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his publication is for people who plant trees in public landscapes, such as streets and parks. Much 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.

Start planning 6 to 12 months before planting and allow time to conduct a thorough site analysis, find and obtain quality trees, and arrange for supplies, equipment, and workers. Trees should be selected that are well adapted to the planting site 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, attractive, and to grow to a mature size.

Understanding the Planting Site

Trees di er in their requirements for growth. Selecting trees that will become established and thrive in the biological and physical conditions of the planting site requires observation and thought. A thorough planting site analysis will identify important site conditions that can a ect the survival and growth of the trees to be planted. Experienced tree commission members or arborists are best qualified for analyzing tree planting sites, but even a novice can do a site analysis reasonably well using good information and common sense.

Essentials for Evaluating Planting Sites

- Temperature extremes
- Moisture
- Light
- Wind

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

- Volume 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

- Design themes, sense of place
- Complement existing flora
- Climate modification
- Noise reduction
- LL L

are available at your local library or county extension o ce, in many nursery catalogs, or in . . *F . . .* (Gerhold et al. 1993).

- 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.

- Space is often limited in urban areas. Look up, look down, look all around! e planting space above and below the ground should be large enough for the selected trees to reach their mature height, branch spread, trunk diameter, and root extension without interfering with surrounding objects and the activities of people. Roots can extend well beyond the spread of branches. Identify objects such as buildings, roads, sidewalks, signs, and underground and above-ground 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.

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- An adequate amount of fertile soil is crucial for tree growth. Tree roots need su cient amounts of water, oxygen, and nutrients supplied from 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. If compaction or drainage is a concern, 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 8 hours, consider planting the tree in another location that has better drainage. Replacing the soil in a planting area may or may not help drainage problems caused by surface or subsurface soil compaction; suggestions for managing compacted soils are provided later in this publication. Some species of trees such as red maple, red oak, pin oak, and sweetgum cannot tolerate alkaline soil (pH above 7.0). If concerned about the fertility or pH of a soil, ask for advice about completing a soil test from your county extension o ce.

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- e 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 or chlorotic leaves can indicate sites that are hot, droughty, compacted, or that have a high pH or road salt problems. Some species tolerate certain adverse conditions better than others do. Also, the condition of neighboring trees can indicate insect or disease problems such as plant bug, verticillium wilt, or fire blight that can cause problems to susceptible tree species.
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To find information on tree species and cultivars consult a cooperative extension specialist or a publication such as *F…* (Gerhold et al. 1993).

Buying Quality Nursery Stock

To improve the chances for success in tree planting, it is important to begin

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- 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
- been freshly dug, briefly stored with moist packing material (for bare-root stock)
- the specifications listed in the *A…*

- e proper root ball size of a B&B

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- 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. Trees that were planted too deep in the nursery or that have been covered with soil by mechanical cultivation are too deep in the root ball.

If a large number of 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 being used to move and plant trees. Below are some tips for shipping and handling trees.

- When transporting trees in an open vehicle, even for short distances, cover trees with a tarp to prevent them from drying out and being damaged by the wind.
- e protective covering around the trunk should remain in place until the tree has been planted to protect against damage from equipment or shovels. en the covering should be removed.
- Always try to unload the tree as close to the planting site as possible and gently lower the tree into the planting hole. Never drop trees o a truck since 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 a root ball. Be careful not to drop a tree onto the legs or feet of people standing in a planting hole.
- Always lift a tree by its root ball. Never drag or lift a tree by the trunk because the root system can separate from the soil and break roots. Do not wrap chain or rope around a 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 a tree, always hook to at least two wires. If hooked to just one, the wire can break and injure people.

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

- e roots of bare-root trees must be kept moist at all times. It is best to plant bare-root trees within one wo pliftkto

Planting Trees in Spacious Places

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

- Arrangements for workers, volunteers, and equipment should be made months in advance.
- To avoid hitting underground utilities while digging, contact the One-Call System a few weeks before the planting date. is 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.
- e ideal time for planting in the temperate zone is 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 can be started in early September. Some trees such as oaks and ornamental pears 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

- In the center of the loosened soil, dig a hole that is twice the diameter and exactly as deep as the root ball. To prevent the root ball from being planted too deeply, it should sit on solid, undisturbed ground rather than on 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,

Planting in Sidewalks and Other Harsh Environments

e 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 can be used to modify harsh or confined planting areas, but these usually are expensive; some should be designed with the assistance of an engineer or landscape architect. It is important to properly water and maintain trees that are planted in harsh environments. ere is no sense in designing

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e 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 as soon as possible but within a week.

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

quent recommendations for managing compacted soils.

Limestone gravel and cement associated with streets, sidewalks, or patios increase soil alkalinity, so only plant trees in these areas that are tolerant of alkaline soils. Do not plant red oak, pin oak, sweetgum, or red maple in these areas. In places with heavy pedestrian tra c, 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 or tra c signs or sight visibility at intersections or be hit by car doors and bumpers. Alternatives for using pavers and other surface materials are discussed later. Sidewalk, patio, or parking lot cut-outs can be improved by using shared space for trees, continuous planters, or raised planters, especially when major repair or sidewalk construction is being planned.

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Remove all nonfertile soil in minimum 4' x 4' x 4' pit.

Construct aeration system per Fig. 20A and fill with fertile topsoil. New soil should be “watered in” to settle and slightly compact.

Dig planting hole in the new soil and plant tree per specifications in Fig.12 (see page 9). Soil under root ball should be lightly compacted to prevent settling of root ball.

Stake to protect street trees.

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Groups of trees can share larger soil spaces, which improve the growing conditions for all of the 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, and parking lots to support groups of trees and other plants instead of the traditional single cutouts in concrete without necessarily increasing costs or taking up more space.

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. Keep the bottom of shared planters open and cultivate new soil into old soil to provide for better root growth.

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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. e planting space should be as deep as the root balls being planted, have an open bottom, and be filled with good topsoil. A cantilevered cement top, brick, or other porous paving material can cover the planting space. is 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.

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Elevating planting spaces above sidewalks or parking lots is a good way to provide positive drainage, avoid salty runo , and discourage compaction due to pedestrian tra c. With heights up to 36 inches, the planter lip can provide seating. Raised planters should be filled with good topsoil and be a minimum of 4 feet wide and 2 feet high. ey can also be quite large and blend into the natural grade of an area. Keeping the bottom of the bed open and cultivating planting soil into the original soil will encourage roots to escape from the bed into surrounding soil. French drains or other channels or sinks filled with gravel can be incorporated into the design to improve drainage.

Tree roots are opportunistic, tending to grow in soil where the air-water balance is most favorable. erefore, 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 materials can also be used to improve soil moisture and aeration.

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. e system depicted in Figures 18, 20, 23, and 23B has two main purposes: to help increase aeration and provide a means of watering and fertilizing the tree. e extent to which embedded pipes may improve root growth has not been well documented, but they certainly do o er a practical means of irrigation that may promote deeper root growth if drainage is su cient.

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, the pipe should be wrapped with geotextile. e tops of vertical pipes should be covered with slotted caps to allow free air exchange, but keep out litter. e 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.

e majority of tree roots can be found within the top 2 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. e likelihood of this occurring increases with compacted soils that limit the depth of root growth, especially when larger trees are planted in small spaces. Preventing root damage to sidewalks and curbs requires selecting species to match the planting site, altering sidewalk construction, installing root barriers, and providing good maintenance such as slow, deep waterings. It is not advisable to plant trees in areas where planting strips are less than 2 feet wide. In strips 2 to 4 feet wide, plant trees with a mature height 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, or reducing sidewalk width to 3 feet while expanding the size of a planting cutout. 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. Root barriers that are commercially available include polypropylene plastic and geotextile fiber impregnated with herbicides. Six-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, no more than once a week. Frequent shallow irrigation may encourage the development of a shallow root system.

A structural soil mix developed at Cornell University can be used in sidewalks, patios, and other confined planting areas. Use of this mix is believed to reduce sidewalk and curb damage and increase tree vigor and life span. e structural soil mix provides both a penetrable rooting volume and a load-bearing surface for asphalt and concrete. e 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). A ratio of 80 percent stone, 20 percent soil, and a small amount of hydrogel is recommended. Limestone gravel should not be used if planting trees, such as pin oak, red oak, and red maple, that are not tolerant of high-pH soils.

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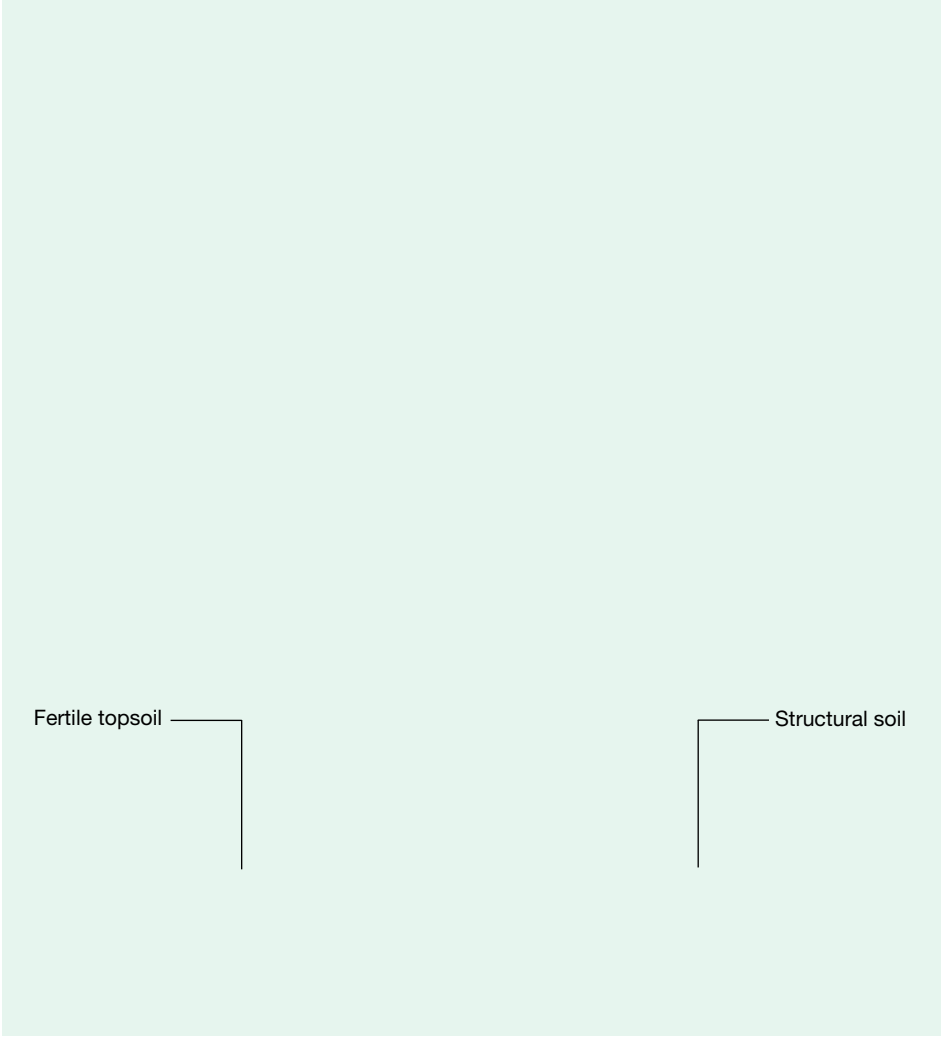

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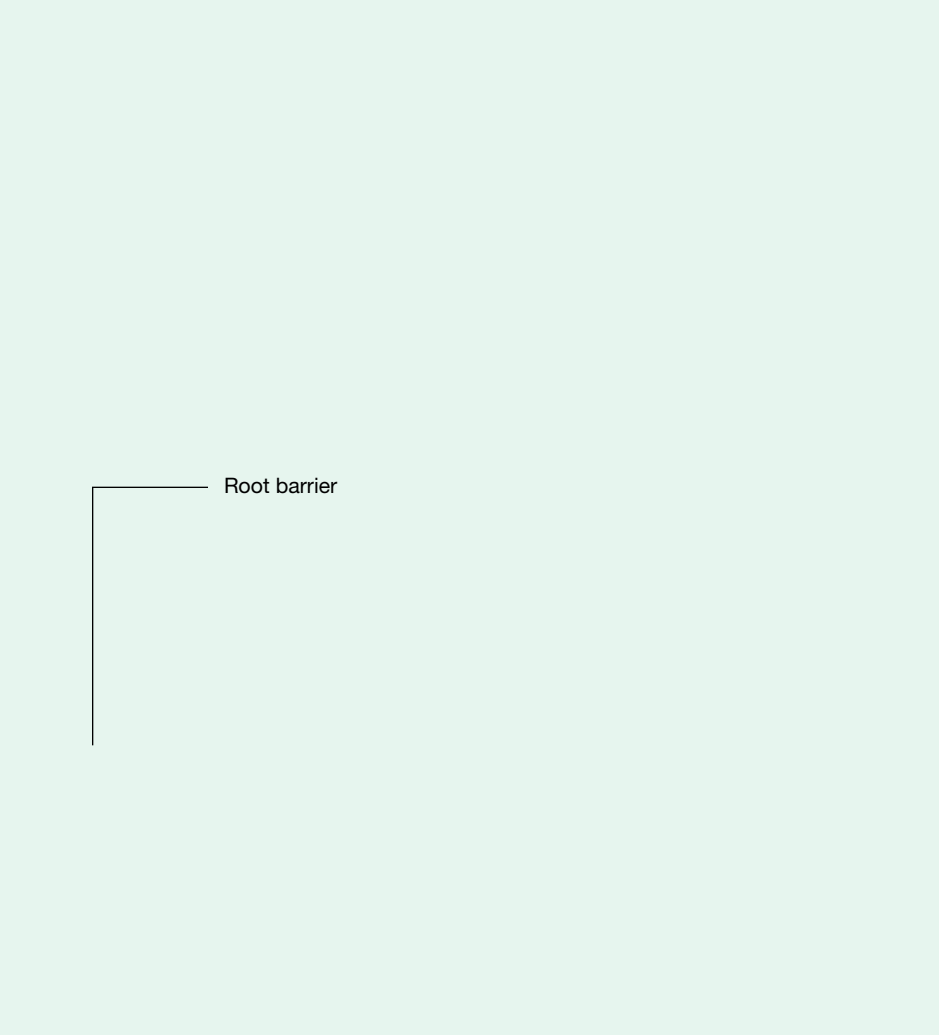

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Managing Soil Problems

Because of grading and construction requirements, soils under pavements and around buildings are mixed and compacted. Even parks that have been graded can have severely compacted soils. Soil compaction can also be caused or worsened by pedestrian and vehicular tra c.

Compacted soils have less oxygen available to tree roots and slower infiltration of water and physically restrict root growth. Suggestions for managing compacted soils before tree planting are as follows.

- Select trees such as sycamore, honeylocust, flowering pear, and thornless hawthorn that are more tolerant of compacted conditions. Do not plant trees that require good aeration such as flowering cherry, magnolia, serviceberry, or sugar maple in compacted soils.
- Adding peat moss, sand, or leaf mold to individual planting holes is usually unnecessary and may be counterproductive. Usually, compacted topsoil should just be broken and loosened, not amended. Some believe that moss acts as a sponge does and may hold excessive water in the planting hole, especially in heavy clay soils.

- e best way to improve both droughty, sandy soils and compacted, poorly aerated/drained clay soils in large planting areas is to incorporate composted organic material into them. Composted organic material will improve the water-holding capacity of sandy soils and the drainage and aeration of heavy clay

- 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

Staking

Before staking a tree, you should consider if it is necessary. Most B&B trees are so heavy 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 from car doors and vandalism when planted near curbs, sidewalks, or playgrounds.

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.

ere are various techniques for staking or guying. A simple method that will meet most planting situations is shown in Figure 12. Common staking prob-

Watering

Inadequate or excessive water reduces the chance that a tree will become established and grow. Trees become established when their root systems adequately support root and branch growth. Trees and other plants must be watered when planted and periodically thereafter until well established. e 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 cause the death of young or newly planted trees. During hot, dry periods it is advisable to water trees every week during the first few growing seasons. A 2-or 2½-inch caliper tree should receive 20 to 40 gallons of water each time it is watered. e need for watering will gradually fade in successive years as trees become established, but it 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.

is can be done by using perforated containers called TREEGATORS® or by using 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.

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Controlling Disease, Insects, and Calamitous Damage

e best way to manage tree problems is to select and plant trees that are resistant to insect and disease problems and tolerant of existing site conditions. To reduce calamitous damage within the community forest from severe storms and unanticipated diseases such as Dutch elm disease, use a planting strategy that creates a diversity in age and species composition. Judicious pruning throughout the life of a tree and removing hazardous trees and limbs will also prevent many problems.

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 decide which branches should be removed.

- Use sharp, clean tools in a safe manner. Common sense, a hand pruner,

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