involves carefully

**PLANTING DETAIL  
CONTAINER-GROWN TREE**



digging around the base of approximately three random trees in each tree block to develop a confidence in the depth of the primary roots. Each tree inspection takes just a few minutes. Most nurseries are quite consistent in their planting techniques, so random checks are usually valid. The trees inspected are not harmed by the inspection, and I've found most growers do not mind the scrutiny. But the requirement for this invasive inspection must be in the specification.

Inspecting container-grown trees is tougher, given the complexity of the root system from different containers used in production and the dense roots that can form within and on top of the container. It is nearly impos-

sible without destructive inspection. If container trees must be used, the root balls of some random plants should be sawed apart, killing the tree; this may take 15 to 20 minutes per tree. The purchase of these trees for testing must be included in the cost of the project. Many container-grown trees in the United States will fail this inspection. Trees with poor root systems can be used if there is considerable root modification at the time of planting. But that will be expensive and time-consuming, and a limited number of trees will die from the modification—causing a complex warranty situation. For large projects, contract growing, with root pruning required in the specifications, may offer a solution.

The problem of poor-quality root systems on trees is one of the great challenges to making healthy, sustainable landscapes. There is currently not a sufficient inventory of trees that meet the standards laid out here. Landscape architects can begin to fix these problems by changing their specifications and by educating their clients, contractors, and growers about good roots and their life-or-death importance. ●

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