Best Management Practices

Tree Planting

Second Edition

Special companion publication to the ANSI A300 Part 6: Tree, Shrub, and Other Woody Plant Management—Standard Practices (Transplanting)

Best Management Practices

TREE PLANTING
Second Edition 2014

Gary Watson

ISBN: 978-1-881956-84-6

International Society of Arboriculture

Editorial Coordinator: Wes Kocher
Copyeditor: Peggy Currid
Production Coordinator: Amy Theobald
Cover Composition and Layout: Kathy Ashmore
Illustrations by Bryan Kotwica
Printed by Martin One Source, Champaign, Illinois, USA2
International Society of Arboriculture
270 Peachtree Street NW, Ste.1900
Atlanta, GA 30303, USA
+1 (678) 367-0981
www.isa-arbor.com
permissions@isa-arbor.com

10 9 8 7 6
0821/CA/400

Table of Contents

Acknowledgments

The Tree Planting Best Management Practices Review Committee (Second Edition)

Mike Arnold, Texas A&M, College Station, Texas, USA
Robert Benjamin, Lombard, Illinois, USA
Fiona Eadie, Thoughtplanters, Dunedin, New Zealand
Francesco Ferrini, University of Florence, Florence, Italy
Edward F. Gilman, University of Florida, Gainesville, Florida, USA
Gordon Ikin, The Specimen Tree Company, Auckland, New Zealand
Sharon Lilly, International Society of Arboriculture, Champaign, Illinois, USA
Richard Rathjens, The Davey Tree Expert Company, Kent, Ohio, USA
E. Thomas Smiley, Bartlett Tree Research Laboratories, Charlotte, North Carolina, USA
John Smithmyer, Bartlett Tree Experts, Charlotte, North Carolina, USA
Daniel Struve, The Ohio State University, Columbus, Ohio, USA
Jeremy Thomas, Botanic Gardens & Parks Authority, West Perth, Australia
James Urban, Urban Trees + Soils, Annapolis, Maryland, USA
Ellen Vincent, Clemson University, Clemson, South Carolina, USA
Christina Wells, Clemson University, Clemson, South Carolina, USA

Purpose

The International Society of Arboriculture (ISA) has developed a series of Best Management Practices (BMPs) for the purpose of interpreting tree care standards and providing guidelines of practice for arborists, tree workers, and the people who employ their services.

Because trees are unique living organisms, not all practices can be applied to all trees. A qualified arborist should write or review contracts and specifications using national standards and this BMP. Departures from the standards should be made with careful consideration of the objectives and with supporting rationale.

This BMP is for the planting of all types of nursery stock, and for trees being dug and replanted (transplanted) from other locations. It also serves as a companion publication for the *American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Management—Standard Practices (Planting and Transplanting)* (ANSI A300, Part 6).

Introduction

It takes only a short time to plant a tree, but how it is done can have lasting effects. Mistakes made when planting trees are difficult and costly to correct later. Even if the species selected is well matched to the planting site, shortcutting the planting process can result in a tree that is short-lived, or will struggle for many years and never reach its full potential as a healthy, vigorous addition to the landscape. Attention to details made at planting time will pay dividends for years.

The process of planting a tree is usually accomplished quickly, but is only one small part of successfully establishing a new tree. The site assessment and preparation that precede planting may involve considerably more time and expense, especially on disturbed sites. Spending more on site preparation than the tree itself is often a good investment. Careful selection of a tree species well matched to the site, and the use of vigorous, healthy nursery stock with a well-developed root system are essential, but they will not compensate for poor or improper site preparation and planting procedures.

The planting job is not finished when the soil is placed back into the planting hole. Care taken during the initial establishment period, especially watering, is also critical to successful tree establishment. Larger trees may require several years to establish, with judicious watering necessary throughout the establishment period. Even the best watering program, however, cannot eliminate stress completely, and stress can lead to other problems, such as canker diseases and susceptibility to wood-boring insects.

The best management practices in this publication focus on the process of tree planting and care during the initial establishment period. Species selection, nursery production, site design, and care after establishment are outside the scope of this BMP. As its name implies, this BMP is the best information available now, derived from research and practical experience alike. Some practices may still be controversial. This brief document cannot fully answer questions about why a practice is best or which alternatives might be available for special situations. More information is available in other publications listed in the references at the end. *The Practical Science of Planting Trees*, available from ISA, is broader in scope, is more in-depth, and contains many references to the scientific literature on tree planting.

1. Time of Planting

Many factors contribute to determining the best season for planting. Choice of transplanting season can either minimize or increase water stress. In temperate climates, the most favorable environmental conditions and appropriate plant growth stage coincide in autumn and spring, making them the preferred seasons for planting, but calendar dates for optimal autumn and spring planting times vary by region. In warmer regions, where rainfall is seasonal, planting just prior to or in the rainy season can minimize the need for irrigation.

Over time, methods have been developed to extend the planting season. In temperate climates, trees are routinely planted throughout the year unless the soil is frozen. All types of nursery stock will require a higher level of maintenance after planting if transplanted at less favorable times.

Bare-root trees are typically dug and replanted while dormant. To hold them for planting later in the season, these trees can be held with their roots in an irrigated pea gravel bed to increase fine root development before planting. This practice is commonly known as the Missouri Gravel Bed system.

For trees dug with soil balls, when to dig is usually more important than when to plant. With proper care, trees dug in the dormant season can be held in the nursery for planting throughout the growing season. Summer digging is possible or even desirable in some situations. Extra steps, such as stage digging or hardening off, may be necessary (see glossary). Trees grown in containers can be planted in any season because root loss is minimal.

Trees planted in the autumn may have additional time for new root growth before the onset of summer heat and stress. However, several weeks of warm soil temperatures (above 50°F, 10°C) are needed after planting to support active root growth. In warmer climates, soil conditions may be suitable for root growth year-round. Some species, such as many magnolias (*Magnolia* spp.) and oaks (*Quercus* spp.), do not transplant well when dug in the autumn, though practices may vary by region.

2. Selection of Nursery Stock

Selecting the appropriate species and nursery stock type, and handling them to avoid root and stem damage after they leave the nursery, is critical for successful planting. Several regional nursery stock grades and standards have been developed to assist consumers in choosing quality planting stock. Trees that arrive at the planting site in excellent condition will have the greatest likelihood of survival. Significant mechanical injury, serious root defects, and trees that show signs of dehydration, are conditions that may be cause for rejection.

It is important to know the source of the trees you purchase. If trees were grown in local nurseries for several years from plant material that originated in a similar climate, there is a good chance they are adapted to local conditions. Trees shipped from a region with a different climate may not be hardy, unless the source of the trees used for propagation was from a region similar to yours and they possess the natural ability to withstand the climate extremes in your region. Also, be aware that hardy stock shipped from a warmer climate early in the season may have already broken dormancy and can be damaged by cold temperatures after it arrives.

Several types of nursery stock are available. Each has its advantages and limitations.

Bare-Root Trees

Bare-root trees are field-grown and dug without soil. This is a common way to produce small trees. Bare-root trees are usually dug when dormant, typically in the autumn, or during winter in moderate climates, to be available for early spring planting. Recommended minimum root spreads for nursery-grown bare-root trees are shown in Table 1.

Trees are stored and shipped before buds begin to swell. To prevent root damage from cold temperatures and desiccation, over-winter trees in temperature- and humidity-controlled buildings. In moderate climates, they can be stored outdoors by covering the roots with sawdust, mulch, or soil, a process referred to as 'heeling in.'

Conditions during shipping are as important as storage conditions. Enclosed, temperature-controlled trucks should be used for long-distance transport of bare-root stock. Pack roots in moist peat moss, straw, shredded newspaper, sawdust, or wood chips, or dip in a clay slurry or hydrogel to reduce desiccation.

In temperate climates, achieve the best success with bare-root trees by planting in late winter or early spring. Planting during these periods allows time for fine root development before the leaves emerge. Some deciduous genera, such as oak (*Quercus*), birch (*Betula*), hackberry (*Celtis*), and hawthorn (*Crataegus*), may benefit from "sweating" (being kept in a warm, humid environment until the buds have begun to swell) before planting, to avoid a delay in budbreak after planting.

Table 1. Examples of recommended minimum root spread for nursery-grown bare-root trees (ANSI Z.60.1).

Caliper*		Height		Minimum Root Spread	
in	cm	ft	m	in	cm
½	1.25	5–6	1.5–1.8	12	30
1	2.5	8–10	2.4–3.0	18	45
1½	3.8	10–12	3.0–3.6	22	55
2	5.0	12–14	3.6–4.2	28	70

*Measured 4 inches (10 cm) above ground level

Ball and Burlap

Moving trees with a soil ball is the most common method of planting trees in colder climates. This type of nursery stock is often referred to as ball and burlap (B&B) or field grown. Table 2 lists the standards for minimum root ball dimensions of nursery stock in relation to tree size in the United States and Europe. Standards for larger trees in the United States maintain the 10:1 root ball diameter/trunk diameter ratio for trees up to 12 inches (30.5 cm) caliper and are reduced to 9:1 for trees 12 to 18 inches (30.5 to 46 cm) caliper and to 8:1 for trees over 18 inches (46 cm) caliper (ANSI A300, Part 6). Some growers increase the minimum root ball sizes, especially for trees dug in summer, for multi-stem forms, and for species that have a reputation for being difficult to transplant.

Root pruning is the process of severing roots of a field-grown tree to increase root branching before final harvest. Each successive root pruning cut, and the final root ball cut, must be located outside the previous root cut. European standards call for root pruning by transplanting up to six times, depending on the size of the tree. This allows for smaller minimum root ball sizes.

Root pruning is not required by the American standards. The practice is sometimes used to increase post-harvest survival or produce a smaller root ball for special situations. Because root pruning can slow top growth, root-pruning practices vary. Trees that grow slowly and those with dense, highly branched root systems are not typically root pruned after being planted in the nursery field and grown to landscape size. Rapidly growing trees are more likely to be root pruned in the first few years after being planted as liners, in part to slow top growth and create a more attractive plant. Root pruning may be essential on wild-collected trees because they have less dense and wider-spreading root systems.

In some areas, container-grown liners are used to produce field-grown trees that are harvested B&B. The early container phase of production can create circling and other types of defective interior roots that will cause future problems. It is best to ask the supplier about their production system, as these defective roots can be difficult to detect.

Table 2. Examples of recommended minimum root ball sizes for field-grown nursery trees. The European standard is based on trunk circumference (cm). The American standard (ANSI Z60.1) is based on trunk diameter. Some values have been rounded to merge the two standards into one table. Smaller root balls recommended in the European standard may be explained by frequent transplanting during nursery production and measurement higher on the trunk.

Maximum Trunk Size				Times Transplanted[3]	Minimum Root Ball Diameter			
Caliper[1]		Girth[1,2]			European Standard		American Standard[4]	
in	cm	in	cm		in	cm	in	cm
1.0	2.5	3.1	8	—	10	25	16	40
1.5	3.8	4.7	12	3	14	35	20	50
2.0	5.1	6.3	16	3	18	45	24	60
2.5	6.4	7.9	20	3	22	55	28	70
3.0	8.0	9.8	25	4	24	60	32	80
4.0	9.6	11.8	30	4	28	70	42	105
4.5	11.1	13.8	35	4	31	80	48	120
5.0	12.7	15.7	40	5	35	90	54	135
6.5	15.9	19.7	50	5	47	120	65	165
7.5	19.1	23.6	60	6	51	130	75	190

[1] Measured 6 inches (15 cm) above the ground, up to and including 4-inch (10 cm) size, and 12 inches (30 cm) above the ground for larger sizes.

[2] Circumference measured 39 inches (1 m) above the soil.

[3] Specified only by the European standard. Using the same criteria, most field-grown trees in the United States would be transplanted twice.

[4] Root ball depth should not be less than 65 percent of root ball diameter when its diameter is less than 20 inches (50 cm). When root balls are 20 inches (50 cm) or larger, the depth should not be less than 60 percent of diameter.

Tree Spade

Tree spades use mechanical steel blades to form the soil ball. Procedures for moving trees with a tree spade are similar to those for B&B. Root ball size should be similar to other methods of digging soil balls.

Tree spades are more frequently used to transplant trees during the growing season than other methods, and trees transplanted using this method may require special care after planting. Frequently watering the root ball may be required to minimize stress. Antitranspirant applications may also be used to reduce water loss (see *Watering*, later in this publication). The period when young, tender leaves are actively growing and not yet mature is usually the most difficult time to transplant trees, and the tree spade method is no exception.

When a spade-dug root ball is placed into another hole dug by a tree spade, there is often a gap between the root ball and the sides of the hole. Fill these air pockets with loose soil using a hand spade or an air excavation tool.

Digging a wide hole is often not practical when using a tree spade, but the practice is beneficial. Alternatively, soil around the root ball can be cultivated and amended, if necessary, to improve soil contact with the root ball and provide a favorable environment for new root growth. Cultivate surrounding soil with a hand spade, rototiller, or air excavation tool.

In-Ground Fabric Bag

In-ground fabric bags are used to restrict root spread of field-grown trees. The fabric sides of the bag are designed to constrict roots as they penetrate the fabric. Roots may proliferate within the bag, resulting in a denser root system in the root ball. Tree size should be within specified limits for the size of the fabric bag (Table 3).

Table 3. Examples of recommended minimum fabric bag sizes for nursery-grown plants (ANSI Z60.1).

Caliper[1]		Height[2]		Fabric Bag Diameter	
in	cm	ft	m	in	cm
1½	3.8	4	1.2	12	30
2	5.0	6	1.8	16	40
2½	6.3	7	2.1	18	45
3	7.6	8	2.4	20	50
3½	8.9	10	3.0	22	55
4	10.2	12	3.7	24	60

[1]Diameter of deciduous trees measured 4 inches (10 cm) above ground level
[2]Shrubs and evergreens

Container Grown

Nursery production of trees has been shifting from in-ground field production to above-ground container production. Container production is now used extensively in warmer climates, and is growing in popularity in some cooler climates. Plastic pots are the most common containers. Wooden boxes can serve as containers for larger trees.

Trees should be the appropriate size for their final container (Table 4), and root systems must be developed well enough to hold the substrate together without excessive circling or matting against the inside of the container. Problems associated with uncorrected circling or descending roots of container-grown stock may not be exhibited for years. Roots that circled in a smaller container used earlier in production may be hidden in the interior of the container or field-grown root ball. These conditions can only be detected by teasing apart or cutting into a section of the root ball. Internal defects usually cannot be corrected, which may lead to down-grading, or rejecting the tree.

Because container substrate is typically well drained and frequently irrigated in the nursery, container-grown trees will require frequent watering to avoid drought stress after leaving the nursery. Trees may dry out quickly during transport. During warm temperatures, irrigation may be required once or twice daily during the growing season. If the root ball of a container plant dries out, the soil may repel water. If that occurs, thoroughly re-wet the soil as soon as possible. Addition of a surfactant may be necessary to re-wet the substrate thoroughly.

Table 4. Examples of recommended minimum container sizes for nursery-grown trees (ANSI Z60.1).

Caliper[1]		Minimum Container Size	
in	cm	Class[2]	Liters
¾	1.8	3	11
1	2.5	5	19
1¼	3.0	7	26
1 ½	4.5	10	38
2	5.0	15	57
2 ½	6.3	20	75
3	7.6	25	95
3 ½	8.9	45	170
4	10.2	65	246
5	12.7	95/100	359

[1]Diameter of deciduous trees measured 4 inches (10 cm) above ground level
[2]ANSI Z60.1 container class designations approximate the volume in U.S. gallons

3. Proper Root Depth

Trees 2 inches (5 cm) caliper or larger may have visible structural roots (buttress roots or flare roots) and a slight swelling at the base of the trunk (trunk flare or root flare). A minimum of three or four of these flare roots are necessary for stability. Trees with deeper roots often grow well in high-quality nursery soil or container substrate, but then struggle to survive when planted at the same depth in landscapes with poor drainage. Avoid this problem by specifying and checking root depth before planting.

According to the American Standard for Nursery Stock (ANSI Z60.1), "Soil above the root flare shall not be included in the root ball depth measurement." If the resulting root-ball depth measurement does not meet the standard, you may reject the tree (Figure 1). You can remove excess soil over the root system if the remaining root ball depth meets standards and if root development at the bottom of the root ball has not been inhibited by the increased soil depth.

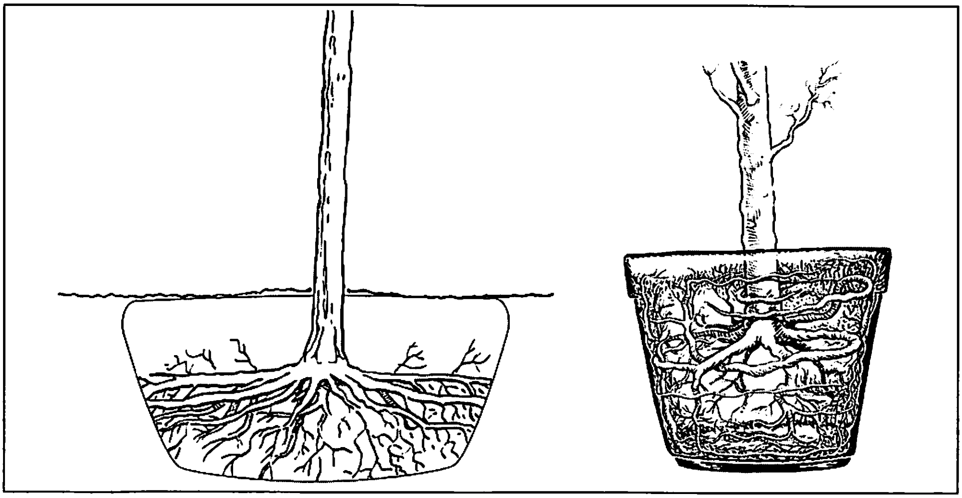


Figure 1. If the bottom of the trunk flare is not close to the surface in the nursery, the root ball will effectively be undersized and not meet current standards once the soil and roots above the trunk flare are removed. This applies to both field-grown and container-grown root balls.

To avoid issues associated with deep roots, check root depth while selecting trees at the nursery. This step allows the opportunity to have the nursery remove excess soil before digging. If that is not possible, contract specifications should define structural root depth and actions that will be taken if the specification is not achieved. If inspection does not take place until the trees arrive at the planting site and you determine that the roots are too deep, the situation may be more difficult to address. By the time plants arrive on the job site, there is often pressure to complete the job and not enough time to replace the trees. The supplier may be more resistant to replacing the stock after delivery.

Signs of root depth may be easily observed on some trees. If a gap forms between the trunk and the surrounding soil of a small, field-grown tree when the trunk is gently moved in a circular or rocking motion, it is an indication that the uppermost roots are too deep (Figure 2). The gap may already be present from natural trunk movement in the wind. If the excess soil above the trunk flare is filled with roots, a gap may not open, especially on container stock.

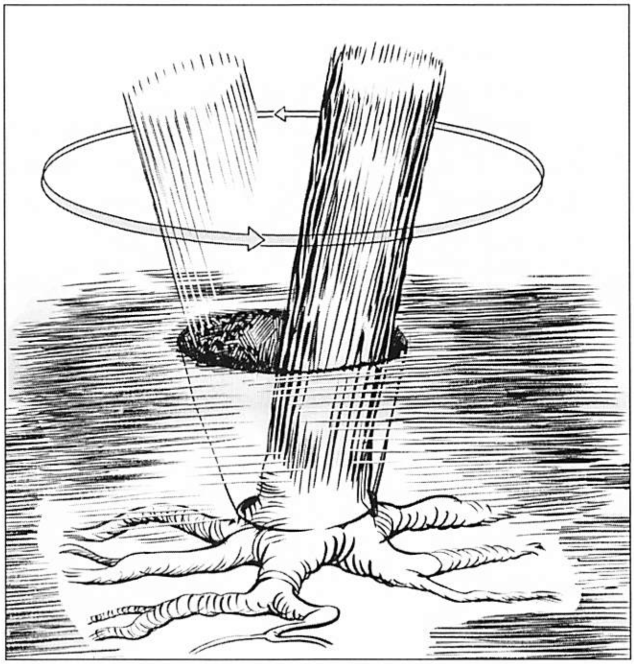


Figure 2. As the trunk moves in the wind, a gap forms around it if the roots are too deep. The deeper the root flare is buried, the wider the gap will be at the surface.

In some production systems, stems of small trees are cut back, usually about 1-2 inches (2-5 cm) from the ground, to promote growth of a grafted cultivar bud, or just to produce a straight, unbranched trunk. This cutting back results in a wound and a temporary crook (dog leg) in the stem. Both the wound and the crook become less prominent as the tree grows. If bud grafted, there may be a permanent change in bark texture at the graft point (Figure 3). These features provide evidence that the tree is planted at the same depth as originally planted in the nursery, but does not guarantee that the roots are at the correct depth.

If none of these three visible signs are present, you can investigate further to determine root depth. You might need to remove soil or container substrate to expose the flare roots. Alternatively, you can probe the root ball with a stiff wire, a surveyor's chaining pin, or screwdriver, to help locate roots. It is best to trace each root for a distance to confirm that it is in fact a root. Checking root depth can be difficult for container-grown trees of certain species that produce prolific roots at the surface.

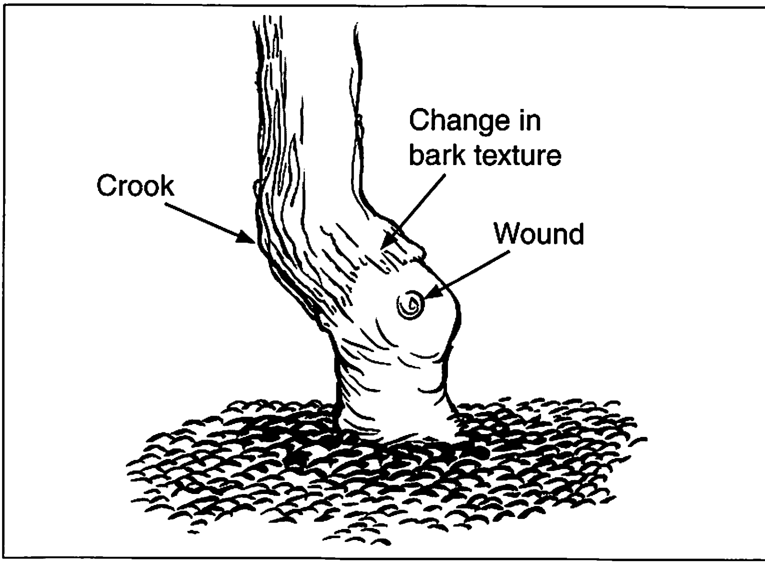


Figure 3. In some production systems, liner stems are cut back during production, creating a visible wound and crook in the stem. If visible, this is an indication that the tree is planted at the same depth as originally planted in the nursery.

4. Handling and Storing Trees

Except for small, bare-root trees, lift all trees by the root ball or container—not by the stem. Very large trees require special equipment, such as chain or strap harnesses, winch trucks, forklifts, or cranes. Lifting cables, chains, straps, and slings must be inspected and certified [*see* Annex C of *ANSI A300, Part 6 (Planting and Transplanting)*]. While the majority of the tree's weight should be borne by the root system, sometimes you must also support trees by the trunk to maintain control as they are tipped (Figure 4). If any part of the lifting or support mechanism touches the trunk, protect the trunk with padding. Use a wide sling that will not dig into the bark tissue. Some species may be more prone to bark separation during spring.

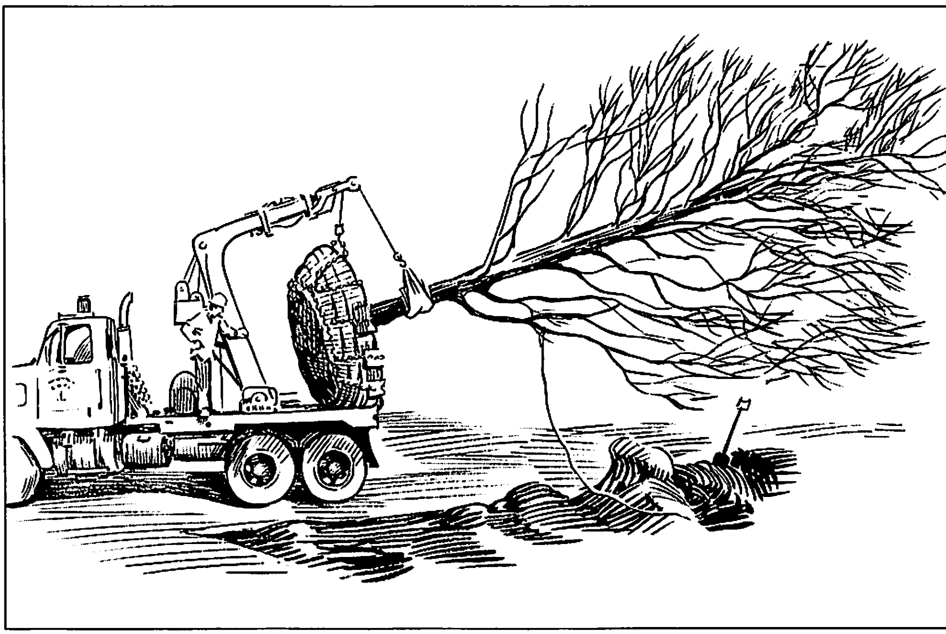


Figure 4. Larger trees must be lifted by the root ball and supported by the trunk to maintain control. The lifting force is directed to the root ball, and the trunk must be protected from damage.

To avoid damage to larger trees with spreading branches during harvest and shipping, tie the branches to reduce their spread. This is often easier to do after the tree is dug and can be tipped more horizontally for better access. Do not tie the limbs so tightly that the bark is compressed by a sharp bend at the base of the branch. Smaller trees often do not need to be tied.

Secure trees as they are loaded onto a truck or trailer bed for shipping, and take care to avoid injuring the tree or breaking the root ball. It is imperative to cover trees in-leaf transported on an open bed. Fabric tarps are commonly used for this purpose. Even dormant trees and their root balls can be desiccated, and branch tips and buds can be mechanically damaged from whipping in the wind when transported uncovered at highway speeds. In warm weather, cover trees in-leaf immediately before transporting and remove the cover immediately after arriving at the destination to avoid heat buildup under the covering.

The importance of keeping the root ball moist during and after shipping cannot be stressed strongly enough. Root balls may arrive at the planting site in a very dry condition if it has been a few days since they were loaded at the nursery. Inspect trees and root balls thoroughly when they arrive. Dry or damaged root balls may violate the contract and may trigger rejection.

Trees can be stored for an extended period in the nursery or after delivery to the planting site, but they must be cared for properly. Do not allow the root ball to dry out or heat up in the sun. To reduce moisture loss, cover B&B root balls with loose, damp wood chips or sawdust, or wrap with white plastic shrink- or stretch-wrap. If being held in the nursery, wrapped root balls are sometimes placed back into the same hole lined with a fabric sleeve, or containerizied by putting the unwrapped root ball into a container and adding soil to fill it. Regular irrigation is required for all these storage methods. For certain species and in some regions, partial shade and wind protection are beneficial to reduce water loss and allow the tree to adapt to this new root configuration, especially in summer.

B&B root balls mulched-in for an extended period may begin to grow into the mulch. The natural tendency is to try to preserve all new root growth when the tree is moved, but doing so may be problematic. It will be difficult and time consuming to reposition the roots in their correct orientation while backfilling the planting hole—and therefore, it will be difficult to prevent kinked or descending roots. It may be necessary to cut roots back to the soil ball to avoid future problems.

5. Planting

Digging a hole, placing a tree into it, and refilling the hole with soil, is often considered tree planting. But what precedes and follows planting is also important. Think of planting as the process that starts with a site condition evaluation and ends with after care.

Drainage

Most tree species cannot tolerate saturated soils during the growing season. Therefore, planting holes must provide adequate drainage. When soil permeability is low, soil in the planting hole can remain saturated for long periods. Even short periods of saturation can kill roots of many species. Irrigation systems designed to provide large amounts of water to lawns often over-irrigate trees. Excess water can easily accumulate in planting holes, even during severe droughts, saturating the soil and driving out the oxygen needed by tree roots.

To assess potential soil drainage issues, you can conduct a simple percolation (or perc, for short) test before planting. Auger a hole 4 inches (10 cm) in diameter and as deep as you expect the root ball to be. Fill the hole with water to pre-saturate the soil. For one hour, refill as needed to maintain the water level, then stop adding water. After 24 hours, refill with water to 12 inches (30 cm) from the bottom of the hole and measure the rate of fall of the water surface. A drainage rate of less than 1/4 inch (0.6 cm) per hour indicates that it might be necessary to provide drainage from the planting hole.

Solving drainage problems can be expensive, but doing so is essential for sustainable tree performance. In poorly drained soil, improving drainage on the entire site is the best approach for long-term tree health. Drainage for individual trees can be improved in several ways to help trees through the initial establishment period, giving the tree the opportunity to adapt to difficult site conditions.

Occasionally, a well-drained layer of soil exists underneath a poorly drained layer. If this is the case, you can drill a vertical hole through the poorly drained layer and fill it with gravel or coarse sand to provide a path for the water to flow down to the well-drained layer.

You can use perforated plastic pipe, or products manufactured specifically to create drainage channels, to discharge water from the bottom of the planting hole to a lower level some distance away from the planting hole.

A 3-inch fall per 100 feet (7.5 cm per 30 m) of pipe is the minimal slope to obtain adequate water flow. This approach works well for trees planted on slopes. If excess water cannot be drained away to a lower area or a deeper soil layer, tree species that tolerate poor drainage may be needed, or the site may not be suitable for planting trees. Small-sized nursery stock may be able to establish better on poorly drained sites than larger trees because their roots are not as deep.

A layer of gravel in the bottom of the planting hole will not improve drainage and can, in fact, make drainage worse. Water accumulates in the finer-textured soil above this layer of coarse gravel until the soil is saturated. This situation creates a perched water table (Figure 5).

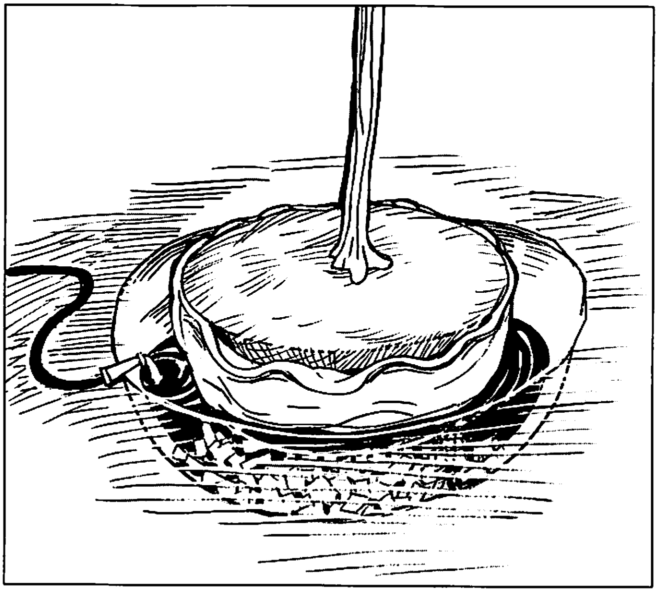


Figure 5. The once common practice of using a layer of gravel at the bottom of the planting hole to improve drainage actually causes water to be held in the soil of the planting hole until it becomes saturated. Only then will water move into and through the gravel layer.

Soil Nutrients, Organic Matter, and pH

Conduct a soil test to determine soil nutrient, organic matter, and pH levels prior to planting. If soil tests reveal conditions that will limit tree performance, amending the fill soil is rarely effective at correcting the long-term problem. Amend the entire planting bed or a large circle around an individual tree to improve long-term performance.

All tree species have ideal pH ranges. Some are quite narrow. It is best to choose a species that is adapted to the site pH. Within limits, soil can be amended to change its pH. Add composted organic matter to increase nutrient and water holding capacity of the soil. If nutrient deficiencies exist, apply fertilizer in accordance with soil analysis results.

Root Depth

American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Management—Standard Practices (Planting and Transplanting) (ANSI A300, Part 6) uses the following wording to describe planting depth: "The bottom of the trunk flare shall be at or above the finished grade." Clarification of this statement is critical for applying the standard during planting.

Trunk flare is defined in the A300 standard as "the area of transition between the root system and the trunk." The nature of the trunk flare can vary with tree species, age, and nursery production method. The trunk flare can be a distinct curve when roots are horizontally oriented (Figure 6, left side), or a gentle slope on very obliquely angled roots (Figure 6, right side). On very small trees, the trunk flare may be quite inconspicuous until a curve develops from enlargement of the top of the roots and base of the trunk.

The standard uses the lower limit of the trunk flare (also called root flare) area as a specific point that determines the proper planting depth, but it does not describe how to locate that point. Therefore, this BMP defines the bottom of the trunk flare as the upper surface of the root at the point on the trunk flare where the root becomes distinctly separated from the base of the trunk.

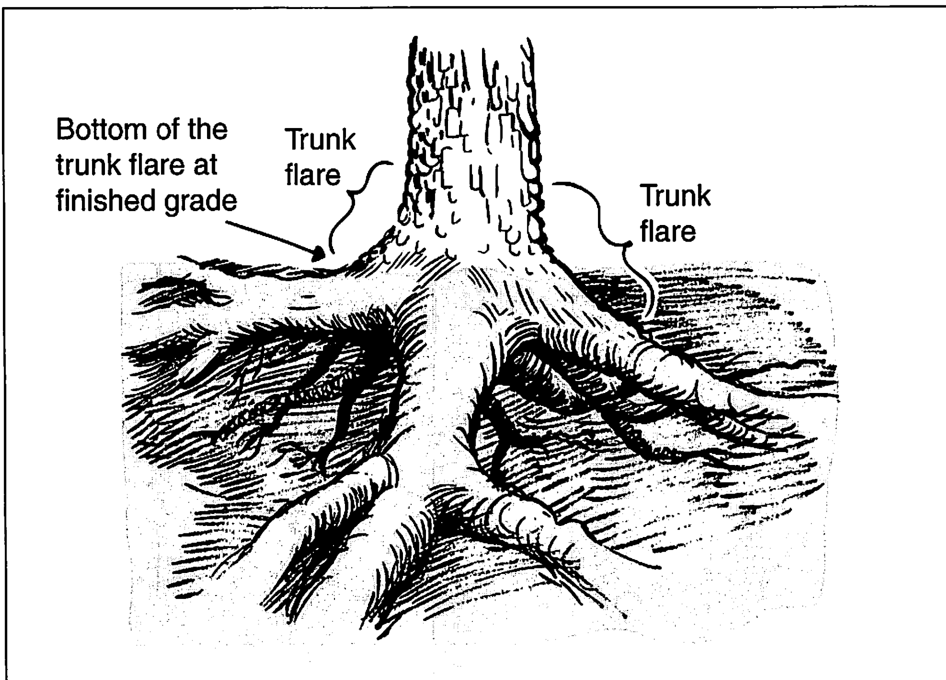


Figure 6. The trunk flare is the area of transition between the root system and the trunk. The lower limit of the trunk flare on the shallowest root should be at grade.

Each root at the base of the tree has a trunk flare but they are not all located at the same depth. The shallowest "bottom of the trunk flare" determines the planting depth (Figure 6, left side).

The bottom of the root flare is not always at the surface of the soil ball on trees received from the nursery, but it is impractical to reject every tree with excess soil over the roots. Dig a planting hole shallow-enough to compensate for the excess soil and remove the soil above the buttress roots (Figure 7). However, this can create other problems.

Figure 7. If structural roots are below the surface in a root ball, adjusting the planting height to place the trunk flare at the correct depth is an option. Removing excess soil could cause sudden injury to sensitive bark.

There are currently no widely accepted guidelines supported by research or practice for how much soil over the roots can be removed without risking harm to the tree. Understanding the implications of the roots being too deep can help guide this decision. On field-grown trees, extra soil over the roots often means the absence of soil containing roots at the bottom of the root ball, resulting in a smaller harvested soil ball and root system than called for by standards. Because there are typically fewer fine roots at the bottom of a field-grown root ball than near the surface, root loss may not be proportional to the amount of soil absent. A 20 percent reduction in soil volume may be only a 10 percent reduction in roots in the ball. Container root balls are usually filled with roots uniformly, and root loss is more proportional to the amount of container substrate removed over the trunk flare.

When soil is removed from the top of the soil ball, bark that was protected by soil is suddenly exposed to the more extreme aboveground environment. Injury from heat and cold has been reported under these circumstances, especially on young, thin-barked trees. To help the bark acclimate, replace the soil with mulch that will decompose and slowly expose the tissues.

Planting Hole Depth

Placing flare roots too deep in the planting hole is the most common mistake made during planting—a mistake that is difficult to correct when discovered months or years later, without replanting the tree. To minimize settling, do not disturb the soil under the root ball. Re-compact the soil if it has been disturbed. For B&B root balls with the bottom of the trunk flare correctly located at the surface, the planting hole can be 1-2 inches (2.5-5 cm) shallower than the root ball depth, in anticipation of some minor settling and flattening of the root ball. Container-grown stock has been shown to settle more than B&B because of the soil-less substrate used, so holes can be 1.5 to 2.5 inches (4-6 cm) shallower than the container's depth.

Planting Hole Width

For most transplanted tree species in humid areas, the majority of the initial root growth radiates out from the root ball at a fairly shallow depth, typically within the upper 6-12 inches (15-30 cm) of soil. The planting hole should not restrict initial root growth.

On sites with high-quality soil, the planting hole needs only be wide enough to facilitate planting. On sites with poor-quality soil (compacted, clayey, rocky, or poorly drained), dig wider planting holes. A wider hole, or cultivated surrounding soil, provides a greater volume of friable soil for rapid initial root growth and faster initial establishment.

Digging a wide hole with sloped sides uses the majority of the digging effort to excavate surface soils where the roots will grow most vigorously. If the roots are unable to grow into the compacted subsoil, a hole with sloped sides will allow them to gradually grow back up toward the better-quality surface soils and continue to spread beyond the planting hole. For most species planted on sites with poor soils, a planting hole or loosened soil area that is *at least* two times the width of the root ball diameter is required. A wide hole dug to the full depth of the root ball may not provide any additional usable root space if the soil at the bottom of the hole is saturated at times.

When preparing a wide planting hole, it may not be necessary to remove all the soil from the hole and then put it back again (Figure 8). It may be more efficient to first dig a planting hole at least one and one-half (150%) as wide as the root ball. Then, after the tree has been set but before the hole is backfilled, use a shovel to slope the edges to about half the hole's depth and allow the soil to fall in the hole.

Species with very aggressive root growth, such as American elm (*Ulmus americana*) and poplar (*Populus* spp.), may be able to establish on poor-quality sites without the planting hole being enlarged. Remember, the same characteristics that help these species grow well under difficult conditions also make them most likely to have root conflicts with infrastructure, especially if planted too close to pavements and structures.

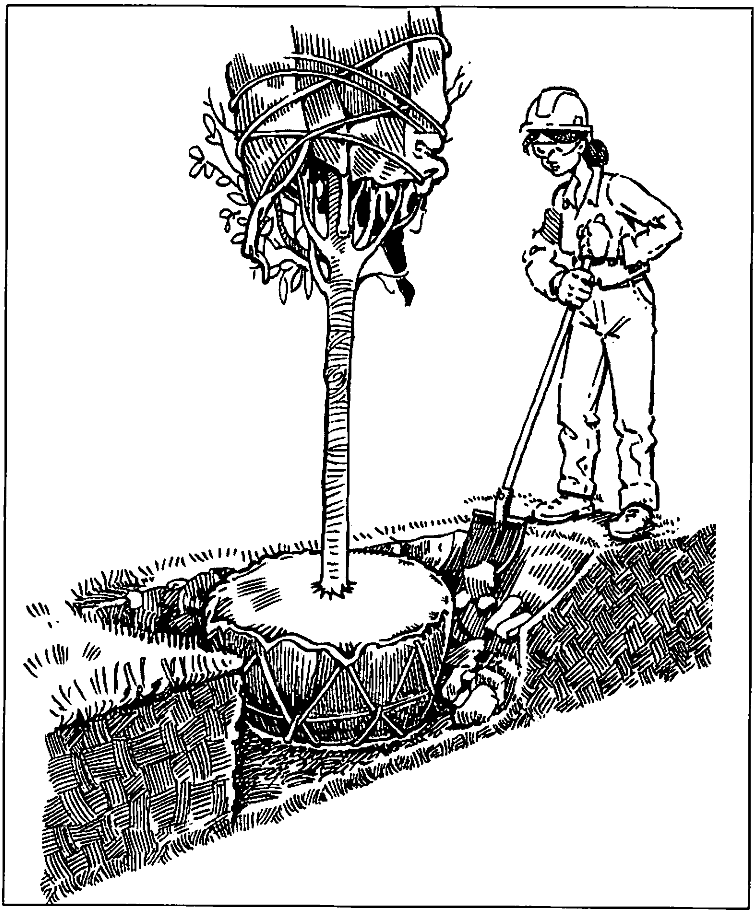


Figure 8. The planting hole should be wider at the top than at the bottom to accommodate the natural root growth pattern. Augered holes with vertical sides can easily be widened with a shovel.

Glazing and Drying

Glazing is the localized compaction of soil that may restrict root development. Digging with an auger or mechanical tree spade sometimes results in soil glazing along the perimeter of the planting hole. Clay soils glaze most readily. Roots may have difficulty growing through the glazed surface. It is best to eliminate the potential for trouble by using a shovel, hard tine rake, or other hand tool, to break up glazed surfaces before planting.

If holes are dug in advance and left exposed, the soil along the hole's perimeter may become dry and very hard. Break up the dry surface to expose moist soil before planting.

Preparing the Root Ball for Planting

After digging the planting hole, prepare the root ball. For containerized stock, either pull or cut off the container. For fabric bag stock, remove the entire bag before placing the root ball in the planting hole. For B&B trees, it is best to leave the wrappings on until the root ball is in the final location in the hole to minimize damaging it, but this is not always possible. If the root ball is covered with synthetic burlap or plastic, it may need to be removed before placing the tree in the hole in order to remove it completely. If the root ball is wrapped with a wire basket and natural burlap, remove the upper 1/4 to 1/3 of the wire and burlap after the ball is set in the hole. For bare-root stock, shake off excessive amounts of any material used to keep the roots moist.

Once the root ball is exposed, this is the last opportunity to cut circling and defective roots that may affect future tree health and stability. Remove all roots growing against the inside of the container wall with a shovel, or pull them apart with a stiff-tined tool. Shaving the root ball is an effective method for reducing future root defects, and is done by removing (or 'shaving') a thin layer from the sides and bottom of the root ball. It may be possible to sever interior circling roots by plunging a shovel, axe, hatchet, or similar tool, deeply into the root ball toward the trunk, but the tree may not survive this extensive damage to the root system.

After the planting hole and root ball are prepared, carefully place the tree in the middle of the hole, support the trunk in the vertical position. Stabilize the root ball by tamping soil firmly around its base. Add the remaining backfill soil in layers, or 'lifts,' typically 6 inches (15 cm) at a time. Lightly tamp or thoroughly water each lift to reduce the number of large voids. If the soil is at all dry, apply water after each lift is tamped. For bare-root stock, use water to wash soil between the roots and stabilize the tree by lightly tamping the planting hole after it is filled.

If water infiltration into the root ball's soil is slow after the fill soil is added, create a ring of soil around the outer edge of the root ball. This soil ring can help water penetrate into the root ball without running off into adjacent soil. Irrigate the entire planting hole area after planting to thoroughly wet the root ball and backfill soils. Routine irrigation is needed during the establishment period (see *Watering*, later in this publication).

Mulching

Mulch can improve growth and establishment of newly planted trees. Use organic mulches to conserve soil moisture, buffer soil-temperature extremes, control weeds and other competing vegetation, and replenish organic matter and nutrients in the soil. All of these benefits lead to improved root growth.

Water from light rainfall or irrigation may be absorbed or shed by the mulch layer, causing root-ball soil to be drier, especially in the first few months after planting when the root spread is limited. Increasing the amount of irrigation, applying water via drip irrigation below the mulch, or delaying application of mulch, may be necessary in such cases.

The size of the area to mulch depends somewhat on the size of the tree. For landscape trees up to 3-inch (7.5-cm) caliper, a 6- to 9-foot (2- to 3-m) diameter circle of mulch is enough. In temperate climates, it may be best not to apply mulch to trees installed in the early spring until after the soil has warmed, because mulching may delay soil warming. This is usually not a major problem in established mulch areas because the mulch insulates the soil over the winter.

The mulch layer should not be more than 2 inches (5 cm) deep after settling. Do not allow mulch to cover the base of the trunk because contact may lead to bark injury from fungi or rodents. Mulch is often incorrectly piled up to a foot (30 cm) deep in a small circle only about 3 feet (1 m) wide around the tree trunk. This mulching practice is of little or no benefit to the roots—it sheds water, can be potentially damaging to the trunk, and is aesthetically unpleasing.

Crown Pruning

Pruning is necessary to develop a strong structure. However, at the time of planting, pruning should primarily be for removal of broken, dead, weak, or diseased branches, and unnecessary sprouts from the root system. Pruning to compensate for root loss has been shown through many research studies to be unnecessary. Over-pruning reduces photosynthesis and production of root-stimulating auxins to such an extent that all growth could be reduced. Excessive pruning can also destroy the tree's structure and introduce decay.

Additional pruning may be required to develop a central leader to the very top of excurrent trees, if this was not accomplished in the nursery, or if the leader has been accidentally broken. Transplanting stress can reduce apical dominance in the years following planting. To prevent development of codominant stems, remove or reduce the length of upright-oriented stems throughout the crown, including those in the top half.

Support Systems

Staking, guying, and bracing are methods for mechanically supporting the trunk of a newly planted tree to keep it in an upright position. Such support is not required for all newly planted trees. Bare-root trees, as well as fabric-bag and container-grown trees with small, lightweight root balls, may require support until lateral or anchor roots develop. Large evergreens may need to be guyed because of the high wind resistance of the foliage and extra weight of snow and ice accumulation during winter. Locations with persistent or strong winds or other unusual circumstances may require more frequent use of support systems.

Disadvantages of staking include expense, trunk girdling if guys are not removed (or adjusted) after approximately one year, and the potential tripping hazard created by the stakes or guys.

Attach supports low on the trunk to keep the tree in place while permitting the top to move freely. Two stakes with separate flexible ties are commonly used, but they provided inadequate support when tested. Three stakes provide better support. It is often easier to install stakes before the hole is backfilled. Guy wires and soil anchors are used on larger trees. Turnbuckles can be installed to make adjustments in guy-length. Compression springs can provide flexibility for trunk movement. Excessive tension in the guy wires can cause the trunk to break at the attachment point as the tree bends sharply in the wind.

Table 5. Examples of minimum material requirements for tree guys.

Maximum Tree Caliper		Minimum Working Strength		Polypropylene Rope		Polypropylene Webbing*		Steel Wire Class I, Galvanized		Soft Galvanized Cable 1 × 7		Aircraft Cable, Galvanized, 7 × 19	
in	mm	lb	kg	in	mm	in	mm	gauge	mm	in	mm	in	mm
1.5	38	75	34.0	3/16	4.8	3/4	19	16	1.3	NA	NA	1/16	1.6
2.5	63	100	45.4	1/4	5.4	3/4	19	16	1.3	1/8	3.2	1/16	1.6
4	101	180	81.6	5/16	7.9	3/4	19	14	1.6	3/16	4.8	3/32	2.4
6	152	320	145.1	3/8	9.5	1.0	25	12	2.0	1/4	6.4	1/8	3.2
8	203	640	290.3	NA	NA	1.25	32	NA	NA	5/16	7.9	3/16	4.8

Source: Dr. E. Thomas Smiley, Bartlett Tree Research Laboratory
*Polypropylene webbing strength varies by thickness. These sizes assume webbing is heavy duty; weaker and stronger webbings are available. In this table, ¾-inch webbing has a rated breaking strength of 900 lb (408 kg).

The traditional material for guying trees to stakes is a wire slipped through a piece of garden hose, but this method can sometimes cause damage. Guying material should be wide, smooth, nonabrasive, flexible, and, if possible, photodegradable. To prevent bark injuries, examine support systems at least once during the growing season and adjust if necessary. Table 5 contains examples of minimum material requirements for tree guys.

Underground root ball-stabilization systems are very effective and are sometimes necessary for aesthetic or safety reasons. They are made of structures or fabric straps over the root ball that are anchored into the soil at the bottom of the planting hole.

A simple and effective system can be constructed on the planting site by placing two pieces of untreated wood over the root ball, holding them in place with 4-foot-long (1.2-m) stakes at the edge of the root ball. The wood can be covered with mulch and will rot away in a few years (Figure 9). Avoid using a system that requires additional soil over the root ball. Consider the possibility of future damage to stump-grinding machines and injury to operators if using steel ground-anchors or cables.

Specially designed trunk guards and grates are often installed to prevent vandalism and to cover planting pits. Both structures can eventually interfere with tree growth. Although guards and grates may be desired in high-traffic areas, plan for their enlargement or removal as the tree grows. Alternatives include pavers and open planters surrounded by a low fence.

Trunk Protection

Where sunscald or frost cracks are common, wrap trunks of thin- and/or smooth-barked trees to prevent injury from winter sun. Trunk temperatures may rise well above freezing on cold, sunny days. Sunset or sudden shade from cloud cover can cause the bark to refreeze rapidly, possibly resulting in cambium injury. Damage appears several months later as dead bark that sloughs off in a long, narrow strip, usually on the south or southwest side (in the Northern Hemisphere) of the trunk. Wraps may also be used to protect trunks from the hot summer sun.

Not enough research data exists to completely support or reject the use of specific trunk wrap materials. The best wraps are light in color and biodegradable. Paper wrap continues to be the most widely accepted material, and users consider it effective in preventing sunscald. Maintaining directional orientation from the nursery to planting and proper watering may help minimize the stress that leads to trunk injury.

Wrap trunks starting from the bottom to the top so that layers overlap and shed water. At the top, secure the wrap with biodegradable tape or office staples. Never use nylon cord, wire, or fiber-reinforced tape.

Expandable plastic guards are sometimes used as protection against damage from sun, equipment, and animals. These guards can prevent small mammals from feeding on the bark at the tree's base, girdling the stem. Guards also protect against light mechanical injury from lawn mowers and string trimmers. Thin-barked trees are most susceptible to such damage. In trees stressed from transplanting, small wounds can enlarge to become a serious problem. If such guards are used, remove them after one or two years.

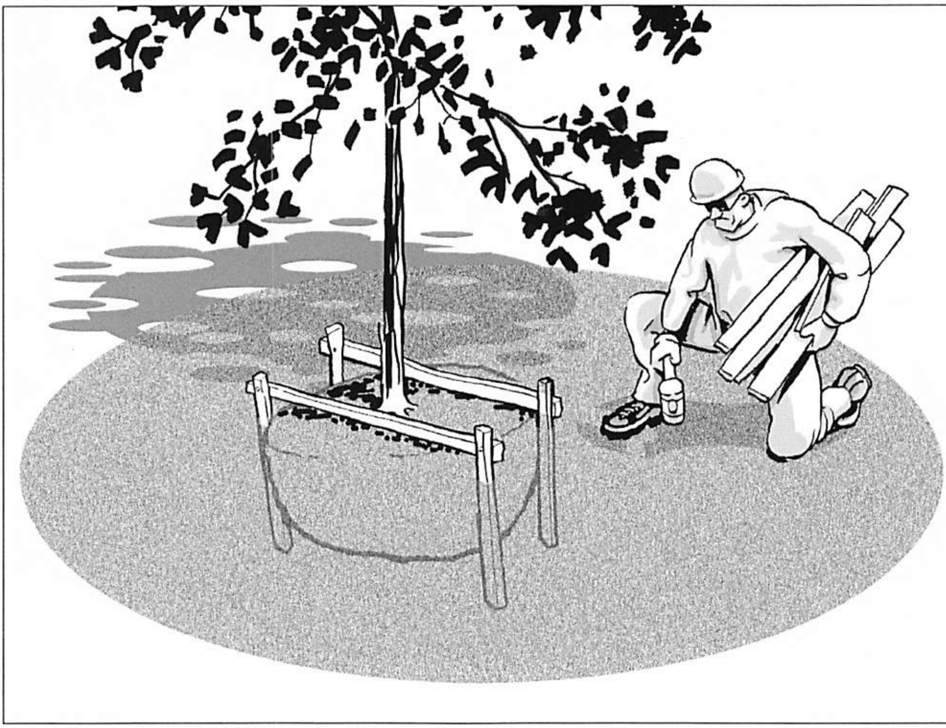


Figure 9. Underground guying systems can provide support for the tree.

Palms

Palms differ from deciduous and evergreen trees in a few important ways. Palms have an adventitious root system composed of numerous fibrous primary-roots with little branching that arise independently and continuously from the root initiation zone at the base of the stem. Some roots die back to the base when roots are cut during transplanting, and new roots are produced from the base.

For most species, a root ball with a 12-inch (30-cm) radius from the trunk and 12 inches (30 cm) deep is adequate to capture more than half the roots that will survive and produce new roots after being cut. In southern Europe, it is common practice for most palm species to be dug with root balls three times the diameter of the trunk. Species with relatively large trunks (such as *Phoenix canariensis* and *P. dactylifera*) are dug with root balls twice the diameter of the trunk. The few species, such as cabbage palms (*Sabal palmetto*), that must grow nearly all their new roots from the trunk after transplanting, need a root ball only large enough to protect the root initiation zone, about 6 inches (15 cm) out from the trunk, if transplanted directly from the field. Field-dug plants can be placed in a container to allow development of new roots and foliage that can be moved with the tree.

The small size and weight of the root ball offers no logical means of lifting by the ball. In most instances, palms are lifted by a strap or sling placed on the trunk just above the estimated balance point (center of mass). Use fabric slings with adequate padding because they offer a high degree of protection for the palm trunk.

Palm root balls are sometimes planted at varying depths to make crown heights more even. For most palm species, 2 inches (5 cm) of root initiation zone (often visible as a portion of the trunk where roots form above ground) should remain above the soil line. Research has shown pygmy palms (*Phoenix roebelenii*) to be an exception to that guideline. They can be planted with the visible portion of the root initiation zone buried.

Often, on trees freshly dug from a field nursery, some or all palm fronds are removed before transport. Complete frond removal to reduce transpirational water loss greatly improves survival of species such as sabal palm (*Sabal palmetto*), which must generate an entirely new root system after transplanting. For many species, frond removal offers no benefits. Some lower fronds may die soon after moving certain palms, and removing lower fronds that are likely to die and turn brown from transplant stress can improve post-transplant aesthetics. It is not necessary to remove any fronds from container-grown palms. Carefully protect the terminal bud on palms from damage, because it is only from this point that new growth develops.

Large palms are commonly supported with props or guys after planting (Figure 10). However, do not insert nails, screws, or mechanical devices into the trunk. A common method of bracing or guying is to strap short, vertical pieces of boards around the trunk with steel bands. The boards serve as an attachment point for angled support braces or screw eyes for guy wires.

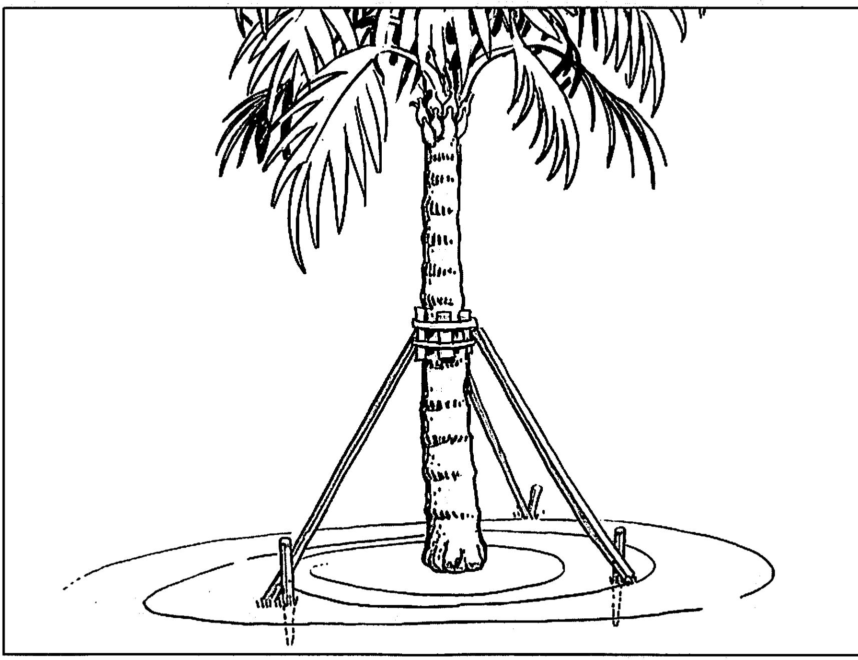


Figure 10. Palms often need support after transplanting. Use a system that will not injure the trunk.

6. Establishment After Planting

Newly planted trees experience water stress until the root system is established on the new site. Bare-root trees may lose much of their fine root system during transplanting but may retain most of their woody roots. Root balls of field-grown trees lose approximately 90 percent of their fine, absorbing roots during harvest (Figure 11). Root pruning in the nursery can increase this percentage. Container trees do not suffer such a major root loss during the planting process, even when root balls are shaved, but the roots only have access to very limited moisture in the small volume of container substrate, which typically has a very low water-holding capacity. Unless they are irrigated frequently, all trees experience high levels of post-planting stress from lack of water until the roots can grow into the surrounding soil and access adequate moisture.

The rate of new root initiation and growth out of the root ball is influenced by species, as well as by soil temperature, oxygen, moisture, and other physical and chemical characteristics of the site soil. For most species in warm soils, new roots will initiate in one week to two months. In cold soils, new root growth may not occur for many months.

Maximum root growth in most tree species occurs in spring to early summer, when soils are warm and moisture is adequate. In regions with cold winters, root growth may be minimal from late autumn through early spring (Table 6). In Hardiness Zone 5 (United States Department of Agriculture maps, based on the average annual minimum winter temperature), with its warm summers and frozen winter soils, roots grow at an average annual rate of approximately 18 inches (0.5 m). In Hardiness Zone 9, where the growing season is nearly year-round, annual root growth can be more rapid—up to 6 feet (2 m) on fast growing species. However, in warmer climates, summer soil temperatures may rise to levels that slow root growth.

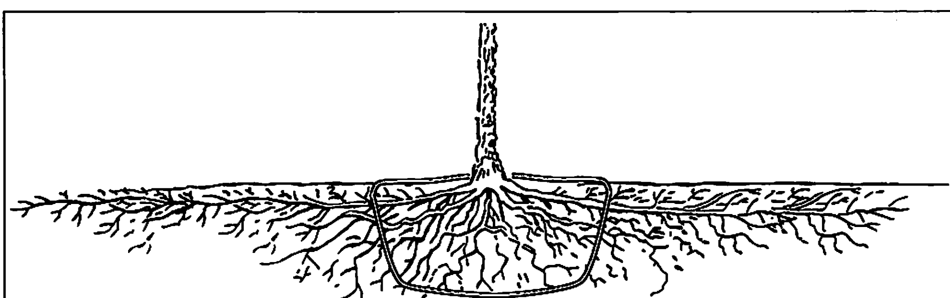


Figure 11. Field-grown trees lose the majority of their fine root system when harvested. Proper root pruning during the production process can reduce the amount of root loss.

Soil compaction can also reduce root growth. The level of soil compaction that inhibits root growth depends on soil type, soil moisture content, and tree species. Bulk density is not easily determined in the field. Experience is often the best tool for determining whether compaction is present.

Many products have been marketed as root stimulants for newly planted trees. Claims usually refer to "better" or "improved" root growth without reference to specific effects on the root system or to how they promote faster establishment after planting. Contents of root stimulant products may include growth hormones, nutrients, vitamins, sugars, amino acids, humic acids, extracts of plants, and inoculum of beneficial fungi and bacteria.

Research studies on the effects of these products on landscape trees and shrubs have been inconsistent. Given the wide variety of species and site conditions encountered in urban landscapes, it is not possible to predict whether the products will be beneficial in any one particular situation if added at planting time.

The most reliable way to increase root development is to manage soil moisture and aeration to provide a high-quality soil environment for roots to grow in.

Table 6. Roots grow best when soil temperatures are above 50°F (10°C). The number of days soil temperatures are above that level varies greatly from north to south. The longer that temperatures are at 50°F (10°C) and above, the more roots can grow in a single season and the faster a tree will establish.

	Date soil temperature at 4 inches deep (10 cm) reaches 50°F (10°C)		
USDA Zone	**Spring**	**Fall**	**Days above 50°F (10°C)**
8b	year-round	year-round	360
7b	26-Feb	15-Dec	289
6b	25-Mar	17-Nov	232
5b	9-Apr	4-Nov	205
4b	3-May	22-Oct	169
3b	14-May	16-Oct	152

7. Maintenance During Establishment

Watering

It is important to keep the root ball moist but not overwatered the first year or two after planting. Root ball soil is the major source of water for the tree until the root system develops outside of it. Before extensive root growth beyond the root ball, monitor its moisture level. Surrounding soils where there are few roots absorbing moisture often stay moist, but the root ball dries out quickly.

Newly planted trees require frequent watering to keep the root ball from excessive drying. Summer showers are usually not adequate to keep the root ball consistently moist. Even in cool climates, throughout the first summer, a newly planted tree will probably need water about twice a week, possibly more for container-grown trees. Recently transplanted container-grown trees in warm climates will often require more frequent irrigation—sometimes as frequently as daily—depending on soil type, substrate composition, and size of the transplant.

Estimates of the weekly amount of water required vary widely with weather conditions. In very hot summer weather, up to 10 gallons (40 L) of water per caliper inch per week may be needed. In cooler weather, that amount can be reduced by at least 50 percent. Products are now available that let water drip out slowly at the base of the tree and soak into the root ball, but frequent refilling is still necessary to keep the root ball from drying out.

To avoid overwatering or underwatering, monitor the moisture in the root ball. Probe the root ball and the backfill with a pointed metal rod or stiff wire for a good estimate of soil moisture. Very dry soil resists penetration of the rod and indicates the need for watering. If suction develops when removing the rod and the rod surface is muddy when removed, the soil is too wet. With practice, this can be an efficient and effective way to monitor soil moisture. Tensiometers can be used for more precise measurements.

Irrigation systems must be properly designed for trees. Systems that provide large amounts of water to surrounding lawns often over-irrigate trees. It is best if irrigation systems are zoned to separate trees and shrubs from turf. Irrigation may also need to be adjusted for the requirements of individual trees or shrub species.

In poorly drained soils, often one of the easiest remedies is to reduce irrigation rates. In excessively well-drained soils, irrigation rates during tree establishment may need to be increased.

Fertilization

Drought stress limits the growth of newly planted trees more than any other factor, until the root system can grow and absorb more water. Adding fertilizer at planting is not usually effective in speeding establishment. However, there may be special circumstances where addition of slow-release fertilizer at planting may be beneficial, including:

- Small trees that rapidly overcome post-planting stress may benefit from slow-release fertilizer applied at planting, especially those that have the potential to produce multiple flushes of growth.
- Trees with a constant and ample supply of soil moisture will be less water stressed, develop new roots more quickly, and benefit from fertilization earlier than infrequently irrigated trees.
- Root balls with low nutrient-holding capacity (for example, soilless substrate in containers, or sandy B&B root balls) may require earlier and more frequent fertilization to avoid nutrient deficiency, until the roots grow and have access to nutrients in the backfill and surrounding soils.
- Trees in climates with warm soils year-round may benefit from supplemental fertilization sooner than trees in colder climates.

In most cases, it is best to conduct a soil nutrient analysis before planting, then apply fertilizer to correct identified soil deficiencies.

Fertilization, especially with phosphorus, is often thought to cause a direct increase in root growth. There is no evidence that phosphorus increases root growth unless the soil is phosphorus deficient. Nitrogen has been shown to cause a localized increase in root growth, but other parts of the root system may be unaffected.

If fertilizing new transplants, use only a slow-release product (≥ 50 percent of nitrogen as water-insoluble nitrogen). See ISA's *Best Management Practices: Tree and Shrub Fertilization.*

Antitranspirants

Antitranspirants are foliage sprays that reduce water loss through the leaf surface. The spray dries and forms a thin, protective film on the leaf surface that usually lasts for several weeks before it cracks or weathers off. The film minimizes water loss by reducing all gas exchange in the leaf, so it can also reduce cooling and photosynthesis; therefore, do not over-apply an antitranspirant.

Antitranspirants provide a useful method of manipulating the water balance of trees after transplanting and can increase summer transplanting success. They are also effective in protecting autumn-planted conifers from excess desiccation during their first winter. Timing of application is crucial to successful use of antitranspirants. Do not substitute the use of antitranspirants for good transplanting practices and adequate maintenance after planting.

Pest Management

Wood-boring insects often attack newly transplanted trees. To prevent problems on susceptible species such as cherry (*Prunus* spp.) and maple (*Acer* spp.), insecticide treatments can be applied.

Fungal cankers are another common problem with new transplants. These fungi usually infect wounds. To reduce the likelihood of infection, treat any wounds created during transplanting with a registered fungicide or fungicide-enhanced wound treatment. Avoiding water deficiency or waterlogged soils is the best way to prevent cankers.

Pruning to Improve Structure

Improving branch structure may require pruning over several years. Improve the branch structure of large-growing decurrent (round-headed) trees by pruning when they are young. Rapidly growing lateral branches can compete with the central leader for dominance and develop weak branch attachments that could eventually fail. First, cut back these vigorous laterals to slow their growth. Remove them completely, if necessary, about two years later to fully establish a strong central leader (Figure 12). Permanent branches should be widely spaced vertically on the trunk and evenly distributed around the trunk, though proper spacing may take 10 to 25 years to develop.

When removing a branch, make pruning cuts just outside the branch collar when present. Use the standard three-cut procedure to avoid tearing bark on large limbs. See ISA's *Best Management Practices: Tree Pruning* for more details.

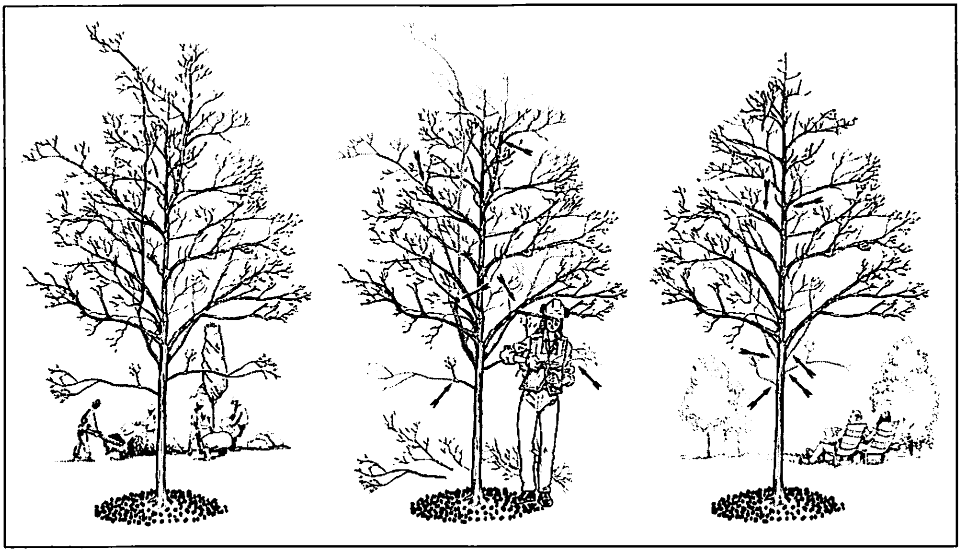


Figure 12. Rapidly growing lateral branches can compete with the central leader for dominance and develop weak branch attachments (left). Cut back these vigorous laterals at planting to slow their growth (middle). Cut them off completely about two years later to fully establish a strong central leader (right).

8. Inspection

Because many of the key components of transplanting are not visible at the end of the process, conduct inspections at several steps in the process whenever possible.

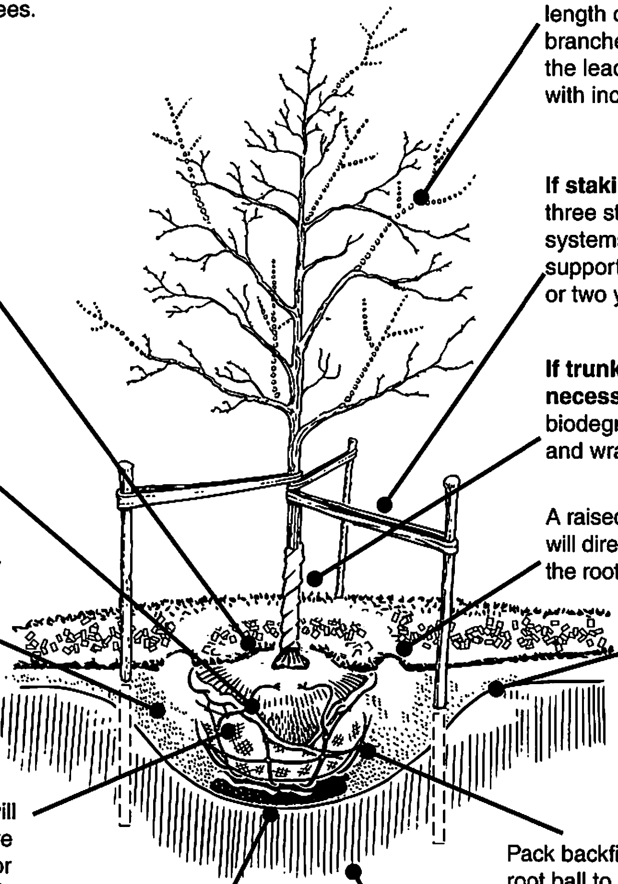
During Transplanting

- Is the hole at the specified depth?
- Is the hole of sufficient width?
- Have defective and damaged roots been eliminated?
- Have at least the upper portions of the root ball wrapping materials been cut away?

At Final Inspection

- Is the tree planted at the correct depth?
- Is the trunk vertical?
- Is a raised ring of soil necessary to hold irrigation water over the root ball?
- Have broken, dead, dying, and diseased branches, and unnecessary sprouts from the roots been removed?
- Has mulch been applied to the soil surface around the root ball with only a light layer over the root ball?
- Was the root ball and backfill soil watered thoroughly?
- Have the extra soil, root ball wrappings, pruned branches, and other debris been removed from the site?
- If tree staking is required, do the ties allow for growth and movement of the trunk? Have provisions been made for timely inspections and future removal of the support system?
- Has the owner or manager agreed to water during droughts and provide annual maintenance?

Appendix:
Tree Planting Diagram



Glossary

ball and burlap (B&B)—tree or other plant dug and removed from the ground for replanting, with the roots and soil wrapped in burlap or burlap-like fabric.

bare root—tree or other plant removed from the ground for replanting without soil around the roots.

burlap (Hessian)—strong, coarsely woven cloth made from fibers of jute, flax, hemp, or synthetic fibers.

buttress root—roots at the trunk base that help support the tree.

caliper—thickness or diameter of the trunk of a tree taken at a standard height, used in specifying nursery stock.

circling root—roots that grow in a circular pattern when a plant is confined in the same container longer than necessary. If not corrected, will prevent a tree from establishing well when planted and will create future problems, such as blow-over, girdling roots, and strangulation.

codominant stems—forked branches nearly the same size in diameter, arising from a common junction and lacking a normal branch union; may have included bark.

container grown—tree or other plant that has been grown and marketed in a container.

containerized—field-grown plant placed into a container for a time and then sold as a potted plant. Term does not include a plant that has initially been grown in a container.

flare root—see buttress root.

girdling root—root that encircles all or part of the trunk of a tree or other roots and constricts the vascular tissue and inhibits secondary growth and movement of water and photosynthates.

grade—surface level of the ground.

guy—a steel or synthetic-fiber cable between a tree or branch and an external anchor (another tree, the ground, or other fixed object) to limit movement and provide supplemental support.

hardening off—a process that acclimates B&B trees to water stress when dug with foliage. Foliage should be shaded, shielded from wind, and sprinkled frequently for several weeks. Also used in reference to acclimation to cold temperatures.

heeling in—method of storing bare-root trees by covering roots with sawdust or mulch until ready to plant.

included bark—bark that becomes embedded in a crotch (union) between a branch and trunk, or between codominant stems. Causes a weak structure.

liner—a young tree planted out in nursery rows and grown to suitable landscape size (also known as lining-out stock). Many sizes and methods of propagation are used.

planting—installing a plant in the landscape.

root ball—soil that contains all (i.e., container grown) or a portion (i.e., B&B) of the roots that are moved with a plant when it is planted or transplanted.

root flare—see trunk flare.

root pruning—process of cutting roots on a field grown tree or pre-digging a root ball to increase the density of root development within the final ball.

shaving—removing the entire outside periphery (sometimes including the bottom) of a container root ball.

soil amendment—material added to soil to improve its physical, chemical, and/or biological properties.

soil anchor—device that is driven, screwed, buried, or otherwise inserted into the ground, to which a guying cable is attached.

stage digging—process to reduce sudden stress when deciduous plants must be dug in leaf. The root ball is dug (and roots are cut) section by section over a period of time.

transplanting—process of moving a plant to a new location.

tree spade—mechanical equipment to dig, transport, and replant trees with a sufficiently large volume of roots and soil.

tree wrap—material used to wrap the trunks of newly planted or transplanted trees to protect them from injury.

trunk flare—transition zone from trunk to roots where the trunk expands into the buttress or structural roots. Root flare.

wire basket—type of metal basket used to support the root ball of a B&B tree or a tree dug with a tree spade.

Selected References

American National Standards Institute. 2012. *American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Management—Standard Practices (Planting and Transplanting) (A300, Part 6)*. Tree Care Industry Association, Manchester, New Hampshire, USA.

American National Standards Institute. 2004. *American Standard for Nursery Stock (Z60.1)*. American Nursery and Landscape Association, Washington, DC., USA. Accessed May 2014. http://www.anla.org/applications/Documents/Docs/ANLAStandard2004.pdf

Craul, P.J. 1992. *Urban Soil in a Landscape Design*. John Wiley & Sons, New York, NY.

European Nurserystock Association. 2010. *European Technical & Quality Standards for Nurserystock*. Accessed May 2014. http://www.enaplants.eu/EXEN/site/quality.aspx

Gilman, E.F. 2012. *An Illustrated Guide to Pruning* (3rd ed.). Delmar, Cengage Learning, Albany, New York, USA. 476 pp.

Gilman, E.F., and S.J. Lilly. 2008. *Best Management Practices: Tree Pruning*. International Society of Arboriculture, Champaign, IL. 35 pp.

Harris, R.W., J.R. Clark, and Nelda P. Matheny. 2004. *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines* (4th ed.). Prentice Hall, Upper Saddle River, New Jersey, USA.

International Society of Arboriculture. 2003. *Tree Selection and Planting: A Collection of CEU Articles*. International Society of Arboriculture, Champaign, Illinois, USA.

Neely, D., and G.W. Watson (Eds.). 1998. *The Landscape Below Ground II: Proceedings of an International Workshop on Tree Root Development in Urban Soils*. International Society of Arboriculture, Champaign, Illinois, USA. 265 pp.

Smiley, E.T., S.J. Lilly, and Les Werner. 2013. *Best Management Practices: Tree and Shrub Fertilization.* International Society of Arboriculture, Champaign, Illinois, USA. 39 pp.

Watson, G.W., and E.B. Himelick. 2013. *The Practical Science of Planting Trees.* International Society of Arboriculture, Champaign, Illinois, USA. 250 pp.

Watson, G.W., and D. Neely (Eds.). 1994. *The Landscape Below Ground: Proceedings of an International Workshop on Tree Root Development in Urban Soils.* International Society of Arboriculture, Champaign, Illinois, USA. 222 pp.

Watson, G.W., L. Costello, B. Scharenbroch, and E. Gilman (Eds.) 2009. *The Landscape Below Ground III: Proceedings of the International Workshop on Tree Root Development in Urban Soils.* International Society of Arboriculture, Champaign, Illinois, USA. 403 pp.

About the Author

Gary Watson is a senior research scientist at The Morton Arboretum, working on root development of trees in urban landscapes. Dr. Watson has received the Award for Arboricultural Research, Author's Citation, and Honorary Life Membership from ISA, and the Award of Merit from the Illinois Arborist Association. He is a past president of ISA, the Arboricultural Research and Education Academy, and the Illinois Arborist Association. He was the organizer of the Landscape Below Ground and the Trees and Building Sites conferences, and co-editor of the proceedings.

ISBN 978-1-881956-84-6

ISA
International Society of **Arboriculture**
www.isa-arbor.com • p. +1 678.367.0981 • isa@isa-arbor.com

9 781881 956846 >