Planting and Aftercare of Community Trees

PennState Extension

Contents

This publication is for people who plant trees in public landscapes, such as along streets and in parks. Most of the advice is also useful to those who plant trees around homes and businesses. To properly plant trees, you should understand the characteristics of planting sites, the tolerances and growth characteristics of tree species, and the benefits you want to receive from the trees.

Before you start planting, it pays off to prepare. For larger projects, it's advisable to start planning 6 to 12 months before planting. Allow time to conduct a thorough planting site assessment, find and obtain quality trees, and arrange for supplies, equipment, and workers or volunteers. Trees selected should be well adapted to their planting sites and strategically located so their roots, trunks, and branches have adequate room to grow. Trees need adequate space above and below the ground to remain healthy, safe, and attractive, and to grow to a mature size.

Understanding the Planting Site

Trees differ in their requirements for growth. Selecting trees that will establish and thrive in the biological and physical conditions of the planting site requires observation and thought. A thorough planting site assessment will identify important site conditions that will affect the survival and growth of the trees. Experienced tree commission members or arborists are best qualified for assessing tree planting sites, but even a novice can do a site analysis well using good information and common sense.

Visit or meet with people in the neighborhood to inform them, listen to their concerns, and seek their assistance in planting projects. People can help care for trees, or they can ignore or vandalize them, so the attitudes of people living where street and park trees are to be planted are important.

Ensure that all legal requirements are met. Many municipalities have street tree ordinances describing who may plant trees, what kind of trees may be planted, and where trees may be planted.

Consider landscape design. Trees are used for various design purposes, such as creating a sense of place, security, and comfort. They may complement important views and architectural features. Tree plantings can be formal and uniform or informal and diverse. Narrow trees can accent or frame significant features; broad trees or groups can soften or screen harsh features. Their flowers, fruit, foliage, and bark can stimulate the senses in all seasons with fragrance, texture, and color.

Trees can have a long lifespan if properly selected, planted, and maintained. If trees will not receive proper pruning, watering, and other care, then select trees that tolerate a lower level of care. Consider the future health of trees by thinking about the size and form that a mature tree will have both above and below the ground.

The trees selected for planting must be able to withstand the coldest temperature that can be expected in the area. Determine the hardiness zone of your tree planting site by checking a hardiness map based on low temperature extremes. These maps are available at your local library, in many nursery catalogs, or online.

Essentials for Assessing Planting Sites

Climate and Weather

Planting sites in sidewalks and other built places can be hot with little water.

- Temperature extremes
- Moisture
- Light
- Wind

Soil

Soils in built landscapes can be altered, polluted, and compacted.

- Structure
- Texture
- Compaction (bulk density)
- Drainage
- Depth to hardpan or rock
- pH (acid or alkaline)
- Fertility
- Salinity
- Contamination and pollution

Growing Space

The size of the growing space determines whether small, medium, or large trees can be planted.

- Volume/amount of soil for roots
- Space available for trunk and crown growth
- Placement of utilities
- Constraints of sidewalks, curbs, streets, and buildings
- Conflicts with pedestrian and vehicular traffic

Ecosystem Benefits of Trees

Trees provide many benefits, including stormwater management and increased property values.

- Design themes, sense of place
- Complement existing flora
- Climate modification
- Noise reduction
- Screen or enhancement of views
- Pedestrian and vehicular traffic considerations
- Erosion control
- Wildlife food and cover

Large-growing trees such as red oak and Norway maple should not be planted under power lines.

Safety is important. Consider how clearance for pedestrians, vehicles, lighting, signs, and utilities will be maintained. Visibility at street intersections is reduced as trunks grow in diameter, and vehicle sight lines should be considered.

Space is often limited in urban areas. Look up, look down, look all around! The planting space above and below the ground should be large enough for trees to reach a desired height and to accommodate branch spread, trunk diameter, and root extension without interfering with surrounding objects and the activities of people. Roots can extend beyond the spread of branches. Identify buildings, roads, sidewalks, signs, and underground and aboveground utilities that could restrict or conflict with the growth of roots and canopy. If enough space exists for a tree to grow to its mature size, damage to sidewalks and curbs will be reduced or eliminated, and severe pruning will not be required later.

An adequate amount of fertile soil is crucial for tree growth. Tree roots need water, oxygen, and nutrients supplied from the soil to grow. Investigate critical soil factors such as depth, texture, structure, amount of rocks and other debris, compaction, drainage, pH (acidity or alkalinity), and fertility levels by digging one or more test holes. Soil compaction restricts root growth. Poor drainage and standing water can cause a tree to be unhealthy, limit its growth, or kill it. Some trees cannot withstand high-pH (alkaline) soils and will not ever grow well if planted in them.

The condition of nearby trees and other plants can indicate whether health problems can be expected and what tree species may or may not do well. Browning and scorching of leaves during summer, premature fall coloration, and yellow (chlorotic) leaves can indicate sites that are hot, droughty, or compacted or have high pH or road salt. Some species are tougher and

Planting large trees in confined areas causes sidewalk and other damage.

There is not enough room above or below the ground to plant trees here.

tolerate certain adverse conditions better than others. Also, the condition of neighboring trees can indicate insect or disease problems, such as plant bugs, verticillium wilt, or fire blight, that can cause problems to susceptible tree species.

Investigate the sun and shade patterns of the site. Some trees need full sun, others will tolerate or prefer partial shade, and only a few prefer full shade. Trees can be planted strategically around buildings to provide summer shade and decrease winter shade, which reduces energy expenditures for air conditioning and heating. Plant trees on the west and east sides of buildings to create shade during summer. To decrease the shading of windows and buildings during the winter, keep trees away from the south side of buildings at a distance at least twice the mature height of the tree. Thicker rows of evergreen trees can be planted on the north side of buildings to provide a shield against winter winds.

How to Kill a Tree

- Plant too deep (root collar should be visible)
- Don't irrigate during hot dry weather
- Overmulch (only 2 to 3 inches of much is needed)
- Damage with string mowers and lawnmowers
- Plant trees that are not tolerant of the site conditions

A Deeper Conversation about Soils in Built Landscapes

Soil Definitions

Acidic soil: any soil that has a pH value less than 7.

Alkaline soil: any soil that has a pH value greater than 7.

Bulk density: a measure of compaction; the mass of a dried soil per unit volume. Compacted soils in a given volume weigh more than uncompacted soils.

Compaction (also called layering): results when machinery or another pressure breaks soil structure and increases its bulk density. Structure is crushed and disintegrates, causing the collapse of pore spaces essential for water, air, and root movement.

Engineered soil: a soil mix adjacent or under sidewalks, patios, or other hardscapes that supports the weight of the hardscape but allows for air, water, and root growth. Soil mixes can be composed of sand or fractured gravel.

Fertility: the status of a soil with respect to the amount and availability of nutrients necessary for plants to grow.

Friable: the looseness or ease of crumbling of soils.

Hardpan: a hardened soil layer in the lower A or the B horizon caused by the cementation of soil particles with organic matter or materials such as calcium carbonate. Hardpans are also caused by rock formations, old parking lots and street sections, and underlying layers of soil that have been compacted.

Infiltration: the downward entry of water into a soil.

Parent material: the weathered geological material from which a soil has been derived.

Percolation: the downward movement of water through a soil. Unless saturated with water, sandy soils will have much higher infiltration and percolation rates than clay or compacted soils. But clay soils have higher nutrient-holding and provision traits than sandy soils.

Permeability: the ease with which gases, liquids, or plant roots penetrate or pass through a mass of soil. The more friable a soil is, the more permeable it is.

pH: the degree of acidity (lower pH) or alkalinity (higher pH) of a soil. Most plant materials prefer a slightly acidic pH. Neutral is close to 7.0; slightly acidic is 6.6 to 6.0; slightly alkaline is 7.4 to 8.0; strongly acidic is 5.0 to 4.0; strongly alkaline is 9.0 to 10.0; very strongly acidic is 4.0 to 3.0; and very strongly alkaline is 10.0 to 11.0.

Saturation: to fill all the voids or pores between soil particles with a liquid. Soils saturated for longer periods can have poor aeration and high levels of carbon dioxide (CO_2), both of which are detrimental to root respiration and growth.

Topsoil: the upper layer of native soil usually moved during cultivation or grading. The highest concentration of microorganisms and organic matter can be found in these top 2 to 8 inches of soil; however, the amount of organic matter varies in different soil types. A desirable topsoil should contain about 45 percent mineral matter, 50 percent pore space, and 5 percent organic material. Topsoil differs from gardening soil and quality soil that is sold under the same name. Many forms of soil that are sold for gardening contain a mixture of many different media and soil types. There are no state or federal standards for what constitutes topsoil.

Soil Texture

Soil texture is the amount of sand (larger soil particle size), silt, and clay (smallest particle size) present in any soil. Texture affects potential for compaction, water percolation, water retention, aeration, nutrient capacity and retention, and root and plant growth. In natural soils, much of the texture is provided by a soil's parent material, the underlying rock, and how this material has interacted with air, water, cold, heat, gravity, and other environmental conditions over time. Because of mixing, dumping, and removal in soils affected by construction, it can be difficult to determine what the parent material, or basis, for a soil's texture is, and soil texture can change in any given place of a developed landscape.

You can explore soil texture by picking up and gently rubbing a soil sample between your thumb and fingers. It is helpful to dampen the soil to feel the amount of clay, or plasticity. The way a damp soil develops a ribbon as it is rubbed gives a good idea of how much clay is present. Sandy soils feel gritty, and silt has a floury feel when dry and is smooth and not claylike or sticky when wet. Different types of soils are described below to help you explore what type of soils you have through rubbing. The sources for these descriptions can be found in Phillip J. Craul's *Urban Soils: Applications and Practices* (John Wiley and Sons, 1999) and Nyle C. Brady's *The Nature and Properties of Soils* (Prentice Hall, 2007).

Sandy

Typically, larger-grained, sandy-textured soils have better water percolation and aeration than smaller-grained, clay-textured soils, but their ability to retain and provide water and plant nutrients is lower. Water and nutrients simply leach through sandy soils quickly. Soils with sandy textures are harder to compact but can be extremely droughty and infertile—think of the beach. With large particle sizes, sandy soils have better water and air movement because of more and larger soil pores (spaces between soil particles that can be filled with and help move water and air). Sand particles can make any soil more friable or loose and promote root growth.

Soils where the sand makes up 70 percent or more of the material by weight are classified as sandy. They are not sticky like the heavier clay and loam soils are, but they are loose and single grained. Squeezed in the hand when dry, they fall apart. Squeezed when dampened, they form a cast or ribbon that will fall apart if touched.

Silty

Silty soils have particles that are intermediate in size between sand and clay. Because of their smaller particle size and pore spaces, silty soils have a slower water-intake rate but a higher water- and nutrient-holding capacity than sandy soils. Water does not drain through these soils as quickly, but they are also more easily compacted than sandy soils. Although there are few truly silty soils in Pennsylvania, some portion of silt is an essential part of a desirable soil.

Clay

Because of their small particle size and associated small size of soil pores, clay soils are much easier to compact, which affects water, air, and root movement. Clay particles are stickier and can bind both water and soil nutrients. One property of clay is an attraction for positive nutrient ions such as calcium, magnesium, and ammonia. Because of this, clay soils can hold and store large amounts of these plant nutrients. On the other hand, negative

Diameters of sand, silt, and clay particles. Sand is the largest soil particle, and clay is the smallest.

Diameter of Particles				
Millimeters	2.0	0.05	0.002	0
Inches	0.08	0.002	0.00008	0
gravel, stones	sand	silt	clay	
Particles visible to the naked eye		Particles visible under a microscope	Particles visible under an electron microscope	

plant nutrient ions such as nitrate, phosphate, and sulfate are repelled by clay particles and only stored for plant use to the extent they are dissolved in any water held in soil pore spaces. Clay is a major ingredient of a healthy soil, but in some cases, clay soils can bind water and nutrients so tightly that they are unavailable to plant roots. As with sand and silt particles, a portion of clay particles is desirable in healthy soils because of high nutrient- and water-binding or holding capacity, which adds to soil fertility.

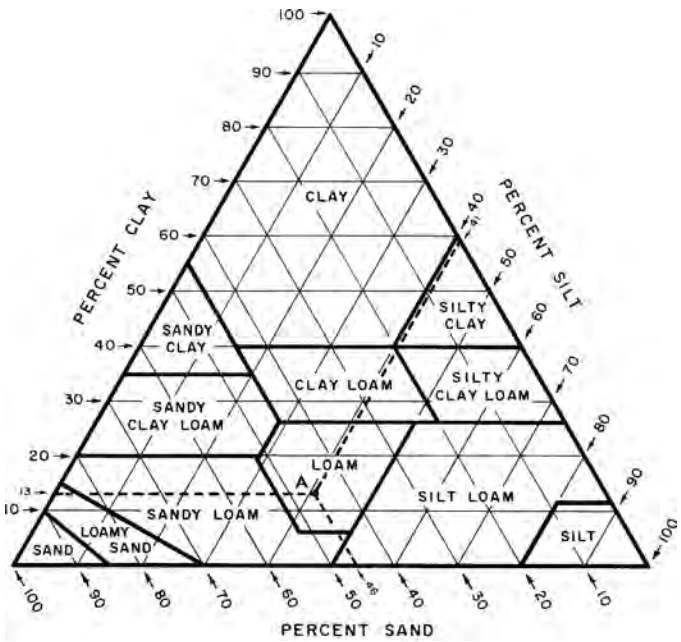
Clay soils have between 35 and 40 percent clay. They are fine-textured soils that usually form hard lumps or clods when dry and are quite plastic and sticky when wet. When the moist soil is rolled, it will form a long, flexible ribbon that will not break or fall apart.

Loam

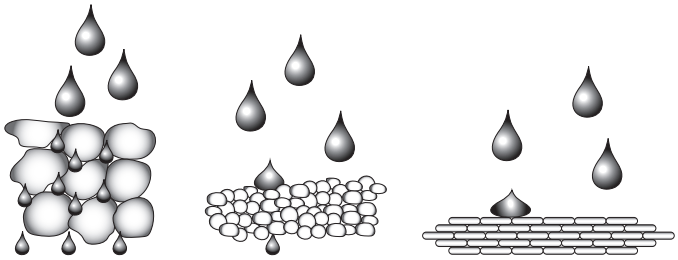
A loam soil has intermediate, approximately equal properties of sand, silt, and clay. Loam soils have good characteristics in terms of water movement and storage, nutrient holding, fertility, and friability for root growth. For many plants, a sandy loam soil is the desired soil for good plant growth and survival. This type of soil texture shares all the positive traits that sand, silt, and clay textures provide. Loam soils are called topsoil by some people.

Most soils of agricultural importance are some type of loam. A loam soil has a relatively even mixture of different grades of sand, silt, and clay. They exhibit light or sandy (good drainage) and heavy or clay (nutrient- and water-holding capacity) properties in about equal proportions. Loams are mellow with a somewhat gritty yet smooth and slightly plastic or claylike feel. Squeezed when dry, they form a ribbon that will bear careful handling, and the cast formed by squeezing the moist soil can be handled freely without breaking. They are classified by the amount of sand, silt, and clay that they contain: sandy loam, silt loam, and clay loam.

The "soil triangle" shows different soil textures. Most soils of agricultural importance are some type of loam.



The amount of sand, silt, and clay particles found within a soil make up a soil's texture. Soil structure is how these particles are grouped together.



Soil Structure

Soil structure is how the individual soil particles (sand, silt, clay) are arranged, aggregated, held, or come together in peds or clods. Good soil structure allows for water and air infiltration and movement, as well as root growth. Soil structure is developed over time through rain, frost, and other weather impacts. It is also affected by the amount and type of organic material that leaches into the soil. Although developed gradually in nature, structure can be destroyed quickly by machinery, grazing livestock, cultivation, and other human impacts.

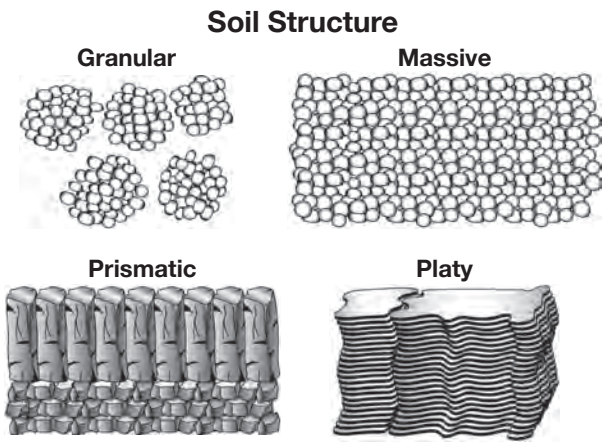
Typical types of soil structure include granular, blocky, prismatic, massive, and platy. Soil texture influences the type of structure a soil can have (for example, a sandy soil has granular structure and clay soil has blocky structure), and both texture and structure affect the movement of air, water, and roots. Sandy soils often have little or no structure, while clay structures can have very heavy peds or clods (blocky or prismatic structures). It is important to have well-developed structures in heavy clay soils to allow for water, air, and root movement.

Soil structure is crushed and destroyed by compaction or rough treatment. In soils that have been damaged by construction, structure is often compressed, crushed, or compacted, especially in clay soils. This means that soil pore spaces are crushed; the soil becomes layered (platy); and water, air, and roots have a difficult, if not impossible, time moving into and through the soil. Also, compacted soils tend to have poor gas exchange due of a lack of pore space and levels of CO_2 produced by root respiration that have built up in the soil, slowing root respiration and growth. This buildup of CO_2 also happens in soils that are highly saturated for periods of time because of poor drainage or overirrigation.

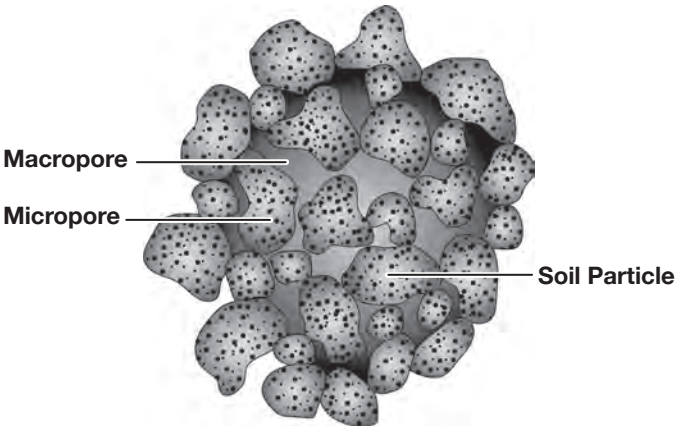
Soil Horizons and Profiles

As weathering and plant growth continues over long periods, changes occur that cause distinctly visible layers in a soil. These

Four examples of soil structure. Granular would be related to sandy soils, and prismatic, and platy to clay soils.

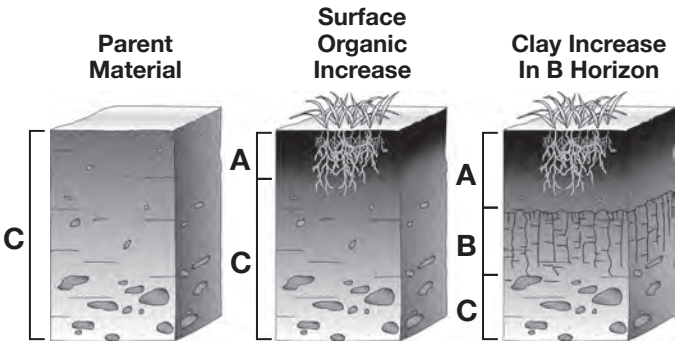


Compaction smashes a soil's pore spaces, impeding air, water, and root movement.



Operating heavy equipment has ruined this soil. Soil structure must be protected to plant or preserve trees.

Example of very simple soil horizons.



layers are called horizons, and the sum of horizons for a soil is called its profile. Simple soil horizons are designated by the letters A, B, and C, going down from the surface. The first (lowest) horizon in a young soil is the C horizon, or the weathered parent material. With more weathering, time, and other forces, other horizons develop. The upper layer of many soils is a dark-colored zone that extends downward a few inches from the surface. This is the A horizon and its dark color is due to well-decomposed organic material, or humus. More humus and larger A horizons are found in soils in cooler climates rather than in hot climates, wetter climates rather than in dry climates, and under grasslands rather than under forests. The B horizons form very slowly and are an accumulation of clay in a layer beneath the A horizon. The B horizon builds up because of the downward movement of fine particles by percolating water and the formation of clay particles from chemical reactions in a soil over time.

As with soil texture and structure, soil horizons and a soil's profile are usually destroyed by construction. For example, in most developments organic A horizons are removed, leaving only the B horizon of clay, which forms a barrier to water and air penetration and root growth when compacted.

Made Soils

Soils in commercial, residential, and other landscapes that have been involved in construction are often different from soils in places that are undeveloped or uncultivated. Soils in developed places can be referred to as fabricated or "made" soils. Because of grading (soil fill and removal), moving equipment, cleaning equipment, and other activities in places that have undergone construction, made soils can be highly mixed, altered, and compacted. These soils can change in fertility, pH, compaction, and drainage from foot to foot. As a result, soil maps provide little useful information about the characteristics and capacities of construction-damaged or made soils.

When planting trees and other plants in construction-damaged soils, you're probably dealing with made soils both horizontally and vertically. These damaged soils can be heavily

compacted, polluted, unfertile, and full of trash and debris; have unhealthy high or low pH ranges; and have strange transition zones (hydrological differentiation) between mixed and crushed layers. These traits can hinder tree establishment (root growth to support plant growth), normal growth and appearance, and plant longevity. There are many examples of construction-damaged soils. Compaction by people or equipment crushes soil structure, impeding air, water, and root movement. Organic soils are often stripped and removed from construction areas, leaving compacted, mostly clay soils. Transition zones, caused by dumping one type of soil on top of another, are often impermeable barriers to water, air, and roots. For successful tree and plant growth, it's important to understand the characteristics and capacities of the soil in which you are going to plant, especially soil damaged by construction.

Problems Found in Construction-Damaged Soils

When planting trees and other plants in developed landscapes, a shovel, your hand, and a soil test are your best tools to understand the characteristics and capacities of the soil you are using. Dig small holes to investigate structure, garbage, depth, compaction, and drainage. Squeeze dampened soil between your thumb and fingers to investigate texture. Always use a soil test to find out about soil texture, fertility, pollution, and pH. These tests, and the directions for their use, are available from extension offices.

High (alkaline) or low (acidic) pH, the amount of fertile soil available for root growth, soil compaction, and salt spray or drainage are serious concerns when planting in constructed landscapes such as parking lots, patios, sidewalks, compacted lawns, and along roads.

Considering pH

The ability of a tree to withdraw and use nutrients from soil is affected by a soil's pH. Most trees and plant materials prefer a slightly acidic pH. Many trees (for example, pin oak, red oak, red maple, and sweetgum) will not grow in high-pH (alkaline) soils, but many soils in the limestone regions of Pennsylvania and around construction sites (because of the amount of cement and limestone gravel used) are higher in pH. In Pennsylvania, high-pH soils may be more abundant than low-pH soils. Problems with pH and altering unhealthy pH ranges can be difficult to deal with, especially after trees that are not tolerant to pH extremes have been planted. Do not rely on liming to raise pH or sulfuring to lower pH. These are short-term treatments affected by leaching and other forces. They will not help in the long term when pH is a concern. If pH is a concern, select and plant pH-tolerant material that can handle both high and low pH (for example, zelkova, Kentucky coffeetree, ginkgo, and London plane).

Soils in these developed areas have been stripped of organic material, compacted, and contain a certain amount of garbage and debris.

Strategies for Tree Planting in Construction-Damaged Soils

- Use a shovel and a soil test to find out about compaction, drainage, pH, and other important soil characteristics.
- Plant the easy places first. Plant trees in a front yard rather than a small sidewalk cutout or small tree lawn.
- Select the right type of tree. Put the right tree in the right place and make the place right for the tree. Choose trees that are more tolerant of heat, drought, compaction, poor aeration, and low fertility.
- If possible, preserve and use existing soils in yards and other larger planting areas. If the soil in which you are planting has a decent texture and is fertile, softly break existing compaction and reuse. Do not smash soils that you are going to use because this will destroy structure. Loosely dig these soils and break them apart with a shovel or other equipment.
- Consider replacing poor soils in tree planting pits or planters with a fertile, rich topsoil.
- In sidewalks, patios, and parking lots, design and construct larger planting areas to provide space for root growth. Design tree lawns that are at least 6 feet wide and use continuous planters that run parallel to the curb as well as larger sidewalk, patio, and parking lot planters. Larger cutouts or continuous planters (for example, to accommodate the growth of two large trees, 24 feet long, 5 feet wide, and 3 feet deep) have been used in Philadelphia and other cities to plant trees in downtown sidewalk areas.
- To increase rooting volume, use engineered soil mixes such as a structural soil under newly constructed or replaced sidewalks and patios.
- If necessary, break compaction, amend or replace soils, and maintain or create drainage using French drains, plastic piping, or other engineering.
- Use proper mulching (2 to 3 inches of a coarse-ground, well-cured, composted mulch kept away from the tree trunk) and mulch management to provide for vertical amendment of the soil over time. Remember that too much mulch or mulch that has been compacted by foot or other traffic can impede water and air percolation and movement and cause dry, unhealthy growing conditions.

Managing Compacted Soils

Soil compaction can be measured by soil bulk density: the mass (weight) of dried soil per unit of bulk volume, which includes both solids and the quantity of pore space. Because of the amount of uncompacted pore space, soils that are uncompacted, loose, and friable have lower weights per volume. Soils that are more compacted have higher weights per volume because their pore spaces have been crushed, allowing for more soil in any given volume. Soil compaction, whether surface or subsurface, can also be measured by a penetrometer—a tool that mimics a plant root. A penetrometer measures the resistance in pounds per square inch of a soil to a rod that is driven into it at approximately one inch per second. Most plant root growth is restricted at a penetration resistance of 300 pounds per square inch. An easy way to test for compaction or drainage is to pour a gallon of water into a 12-inch-wide, 24-inch-deep test hole. If the water does not drain from the hole in eight hours, consider planting the tree in another location that has better drainage or providing drainage using a French drain or other engineered system.

Compaction (or destruction of soil structure) is a major problem when planting trees and other plant material in developed landscapes. Because of grading and construction requirements, soil under pavements and around buildings is mixed and compacted. Even parks that have been graded and planted with turf have severely compacted soils. Soil compaction can also be caused or worsened by pedestrian and vehicular traffic.

Compacted soils have less oxygen available to tree roots, allow slower infiltration of water, and physically restrict root growth. Consider the following suggestions when planting trees in compacted soils.

- Select trees such as London planetree, honey locust, and thornless hawthorn, which are more tolerant of compacted conditions. Do not plant trees that require good aeration and drainage, such as flowering cherry, magnolia, serviceberry, or sugar maple, in compacted soils.
- Within a proper soil moisture content, loosely break up existing soils that are fertile but compacted using a shovel, air spade, or cultivator in larger areas.
- Carefully cultivate and amend whole planting areas, not just the planting pit, with composted organic material. Adding peat moss, sand, or leaf mold to individual planting pits is unnecessary and may be counterproductive. Some believe that moss and other organic material act as a sponge and may hold excessive water in the planting hole, especially in heavy clay soils. Usually, topsoil taken from a tree planting pit should just be broken and loosened, not amended. (Amending soils is further discussed on page 11.)
- Consider removing and replacing the soil along streets or other sites that have mainly infertile fill, building rubble, or

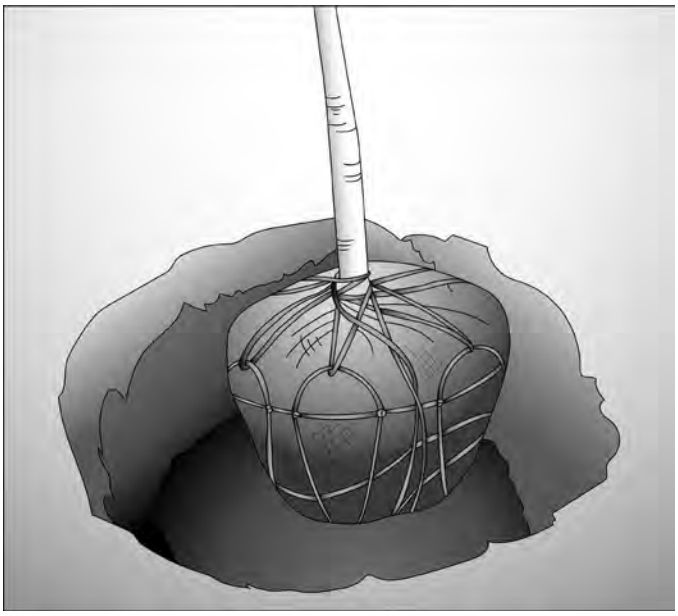
other barriers to root establishment and growth with a fertile topsoil similar in texture and structure in a long, continuous planter that is as long as possible, at least 6 feet wide, and 3 to 4 feet deep.

- If individual trees must be planted in compacted soil, such as in a park or schoolyard, mark out a planting area that is five times the diameter of the root ball. Loosen and mix the soil in the entire planting area to the same depth as the root ball.
- Another alternative for planting in compacted soils is to dig a planting hole that is 3 to 4 feet wider than the root ball and then dig three to five trenches as deep as the root ball and extending 5 to 10 feet radially out from the planting hole. The trenches will look like spokes from a wheel hub. The soil in the trenches should be broken up or replaced with a fertile topsoil. Roots from the tree can then grow into the loosened soil.
- Restrict pedestrian or vehicle movement in areas where compaction is a concern.

Radial trenching can be used to break compaction for new and mature trees.

Air spades can be used to break compaction under existing trees. Exposed roots must be protected from desiccation.

Larger holes should be dug when planting trees near schools, parks, and other areas with compacted soil.



Providing More Soil Volume in Confined Areas: Structural Soils

A structural soil mix developed at Cornell University can be used under sidewalks, parking lots, patios, and other confined planting areas that must be compacted to support the weight of asphalt or cement. Use of this mix is believed to reduce sidewalk and curb damage and increase tree vigor and life span. The structural soil mix of crushed stone provides both a penetrable, fertile rooting volume and a load-bearing service for asphalt or concrete. The three components of the mix are an angular crushed stone (to provide a skeleton to hold weight), a clay soil (to provide for nutrient- and water-holding capacity), and a small amount of hydrogel (to bind soil and stone together). The mix is patented by Cornell, and contractors must be licensed to create these soils at the construction site. A ratio of 80 percent stone, 20 percent clay, and a small amount of hydrogel is recommended. Tree selection and irrigation is important because structural soils are often droughty and lack fertility.

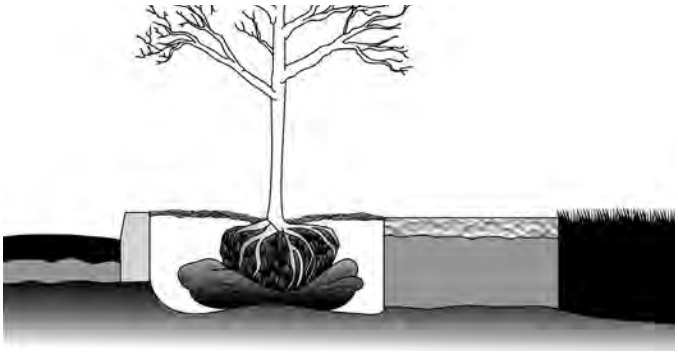
Structural soils must be mixed carefully using the correct gravel size, and they cannot be transported very far because the clay soil will separate from the gravel. Proper structural root growth in trees planted only in the gravel of structural soils may be a concern. Limestone gravel should not be used if planting trees that are not tolerant of high-pH soils, such as pin oak, red oak, and red maple. Sand and other engineered soils are also available. Consider consulting a knowledgeable person when engineering and replacing soils. For more information on structural soils, see Nina Bassuk's material at https://blogs.cornell.edu/urbanhort/outreach/cu-structural-soil/.

Another Engineering Option: Silva Cells

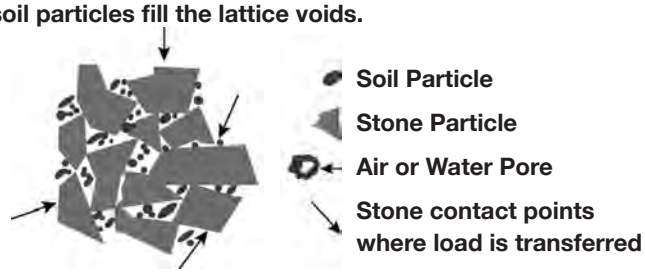
Though expensive (up to $12,000 per tree) Silva Cells allow trees to grow larger and longer in difficult streetscape environments. A Silva Cell is a modular suspended pavement system that provides soil volumes to support large tree growth. Each Silva Cell is composed of a frame and a deck that resemble stacked milk crates. Frames are 48 inches long by 24 inches wide by 16 inches high, and each cell holds 10 cubic feet of soil.

Structural soils can be used under new sidewalks and parking lots, especially those being removed and rebuilt.

Although soil is used in the planting pit, structural soils can be used under sidewalks to expand the soil volume and allow roots to grow under the sidewalk to areas where soil is available.



In structural soils, the stone lattice bears loading while the soil particles fill the lattice voids.



Replacing and Amending Soils

When planting trees, poor soil is replaced by a high-quality topsoil or an engineered soil like structural soil. Because organic material can hold too much water, especially in clay soils, and are prone to decay and sinking, adding large amounts of peat moss and other organic material to individual tree planting pits is not recommended. Although more concern is being expressed about the removal of topsoil from construction sites, there are situations when poor soil in tree planting pits and parking lot and other planters can be removed and replaced using a fertile, rich topsoil. This may help trees establish and grow, but sooner or later the tree will have to deal with existing soil conditions.

When replacing soil, a soil that is similar in texture and structure or coarser than the original should be used. Replacement soils should be cultivated into the bottom of the planting area to help ensure drainage. To provide more soil volume, larger planters have been constructed both in sidewalks and within large areas of compacted soil. Depending on the size of the root ball, soils should be replaced 3 to 4 feet in depth and the size of the planter.

When soil amendment is required (e.g., converting old parking lot into landscape area), it is done over a large area, not just in or around planting pits. These projects often use a combination of soil ripping, topsoil and organic amendments, fertilizer, and cultivation. Drainage is often a concern in these situations and amending soil does not guarantee proper drainage will be provided.

During infill development and reconstruction, turning parking lots and other larger areas into places for planting trees and other plant material may be desired. Often the soils found under existing infrastructure are of poor quality and have fertility, compaction, and drainage problems. In some cases, these soils can be replaced or amended. Contact your extension office or other expert for assistance when considering soil replacement or amendment.

One way to improve both droughty, sandy soils and compacted, clay soils in large areas is to cultivate/incorporate composted organic material into them. Although the organic fraction or component of a fertile soil is usually small (around 3 to 8 percent by volume), this component is important for providing a reservoir of nutrients and water and improving the friability and structure of soils. Soil microorganisms must break down organic compounds to provide for essential plant nutrients—a process known as mineralization.

Amending soils with organic materials can improve water-holding capacity and fertility by affecting both texture and structure. Composted organic material can improve the water-holding capacity and fertility of sandy soils and the drainage and aeration of heavy clay soils. Over time, organic materials provide gums that can help bind together smashed

soil particles, improving structure. But, as has been pointed out by authors such as Phillip and Tim Craul, the addition of large amounts of organic material may be necessary to alter the characteristics of highly damaged or modified soils. Poor drainage is often an inherent problem in damaged soils, and adding excessive organic material (usually more than 20 to 30 percent on a volume basis) can increase or cause problems such as soil settlement and poor drainage, and increase of water-holding capacity to a point where soils stay wet for long periods. These problems are detrimental to root growth and function, especially in heavy clay soils. Undue wetness creates unfavorable aeration conditions, increases carbon dioxide in soils around plant roots, and can impede root function, the breakdown of organic material, and the release and use of plant nutrients.

Although some recommendations for amending soils are provided below, both amending and replacing soils are site specific, can be complicated, and depend on location, use, types of plant material desired, and the characteristics of existing soil and amendment, including their pH and salinity.

Depending on the condition of the soil and site, there are a number of recommendations for amending planting areas before planting, including (if possible) breaking compaction by ripping or cultivating and then cultivating/incorporating well-cured composted organic material (mushroom compost, leaves, grass clippings, wood chips) at 25 to 30 percent or, if drainage is a concern, at 10 percent organic material and 20 percent sand. The amendment(s) should be incorporated into the total soil volume of the upper 6 to 8 inches or so of the entire planting area, not just the planting pit. In general, 3.1 cubic yards of compost will cover 1,000 square feet with 1 inch of mulch. The actual amount of amendment required should be calculated by understanding the characteristics of the existing soil and amendment(s) and using the bulk density of the existing soil, the bulk density of the amendment materials, and the total volume of the amendment area.

Because of high pH and other considerations, well-cured composted sewage sludge is satisfactory, but it should not be used for more than 25 percent of the total amended soil volume. Regulations and public sentiment about the use of sewage sludge should be considered. Additions of composted municipal or other yard waste can help offset high ammonia content within these biosolids, and a mix of composted sewage sludge and composted yard waste is acceptable.

When using composted organic material, thoroughly mix the native soil and amendment together throughout the planting area, not just in and simply around planting pits. Whenever amending soils, it is important to blend the amendment(s) together with the existing soil so that sharp soil interfaces are

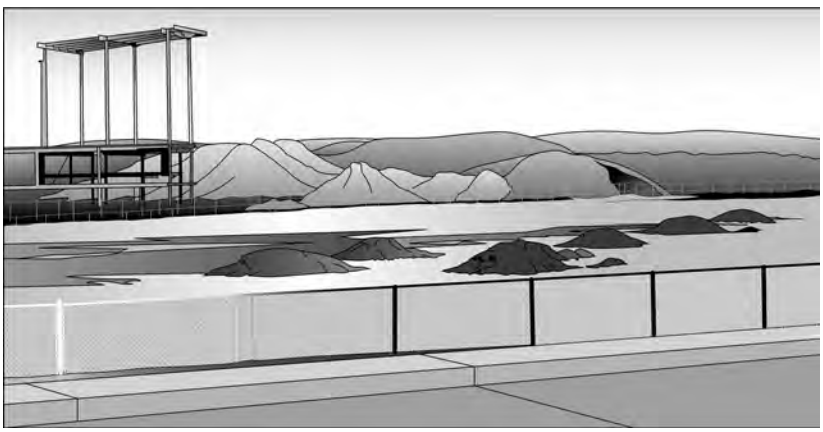
Learning from Strip Mine Reclamation

Poor, compacted soils associated with strip mines have been improved to better support plant material by:

- Ripping by heavy machinery to break up soil compaction
- Engineering for drainage
- Incorporating organic material and/or topsoil into existing soils
- Mulching the surface of soils for vertical amendment
- Planting nitrogen-fixing and other appropriate plant material
- Controlling herbaceous weeds around trees

Even if compaction has been improved in upper portion of a soil profile, proper drainage should be provided for.

As shown in these two illustrations, soil amendments are applied and cultivated throughout the planting area, not just the planting hole.



not created. Soil interfaces do not allow free movement of air, water, or roots. Amending in individual planting holes and covering existing soil with a layer of amendment or soil are not recommended. Abrupt transitions and dramatic differences in soil texture and fertility at the edge of a planting hole or between soil types can inhibit the movement of water and air and the growth and spread of roots.

Proper drainage may be a concern in areas where soils are being replaced or amended. Replacing and amending soils does not guarantee drainage. Systems using French drains, sand fields, flexible tile lines, or perforated PVC may have to be engineered for drainage.

Soil texture and structure can also be modified by adding coarse sand or clay, depending on the desired change. Water-holding capacity, bulk density, and drainage are all modified by these amendments, but these modifications are very site dependent and beyond the scope of this publication. Seek the advice of an expert and do not rely on rule-of-thumb additions of amendments when dealing with heavily damaged or modified soils found under parking lots and other large areas. Again, replacing, cultivating, or amending soil in areas with poor drainage may or may not help drainage, depending on the underlying cause of the problem, such as hardpans, old parking lots, and rock formations. Plantings in these areas may have to be further engineered for drainage (French, PVC, drainage tiles, or other drainage systems), planted in mounded beds, or provided with some other special type of planting. For more information on soil amendment in larger areas, see Nina Bassuk's material at https://blogs.cornell.edu/urbanhort/outreac/scopp-and-dump-soil-remediation/.

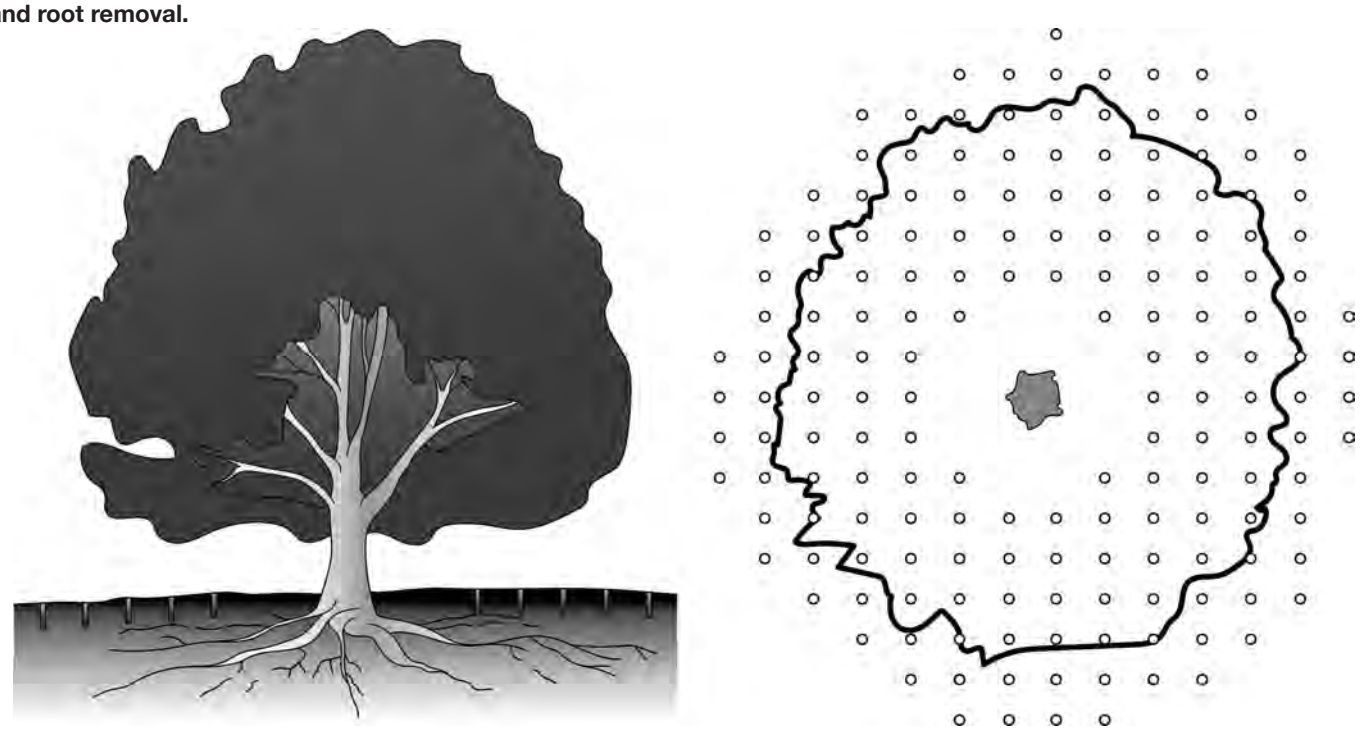
Breaking Compaction in Soils under Existing Trees

Air spades and vertical mulching can relieve compaction and help fertility in soils under existing trees. However, when working with soils, pay close attention to the soil moisture content. Working a soil that is too dry can pulverize it, destroying the structure. Working soils that are too wet increases compaction. If the soil smears when dug or if water is visible within the soil pores, the soil is too wet.

Vertical mulching is carefully drilling lines of holes (12 to 18 inches deep and 2 feet apart) in concentric patterns beneath a tree and filling them with a composted organic material. This is often combined with irrigation and broadcast fertilization of a nitrogen-based fertilizer in slow-release forms in light to moderate amounts (for example, 25-14-14). Fertilization amounts should be based on a soil test and the possibility of irrigation. Irrigation amounts should be based on past irrigation, rainfall, and recognized standards (for example, 20 gallons of water per inch of tree diameter at 4.5 feet on the trunk).

Air spades can be used to remove or fracture compacted soils in large areas, trenches, or spokes through the root zone. If poor-fertility or polluted soils are removed, they should be replaced with a high-quality topsoil. Roots and soils must be protected from the force of the air spade and from weather, such as cold and hot temperatures. Do not expose tree roots on very hot or cold days.

Vertical mulching can help repair compacted soils and help trees recover from root systems damaged by compacted soils and root removal.



Tree Selection, Purchase, Shipping, and Storage

Native or Nonnative Trees

Using natives reduces the likelihood of introducing the next bad nonnative invasive tree like Norway maple or ornamental pear. Native trees support biodiversity, local wildlife and insects, and historic landscapes. Native trees are particularly appropriate in and around parks and other large landscapes. But in some places, such as downtown sidewalk plantings, nonnative trees may perform better than natives. In these cases, consider using nonnative trees like ginkgo, honey locust, and London planetree that are already in widespread use and not causing new problems.

Selecting the Right Tree

The tree chosen for a planting site should be tolerant of the site conditions determined during site analysis, compatible with landscape design, and capable of providing the desired benefits. Important characteristics to consider when deciding what tree to plant include cold hardiness, mature size and shape, branch structure and strength, flowers and fruit, growth rate, longevity, rooting characteristics, and resistance to common insect and disease problems. Also consider the tree's tolerance to soil compaction, heat, drought, sun or shade, and pollutants such as deicing salt. Keep in mind possible maintenance challenges as well—some trees require more pruning, while others drop messy fruit and flowers. Examples of recommitted trees for small, medium, and large planting areas can be found in Appendix II.

Tree risk should be considered. Because of the type and strength of branch attachments, the length and weight of mature branches, and the susceptibility to root and trunk decay, some trees can have more or less risk of failure when they mature.

The ornamental benefits of trees such as fall color, showy flowers, fruit, and bark are important. Trees can be used to control pedestrian and vehicular traffic, hide unsightly buildings and views, and increase human comfort by screening the wind and shading buildings, sidewalks, and parking lots. They can provide feelings of security and comfort as well as cover and food for birds.

Selecting a tree not well adapted to a planting site can lead to low survival, sickly or unattractive growth, and premature death. Planting the wrong tree also can lead to unattractive streets, increased sidewalk and curb damage, and interference with utilities and signs. Desirability of tree fruit by birds and wildlife is an additional consideration in species selection since bird droppings can be a nuisance in parking lots and other public places. All of these add to long-term maintenance costs.

Besides the many tree species available, nurserymen and horticulturists have developed numerous cultivars and hybrids. Cultivars originate when an individual tree is selected for its superior qualities, such as form, fall color, size, or disease resistance. Cultivars are asexually propagated by budding onto ordinary seedlings, rooting of cuttings, or tissue culture. All the trees of a cultivar are uniform in genetic traits, including appearance, and their disease tolerance, growth, fall color, flowering, and fruiting are predictable. A hybrid is breeding two species of trees to create a third species that has selected traits (for example, fall color, tolerance of urban conditions, and branch structure).

Choosing the appropriate tree size is important. Mature tree size is often described as small (less than 30 feet in height), medium (30 to 45 feet in height), and large (greater than 45 feet in height). Small trees can be planted in places where space is limited, such as in tree lawns that are 2 to 4 feet wide and under utility lines. Medium-sized trees can be planted in

Tree Classification, Cultivar, and Hybrid

Trees and other plants are organized into groups using a hierarchical structure. The levels used in this organization are family, genus, and species. The following example uses red maple (*Acer rubrum*) to illustrate hierarchy.

Family: Aceraceae contains all maple trees.
Genus: *Acer* is a subset of Aceraceae that contains all maples with common characteristics.
Species: *rubrum* specifies only red maple within the genus *Acer*.

A cultivar is a tree variety/individual selected for certain traits (flowers, fall color, branching) and bred asexually to maintain genetic makeup.

Acer rubrum 'Autumn Flame': Autumn Flame red maple bred for faster growth, uniform canopy, and fall color.

A hybrid is made by breeding two species of trees to create a third species that has selected traits (e.g., fall color, tolerance of urban conditions, branch structure).

Acer × *freemani* 'Autumn Blaze' is a hybrid of red maple and silver maple bred for solid branch structure, tolerance of urban conditions, and fall color.

Trees grow in many different shapes and sizes, from broadly spreading to upright.

larger places, such as tree lawns that are 4 to 6 feet wide. Large-growing trees should only be planted in large places, such as tree lawns over 6 feet in width. Trees with mature heights of less than 30 feet are appropriate to plant under or near power lines. To allow each tree room to develop as it matures, consider the following distances between trees when planting along streets and in other rows: small trees, 25 feet apart; medium-growing trees, 30 to 40 feet apart; and large trees, 40 to 60 feet apart.

Because of quicker root establishment and function, smaller-sized nursery stock that is 0.5 to 1 inch in caliper (caliper is trunk diameter 6 inches above the ground) can grow quicker than and often catch up to larger-sized and more expensive trees that are 3 to 4 inches in caliper. Because of concerns with vandalism and aesthetics, larger trees are used for street and park plantings, while cheaper, smaller-sized nursery stock is often used for riparian and other ecological restoration projects.

Selecting and Purchasing Quality Nursery Stock

To improve the chances for success in tree planting, it is important to begin with healthy plants with good structural form that have been properly grown, dug, and transported.

Trees are available in three nursery types: balled-and-burlapped (B&B), containerized, and bare-root. Each type has advantages and disadvantages. With proper planting and maintenance, B&B trees can be reliable for good survival and growth because many fine roots are intact in the root ball and ready to proliferate. However, B&B trees are heavy and much of their root system is severed and left behind at the nursery when the trees are dug.

Containerized stock is grown in a growth medium, is much lighter, and has intact root systems, but it can have problems with circling and girdling roots if it remains in the container too long. Containerized trees need to be watered more frequently than B&B trees until they are established, and they often need to be staked.

Bare-root stock is smaller and easier to handle. It can only be harvested and planted when dormant, so it's available only in early spring and late fall. It is more likely to suffer from drying and requires greater care in handling and faster planting after digging. The roots of bare-root trees must be kept moist during shipping, storage, and planting. Roots can be dipped in water to moisten them, but they should not be immersed in water for long periods because roots need to "breathe."

Genetic adaptation to site conditions is just as important as the physical quality of trees. Trees such as red maple and sweetgum, which are native to Pennsylvania, are not necessarily winter hardy if they are grown from seed collected in southern regions. To avoid this possibility, buy cultivars that are known to be hardy or obtain plants that have been grown several years in Pennsylvania nurseries or other states with similar climates.

Table 1. Advantages and disadvantages of different nursery trees.

Type	Advantages	Disadvantages
B&B	Less irrigation	Heavy
	Soil ball keeps roots moist	Roots lost during transplanting
	Large trees harder to vandalize	Time for root establishment
	Staking not always needed	Removal of portion of wire basket
Containerized	Lighter	Irrigation required
	Easier to move and plant	Staking required
		Girdling roots
Bare-Root	Light	Irrigation required
	Easier to move and handle	Staking required
	Larger root system	Must be planted quickly

Characteristics of a Good Tree for Planting

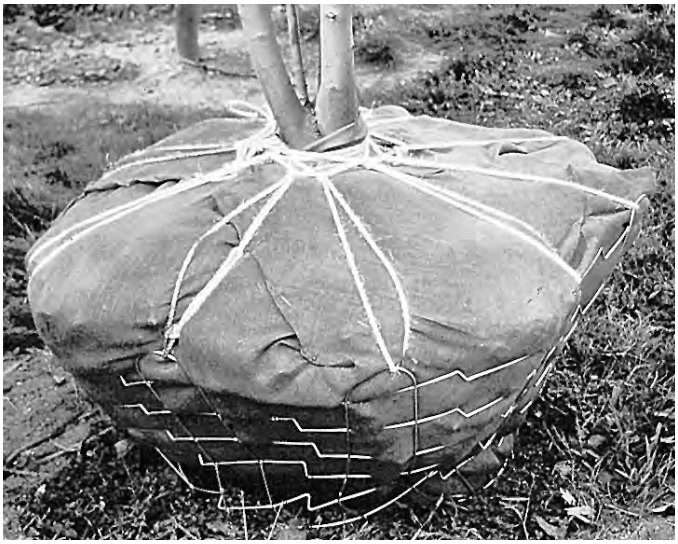
- A strong, straight trunk
- Bark that is not cut or damaged
- Branches that are evenly spaced along and around the trunk
- Branches that are not split or broken
- Dense, dark-green foliage
- No diseases or harmful insects
- A firm root ball that is securely wrapped with fresh, nonsynthetic burlap
- No roots growing out of the bottom of the container
- No roots circling the inside or top of the container
- No weeds growing in the container or from the root ball
- Moist soil in the root ball
- Freshly dug, briefly stored with moist packing material (for bare-root stock)
- The specifications listed in the *American Standard for Nursery Stock*

The *American Standard for Nursery Stock*, ANZI 760.1 (American Landscape and Nursery Association, 2014), provides the many important characteristics to consider when purchasing nursery stock, such as height-diameter relations and root ball sizes. In general, the following are important in obtaining a high-quality tree:

- To improve chances of obtaining the type and size of trees you desire, order them 6 to 12 months ahead of the planting date and check prices at several nurseries. Nurseries often sell out of the most popular trees.
- Getting the best price for trees should be a secondary consideration to quality. Low-priced trees that perform poorly or die are no bargain.
- Many nurseries allow customers to inspect and tag trees for future delivery. This helps ensure the quality of trees you want.
- Look for reasonably straight, single trunks with healthy, well-spaced branches and reasonable crown symmetry, and make sure trunks and limbs are free of scrapes or other damage.
- The most common sizes used for street trees are from 1.5 to 2.5 inches in caliper. Caliper is the diameter of the trunk measured 6 inches from the ground on trees that are 4 inches or smaller, and 12 inches above the ground on larger trees. Trees larger than 2 inches in caliper are most suitable for areas where vandalism is likely or pedestrian traffic or children's play is frequent. Larger trees can be used if a prominent landscape effect is desired immediately.

This tree has poor branching structure and should not have been purchased or planted.

Although a good example of a B&B root ball—large enough, firmly wrapped and caged, and with roots covered with fresh burlap—this tree should not be purchased because of the two competing leaders.



An example of a poor B&B root ball: too small, loosely wrapped and caged, and with roots exposed.

Encircled roots can be a problem with containerized trees. Kinked roots can be a problem with bare-root trees. Trees with these root problems should not be purchased or planted.

This tree was planted too deep at the nursery, resulting in a small root mass when the tree was balled and the root collar being buried. The root collar should be visible and large roots should only be 2 to 3 inches below the soil in the root ball.

- The proper root ball size of a B&B tree is determined by its caliper. See Table 2 for sizes and weights of root balls for trees of different calipers. Tree trunks should be centered in the root balls.
- Root balls should be moist, tightly wrapped, and free of cracks. The trunk should not move loosely in the root ball.
- Be cautious with trees whose root balls are wrapped in plastic burlap or if fresh burlap has been placed over old burlap. Plastic burlap and twine must be completely removed after a tree has been placed in the planting hole. To determine if you are working with plastic burlap, try burning the burlap. Plastic will melt; natural burlap will turn to ash and blow away.
- Some nurseries will guarantee the replacement of trees that die within a year at an added cost.

Table 2. Typical sizes and weights of deciduous B&B trees.

Caliper (inches)	Ball Diameter (inches)	Approximate Weight (pounds)	Typical Height (feet)
1.5–1.75	20	225	10–12
1.75–2	22	260	11–13
2–2.5	24	300	12–14
2.5–3	28	600	13–15
3–3.5	32	750	14–16

It is important to inspect trees both in the nursery and when delivered. Consider rejecting trees if any of the following are present:

- Two main trunks or double leaders. This is especially important for street trees. If planting ornamental trees in a lawn, you may plant certain trees that have double leaders or multiple trunks.
- Fungal cankers on branches or the trunk. Look and feel for discolored, sunken, or swollen areas in the bark.
- Signs of drying, such as dead buds, brittle twigs, parched root balls, or dried-out bare roots.
- Scrapes or other damage to the bark that exceed one-quarter of the trunk circumference.
- Cracked or loosened root balls.
- Unhealthy, circling, or kinked roots. Containerized stock, especially if left in a container too long, can have circling roots that can eventually kill a tree or slow its development.
- A root crown that is too deep in the root ball. The roots of trees that were planted too deep in the nursery or have been covered with soil by mechanical cultivation are too deep in the root ball.

If many B&B trees have been ordered, remove the burlap from the top of the root ball of a few trees and determine how much soil is covering the roots. If there is more than 6 inches of soil, additional trees in the order should be inspected. Trees with more than 6 inches of soil covering roots should be rejected. Entire root balls of containerized plants can be inspected. Trees with heavily kinked or encircled roots should be rejected.

Shipping and Handling

After trees have been selected and purchased, it is important to ensure proper shipping and handling, especially if inexperienced municipal employees or volunteer crews are moving and planting the trees. Below are some tips for shipping and handling trees.

- When transporting trees in an open vehicle, even for short distances, cover the trees with a tarp to prevent them from drying out and being damaged by the wind.

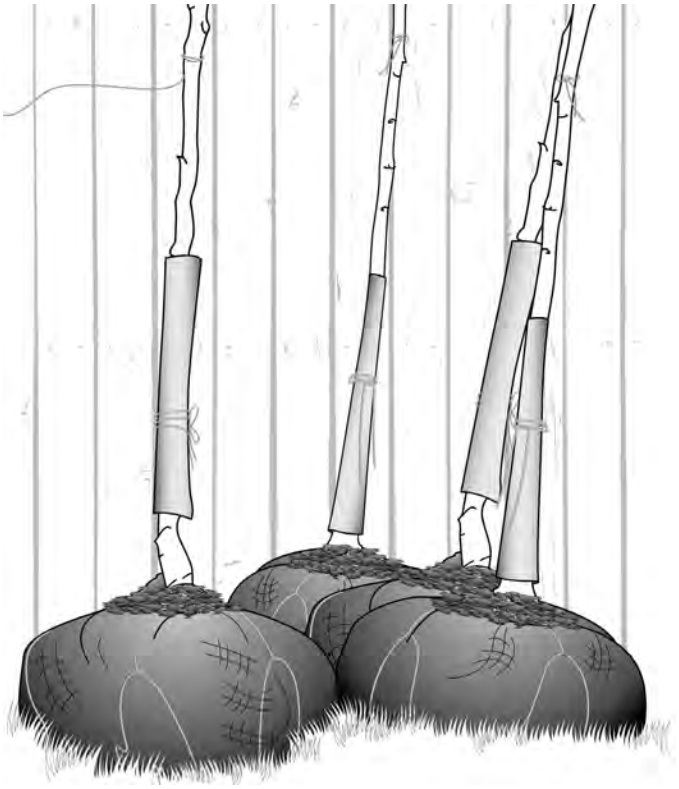
- The protective covering around the trunk should remain in place until the tree has been planted to protect it against damage from equipment or shovels. Then the covering should be removed.
- Always unload the tree as close to the planting site as possible and gently lower the tree into the planting hole. Never drop trees off a truck because this can cause cracks in the root ball and serious root damage.
- Remember that B&B trees are very heavy. Use a front-end loader or backhoe to unload them. Make sure that enough people are helping when lifting and lowering the root ball. Be careful not to drop the tree onto the legs or feet of people standing in a planting hole.
- Always lift the tree by its root ball. Never drag or lift the tree by the trunk because the root system can separate from the soil and break roots. Do not wrap chain or rope around the tree's trunk to lift it. Alternatives for lifting and moving trees include using a tree sling, hand truck, or front-end loader. If hooking a chain into the wire basket on the tree, always hook to at least two wires. If hooked to just one, the wire can break and injure people.
- The roots of bare-root and containerized trees must be kept moist during shipping.

Storage

Trees can be stored temporarily, but they should be planted as soon as possible after delivery. Tips for proper tree storage are as follows:

- The roots of bare-root trees must be kept moist. It is best to plant bare-root trees within one week of delivery. If trees are to be stored longer, they should be kept at a low temperature (around 35°F) and high humidity. Keep wrapping materials on bare-root trees until you are ready to plant them. Keep trees out of the sun and their roots cool and moist by covering them with a damp cloth or moist packing material.
- B&B trees can be stored longer by using these procedures: (1) stand the trees upright together in a group close to the shaded north side of a building or under and awning; (2) cover the containers or balls with mulch; and (3) water the trees enough to keep the root balls moist. Avoid temperature extremes when storing the trees and do not let the root balls become dry or overwatered. If B&B trees have been stored for a long period, handle them carefully since the burlap and twine may have begun to rot. If the burlap has rotted, wrap the root balls in fresh burlap before handling them.
- Containerized trees can be stored in any open, flat area. They should not be stored with B&B plants because they require more frequent irrigation, especially after bud break. Since they are well drained, containerized trees may have to be watered every day.

These trees are stored incorrectly; they should be in a shady area and covered with damp mulch.



Tree Planting

Planting Trees in Spacious Places

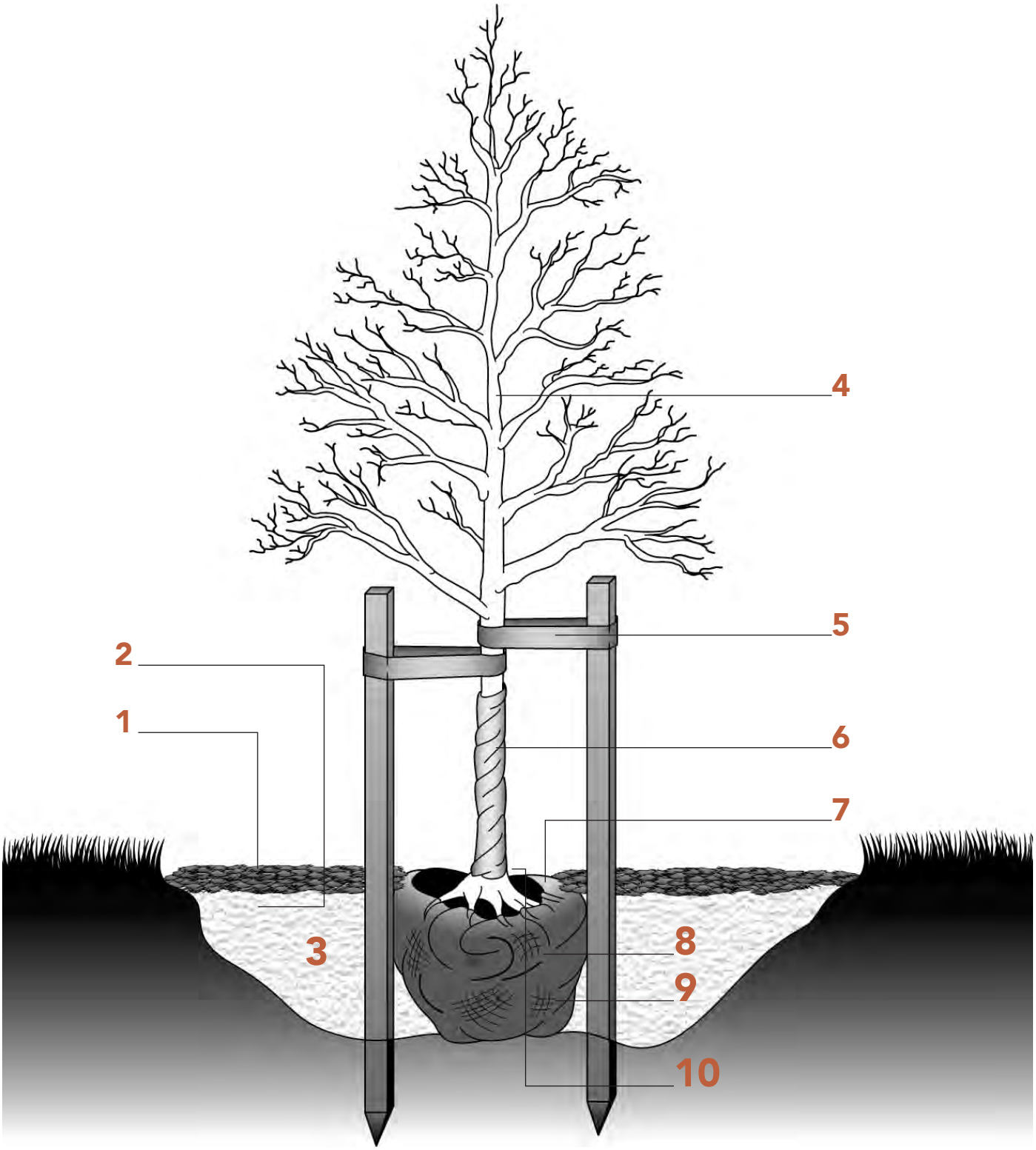
Techniques for planting B&B and container-grown trees do not differ greatly when there is ample space. The following guidelines can be used for planting trees in parks, lawns, large lawns along streets, or other spacious areas.

Planting Trees in Spacious Areas

- Loosen compacted soils as much as possible.
- Test for soil pH and fertility.
- Replace poor soils with a high-quality topsoil.
- Locate trunk flare and do not the plant tree too deep.
- Dig a wide, saucer-shaped hole with rough sides.
- Leave the soil undisturbed at the level the root ball will rest.

- Arrange for workers, volunteers, and equipment months in advance.
- To avoid hitting underground utilities while digging, contact the One-Call System a few weeks before the planting date. This system will schedule someone to identify the location of underground utilities. Check with the public works department in your municipality to locate the One-Call System.

Planting a tree in a spacious place.



1. 2- to 3-inch mulch of bark or wood chips
2. Wider hole if soil is compacted
3. Good native soil or topsoil
4. Single, straight trunk
5. Slack rubber strap
6. 1.5- to 2.5-inch caliper. Remove Trunk wrap or guard
7. Keep mulch away from root collar
8. Remove burlap or fold in bottom of planting pit. Cut and remove at least two-thirds of wire basket
9. Root ball on undisturbed soil
10. Root collar should be visible and main roots 2 to 3 inches below soil in root ball

- The ideal time for planting in the temperate zone is in the spring, as soon as the ground has thawed and excess moisture has drained from the soil. Fall plantings should be done soon after deciduous trees have dropped their leaves and before the ground has frozen, but they can be started in early September. Some trees, such as oak and zelkova, are not recommended for planting in the fall because of the potential for excessive mortality.
- Digging proper planting holes by hand can be extremely time consuming and labor intensive, especially for youth and other volunteers. Try to obtain a backhoe and operator from the municipality, borrow one from a construction firm, or rent one. A backhoe not only makes it easier to plant trees but also helps in the correct digging of wide planting holes. Communicate with the backhoe operator to make sure the operator understands the size of tree planting holes that you want, or you will be filling in holes that are too deep, which can cause trees to settle, tilt, or be planted too deep.
- Mark out a planting area that is three to five times the diameter of the root ball; the wider the planting hole, the better. Loosen the soil in the entire planting area to the depth of the root ball. At a minimum, the planting hole should be two and a half times the diameter of the root ball and soil loosened to 12 inches as far around the planting hole as possible.
- In the center of the loosened soil, dig a hole that is twice the diameter of and exactly as deep as the root ball. To prevent the root ball from being planted too deep, it should sit on solid, undisturbed ground rather than loose soil. To plant the tree at the proper depth, make sure the upper surface of the root ball is level with the existing grade of the area. Because of cultivation in the nursery, B&B stock may have soil piled on top of the root collar (where the tree trunk flares out to the roots), causing trees to be planted too deep. Pull excess soil away to identify the root collar and determine the proper depth of the planting hole.
- Before placing the tree upright in the planting hole, carefully remove any twine that may be holding branches together.
- Once the tree is properly situated in the planting hole, cut and remove any twine holding burlap in place. Remove burlap from at least the upper third of the root ball; cut it off or shove it down into the planting hole. All artificial burlap must be removed from the planting hole. If a tree has come in a wire basket, cut at least the top one-third or two tiers of wire and remove it. Before backfilling, check from two sides and be sure the trunk is vertical.
- Hold the tree upright while backfilling around the root ball. Gently pack the soil to prevent any major air pockets; water occasionally to help settle the soil. When the root ball has been covered with soil, rake the soil evenly over the entire planting area and cover the area with 3 to 4 inches of com-

For good establishment and growth, trees must be planted at the right depth, as shown here, with the top of the root ball level with the existing grade. Note that the root collar is exposed.

This tree was planted about 7 inches too deep, which can cause death or long-term decline.

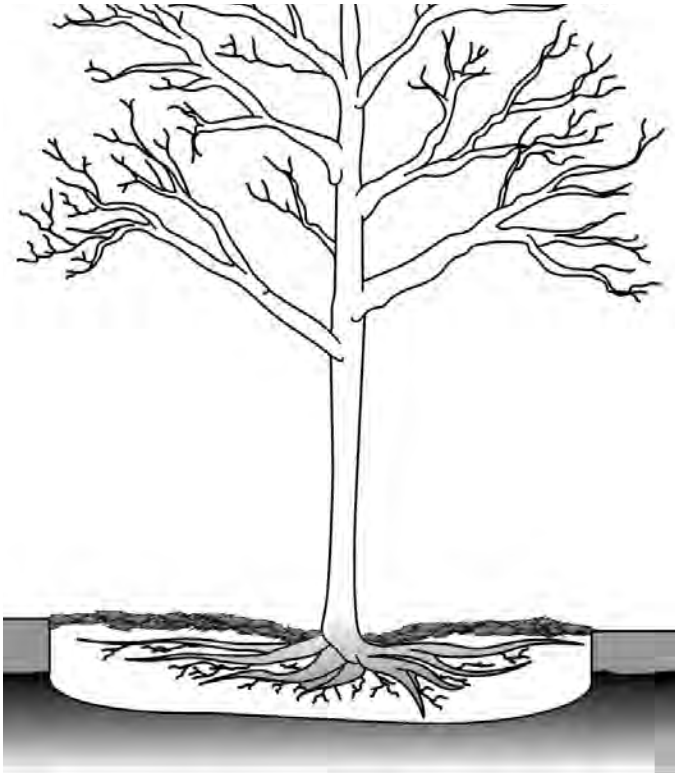
This tree was planted slightly too high and the twine and burlap should have been removed. The suckers growing from the base should have been removed.

The twine, burlap, and metal cage should be removed from at least the top third of a B&B root ball to avoid poor root growth and root girdling.

posted mulch. Keep mulch a few inches away from the tree trunk because mulch piled around the trunk may keep it too moist and lead to fungal problems. Deeply water the entire excavated area.

- Mounding the soil at the outer edge of the root ball to form a water-holding berm can help hold a larger quantity of water, but it may also encourage root growth to remain close to the tree. If you decide to use a watering berm, the berm should be made slightly beyond the root ball to promote root extension into the surrounding soil. Cover the berm with mulch, but keep mulch away from the tree trunk.
- The roots of bare-root trees should be supported by a mound of soil within the planting hole so they will be evenly distributed within the planting hole. Do not kink the roots of bare-root trees to force them into a planting hole that is too small. Their root collar should be positioned level with the existing grade.

Bare-root tree roots should be spread out in the planting pit, not kinked. Bare-root trees are lighter but must be staked and irrigated.



Planting Bare-Root Trees

The Urban Horticulture Institute at Cornell University has developed a system for transplanting large bare-root nursery trees that can be used to replace B&B trees in plantings. Instead of shipping trees balled and burlapped, bare-root trees are dipped in a slurry of hydrogel and placed in large, pleated plastic bags. Trees are treated at the nursery and loaded into an enclosed truck or an open bed covered with a tarp. Store the trees in a cool, shady spot and plant them as soon as possible, but within a few days.

Larger bare-root trees should be planted in a shallow hole no more than 12 to 18 inches deep and wider than the spread-out root system. Fill the planting hole with loosened fertile soil and mulch the planting area correctly. Because there is no added weight from a root ball, bare-root trees need to be staked. It is important to keep bare-root trees adequately watered during warm weather in the first few growing seasons.

Trees should be planted when they are dormant in late fall or early spring, and only deciduous trees can be planted using this method. Trees that have responded well to this new method of planting include hybrid freeman maple, hedge maple, shadblow, crabapple, Japanese tree lilac, shantung maple, Norway maple, sycamore maple, black alder, ash, ginkgo, honey locust, Kentucky coffeetree, sweetgum, scholar tree, linden, and Japanese zelkova.

Planting in Sidewalks, Patios, Cutouts, and Other Harsh Landscapes

The size that a tree can attain depends mainly on the volume and quality of soil accessible to its roots. Providing an adequate amount of soil volume will increase the amount of moisture and nutrients available to a tree, leading to larger, healthier, and long-lived trees. Various techniques, such as structural soils and Silva Cells, can be used to modify sidewalks or other confined planting areas. Silva Cells are usually expensive, and any technique to increase soil volume should be designed with the assistance of an engineer or landscape architect. Examples of nine tree planting details can be found in Appendix I.

It is important to properly water and maintain trees that are planted in sidewalks, patios, and other built landscapes. There is no sense in designing and constructing special planting areas only to have trees perish because they were not watered. Before trying extraordinary site-modification techniques, consider whether tree planting sites can be relocated to nearby yards or other more favorable areas.

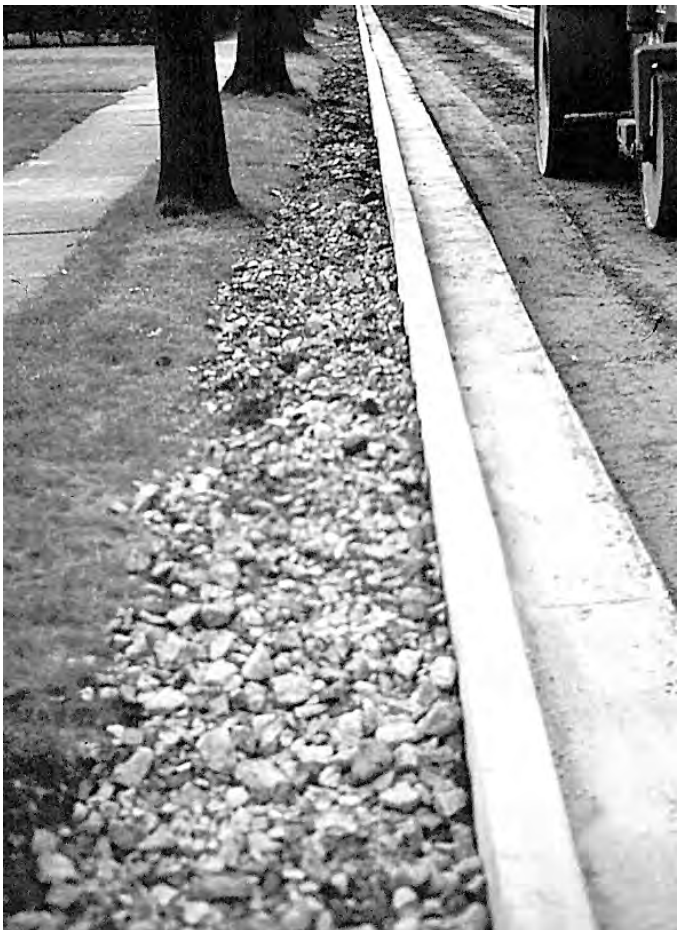
Many people recommend large cutouts with a minimum available rooting volume of at least 800 cubic feet per tree. These are extremely large areas (14 by 14 by 4 feet or 16 by 16 by 3 feet) and may not be available in all planting situations, especially when working with older sidewalks and other planting areas that will not or cannot be redesigned or rebuilt. Cutouts for trees in parking lots, sidewalks, and patios should be a minimum of 5 by 5 by 3 feet (6 by 6 by 3 is a minimum recommended by some, but bigger is better; for example, if cutout length can be increased, a cutout 10 to 12 feet long, 5 to 6 feet wide, and 3 feet deep is preferred to support one large-growing tree such as oak). However, allowing that much space may be impossible in some situations. Depending on the size of the tree, the depth of the soil available for rooting volume should be at least 3 feet for windfirmness.

Cutouts measuring 5 by 5 by 3 feet (75 cubic feet of fertile soil) are the minimum size for planting trees in sidewalks, patios, or parking lots. Pits measuring 5 by 10 by 4 feet are used in Philadelphia and other cities to plant large trees such as oak and sycamore.

Planting Trees in Sidewalks, Patios, and Other Confined Places

- To provide adequate soil volumes, planting cutouts should be as large as possible.
- Structural and sandy soils can be used to increase soil volumes and rooting areas under sidewalks and patios.
- Both structural and sandy soils do not hold water well, so drought-tolerant trees and irrigation must be used.
- The use of BioChar, a charcoal soil amendment, may improve the properties of urban planting soils.
- Larger tree-planting areas such as continuous planters can be engineered as rain gardens and bioretention basins.

Limestone gravel, cement, and asphalt will raise the soil pH in planting sites. Pin oak, red oak, red maple, and other trees intolerant of alkaline soils should not be planted in these areas.



In new construction, structural or other designed soils systems should be engineered to increase rooting volumes under concrete and other hardscapes. In contrast, planting trees in existing sidewalks and patios can be a challenge. Sometimes in confined places such as existing sidewalks, a decision must be made whether to plant a tree or not. If a tree is planted in less than the minimum planting cutout size recommended above (5 by 5 by 3 feet), problems with hardscape damage and tree condition should be expected, including issues of tree size, health, longevity, and the strength of root structure. These concerns may be minimized by providing the largest planting area possible, planting an appropriate tree species, and watering properly. Minor hardscape damage, smaller mature tree size, and other problems are offset by the economic and environmental benefits that a reasonably healthy tree will provide a downtown area, parking lot, or other populated landscapes over time.

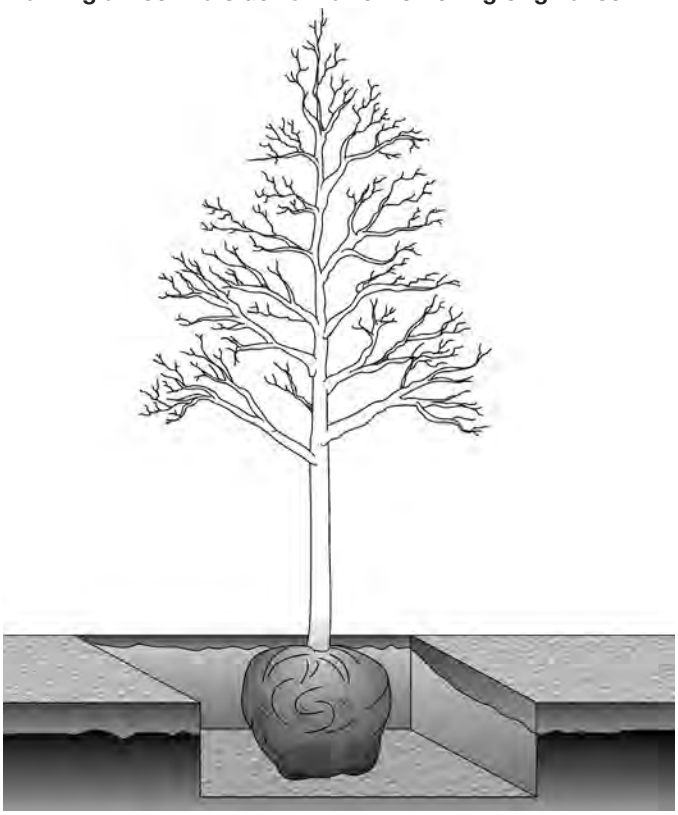
To plant a tree in a cutout, loosen all soil within the planting pit and plant the tree as described for spacious areas. If the excavated soil is poor or full of debris, do not amend the soil with sand or organic material; instead, replace it with a fertile topsoil. Replacement soils must be cultivated with the original soils at the bottom and sides of the planting areas to prevent transition zones. If structural soils are being used to support concrete, topsoil should be used to refill the actual planting pit. If the drainage of the area is poor, consider moving the planting location or using recommendations for managing poorly drained, compacted soils.

Do not plant red oak, pin oak, sweetgum, or red maple in areas where alkalinity is a concern. In places with heavy pedestrian traffic, use stakes or iron guards to protect trees from damage and vandalism. Sidewalk planting pits should be located so that trees will not interfere with business signs, traffic signs, and sight visibility at intersections or be hit by car doors and bumpers. Sidewalk, patio, or parking lot cutouts can be improved by using structural soil, shared space for trees, continuous planters, or raised planters, especially when major repair or construction is being planned and designed.

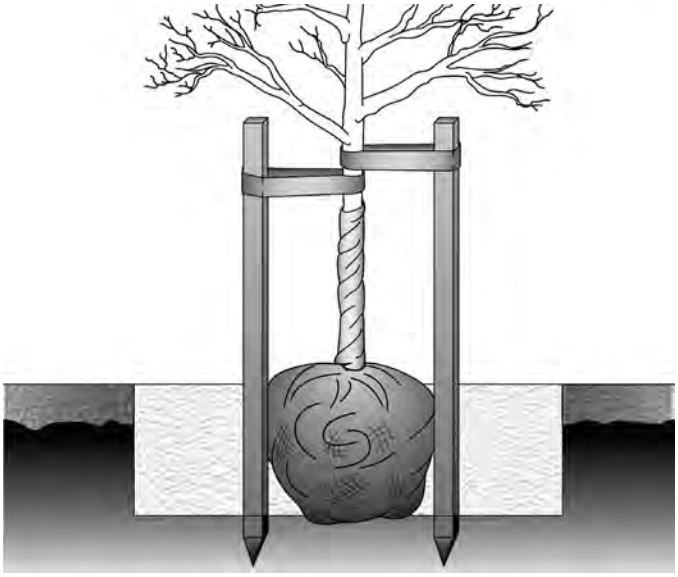
Trees for Sidewalk and Patio Plantings

- Ginkgo: 'Autumn Gold', 'Princeton Sentry', and 'Lakeview'
- Hardy rubber tree
- Honey locust: 'Imperial' and 'Skyline'
- Hybrid maple: 'Autumn Blaze', 'Celebration', and 'Scarlet Sentinel'
- London planetree: 'Bloodgood'

Planting a tree in a sidewalk after removing original soil.



Remove all nonfertile soil from pit that is at minimum 5 by 5 by 3 feet (75 cubic feet).



Stake to protect street trees.

Although 5 by 5 by 3 feet to 6 by 6 by 3 feet are the recommended minimum cutouts, larger planters such as 6 by 12 by 3 feet should be used to plant large trees in downtown areas.

Large sidewalk cutouts and innovative planting design should be used for larger trees.

Do not cover cement and other debris with a few inches of topsoil. All garbage and construction gravel should have been removed from these parking lot and other planting cutouts. These and other planters should be filled with topsoil or a professionally designed soil.

For best results, innovative designs that provide for more fertile soil, rooting areas, and stormwater management should be used.

Continuous planters provide good soil volume and can be covered with brick or other permeable panels. Structural soils can be used under sidewalk to increase rooting area.

Continuous Planting Spaces

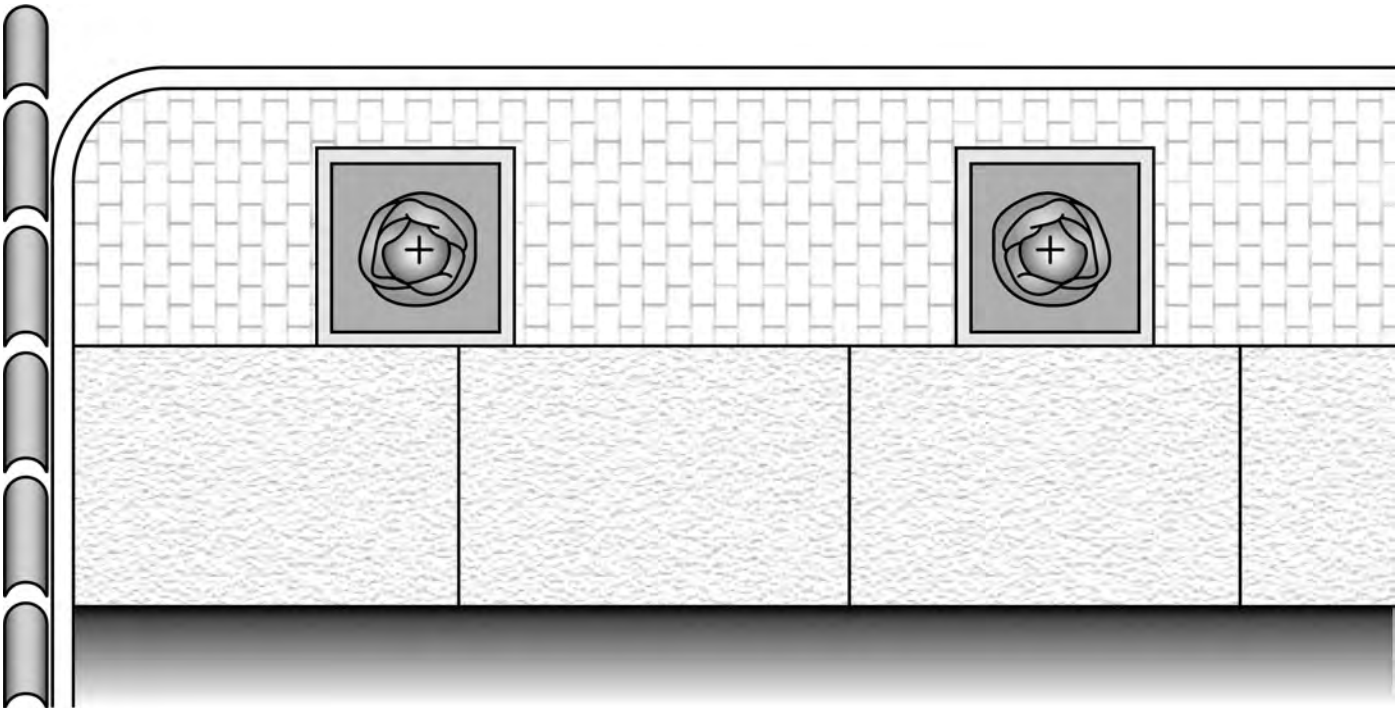
In wide sidewalks, a continuous tree planting space can be constructed by cutting a minimum 4-foot-wide strip parallel to the curb and trenching to break soil compaction, or by removing and replacing poor or contaminated soil with topsoil. The shared planting space should be as long as possible and as deep as the root balls being planted and have an open bottom. Brick or other porous paving material should cover the planting space. This type of planting space can promote root growth parallel to the curb and provide trees with larger, shared rooting volumes in sidewalks or other paved areas. Areas for root growth can be further increased by using structural soils covered with permeable pavers under hardscapes surrounding a continuous planter (see page 9).

Shared Spaces and Cluster Plantings

Groups of trees can share larger soil spaces, which improves growing conditions for all trees. Shared spaces promote a mutually beneficial environment that provides cool shade, higher humidity, and organic material to improve soil structure and fertility. Larger planting areas can be designed in sidewalks, patios, parking lots, or within large areas of compacted soils to support groups of trees and other plants instead of the traditional single cutouts in concrete.

In shared planting areas, it is beneficial to loosen all soil in the planter to the depth of the root balls being planted, and then plant trees as described in the section on planting in spacious areas. If existing soil is poor, replace it with a high-quality topsoil, not gravel. Keep the bottom of shared planters open and cultivate new soil into old soil to provide for better drainage.

Plan view of a continuous planter.



Shared planters can be used to provide more soil nutrients, moisture, and shade to tree roots. Keep the bottom of shared planters open to provide better drainage.

Raised Planters

Elevating planting spaces above sidewalks or parking lots is a good way to provide positive drainage, avoid salty runoff, and discourage compaction due to pedestrian traffic. With heights up to 36 inches, the planter lip can provide seating. Raised planters should be filled with good topsoil and be as large as possible to avoid excessive heat and cold. Keeping the bottom of the bed open provides for better drainage and root growth. French drains or other channels or sinks filled with gravel can be incorporated into the design to improve drainage.

Designing Aeration Systems for Confined Planting Areas

Tree roots are opportunistic, tending to grow in soil where the air–water balance is most favorable. It has been proposed that aeration systems can be built into concrete cutouts, continuous planters, or containers to improve the root environment and encourage root growth. The extent to which embedded pipes may improve root growth has not been well documented. Aeration systems do not replace the need to provide

Raised planters can be used to provide more soil volume, avoid road salt and other runoff, and provide shady seats. The bottoms of raised planters should be kept open.

adequate irrigation to newly planted trees using Gator Bags or other techniques for deep watering. Aeration systems may encourage deeper rooting of trees by increasing oxygen and water at greater depths than would normally occur under sidewalks, parking lots, and other confined areas. Promoting deeper root growth will improve the health and longevity of trees and result in less damage to sidewalks and curbs from surface rooting. Constructing parking lots and sidewalks with permeable paving materials can also be used to improve soil moisture and aeration.

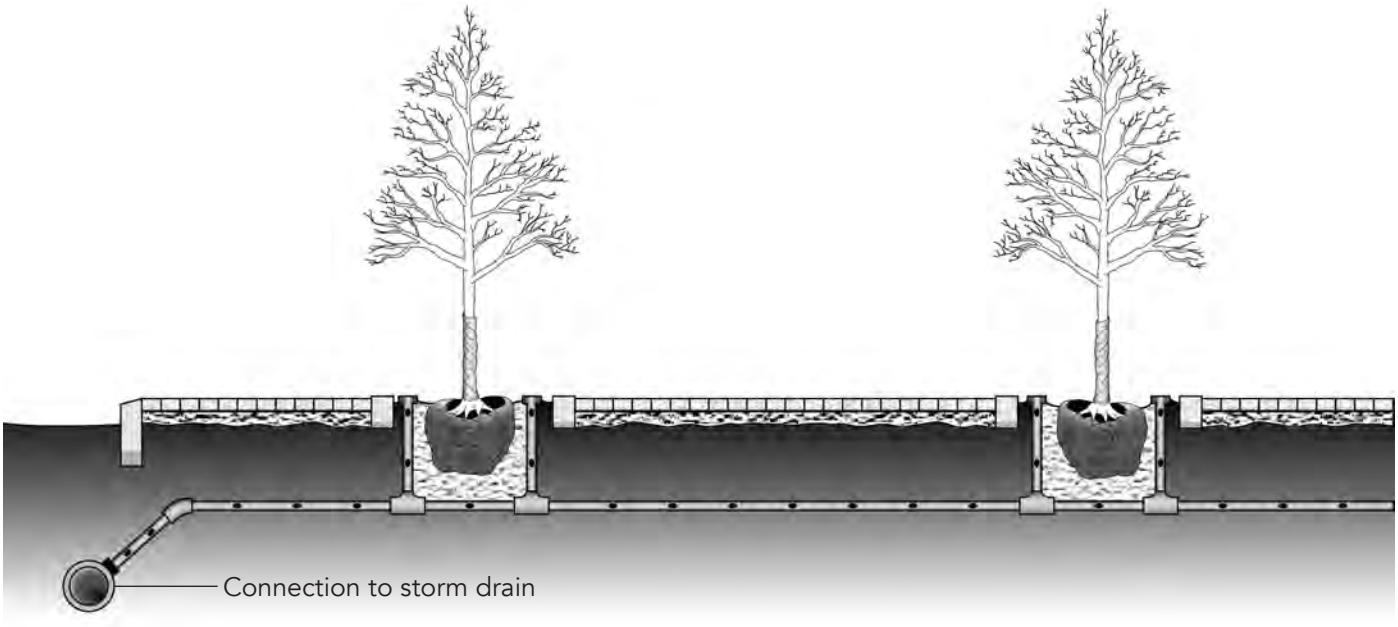
An aeration system is best designed and installed by an expert when major sidewalk or parking lot work is being completed. To prevent tree roots from clogging the system, pipes should be wrapped with geotextile. The tops of vertical pipes should be covered with slotted caps to allow free air exchange but keep out litter. The pipe system can be attached to a storm drain or other channel of moving air to help increase aeration and move excess water away from tree pits. In more complicated systems, a check valve should be installed at the connection to the storm drain to prevent water backflow.

Preventing Root Interference with Sidewalks

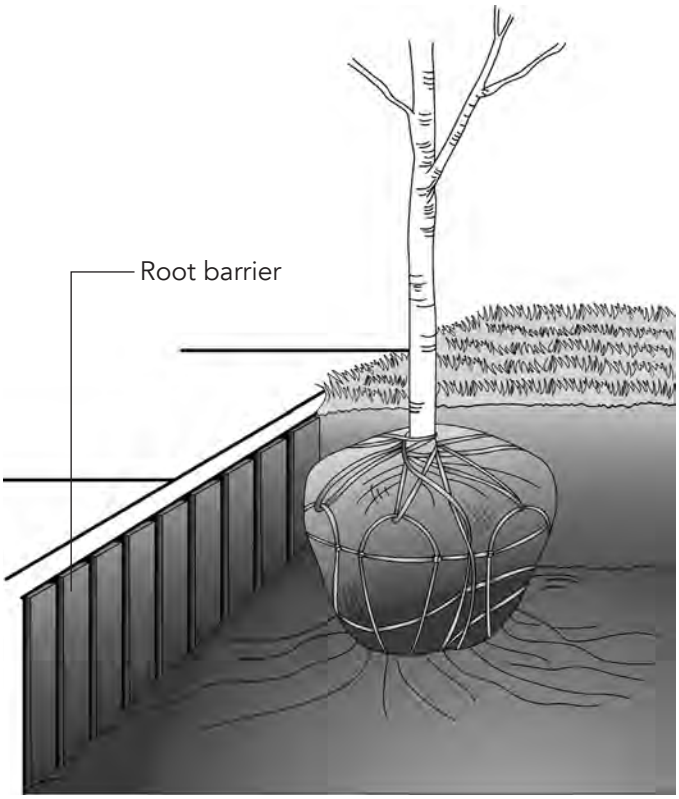
Because of the need for air, moisture, and fertile and friable soil, most tree roots can be found within the top 2 to 3 feet of soil. When a tree root encounters an obstruction such as a sidewalk, it may extend underneath and raise the concrete as it grows in diameter every year. The likelihood of this occurring increases with compacted soils or poor drainage which limit the depth of root growth, especially when larger trees are improperly planted in small growing spaces. Preventing root damage to sidewalks and curbs requires selecting species to match the size of the planting site, altering sidewalk construction, installing plastic or other root barriers, and providing good maintenance such as slow, deep watering using Gator Bags. It is not advisable to plant trees in areas where planting lawns/strips are less than 2 feet wide. In strips 2 to 4 feet wide, plant trees with a mature height of less than 30 feet. In strips 4 to 6 feet wide, plant trees with a mature height of less than 45 feet. Trees that grow taller than 45 feet can be planted in planting areas over 6 feet wide.

Tree roots are less apt to raise sidewalk blocks if the cement blocks are thick and heavy enough and properly engineered. Sidewalk design can be altered by using more expansion joints near trees, curving or bowing sidewalks around trees, reducing sidewalk width to 4 feet wide, and expanding the size of planting cutouts and tree lawns. Using root barriers between planted trees, sidewalks, and curbs can reduce damage, but the use of root barriers should be coupled with good tree selection, planting area and sidewalk design, proper planting, and proper maintenance, including deep watering. Root barriers that are commercially available include polypropylene plastic and geotextile fiber impregnated with herbicides; 6-mil plastic film also has been suggested as a root barrier. Barriers should be installed in trenches along the sidewalk or curb to a depth of 12 inches and extend 3 to 4 feet in each direction from the tree trunk. Water recently planted trees slowly and thoroughly, but not more than once a week. Frequent shallow irrigation may encourage the development of a shallow root system.

Elevation view of a continuous planter. Where needed, the pipe system can be connected to a storm drain to provide drainage.



Root barriers used along with proper site preparation, species selection, planting, and watering can decrease damage to curbs and sidewalks.



Important Details on Mulching

- Apply no more than 2 to 3 inches of mulch around, but not touching, the tree trunk.
- Do not apply mulch cones or volcanoes.
- Mulch outward from a tree trunk to a reasonable distance (at least to the edge of the planting pit).
- Maintain a 2- to 3-inch layer by removing and replacing old mulch.
- To provide for air and water, replace mulch that has been compacted by pedestrian or other traffic.

Caring for Trees

Using Mulch and Other Porous Surface Materials

Mulching newly planted trees is one of the easiest and most effective ways to protect them and encourage root establishment. Mulch conserves soil moisture, stabilizes soil temperatures, reduces competition from grasses and weeds, provides nutrient-rich organic material to a soil, lessens lawn mower and weed trimmer damage, and prevents soil compaction by pedestrians. Composted, coarse-shredded mulch should be used for street and other plantings because it is less likely to be blown away or compacted. Mulch should not be applied too thick and never placed against a tree trunk. Apply 2 to 3 inches of mulch over and somewhat outside the rooting area of a tree. Because noncomposted mulch may take nitrogen from the soil, composted mulch is preferable. Leaf mulch is another option, but it will decompose more quickly and will have to be replenished more frequently. Maintaining the mulch layer each year will improve tree health substantially and can improve the structure of compacted soils. In high pedestrian areas, mulch can become compacted and seriously limit the amount of water and air available to tree roots. Compacted mulch should be removed and replaced in a timely fashion.

Other materials can be used in sidewalk cutouts and areas where mulch may be impractical. Although expensive, iron tree grates are long lasting and require little maintenance. Every few years the sections that interfere with the enlargement of the tree trunk must be cut out. Grates should have small openings that will not cause pedestrians to trip and won't collect debris. Bricks or paving stones set in sand are sometimes used, but these tend to settle and must be reset periodically. Special paving bricks that support one another can avert this problem. A mulch or gravel surface is practical only if it can be contained within an edging barrier. Avoid paving materials that permit little water to infiltrate and deprive trees of moisture essential to their health.

Mulch improves soil and protects trees from lawn mower and weed trimmer damage. Only 2 to 3 inches of mulch is needed, and it should be kept away from tree trunks.

Decay damage done by adding too much mulch and placing mulch against the tree trunk.

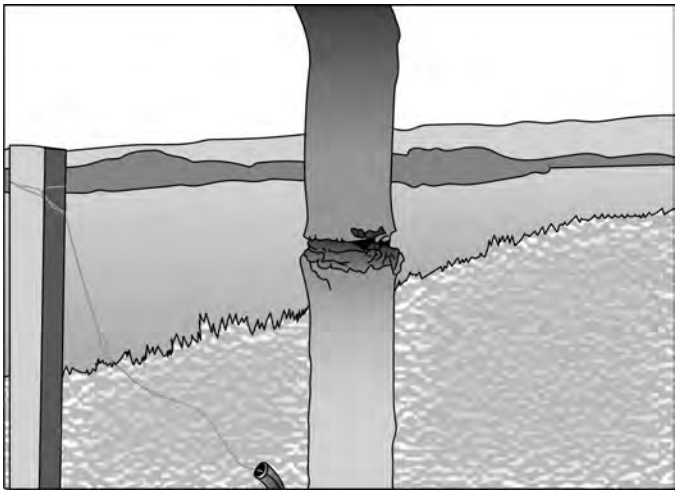
Staking

First, consider whether staking a tree is necessary. Most B&B trees are so heavy that they do not require staking to hold them upright. Staking is recommended only if a tree needs support or protection. Staking should be used to protect trees planted near curbs, sidewalks, or playgrounds from car doors and vandalism.

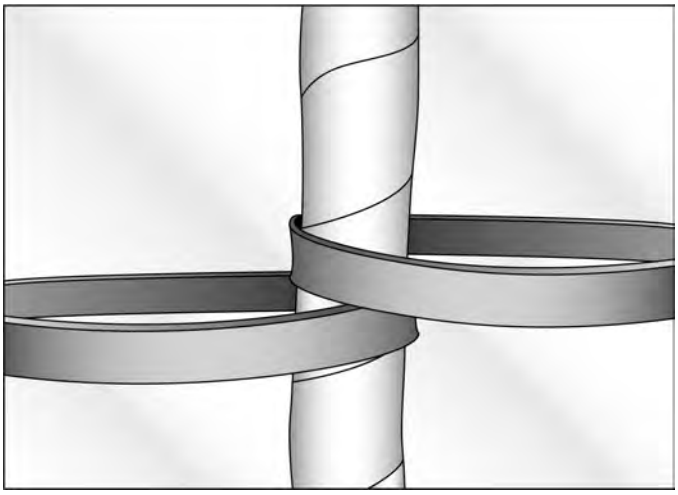
Staking should keep a tree in an upright position but allow for trunk movement. Trunk movement caused by the wind promotes taper in the trunk and increases trunk diameter and strength. There are various techniques for staking or guying. Common staking problems can be avoided by following these guidelines:

- Ties can be made in various ways. A loosely fitted figure-8 tie of rubber or webbed strap is easy to install, provides good support, and cushions the tree from rubbing. Do not use wire ties.
- Regardless of the tree size or the tie used, always allow enough slack to let the tree sway. This movement is necessary for building the strength of the trunk.
- Avoid driving stakes through the root ball or damaging tree roots when staking.

Wire ties should not be used when staking because of girdling and other wounds. Ties should be removed after the first season.



Only soft materials, such as rubber straps, should be used to attach trees to stakes.



- Remove stakes and ties within one year, before ties girdle the trunk. If a tree will not stand on its own after one year of staking, consider removing the tree and replanting it.

Watering

Inadequate or excessive water reduces the chance that a tree will become established and grow. Improper irrigation is one of the biggest killers of newly planted trees. Trees become established when their root systems adequately support root and branch growth. Trees and other plants must be watered when they are planted and periodically thereafter until they are well established. The amount of water needed and when to apply it depends mainly on inadequate rainfall but also on the moisture-holding capacity of a soil, drainage, and the type of mulch used.

Rapid water loss on hot summer days can kill young or newly planted trees. During hot, dry periods, water trees every week during the first few growing seasons. A 2- or 2.5-inch caliper tree should receive 20 to 40 gallons of water each time it is watered. The need for watering will gradually fade in successive years as the trees become established, but watering will still be beneficial during extended droughts. Water should be applied slowly and uniformly over the planting area until it penetrates the bottom of the root ball. This can be done by using perforated containers called Treegators® or a 5-gallon plastic bucket with several small holes made in the sides, close to the bottom. Excessive watering combined with inadequate drainage deprives roots of oxygen and can kill them. The symptoms of overwatering are the same as those for drought: wilting, loss of leaves, and poor growth.

Fertilizing

Trees that are grown in good soils in a nursery, receive proper weed control, and are irrigated and fertilized regularly develop a "growth momentum" as a result of high levels of carbohydrates (energy reserves) and nutrients (mineral elements) that accumulate in the trunk, limbs, and roots while growing under optimum nursery conditions. This momentum allows the trees to reestablish both a dense, healthy canopy and root system after planting.

Although there is a debate about the ability of newly planted and young trees to utilize fertilizer because of limited root growth, some nutrients may be needed to replenish a tree following the first flush of growth. If nitrogen is needed, it should be applied in small amounts, compared to phosphorus or potassium. The amount of fertilizer to apply should be based on the results of a soil test.

If Treegators® are not available, 5-gallon buckets with small holes in the sides near the bottom can be used to water trees slowly and deeply.

Important Details on Fertilization

- Many soils are fertile and do not require fertilization.
- Fertilization should be based on a soil test.
- Fertilizer is not plant food; it is a salt that stimulates growth.
- Improper fertilizing can burn roots and cause undesired leaf growth.
- Use slow-release fertilizers with low amounts of nitrogen.
- Apply fertilizer in late fall or early spring.

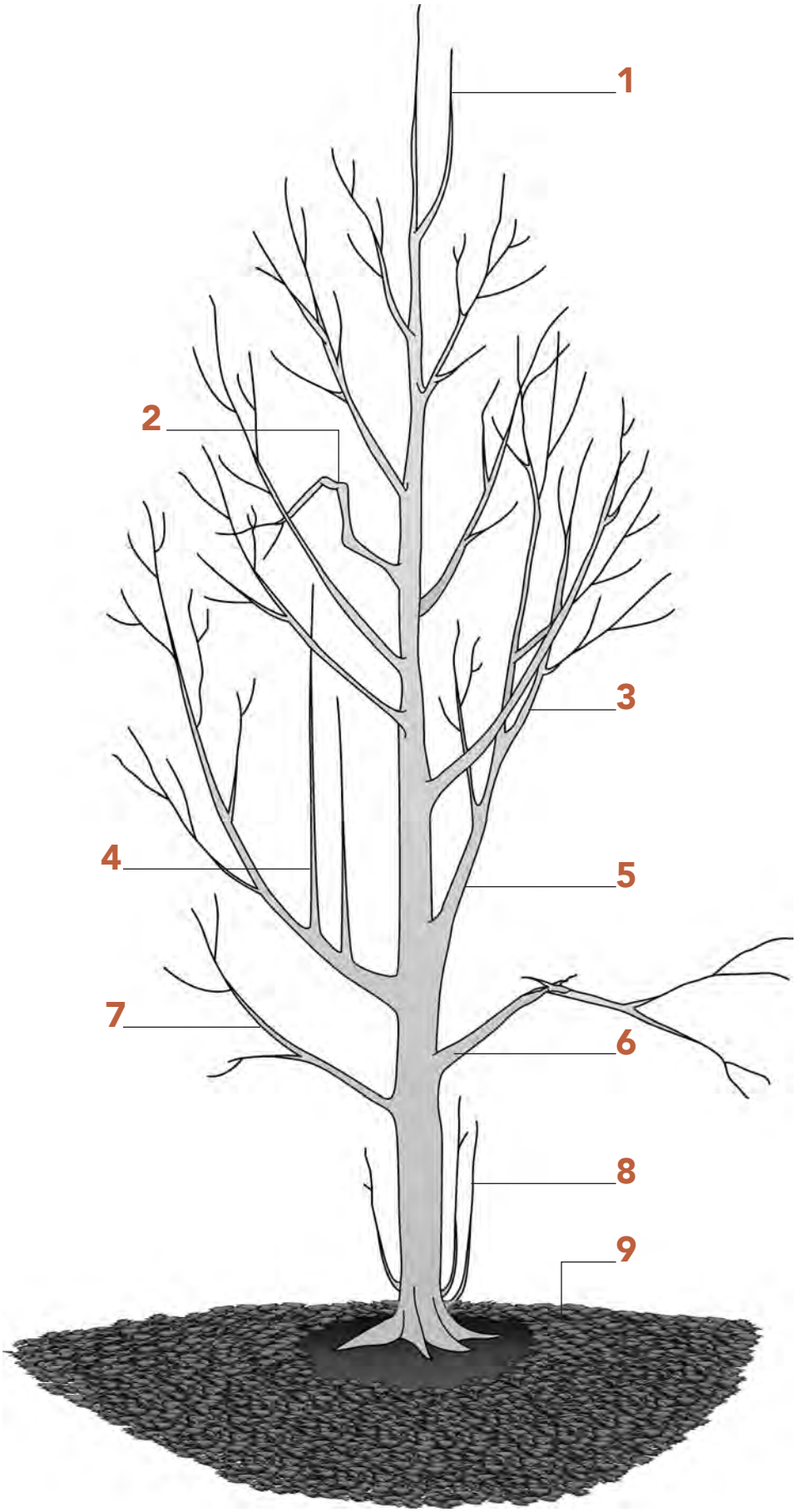
Trees planted in newly developed areas, sidewalk cutouts, and other harsh urban sites without soil amendment or replacement may benefit from fertilization at planting. Since soils in developed areas vary greatly from one site to another, and it is impractical to test the soil at each planting site, a general-purpose, complete fertilizer can be applied. Nitrogen (N), phosphorus (P), and potassium (K) are nutrients that are important to tree growth and condition. A bag of fertilizer lists three numbers on the package that tell you the percentage of N-P-K that is provided (for example, 10-8-6). The first number is the percentage of nitrogen; the second, the percentage of phosphorus; and the third, the percentage of potassium.

Newly emerging roots are sensitive to high salt levels in soils, so only fertilizers with low salt indexes should be used. Fertilizers high in nitrogen can encourage heavy foliage growth, which may place a high demand for water on roots and increase problems with fire blight or other diseases or insects. Use a slow-release fertilizer that has a low proportion of nitrogen, such as a 10-8-6. Recommendations for the amount of fertilizer are based on the number of cubic yards of soil (for newly planted trees) or per 1,000 square feet of canopy for larger trees. One simple recommendation is to broadcast 2 cups of slow-release, low-nitrogen fertilizer evenly around younger trees.

Training Young Trees

Responsibility for the care of newly planted trees should be designated even before the trees have been placed in the ground. Proper maintenance includes not only mulching and irrigation but also judicious pruning. The purpose of pruning is to develop a balanced and well-spaced structure of branches while maintaining the typical form of a tree. Pruning trees while they are young is easier and causes smaller cut surfaces that recover faster and provide smaller entryways for infection. Pruning to promote a strong framework during the first

Examples of branches that should be pruned from newly planted trees.



1. Remove a competing leader. Cut back the less vigorous branch to prevent the development of two leaders, which could cause the fork to split as the tops grow larger.
2. Remove any malformed branch.
3. Remove any crossing branch. It may rub against and damage another branch.
4. Remove water sprouts.
5. Except for trees that have naturally ascending branches, remove any branch growing at a sharp or unnatural angle. When this branch becomes larger, the bark can separate the trunk and the branch. As the tree grows and the limb gets heavier, the added weight can result in the limb splitting from the trunk.
6. Remove any broken or badly damaged branches.
7. Remove lower branches over time. These branches should be removed during the first two years to provide clearance for vehicles and pedestrians.
8. Remove suckers, which take energy away from desirable growth.
9. Apply 2 to 3 inches of composted mulch at the base of the tree. Mulch should be kept 2 to 3 inches away from the trunk of the tree.

10 years of a tree's life is a sound investment that will decrease maintenance problems, efforts, and costs later.

Properly trained trees provide benefits sooner and should require less corrective pruning as they mature and branches become larger. Young trees should be trained so that they have a sturdy, tapered trunk with well-spaced branches typical of the species. Remember that trees grow from the tips and top, not from the bottom. If not pruned, a branch that is at a height of 4 feet on a young tree will be at the same height on a mature tree. The training guidelines provided below apply primarily to large-growing deciduous trees such as maple and oak.

- With proper training and supervision, volunteers can prune young trees. It is important to show volunteers how and what to prune and supervise their work. Before you start pruning a tree, look at the tree from all sides and make decisions about which branches should be removed.
- Use sharp, clean tools in a safe manner. Common sense, a hand pruner, and a curved, narrow-pointed saw are all the tools needed for pruning young trees.
- Do not perform compensatory pruning on young trees to bring a tree's canopy and root system into equilibrium. Trees bring themselves into balance. The less efficient leaves, twigs, and branches will naturally die out as a tree grows. Only prune broken, damaged, poorly attached, malformed, parallel, or crossing branches from newly planted trees.
- To encourage the growth of young trees, it is important to leave the lower temporary branches below the lowest permanent branch. When temporary branches grow to about 1 to 2 inches in diameter, they should be removed so that wounds will be small and heal quickly. The height of the lowest permanent branch will depend on the function and location of the tree. Ornamental trees, such as bronze beech, are meant to have low, drooping branches and should be planted in areas that allow for this. In parks and yards, retain small branches for one to five years to increase trunk size and taper. Gradually remove lower branches over several years, not in one pruning. Depending on their height, street trees should have been pruned up to 4 to 6 feet at the nursery. If additional branches need to be pruned, remove them gradually through multiple prunings over several years to provide clearance for pedestrians (8 feet) and vehicle traffic (15 feet). If needed, temporary branches can be shortened by pruning them back to a lateral branch to provide clearance.
- For most street and park trees, maintain a single, straight trunk or central leader. After the first year's growth, removing or pruning back other competing leaders can encourage a single leader. Overcrowded branches need to be thinned. Retain permanent branches that will provide a strong structure and grow into a shape that is typical for the species. Permanent branches should be adequately spaced vertically and radially. If any need to be shortened, they can be pruned back to a lateral branch. If two major limbs are growing so close together that they will grow into each other, one should be removed.
- Pruning back to a lateral branch or bud can slow the growth of the branch being pruned. By pruning in this manner, the growth of the unpruned branch or leader can be accentuated over another that has been pruned.
- The angle of branch attachment and the relative size of a branch in relation to the trunk of a tree are important for the strength of the branch attachment. Permanent branches should be one-half or less than the diameter of the trunk. Branches with unnaturally sharp angles of attachment should be removed to prevent included bark and weak branch unions from developing. It can be difficult or impossible through pruning to strengthen the clustering of branches that occurs in species like zelkova or elm. Trees with growth forms like this can have problems with branch failure, especially with early or late season ice or snowstorms.
- Wound dressings are unnecessary and can be detrimental.
- As a tree grows to maturity, pruning should concentrate on maintaining or improving the tree's structure and removing deadwood and other branches that increase tree risk. Pruning tree crowns properly based on species, tree age, and tree condition (health and structure) can increase the tree's condition by allowing more light and air into the tree canopy and reducing insect and disease problems and tree risk. Before pruning mature trees, consult the many standards that have been developed for safe and proper pruning. Only a qualified arborist should climb into large trees. Pruning should accentuate the natural form of a tree; trees should not be topped. By planting the right tree in the right place, the need to reduce the size of any tree can be minimized.

Controlling Disease, Insects, and Calamitous Damage

A wide variety of genetic diversity provided by planting different tree genera and tree species is essential for ecological and aesthetic health. Diversity not only adds interest and beauty, it also protects landscapes from cataclysmic problems due to exotic and domestic pests, disease outbreaks, and storms. Rely on species diversity to help avoid environmental, funding, and emotional disasters caused by mass tree die-off from problems such as elm yellows, Dutch elm disease, and emerald ash borer. Never use a single species (monoculture) for large plantings on a street or in a park or neighborhood. Do not allow one tree genus or species to dominate a shopping mall, campus, or alley of trees. Planting three or four types of trees along a street is recommended. One recommendation to increase diversity

is in an entire municipality, limit any species to 10 percent of plantings and limit any genus (a class of things with common characteristics, such as all maple trees) to 20 percent. The best way to manage tree problems is to select and plant trees that are resistant or tolerant to insect and disease problems and tolerant of existing site conditions. Judicious pruning throughout the life of a tree and removing hazardous trees and limbs will also prevent many problems.

Age diversity is established though annual tree removal and planting. As an example, if 2 percent of a municipality's street trees are removed and planted each year as a result of poor health or structure, a 50-year difference in tree ages on any street can be created over time. Because large numbers of trees do not have to be planted or removed in a short period of time, age diversity provides interest, beauty, and continuous replacement and stability of the tree canopy, and helps normalize yearly work and budgets.

Resources

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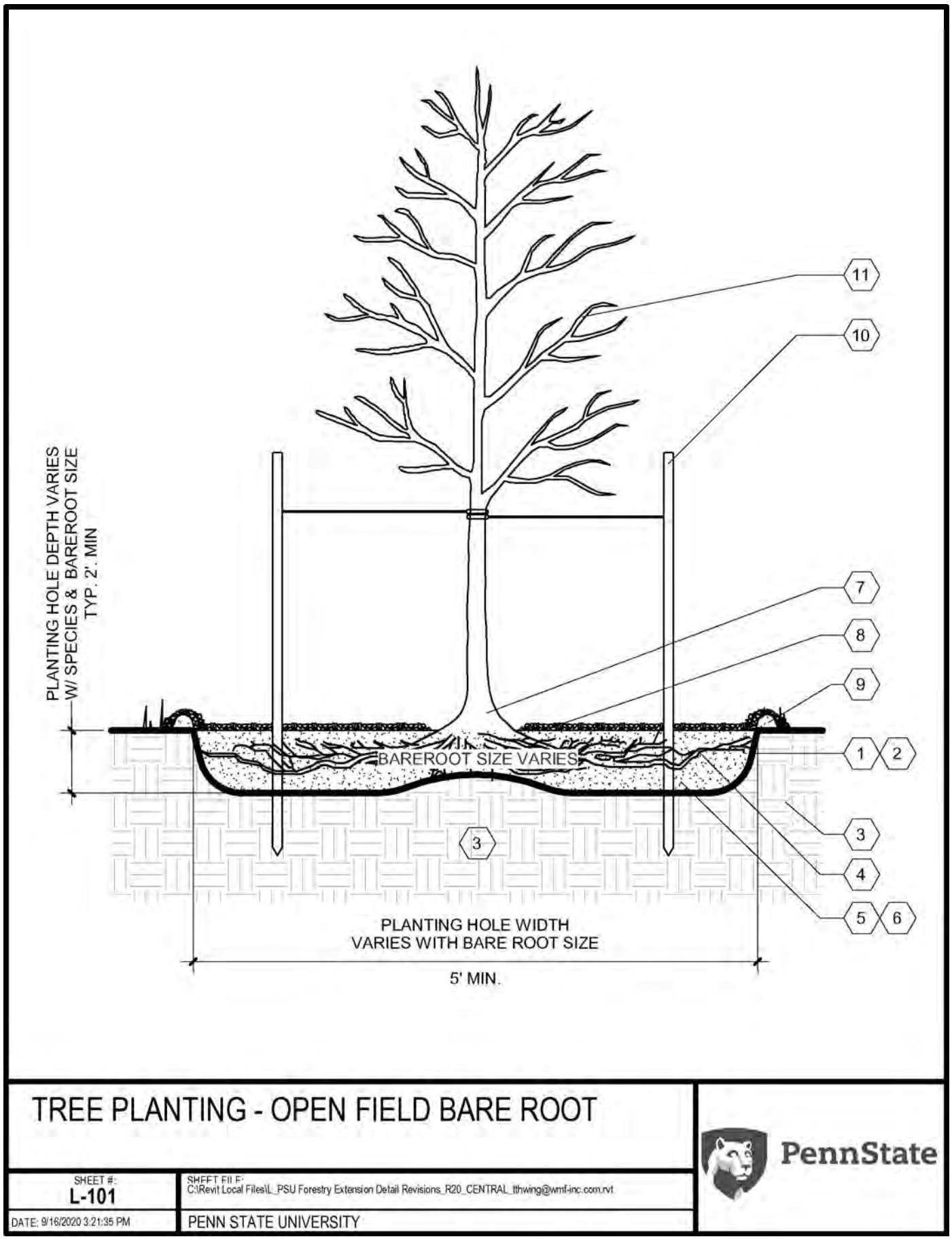
Appendix I


PLANTING HOLE DEPTH VARIES
W/ SPECIES & BAREROOT SIZE
TYP. 2'. MIN
11
10
7
8
9
BAREROOT SIZE VARIES
1
2
3
4
5
6
PLANTING HOLE WIDTH
VARIES WITH BARE ROOT SIZE
5' MIN.
TREE PLANTING - OPEN FIELD BARE ROOT
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L-101
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GENERAL NOTES

A. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors.* HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
B. TREES MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
C. TREES MUST BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. PLACE ROOTS EVENLY AT BOTTOM OF PLANTING HOLE. DO NOT KINK ROOTS.
5. USE ORIGINAL OR QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
6. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
7. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
8. MULCH 2" -3" WITH COURSE GROUND COMPOSTED MULCH. MAINTAIN A 4" CLEAR ZONE FROM BASE OF TRUNK. IN AREAS OF HEAVY FOOT TRAFFIC MULCH MUST BE REMOVED OR REPLACED YEARLY.
9. BUILD 6" HIGH EARTH BERM BEYOND EDGE OF ROOT SPREAD FOR WATERING. COVER BERM WITH MULCH.
10. BARE ROOT TREE MUST BE STAKED. DRIVE HARDWOOD STAKES 18" TO 24" INTO GROUND OUTSIDE OF ROOT AREA. USE SOFT RUBBER TIES. TREE MUST BE ABLE TO SWAY. REMOVE STAKES AFTER ONE YEAR.
11. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

TREE PLANTING - OPEN FIELD BARE ROOT

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SHEET #: L-101	SHEET FILE: C:\Revit Local Files\L_PSU Forestry Extension Detail Revisions_R20_CENTRAL_tthwing@wmf-inc.com.rvt
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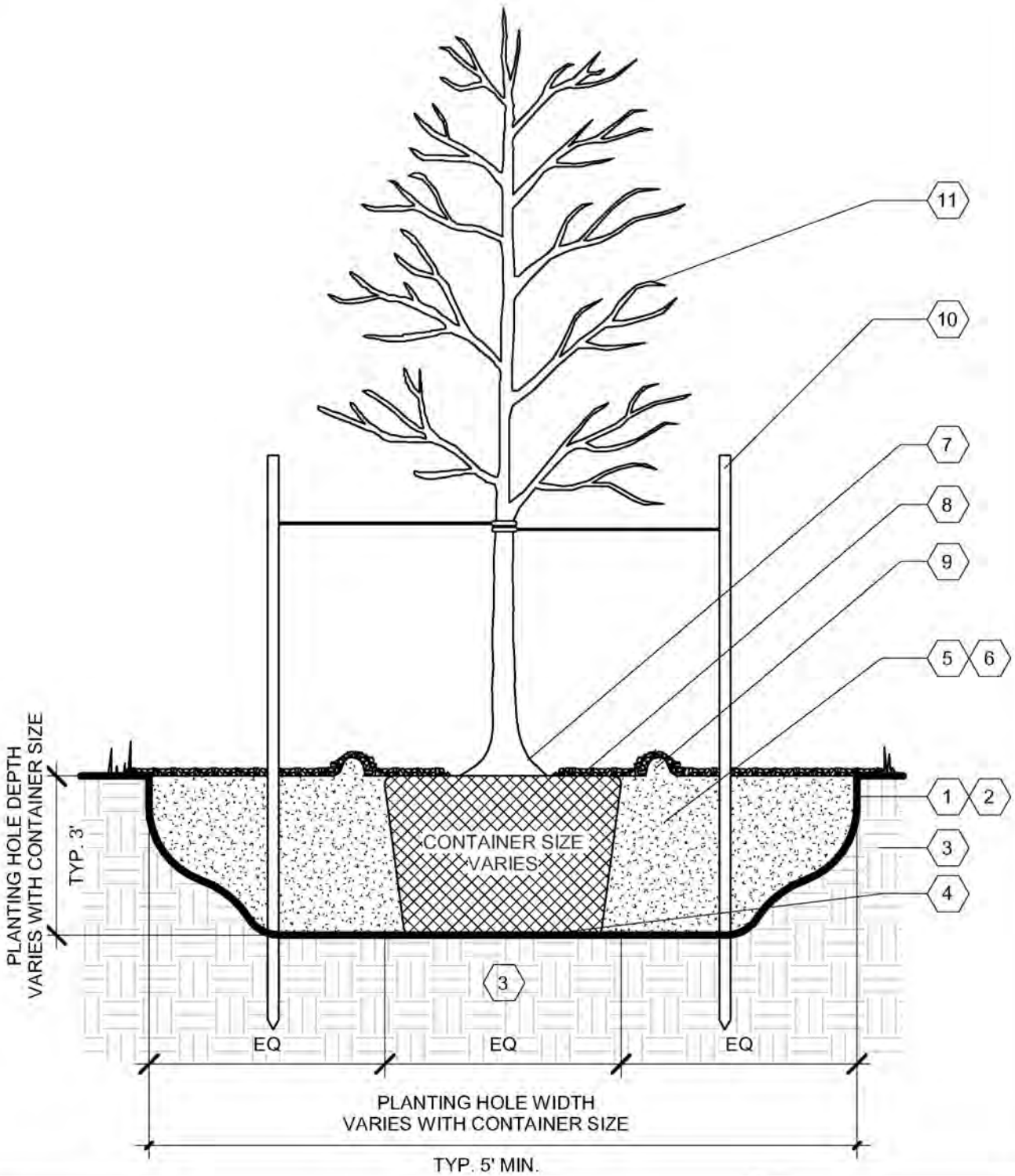

TREE PLANTING - OPEN FIELD CONTAINER

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DATE: 9/16/2020 3:21:37 PM	PENN STATE UNIVERSITY

GENERAL NOTES

A. TREES WITH GIRDLING OR CIRCLING ROOT SHOULD BE REJECTED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors.* HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREES MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D. TREES MUST BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).

SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. SET CONTAINER ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE AND NOT COVERED WITH SOIL OR MULCH.
5. USE ORIGINAL OR QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
6. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
7. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
8. MULCH 2" -3" WITH COURSE GROUND COMPOSTED MULCH. MAINTAIN A 4" CLEAR ZONE FROM BASE OF TRUNK. IN AREAS OF HEAVY FOOT TRAFFIC MULCH MUST BE REMOVED OR REPLACED YEARLY.
9. 6" HIGH EARTH BERM BEYOND EDGE OF ROOT SPREAD FOR WATERING. COVER BERM WITH MULCH.
10. CONTAINER TREE MUST BE STAKED. DRIVE HARDWOOD STAKES 18" TO 24" INTO GROUND OUTSIDE OF ROOT AREA. USE SOFT RUBBER TIES. TREE MUST BE ABLE TO SWAY. REMOVE STAKES AFTER 1 YEAR.
11. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

TREE PLANTING - OPEN FIELD CONTAINER

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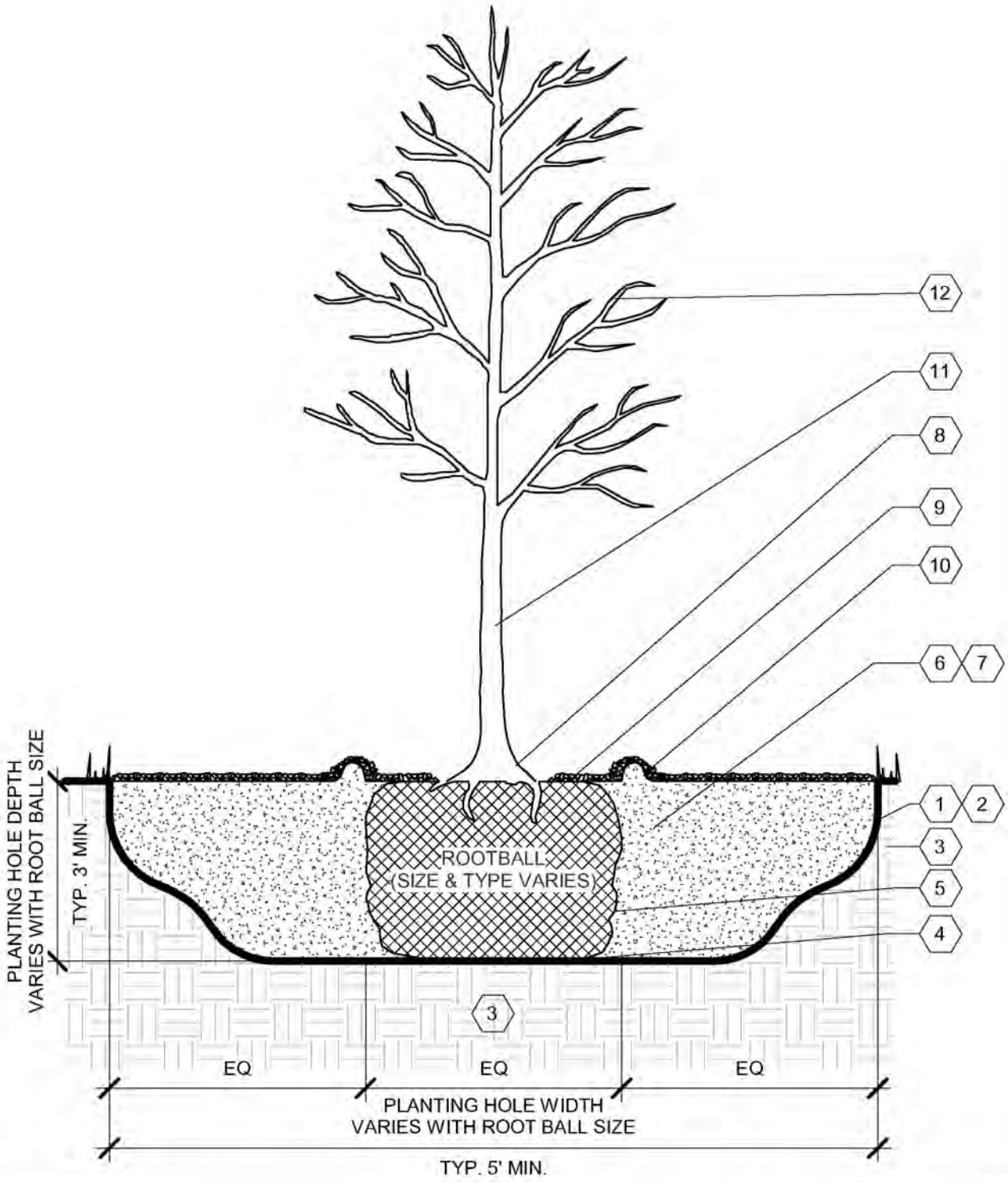

TREE PLANTING - OPEN FIELD BALL AND BURLAP

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DATE: 9/16/2020 3:21:38 PM	PENN STATE UNIVERSITY

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GENERAL NOTES

A. NURSERY STOCK SHOULD BE REJECTED IF ROOT COLLAR IS BURIED AND CANNOT BE LOCATED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors*. HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREE MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D.TREE SHOULD BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).
E. STAKE TREE ONLY UPON THE RECOMMENDATION OF ARBORIST. SEE L-101 FOR STAKING DETAILS.

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. SET ROOT BALL ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE AND NOT COVERED WITH SOIL OR MULCH.
5. CUT AWAY WIRE BASKET FROM TOP 2/3RDS OF ROOT BALL. REMOVE BASKET AND PUSH BURLAP INTO BOTTOM OF HOLE.
6. USE ORIGINAL OR QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
7. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
8. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
9. MULCH 2" -3" WITH COURSE GROUND COMPOSTED MULCH. MAINTAIN A 4" CLEAR ZONE FROM BASE OF TRUNK. IN AREAS OF HEAVY FOOT TRAFFIC MULCH MUST BE REMOVED OR REPLACED YEARLY.
10. 6" HIGH EARTH BERM BEYOND EDGE OF ROOT SPREAD FOR WATERING. COVER BERM WITH MULCH.
11. REMOVE ALL TIES AND TRUNK WRAP.
12. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

TREE PLANTING - OPEN FIELD BALL AND BURLAP

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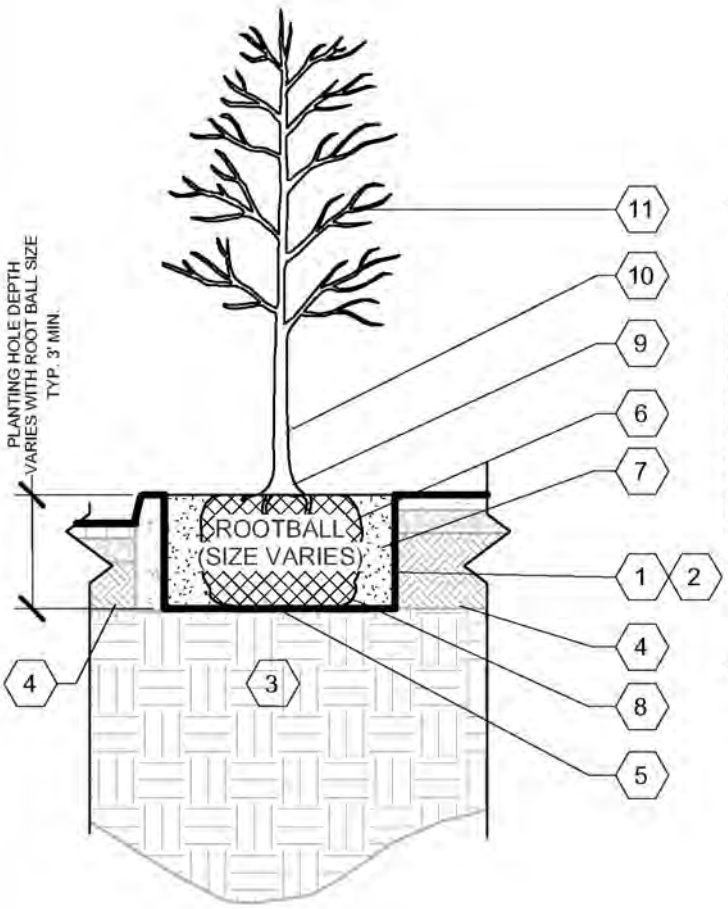

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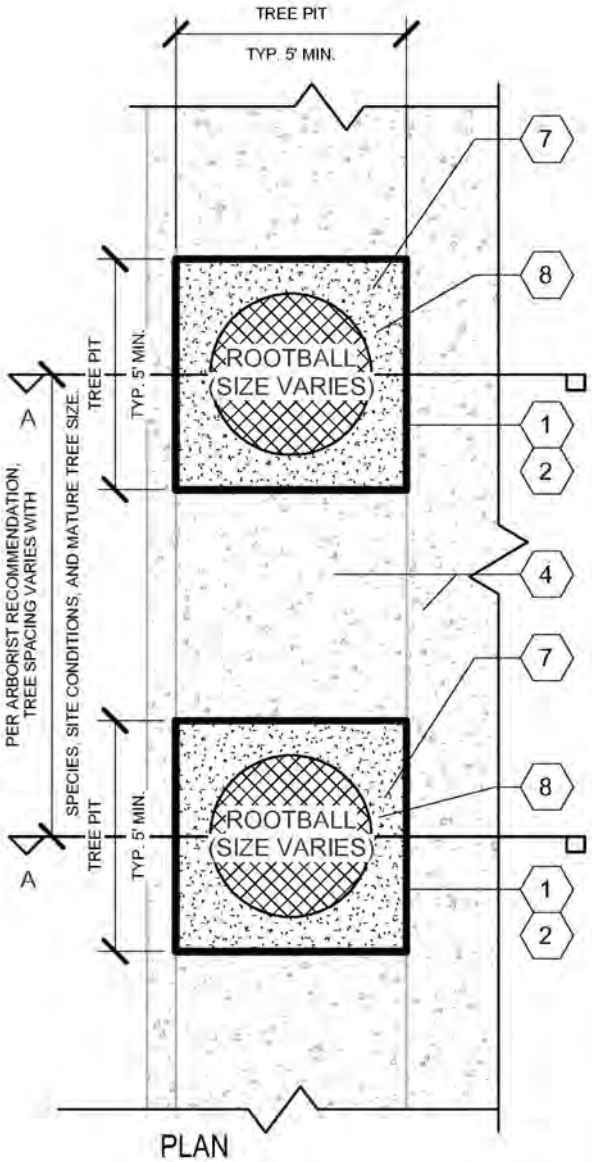

PLAN

STREET TREE PLANTING PIT FOR SIDEWALK & OTHER CONFINED SPACES

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DATE: 9/16/2020 3:21:39 PM	PENN STATE UNIVERSITY

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GENERAL NOTES

A. NURSERY STOCK SHOULD BE REJECTED IF ROOT COLLAR IS BURIED AND CANNOT BE LOCATED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors.* HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREE MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D.TREE SHOULD BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).
E. STAKE TREE ONLY UPON THE RECOMMENDATION OF ARBORIST. SEE L-101 FOR STAKING DETAILS.
F. CUT AND REMOVE EXISTING SIDEWALK TO MEET ADA REQUIREMENTS, BUT PROVIDE LARGEST TREE PLANTING PIT POSSIBLE WITH MINIMUM OF 5' X5'.
G. B&B TREES ARE RECOMMENDED, BUT BARE ROOT AND CONTAINER TREES CAN BE USED WITH ARBORIST RECOMMENDATION.
H. TREE SPECIES SHOULD BE SELECTED FROM ARBORIST APPROVED TREE PLANTING LIST FOR CONFINED SPACES.

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. EXISTING COMPACTED SUBGRADE W/ SIDEWALK OR OTHER SURFACE ABOVE.
5. SET ROOT BALL ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE AND NOT COVERED WITH SOIL OR MULCH.
5. CUT AWAY WIRE BASKET FROM TOP 2/3RDS OF ROOT BALL. REMOVE BASKET AND PUSH BURLAP INTO BOTTOM OF HOLE.
7. USE ORIGINAL OR QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
8. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
9. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
10. REMOVE ALL TIES AND TRUNK WRAP.
11. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

STREET TREE PLANTING PIT FOR SIDEWALK & OTHER CONFINED SPACES

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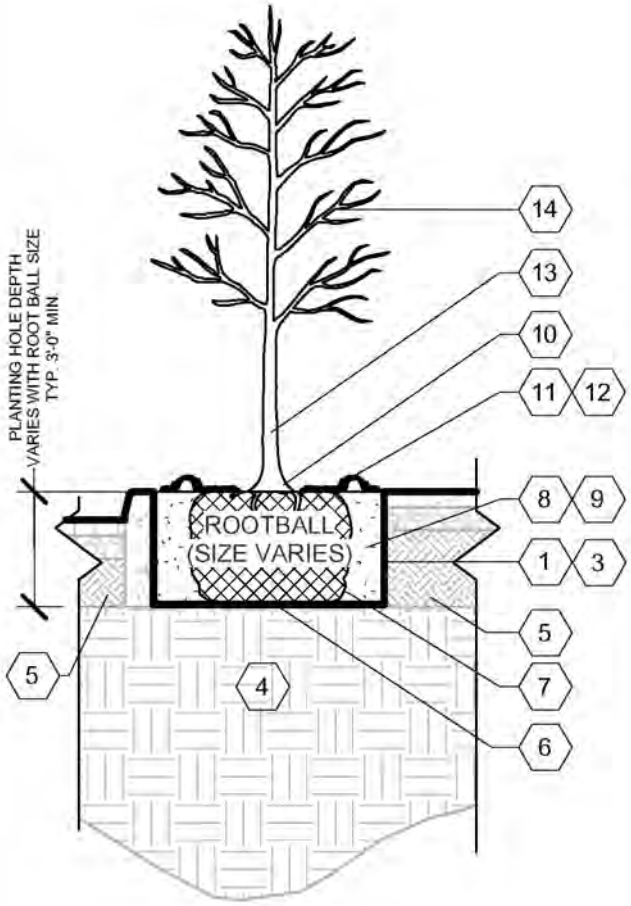

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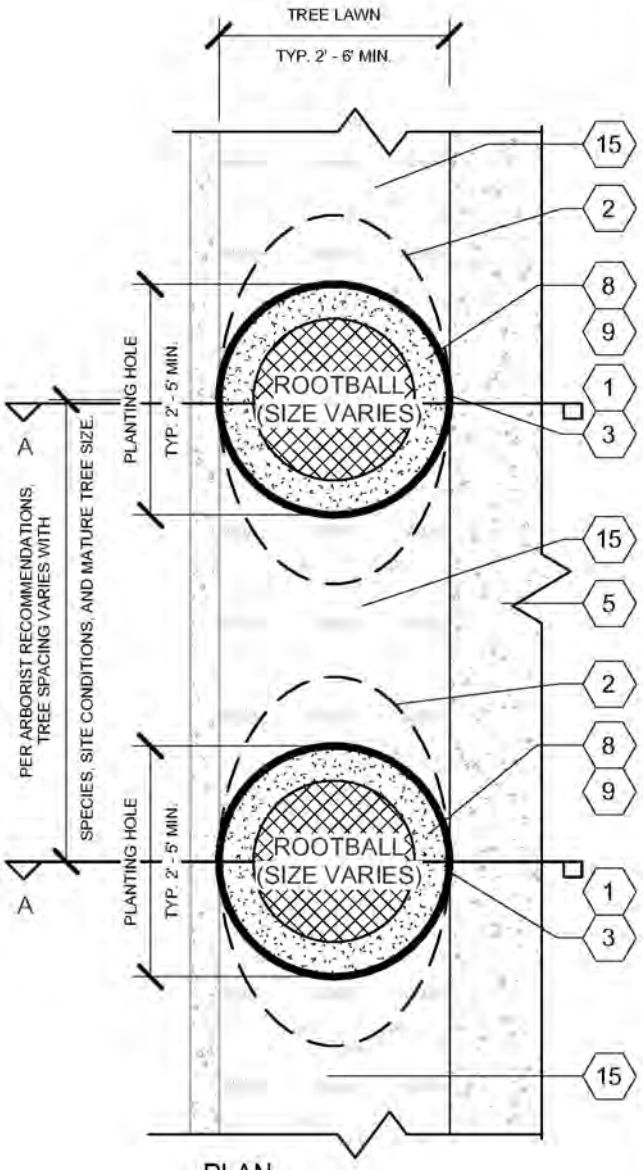

PLAN

STREET TREE PLANTING IN EXISTING TREE LAWN

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DATE: 9/16/2020 3:21:41 PM	PENN STATE UNIVERSITY

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GENERAL NOTES

A. NURSERY STOCK SHOULD BE REJECTED IF ROOT COLLAR IS BURIED AND CANNOT BE LOCATED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors.* HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREE MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D.TREE SHOULD BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).
E. STAKE TREE ONLY UPON THE RECOMMENDATION OF ARBORIST. SEE L-101 FOR STAKING DETAILS.
F. PROVIDE LARGEST TREE LAWN POSSIBLE TYP. 2 - 6' MIN. PLANTING IN A LAWN SMALLER THAN 3' REQUIRES APPROVAL OF ARBORIST.
H. B&B TREES ARE RECOMMENDED, BUT BARE ROOT AND CONTAINER TREES CAN BE USED WITH ARBORIST RECOMMENDATION.
J. TREE SPECIES SELECTION FOR PLANTING DEPENDS ON TREE LAWN WIDTH, OVERHEAD & UNDERGROUND UTILITIES, AND OTHER FACTORS. TREE SPECIES SHOULD BE SELECTED FROM ARBORIST APPROVED TREE PLANTING LIST.

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. PROVIDE LONGER PLANTING HOLE IF POSSIBLE.
3. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
4. EXISTING UNDISTURBED SUBGRADE.
5. EXISTING COMPACTED SUBGRADE WITH SIDEWALK OR OTHER SURFACE ABOVE.
6. SET ROOT BALL ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE AND NOT COVERED WITH SOIL OR MULCH.
7. CUT AWAY WIRE BASKET FROM TOP 2/3RDS OF ROOT BALL. REMOVE BASKET AND PUSH BURLAP INTO BOTTOM OF HOLE.
8. USE ORIGINAL OR QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
9. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
10. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
11. MULCH 2" -3" WITH COURSE GROUND COMPOSTED MULCH. MAINTAIN A 4" CLEAR ZONE FROM BASE OF TRUNK. IN AREAS OF HEAVY FOOT TRAFFIC MULCH MUST BE REMOVED OR REPLACED YEARLY.
12. 6" HIGH EARTH BERM BEYOND EDGE OF ROOT SPREAD FOR WATERING. COVER BERM WITH MULCH.
13. REMOVE ALL TIES AND TRUNK WRAP.
14. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.
15. EXISTING UNDISTURBED TREE LAWN.

STREET TREE PLANTING IN EXISTING TREE LAWN

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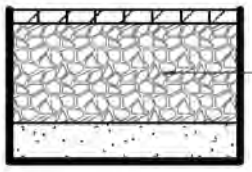

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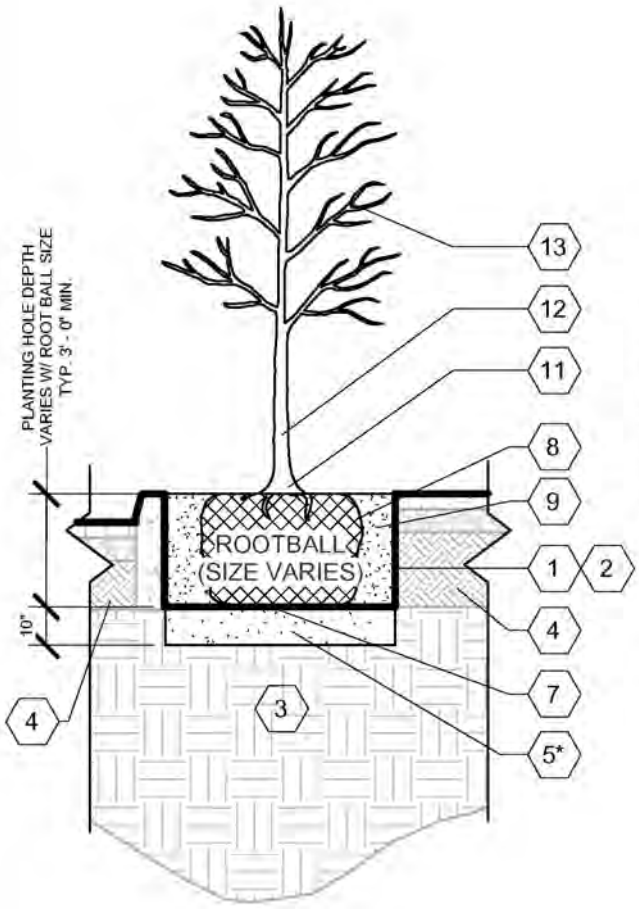

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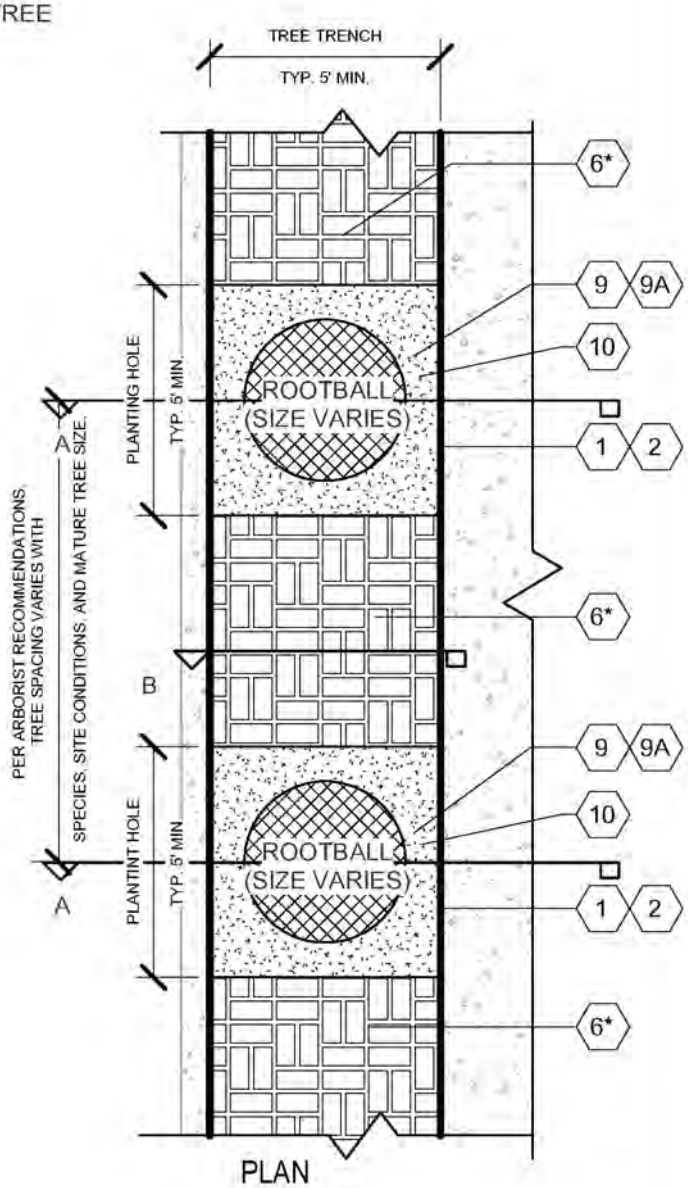

PLAN

HIGHLIGHTED SHEET KEYNOTES:

5*. SYSTEMS CAN BE ENGINEERED IN TRENCH TO IMPROVE DRAINAGE AND STORM WATER MANAGEMENT.
6*. STRUCTURAL SOILS 36" MIN. DEPTH COVERED WITH POROUS CONCRETE OR OTHER APPROVED PERVIOUS PAVING TO OPTIMIZE INFILTRATION. VERIFY POSITIVE DRAINAGE AWAY FROM BUILDINGS AND MINIMUM SETBACKS FROM BUILDINGS & STREET. A RATIO OF 80% CRUSHED STONE, 20% HIGH CLAY SOIL AND SMALL AMOUNT OF HYDROGEL RECOMMENDED FOR STRUCTURAL SOIL.. AVOID LIMESTONE GRAVEL.

STREET TREE TRENCH WITH STRUCTURAL SOILS

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GENERAL NOTES

A. NURSERY STOCK SHOULD BE REJECTED IF ROOT COLLAR IS BURIED AND CANNOT BE LOCATED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors*. HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREE MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D.TREE SHOULD BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).
E. STAKE TREE ONLY UPON THE RECOMMENDATION OF ARBORIST. SEE L-101 FOR STAKING DETAILS.
F. CUT AND REMOVE EXISTING SIDEWALK TO MEET ADA REQUIREMENTS, BUT PROVIDE LARGEST TREE TRENCH WIDTH POSSIBLE TYP. 5' MIN. PLANTING IN A TREE TRENCH SMALLER THAN 3' REQUIRES APPROVAL OF MUNICIPAL ARBORIST.
H. B&B TREES ARE RECOMMENDED, BUT BARE ROOT AND CONTAINER TREES CAN BE USED WITH ARBORIST RECOMMENDATION.
I. TREE SPECIES SHOULD BE SELECTED FROM ARBORIST APPROVED TREE PLANTING LIST FOR CONFINED SPACES.
K. FOR STRUCTURAL SOILS, TREE SPECIES SELECTED MUST BE DROUGHT TOLERANT AND IRRIGATED UNTIL ESTABLISHED.

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. EXISTING COMPACTED SUBGRADE. SIDEWALK OR OTHER SURFACE ABOVE.
5*. **SEE HIGHLIGHTED SHEET KEYNOTES**
6*. **SEE HIGHLIGHTED SHEET KEYNOTES**
7. SET ROOT BALL ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE, AND NOT COVERED WITH SOIL OR MULCH.
8. CUT AWAY WIRE BASKET FROM TOP 2/3RDS OF ROOT BALL. REMOVE BASKET AND PUSH BURLAP INTO BOTTOM OF HOLE.
9. USE QUALITY TOP SOIL AS PLANTING SOIL IN PLANTING HOLE PER ARBORIST SPECIFICATION. IMPORTED TOP SOIL SHOULD HAVE SIMILAR TEXTURE AND 5 - 8% ORGANIC MATERIAL. DO NOT AMEND TOP SOIL WITH ORGANIC MATERIAL.
10. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
11. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
12. REMOVE ALL TIES AND TRUNK WRAP.
13. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

STREET TREE TRENCH WITH STRUCTURAL SOILS

PennState

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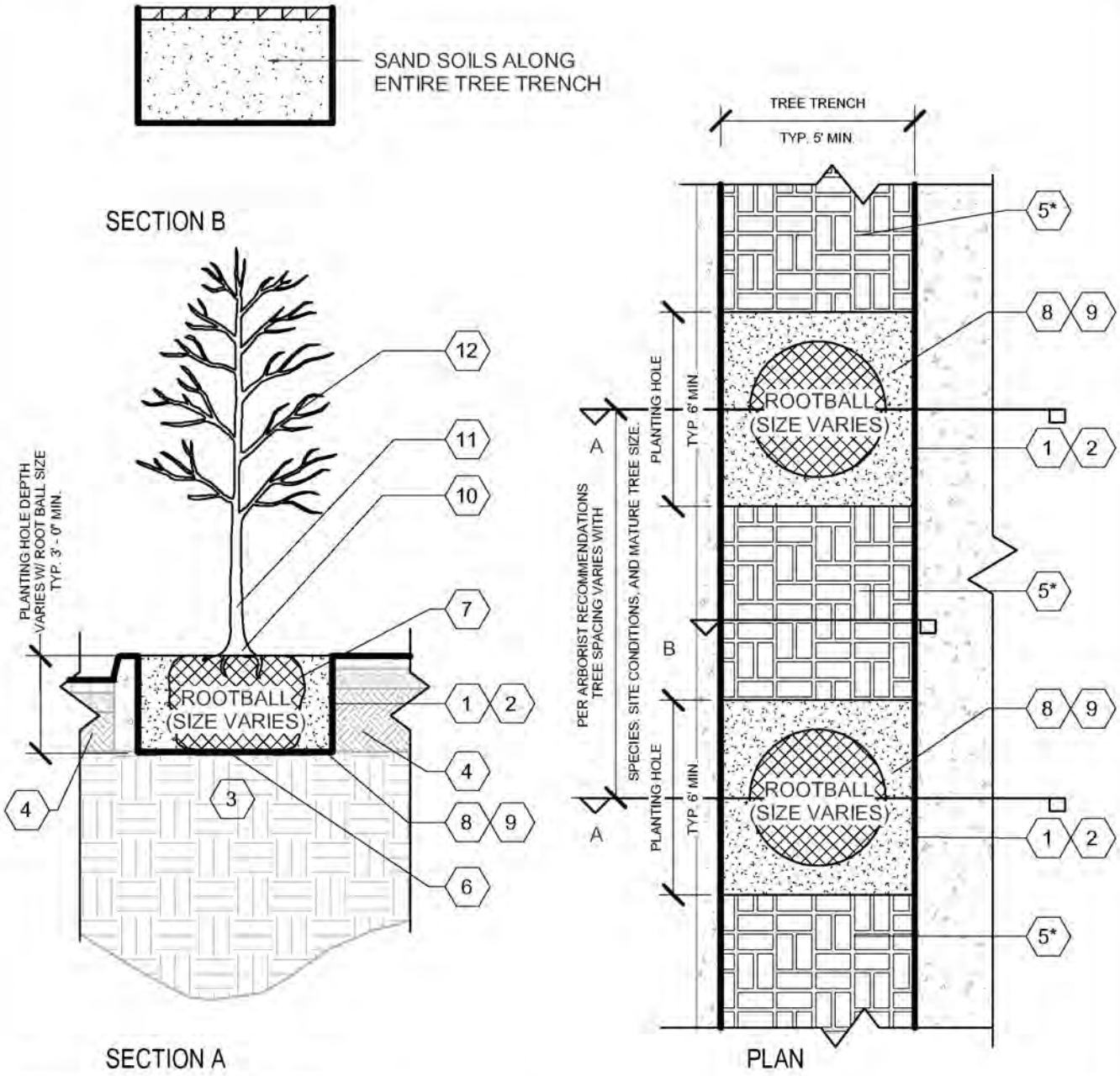

HIGHLIGHTED SHEET KENOTE:

5*. SYSTEMS CAN BE ENGINEERED IN TRENCH TO IMPROVE DRAINAGE AND STORM WATER MANAGEMENT. ENGINEERED SAND SOILS HAVE 3' DEPTH HORIZONTAL COURSE SAND. COVERED WITH POROUS CONCRETE OR OTHER APPROVED PERVIOUS PAVING SURFACE TO OPTIMIZE INFILTRATION. VERIFY POSITIVE DRAINAGE AWAY FROM BUILDINGS AND MINIMUM SETBACKS FROM BUILDINGS & STREET. ENGINEERING SOIL PARAMETER DESIGN ARE SITE SPECIFIC. TREE PLANTING PITS ARE MINIMUM OF 10' X 10' FOR LARGE GROWING (OVER 45' AT MATURITY) TREES AND 6' x 6' FOR MEDIUM (OVER 35' AT MATURITY) TREES. PLANT LOW GROWING DROUGHT TOLERANT VEGETATION THROUGHOUT PLANTING AREA.

STREET TREE TRENCH WITH ENGINEERED SAND SOILS

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GENERAL NOTES

A. NURSERY STOCK SHOULD BE REJECTED IF ROOT COLLAR IS BURIED AND CANNOT BE LOCATED.
B. IF SUBGRADE DOES NOT DRAIN 1/4 - 1/2" PER HOUR, PLANTING LOCATIONS MUST BE MOVED, A MODIFIED PLANTING TECHNIQUE USED (E.Q. MOUNDED PLANTING), OR DRAINAGE SYSTEM ENGINEERED. SEE CRAUL, T. & C. CRAUL 2006. *Soil Design Protocols for Landscape Architects and Contractors.* HOBOKEN, NJ. JOHN WILEY & SONS, OR OTHER PUBLICATIONS FOR ENGINEERING SPECIFICATIONS.
C. TREE MUST BE IRRIGATED WITH 25 GALLONS OF WATER AT TIME OF PLANTING.
D.TREE SHOULD BE IRRIGATED WITH 20-40 GALLONS OF WATER APPLIED SLOWLY WITH TREEGATOR® DURING PERIODS OF HOT / DRY WEATHER UNTIL ESTABLISHED (2-3 YEARS).
E. STAKE TREE ONLY UPON THE RECOMMENDATION OF ARBORIST. SEE L-101 FOR STAKING DETAILS.
F. PROVIDE LARGEST TREE TRENCH WIDTH POSSIBLE TYP. 5' MIN. PLANTING IN A TREE TRENCH SMALLER THAN 3' REQUIRES APPROVAL OF MUNICIPAL ARBORIST.
H. B&B TREES ARE RECOMMENDED, BUT BARE ROOT AND CONTAINER TREES CAN BE USED WITH ARBORIST RECOMMENDATION.
I. TREE SPECIES SHOULD BE SELECTED FROM ARBORIST APPROVED TREE PLANTING LIST.
J. FOR ENGINEERED SAND SOILS, TREE SPECIES SELECTED MUST BE DROUGHT TOLERANT AND IRRIGATED UNTIL ESTABLISHED.

⬡ SHEET KEYNOTES

1. REMOVE SOIL TO MEET PLANTING HOLE DIMENSIONS.
2. SCARIFY PLANTING HOLE SIDES AND BOTTOM 3 - 4".
3. EXISTING UNDISTURBED SUBGRADE.
4. EXISTING COMPACTED SUBGRADE. SIDEWALK OR OTHER SURFACE ABOVE.
5*. **SEE HIGHLIGHTED SHEET KEYNOTE**
6. SET ROOT BALL ON TOP OF SCARIFIED SUBGRADE. IF MIN. DEPTH OF PLANTING HOLE IS DEEPER THAN ROOTBALL HT THEN BUILD UP SOIL AT BOTTOM SO ROOT COLLAR IS ABOVE FINISHED GRADE AND NOT COVERED WITH SOIL OR MULCH.
7. CUT AWAY WIRE BASKET FROM TOP 2/3RDS OF ROOT BALL. REMOVE BASKET AND PUSH BURLAP INTO BOTTOM OF HOLE.
8. TREES ARE PLANTED IN SAND BASED PLANTING SOILS AMENDED WITH ORGANIC MATERIALS MIXED INTO TOP 12".
9. PACK SOIL AROUND ROOTS FIRMLY WITH FOOT PRESSURE.
10. DO NOT COVER ROOT COLLAR WITH SOIL OR MULCH. ROOT COLLAR SHALL BE AT GRADE AND VISIBLE. MAJOR ANCHORING ROOTS NO MORE THAN 2 -3" FROM TOP OF SOIL.
11. REMOVE ALL TIES AND TRUNK WRAP.
12. TREE STRUCTURE TYPICAL OF SPECIES SHOULD BE DEVELOPED BY JUDICIOUS PRUNING FIRST 3 - 5 YEARS AFTER PLANTING. SEE ANSI A300 AND INTERNATIONAL SOCIETY OF ARBORICULTURE (ISA) BMPS FOR PROPER TREE PRUNING STANDARDS.

STREET TREE TRENCH WITH ENGINEERED SAND SOILS

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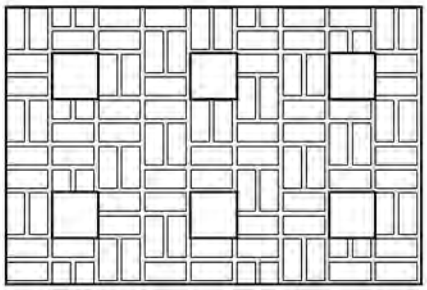
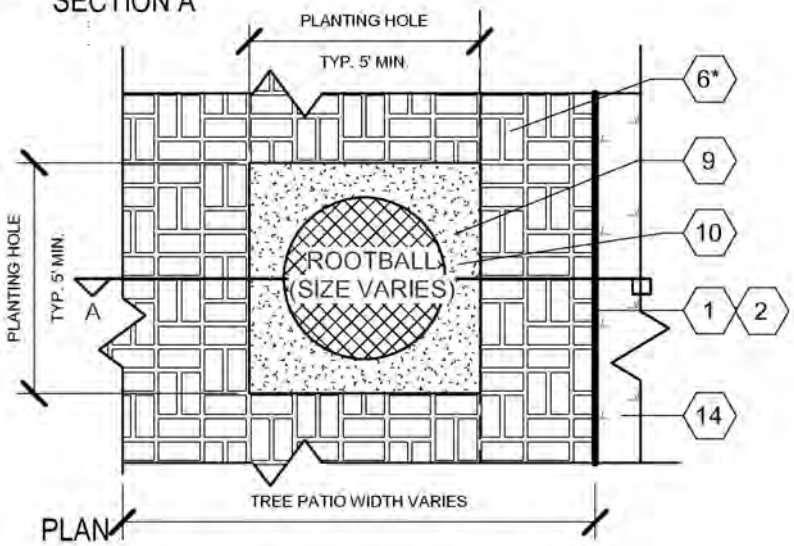


STRUCTURAL SOILS UNDER ENTIRE PATIO

SECTION A



PLAN

HIGHLIGHED SHEET KEYNOTES:

5*. SYSTEMS CAN BE ENGINEERED IN PATIO TO IMPROVE DRAINAGE AND STORM WATER MANAGEMENT.
6*. STRUCTURAL SOILS 36" MIN. DEPTH COVERED WITH POROUS CONCRETE OR OTHER APPROVED PERVIOUS PAVING TO OPTIMIZE INFILTRATION. VERIFY POSITIVE DRAINAGE AWAY FROM BUILDINGS AND MINIMUM SETBACKS FROM BUILDINGS & STREET. A RATIO OF 80% CRUSHED STONE, 20% HIGH CLAY SOIL AND SMALL AMOUNT OF HYDROGEL RECOMMENDED FOR STRUCTURAL SOIL.. AVOID LIMESTONE GRAVEL.

PATIO TREE WITH STRUCTURAL SOILS

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PATIO TREE WITH STRUCTURAL SOILS

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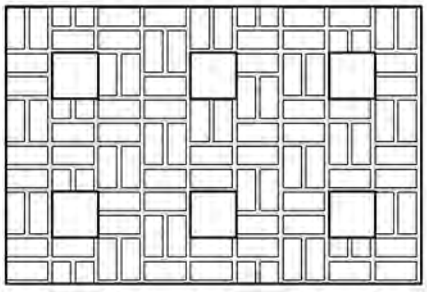
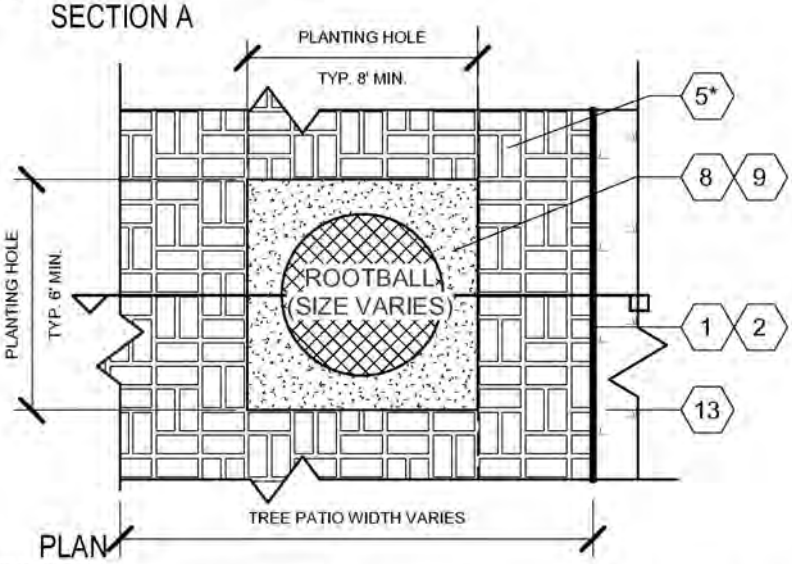


SAND SOILS UNDER ENTIRE PATIO

SECTION A



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PATIO TREE WITH ENGINEERED SAND SOILS

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Appendix II

Small Deciduous Trees

Mature height: under 30 feet
Minimum tree lawn: 2 feet
Suitable under wires

Form Key

C = Conical	R = Rounded	S = Spreading
U = Upright	V = Vase	

	Native to Pennsylvania	Form	Some salt tolerance	Harsh urban conditions	Fall color	Flowers	Notes
Crabapples							general–select for disease resistance and street tree form; plant in full sun
‘Adams’		R	●	●		●	pink flowers
‘Centurian’		U	●	●		●	rose-red flowers; unusual form
‘Donald Wyman’		S	●	●		●	white flowers
‘Indian Magic’		R	●	●		●	deep pink flowers
‘Prairiefire’		R	●	●		●	deep pink flowers
‘Red Jewel’		U	●	●		●	white flowers
‘Sentinel’		V	●	●		●	pale pink flowers
‘Spring Snow’		R	●	●		●	white flowers; fruitless
‘Sugar Time’		R					white flowers
Cherry		R				●	general–sensitive to pollution, drought, and disease; plant in deep moist soils
Chokecherry: ‘Shubert’		R				●	can be short-lived (10-20 years); reddish-purple flowers
Flowering: ‘Accolade’		R				●	can be short-lived; rosy-pink flowers
Flowering: ‘Okame’		U					pink flowers
Japanese Flowering: ‘Amanogawa’		R				●	upright tree with pale pink flowers
Japanese Flowering: ‘Kwanzan’		V					tolerates drought better; deep pink flowers
Dogwood		R			●	●	general–sensitive to salt and drought; select for disease resistance; prefers some shade
Constellation: ‘Rutcan’		V/R			●	●	attractive white foliage and flowers
Eastern	●	R					not resistant to dogwood anthracnose
Kousa		S	●	●	●	●	disease resistant; many cultivars; beautiful white flowers and foliage
Eastern Redbud	●	S				●	attractive small tree with red flowers; prefers shade; acidic or alkaline soils
‘Alba’	●	U			●	●	attractive white flowers
‘Forest Pansy’	●	R			●	●	purple flowers
Hawthorn	●	R	●	●	●	●	general–sensitive to many diseases; tolerates range of sites and stresses; select street tree form
Green: ‘Winter King’		R	●	●		●	vase-shaped; few thorns; white flowers; persistent fruit
Lavalle		U	●	●		●	dark green foliage; white flowers
Thornless: ‘Inermis’		R	●				white flowers; persistent fruit
Washington: ‘Ohio King’		V				●	white flowers; persistent fruit
Washington: ‘Princeton Century’		R				●	white flowers; persistent fruit
Magnolia							general–sensitive to scale insects and drought; attractive white flowers; select for street tree form
Galaxy		U					prefers full sun and rich, moist, acid soils
Star		U/S					small tree; plant in protected area with moist, acidic soil
Maple							general–susceptible to verticillium wilt
Trident		S			●	●	tolerates urban conditions; nice fall foliage
Serviceberry	●	R/S			●	●	general–very small tree/shrub; many cultivars; sensitive to heat and drought; requires some shade
‘Cumulus’	●	R			●	●	tolerates wider variety of sites and soils; white flowers
‘Princess Diana’	●	R	●		●	●	yellow flower buds; white flowers
‘Robin Hill’	●	R	●		●	●	white flowers; attractive fall foliage
Tree Lilac							general–good tree for under power lines; susceptible to powdery mildew
‘Ivory Silk’		R/U	●				more upright form; white flowers
‘Regent’		R	●				small tree-like form; white flowers
‘Summer Snow’		R	●				small tree-like form; white flower

Medium Deciduous Trees

Mature height: 30 to 50 feet
Minimum tree lawn: 3 feet
Most suitable under wires

Form Key

C = Conical	R = Rounded	S = Spreading
U = Upright	V = Vase	

	Native to Pennsylvania	Form	Some salt tolerance	Harsh urban conditions	Fall color	Flowers	Notes
American Hophornbeam	●	C			●	●	sensitive to deicing salt; interesting bark
Birch							general–susceptible to bronze birch borer
River Birch: 'Heritage'	●	C	●				better resistance to borer; choose street tree form; sensitive to alkaline soil
Carolina Silverbell		R				●	choose street form; sensitive to alkaline soil; white flowers
Cherry							general–species sensitive to pollution and stresses
Sargent Cherry		R	●		●	●	toughest of Japanese cherries; pink flowers
Sargent Cherry: 'Columnar'		U	●		●	●	upright form; good for tight places
Yoshino		V					choose street tree form; white flowers
Golden Rain Tree		R	●		●	●	flowers can be slippery on slopes; can localize as a weed
Honeylocust							general–tough urban tree
'Imperial'	●	V	●	●	●		smaller growing
Hornbeam							
American	●	C/R			●		good for small shady spaces; sensitive to drought and heat
European Hornbeam: 'Fastigiate'		U/C			●		upright form good for narrow places; sensitive to drought and heat
Horsechestnut							
Ruby Red Chestnut: 'Briotii'		R	●			●	sensitive to drought and heat; attractive red flowers
Ruby Red Chestnut:'Fort McNair'		R	●			●	sensitive to drought and heat; pinker flowers
Maple							
Hedge: True Species		R	●	●	●		small with tree-like form; can localize as a weed
Hedge: 'Queen Elizabeth'		R	●	●	●		upright form; sensitive to cold; can localize as a weed
Shantung: 'Norwegian Sunset'		U			●		sun loving; drought tolerant; orange-red fall color
Shantung: 'Pacific Sunset'		U			●		sun loving; drought tolerant; orange-red fall color
Oak							
Sawtooth Oak		R	●		●		intolerant of alkaline soils; can produce large nutcrop; can localize as a weed
Purple Robe Black Locust	●	R	●	●		●	weak branch structure; purple flowers
Sassafras	●	C/R			●	●	prefers moist, deep soils; select street tree form
Yellowwood		S	●		●	●	weak branch structure; sensitive to drought; can have low branches

Large Deciduous Trees

Mature height: over 30 feet
Minimum tree lawn: 5 feet
Not suitable under wires

Form Key

C = Conical	R = Rounded	S = Spreading
U = Upright	V = Vase	

	Native to Pennsylvania	Form	Some salt tolerance	Harsh urban conditions	Fall color	Flowers	Notes
Bald Cypress	●	**V/C**			●		sensitive to alkaline soils; reddish fall color
Blackgum	●	**C**			●		beautiful orange/red fall color; sensitive to alkaline soils
Catalpa	●	**R**	●			●	weaker branch structure; large leaves; white flowers
Dawn Redwood		**C**			●		similar to bald cypress; less sensitive to alkaline soils
Elm							general–no elm is resistant to elm yellows; plant in very small numbers; many cultivars and hybrids
'Accolade'		**S**	●				good resistance to Dutch elm disease
'New Harmony'		**S**	●				good resistance to Dutch elm disease
'Valley Forge'		**S**	●				good resistance to Dutch elm disease
Ginkgo							general–tough urban tree; all have beautiful yellow fall color
'Autumn Gold'		**C**		●	●		select male trees only; limited fruit
'Lakeview'		**C**		●	●		select male trees only; conical form
'Princeton Century'		**U**		●	●		select male trees only; upright form
Hackberry	●						general–tough urban tree
'Prarie Pride'	●	**R**	●	●	●		rugged tree; good branch structure
'Magnifica'	●	**R**	●	●	●		better resistance to leafhoppers
Hardy Rubber Tree		**R**	●	●	●		cold sensitive–can be killed by cold winters
Hickory							general–prefers moist soils; nuts can be messy
Bitternut	●	**U/R**			●		better for moist sites; intolerant of drought
Pignut	●	**R**	●		●		better for dryer/harsher sites
Shagbark	●	**R**					interesting bark; fairly adaptable
Honeylocust							general–tough urban tree
'Shade Master'	●	**S**	●	●	●		vigorous growth, less fruiting and fewer thorns; yellow fall color
'Skyline'	●	**S**	●	●	●		upright branching; better yellow fall color
Japanese Pagoda Tree		**R**				●	
'Regent'		**R**				●	some resistance to leafhoppers; smaller growing; white flowers
Japanese Scholar Tree		**R**				●	fruit can be messy; white flowers in summer
Katsura Tree		**C**			●		select street form; drought sensitive
Kentucky Coffeetree		**S**	●	●	●		tough urban tree; seed pods can be messy
'Espresso'		**S**	●	●	●		fewer pods than true species
Linden							general–typically on cool, moist sites; aphids can be messy
American Basswood	●	**C/R**				●	somewhat sensitive to drought and salt; fragrant yellow flowers
American: 'Redmond'	●	**C/R**				●	conical form; sensitive to drought and salt; intolerant of salt; fragrant yellow flowers
Littleleaf: 'Glenlevin'		**C**				●	conical form; fast growing; sensitive to heat and drought; fragrant yellow flowers
Littleleaf: 'Greenspire'		**C**				●	more upright form; sensitive to heat and drought; fragrant yellow flowers
Silver		**C**				●	conical; leaves dark green with silver underside; more reistant to aphids
Silver: 'Sterling'		**C**					better tolerance to heat and drought; more resistant to aphids
Magnolia							
Cucumbertree	●	**C**				●	large dark green leaf; prefers moist, winter sheltered sites; tolerates alkaline soils; yellow flowers
Southern		**R**	●			●	holds leaves all winter; cold sensitive; plant only in southeastern PA in sheltered places; white flowers

Large Deciduous Trees
(continued)

Mature height over 30'
Minimum tree lawn 5'
Not suitable under wires

Form Key

C = Conical	R = Rounded	S = Spreading
U = Upright	V = Vase	

	Native to Pennsylvania	Form	Some salt tolerance	Harsh urban conditions	Fall color	Flowers	Notes
Maple							general–many cultivars and hybrids
Red Maple	●	**R**			●		many cultivars; some may not be native
Red: 'Autumn Flame'		**R**		●	●		fast growing; brilliant fall color
Red: 'Bowhill'		**U**			●		orange to red fall color
Red: 'October Glory'		**R**		●	●		red fall color
Red: 'Red Sunset'		**R**		●	●		red to scarlet fall color
Red/Silver: 'Autumn Blaze'		**R**		●	●		beautiful red fall color; hybrid
Red/Silver: 'Celebration'		**R**		●	●		beautiful yellow to red color; hybrid
Red/Silver: 'Scarlet Sentinel'		**U**		●	●		beautiful yellow to red fall color; hybrid
Oak							
Bur	●	**R/S**	●				massive, stout tree; tolerates alkaline soils
English		**R/S**	●				tolerates drought and slightly alkaline soils
Red	●	**R**	●		●		fast growing after established; intolerant of alkaline soils; bacterial leaf scorch; reddish fall color
Shingle	●	**R**			●		intolerant of alkaline soils; reddish fall color
Shumard		**C/R**			●		moderate to fast growing; intolerant of alkaline soils; brilliant red fall color
Swamp White	●	**R**	●	●	●		tougher than white oak; transplants better than white oak; orange-gold fall color
White	●	**R**			●		can be hard to transplant; red fall color
Willow Oak	●	**S**	●				cold sensitive; requires ardic soil
Sweetgum		**C/R**			●		requires acidic soil; fruit can be messy; attractive reddish fall color
'Rotundiloba'		**C**	●		●		sensitive to cold; fewer fruit than true species; reddish fall color
Sycamore and Relatives							
American	●	**S**	●		●		attractive bark and structure; susceptible to anthracnose; yellow fall color
London Planetree: 'Bloodgood'		**S**			●		tough urban tree; high resistance to anthracnose; yellowish fall color
Tuliptree/Yellow Poplar	●	**U/R**			●	●	impressive tall growing tree; attractive yellow fall color
Zelkova							
'Halka'		**V**	●				better branch structure; planted as substitute for American elm
'Village Green'		**V**	●				better branch structure; planted as substitute for American elm

Prepared by William Elmendorf, Jospeh Ibberson Professor of Community and Urban Forestry. Thanks to Theo Thwing, Associate Landscape Architect, Weber Murphy Fox, Inc., for design and illustration assistance for Appendix I: Tree Planting Diagrams. Developed with support from the Pennsylvania DCNR Bureau of Forestry and the USDA Forest Service. Illustrations by Lori Settlemyer.

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Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

Code EE0388 2M11/20mpc