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The practices discussed in this publication are appropriate for residential, park, institutional, and other landscape plantings and can be used by private property owners and professional horticulturists.

The Cornell Guide for
Planting and Maintaining Trees and Shrubs

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Contents

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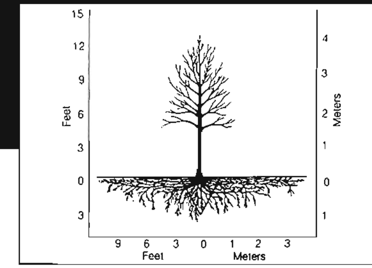
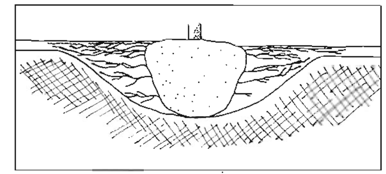
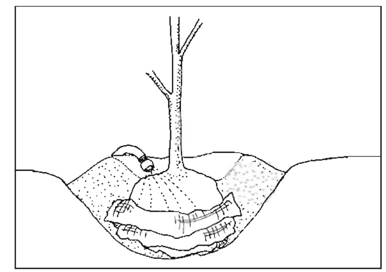
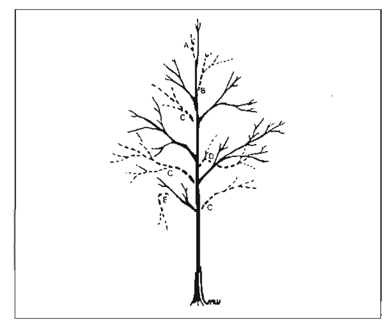
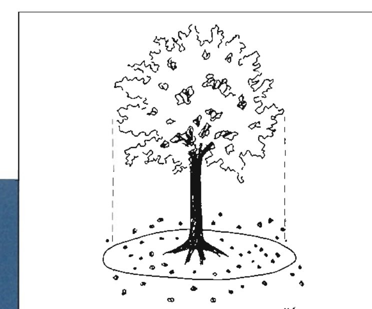










How to Select a Plant from the Nursery

Choosing the perfect tree or shrub can be a challenge, but it does not need to be. There are two major considerations: (1) selecting the species of plant that will best suit the site and (2) choosing the best available specimen once the species has been selected. To select the **right plant for the right place**, decide what characteristics you want the plant to have and then see "Site Assessment" (page 3). It is also important to select the best specimen in the nursery row or block of plants at the garden center. Overall, look for healthy plants that have good vigor, vitality, and structure. Keep the following in mind:

- Ideally, visit a nursery to examine and select your plants. This is especially important if you are looking for a large specimen tree. Mark the north side of the plant you choose so that later you can match its orientation on the planting site.
- For trees whose **caliper*** is 2 inches or greater, look for good trunk taper and the beginning of a root flare at or just below the soil surface (Figure 1). This indicates the development of strong lateral roots. **Root collars** can easily become buried or the soil can be piled up around them during cultivation or digging in the nursery. This makes it difficult to plant at the proper depth, and undesirable **adventitious** roots sometimes can develop at the bottom of the stem.
- For smaller trees and narrow-leaved evergreen shrubs, grasp the main stem about 3 to 4 feet above the soil and move it gently in a circular fashion. The trunk or stem should rotate along with the entire plant and soil ball. *No* space should develop between the trunk or stem and the soil ball (Photo 1). Lack of space indicates that the soil is firm in the ball and is held together by sufficient roots to ensure proper rooting when planted.
- Be sure the root ball is the appropriate size for the type and size of the plant (Table 1, page 7).
- Look for a limited, but adequate, number of branches or canes evenly spaced throughout the plant.
- For trees, look for a strong, well-developed leader.
- For all plants, be sure there are few, if any, crossing or rubbing branches or small nonstructural ones that initiate internally in the plant.
- Branches should be distributed 8 to 10 inches apart along the trunk and evenly spaced around it. All branches should have wide-angle crotches (>45 degrees) for internal strength with no **included bark.**
- Foliage size and color should be uniform and appropriate for the plant species.
- Foliage, branches, and trunk should be free of mechanical damage, insect pests, diseases, and wounds that indicate sloppy pruning.
- Professionals should consult the *American Standard for Nursery Stock* to determine the proper relationship between the caliper and height of a specific tree species.

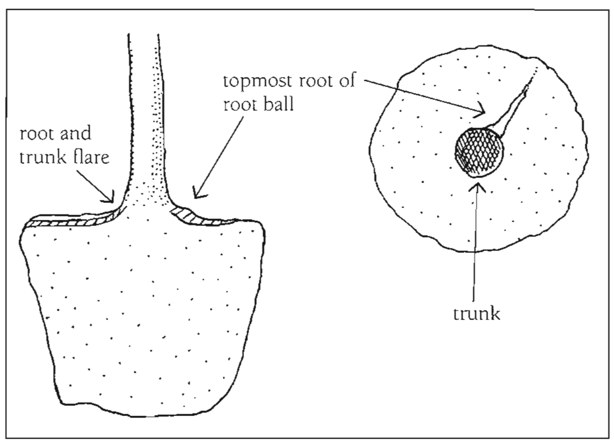


Figure 1. Flaring of the tree trunk must be evident at or very near the soil surface, and roots should radiate outward.

Photo 1. An insufficiently rooted tree in a container. (The trunk should pivot in unison with the movement of the entire soil ball/container, with no evidence of space between the trunk and soil.)

- Select plants that are cold hardy to the area. Trees and shrubs that are purchased locally are not always grown at a nearby nursery. There are, however, instances when **provenance** should be an important consideration. Sometimes stock that has not been grown locally is not hardy at the intended planting site. Or the seed source, of a species that is generally hardy, may be the problem. If the plant species is from a more temperate climate, the genes of that **progeny** may not exhibit the same degree of hardiness that they would if from a colder growing area.

Nursery-Grown Versus Wild Plants: What Makes the Former Far More Desirable?

Many deciduous and evergreen trees, shrubs, and vines grown in nurseries are transplanted or root pruned at least two or three times before they are ready for market. In the process of **root pruning**, the long roots

*Terms that are defined in the glossary appear in green the first time they are mentioned.

are cut off to stimulate the growth of fibrous absorption roots (at the cut ends) in a concentrated mass. Root-pruned plants are easier to dig, pack, transport, and plant, and they become established more quickly than do collected plants when the latter are planted in the landscape. Nursery-grown plants are usually better shaped than trees and shrubs taken from fields and woods. The tops have been pruned for a desirable head, whereas many wild plants require careful pruning to become well formed.

Types of Transplants

Bare-root plants are those grown in the field. They are harvested, shipped, and replanted without soil adhering to the roots. Often the plants are dormant-stored in large quantities and transported with their root systems in tightly sealed plastic bags (with or without a moisture-retaining material). Plants are available in this form by mail order and are shipped and planted only during the dormant season. They must be planted soon after arrival at the site.

Balled and burlapped (B & B) plants are also grown in the field but are dug with a soil ball surrounding the roots. The tightly tied and/or pinned burlap, as well as the lacing twine, hold the soil intact around the roots. Larger plants may receive additional support from wire baskets or cages. The trees or shrubs are generally planted with the burlap partially in place (see page 13 for further discussion). In general, they are dug dormant and can be held above ground for later planting during appropriate seasons.

Container-grown or containerized plants either spend their entire life in a container or are potted from the field when young and then grown in the container. They are often transferred to larger containers, but the roots always remain confined to a pot. The type of container used can vary significantly as can the media, which range from field soil to soilless potting mixes.

Because roots are not lost during digging or planting, containerized plants are available for planting much of the year.

Transplanting is a surgical operation and it is your part to nurse through the convalescence, and know that the proper amount of food and water is given.

COURTESY OF HICKS NURSERIES, FROM THEIR CATALOG, 1913
WESTBURY, LONG ISLAND, NY

Use the following recommendations, in addition to those already mentioned, for each specific type of transplant.

Bare Root

- Adequate and uniform all-around root growth.
- Adequate number of fibrous, and many small, roots.
- Minimum number of roots that have been mechanically injured or damaged by insects.
- Roots that are of good color and have been kept moist.

Balled and Burlapped

- Adequate soil ball for plant type and size, fully intact, with flat-topped surface.
- Firm soil ball.
- Root ball that is not dry.
- Broken or crushed roots outside root ball have been cleanly pruned off.
- Root/trunk collar flare at or near surface (open burlap at top of soil ball).

Container-Grown

- Once removed from container, roots should not be too tightly bound or overly encircle container.
- Trunk should flare and existing root(s) should not be girdled.
- Any roots that are obvious after unpotting should be light in color.

Site Assessment

Assessing the site where trees or shrubs are to be planted helps in choosing the most appropriate plant for the location—the **right plant for the right place**. Every tree or shrub planting should have diversity, and overplanting any one variety of tree or shrub results in a **monoculture** that often encourages the build-up of insect populations or diseases that can destroy an entire planting. According to Nina Bassuk, director of the Urban Horticulture Institute in the Department of Horticulture at Cornell University, landscape architects, installers, and municipalities should place a 5 percent limit on any one species within a total municipal tree population (see Appendix, Site Assessment Checklist).

Assessing Your Site—Below Ground

Restricted Rooting Space

Check for underground obstacles, compaction near curbs and driveways, and other factors that could restrict root growth of trees and shrubs. These obstacles restrict rooting space, which limits the amount of water, nutrients, and oxygen to which the roots have access.

Soil Texture

At the prospective planting site, test for texture using the "feel" method and record your observations. A sandy soil will suffer the effects of compaction less than other soils but may be less able to supply water to trees and shrubs. Conversely, compaction may render a **heavy** clay soil too wet, making oxygen unavailable.

Soil pH

Test the **pH** in several different areas on the site. Most plants tolerate a wide pH range, but some varieties grow better in higher or lower pH. Nutrients and micronutrients are most available in a pH range that is not excessively high or low (Figure 2).

Drainage

Poor drainage caused by compaction, underground obstacles, or soils that are predominantly clay can be estimated easily (see page 9). Dig the soil to a depth of 12 to 15 inches. If there is a gray mottling or a foul odor, suspect poor drainage. If the trees growing in a site are willow, alder, tupelo, or swamp white oak, consider the site poorly drained; if the trees are American sycamore and tulip tree, the soil is likely moist and damp.

Road Salt

In areas where large amounts of road or sidewalk salts are used, planting tolerant species can minimize damage later (Hudler 2004).

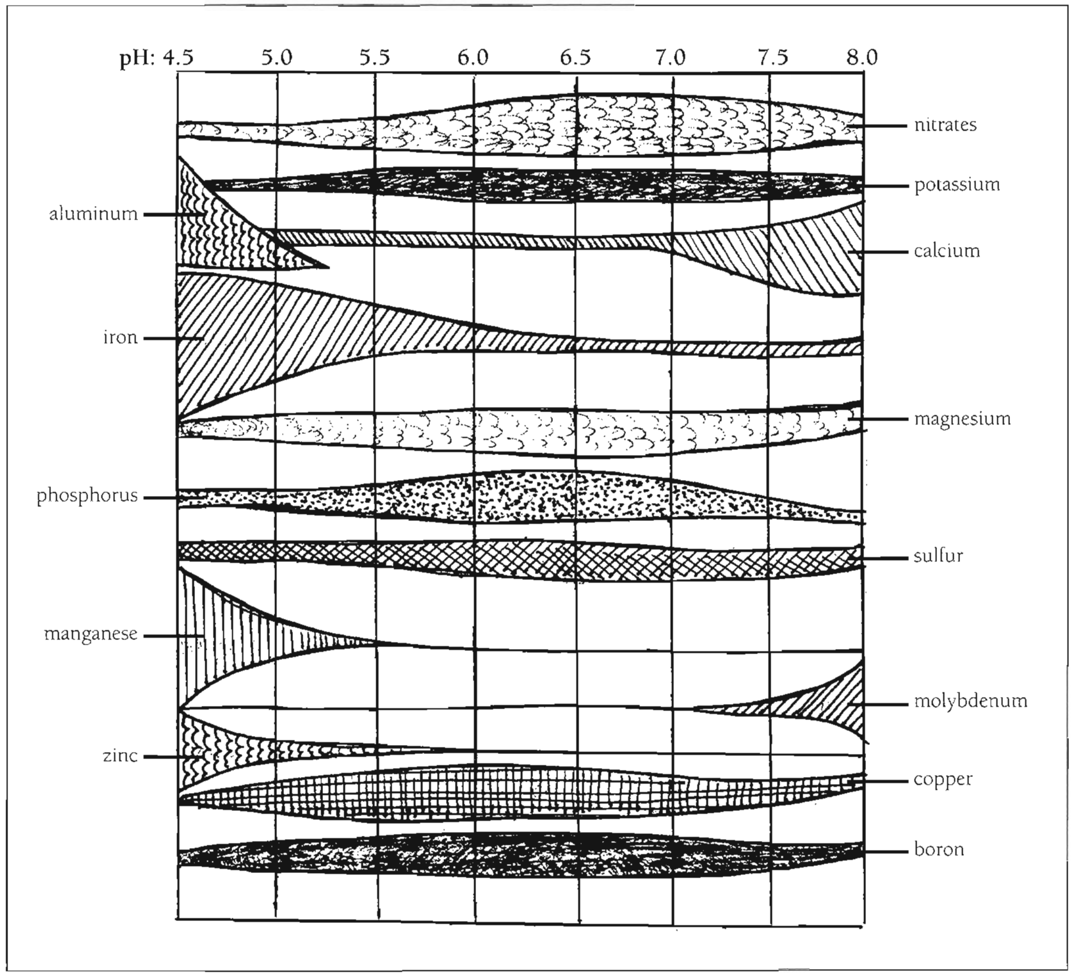


Figure 2. pH and nutrient availability

Compaction

This is generally a result of construction or pedestrian traffic. A simple test is to dig a small pit and gauge the difficulty of hand digging. Repeat the test in several spots on the site. Compaction both reduces drainage and causes the soil to be so dense that root growth is restricted.

Irrigation Systems

Look for underground automatic irrigation systems. Note method of delivery (type of heads); where the stations are delineated; and amount, frequency, and rate of water applied.

Other Soil Considerations

- *Indications of soil layer disturbance.* Look for areas where grading has occurred or soil has been added to or removed from an existing wooded or landscaped site. You may need to add organic matter to improve remaining soil.
- *Indications of recent construction.* Look for newly paved surfaces, retaining walls, and other construction; soil berms; turf that is thinner than in surrounding areas; leftover debris; and apparent pathways on the site (resulting from workers and machinery). The site may need to be remediated or you may need to avoid planting in excessively disturbed or modified locations.
- *Presence of noxious weeds.* Weeds that are generally not native to the site but presumably were brought in with new fill or soil must be eradicated before the landscape is installed.
- *Evidence of soil erosion.* Determine the severity of the situation. Soil erosion is affected by gradient and distance of slope (Figure 3); quality of existing plant material; presence and size of eroded gullies; rate of water percolation; and stability of existing soil, slope retainers, and terraces.
- *Limited soil volume or planting area for tree roots.* Measure the dimension of the available soil area and multiply it by estimated depth of rooting to determine rooting volume. Limited area may necessitate a narrower selection of trees for such a location.

Assessing Your Site—Above Ground

Exposure

Plants in excessively windy sites may need supplemental watering to prevent them from drying out quickly. A southern exposure can be intense in winter, increasing **desiccation** from sun and wind dramatically, especially in the frozen plant parts of broad-leaved evergreens. A smaller range of trees and shrubs can be planted in shady sites (those that receive no direct sunlight and less than six hours of filtered light). Partial sun has a duration of less than six hours and generally occurs during the morning. Most trees and many shrubs require full sun (six or more hours of direct sunlight), but certain varieties may tolerate somewhat less than this.

Setback Buildings or Overhead Wires

Physical barriers such as a large building set back from the street or overhead high-tension wires will necessitate a tree that will not interfere with these structures. You might need to choose a tree with a different growth habit.

Surfaces of Surrounding Buildings

Concrete, asphalt, mirrored, and other building surfaces increase the reflected and reradiated heat load on a tree and can cause more rapid water loss from its leaves. If one of these surfaces is present, you might need to select a different tree species.

USDA Temperature Zones (hardiness zone map)

Choose only cold hardy trees and shrubs for your planting area. A good rule is to plant varieties that are capable of developing sufficient hardiness to survive in your zone or the next colder one. Several hardiness zone maps exist for the United States, but the most recognized one is that published by the USDA. In New York State alone, the hardiness zones range from 7a on Long Island (coldest temperature 0 to -5 °F) to Zone 3 in the Adirondacks (-30 to -40 °F). Trees and shrubs in permanent containers are more susceptible to cold winter temperatures than ones in the ground because of the vulnerability of roots to cold temperatures. Be aware that in any hardiness zone, **microclimates** can provide either colder or warmer temperatures.

Other Limitations in the Aboveground Space

- Heat and air-conditioning vents and exhausts, drainage pipes, downspouts from roofs.
- Signage that must remain visible.

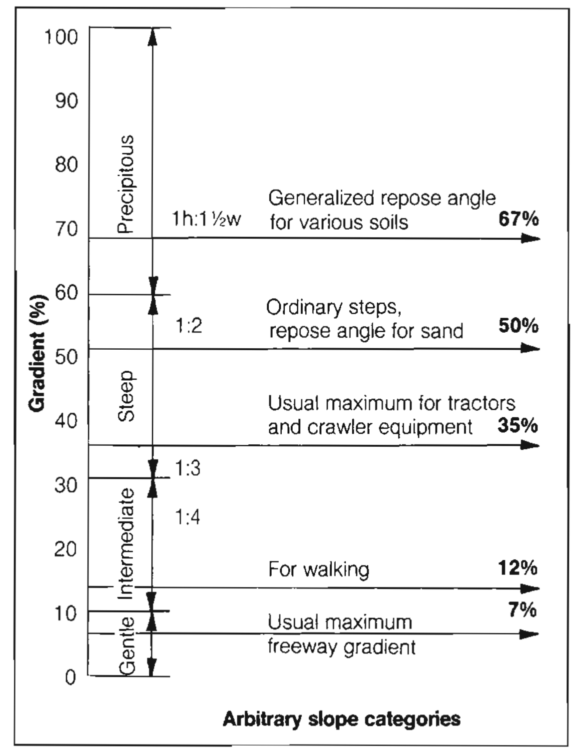


Figure 3. Slope categories (gentle, intermediate, steep, and precipitous) are based on use limitations and repose angles of some materials but have arbitrary ranges.

Visual Assessment of Plants Already on the Site

- Identify the species of plants.
- Determine the approximate height and spread of the plant material.
- Determine the growth rate or annual shoot extension of each plant.
- Look for damage to the tree trunk or other mechanical injury and evidence of good trunk flare.
- Note excessive surface rooting and presence of **girdling roots.**
- Examine leaves and branches for color quality, size, presence of insects and diseases, and any other indicators of stress.
- As a further confirmation, observe trees and shrubs in the immediate area before planting to see if any species are doing particularly well or poorly.

Transplanting

Today professionals can transplant at any time of year thanks to sophisticated digging and lifting equipment and the demand by customers. It is still advisable, however, to dig during dormant periods, whether the plant has been root pruned or not. The stress inflicted by root loss does not need to be amplified further by forcing the plant to support existing foliage during the growing season.

A cautionary note on weight: Soil is very heavy. Do not attempt to dig holes for items that are large. Larger trees and shrubs should always be moved by professionals. As a rough guide, a tapered ball is considered to be about two-thirds of a cube, and 1 cubic foot of moist soil weighs approximately 110 pounds. The root ball of a 2-inch caliper tree trunk weighs approximately 250 pounds. The use of a hand ball cart for wheeling a heavy tree around a property is highly recommended.

Transplanting Shock: Large Versus Small Trees

Recently, the demand for large trees (3 1/2- to 4-inch caliper and greater) has increased dramatically for two reasons. First, a homeowner may not want to wait 15 to 20 years for a tree to attain a look of maturity. Second, the landscapes of commercial business properties demand immediate visual impact.

Root Loss

When a tree of any size is dug for transplanting without root pruning, as much as 90 percent of its root system can be left behind. A large tree loses a much greater mass and lateral spread of roots than a smaller one (Figure 4). For all trees, the original balance between

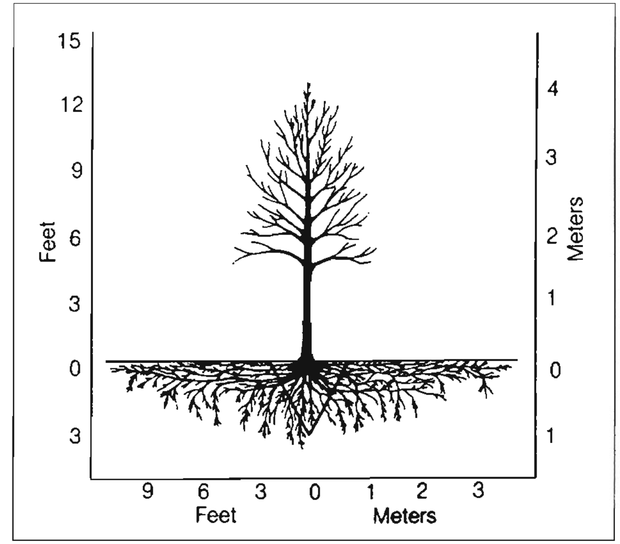


Figure 4. A typical root system based on field data collected from trees growing in a nursery. The triangular area represents a soil ball, 45 inches in diameter and 41 inches deep, which is dug by a tree spade. The tree has a trunk diameter of 4 inches. (Adapted from Bruce 1982.)

the roots and shoots (or at least a good portion of the original root mass) must be restored before normal top growth can resume. Because roots of large and small trees grow at the same rate—roughly 2 to 3 feet each year depending on plant species, soil type, and so forth—it takes the larger tree several years longer to regain the size of its original root system. As a result, large trees often undergo a longer period of slow top growth after being transplanted. Although property owners or managers may be concerned about this extended period of reduced vigor, this period of slow growth should be expected because the plant is being supported by such a limited root system. Until the natural root-shoot balance is restored, the trees will continue to experience some degree of transplanting shock (Watson 1985).

During this time, the reduced root system is unable to supply the necessary quantity of nutrients and water to the upper portion of the tree for normal growth. This problem is caused by the loss of fine roots, including root hairs, that primarily are responsible for water and nutrient absorption. This is the main reason adequate watering and other maintenance practices are so critical after replanting. These essential and remaining absorbing roots are also the first to suffer when water is lost from newly transplanted plants. Further complications of this extended period of establishment are reduced caliper growth and a greater susceptibility to root diseases and aboveground pest problems. Note that the use of mechanical **tree spade diggers** can result in even more root loss and **glazing** of the soil ball and the sides of the new planting hole.

In the Northeast, a tree requires approximately one year of growth after transplanting, for each inch of caliper, to outgrow any setback resulting from transplanting. In the example given in Figure 5, a 4-inch caliper tree required about five years to regain the size of its original root system, which was 18 feet in diameter. A 10-inch caliper tree with a 45-foot diameter root system needed 13 years. The root system of the smaller tree became nearly as large as that of the 10-inch tree after this 13-year period. Thus the increase in the transplanting size of trees may provide only short-term gains.

Root Pruning

As noted above, severing a large proportion of a plant's root system during digging induces moisture stress, causing shock to the plant. To prevent acute stress, it is extremely important to root prune before transplanting (Figure 6). When possible, the complete procedure should be done one or two growing seasons before transplanting. To determine ball size in the root pruning operation, refer to Table 1.

The Actual Transplanting Process

The principles behind transplanting any tree or shrub (see chart) are relatively simple if we remember that roots:

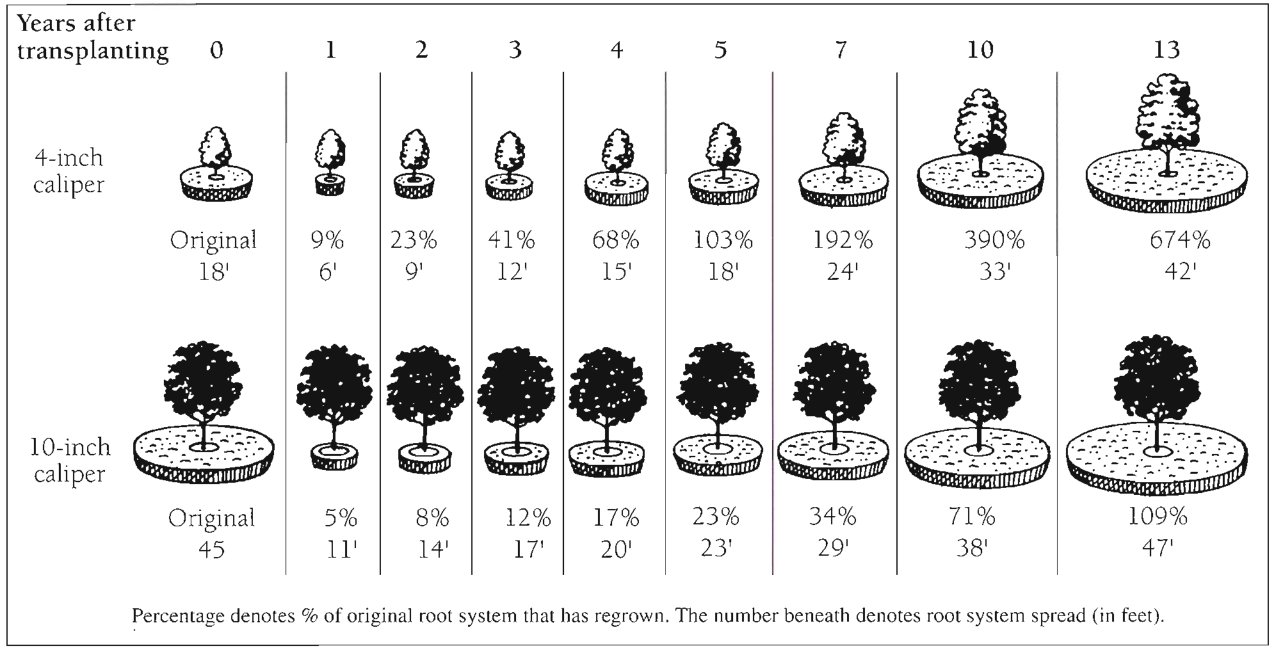


Figure 5. Relationship between root growth and top growth of transplanted trees of 4 inches and 10 inches in caliper at the time of transplanting. The larger tree grows very slowly for many years, while the smaller tree resumes normal growth after only a few years. (Courtesy of Dr. Gary Watson, Michigan State University, East Lansing.)

- keep the cells of leaves and other aboveground parts filled with water (and dissolved nutrients) absorbed from the soil.
- serve as an anchor that prevents the aboveground plant from toppling over in the wind.
- produce hormones that regulate top growth.

Cut and damaged roots perform none of these functions well. Thus the "intensive care" that must be provided for transplants consists first of assisting the damaged roots to perform their primary functions and, second, of providing the best possible environment for quick regeneration and replacement of the missing roots. The remaining roots of the transplant must never be allowed to dry out while out of the ground, before planting or after installation. Watering must be frequent, thorough, deep, and extended for a considerable length of time after planting (see Table 4).

Remember, the actual digging should be done one season or, better yet, one year or more after the root pruning procedure was done. Recall the diameter of the soil ball when the plant was root pruned (Table 1). If the soil is dry, moisten it two to three days before digging. In addition to maximizing the water content in the plant, this will aid in soil handling during the digging process. Refer to Figure 7, which depicts the procedure to be followed. This pertains whether the transplanting is done in the wild or from existing cultivated plantings.

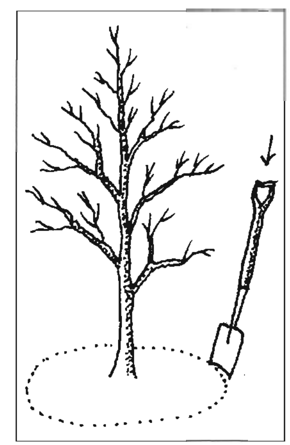


Figure 6. Root pruning being done one year before transplanting.

Table 1. Recommended minimum ball diameters for different sizes of shrubs and trees

Shrubs and small trees		Larger trees	
Height of plant (feet)	*Diameter of ball (inches)*	*Tree diameter, 1 foot above ground (inches)*	*Diameter of ball (inches)*
1 1/2–2	11	1 1/4–1 1/2	18
2–3	12	1 1/2–1 3/4	20
3–4	14	1 3/4–2	22
4–5	16	2–2 1/2	24
5–6	18	2 1/2–3	28
6–7	20	3–3 1/2	33
7–8	22	3 1/2–4	38
8–9	24	4–4 1/2	38
9–10	26	4 1/2–5	48
10–12	29	5–5 1/2	53
12–14	32	5 1/2–6	58
14–16	36	6–7	65

Source: N. F. Childers and J. M. Beattie. 1954. Trees for the home grounds, in *The Care and Feeding of Garden Plants*, American Society for Horticultural Science and the National Fertilizer Association, Washington, D.C.

When to Plant

The most favorable season to plant woody ornamentals varies from one locality to another, depending largely on climate. In the warmer parts of New York State, planting is done successfully in spring and fall. In areas that have early freezes and long winters, it is usually safer to plant trees and shrubs in the spring. Note: the months of these seasons may vary considerably owing to regional climatic differences.

Planting time is also influenced by the degree of exposure to wind, the hardiness of the tree or shrub species to be planted, and the nature of the soil. In places where these conditions are unfavorable or where the plant is known to be difficult to establish, spring planting is usually preferable.

Narrow- and broad-leaved evergreens that are container-grown and balled and burlapped are ideally planted in spring, late summer, and early fall. When evergreen trees and shrubs are planted later in the fall, they need to be protected for winter by a 2- to 4-inch layer of surface mulch and screening from excessive sun and wind. The soil must also have ample moisture before it freezes. Soil temperature is always extremely important: several weeks of 60 to 70 °F temperatures at a 6- to 12-inch depth are desirable for good root development before winter arrives. Furthermore, when plants are put in during the spring, summer watering is extremely important.

Nurseries and garden centers now sell woody ornamentals throughout the summer. The plants are balled and burlapped or in containers and thus remain in reasonably good growing condition until they are planted. As long as they are cared for properly in the sales yard during stressful periods of the summer, they can be purchased and planted during this time.

Transportation and planting do not greatly disturb the root system, and with a little extra care in watering, the plants do well. Bare-root plants, however, must be planted quickly in early spring before there is any indication of growth. (Note: Several common species such as *Tilia cordata* and *Acer saccharum* establish just as well, if not better, when planted in the fall as dormant, bare-root items.) Great care must be given to these plants to avoid excessive drying or freezing of the root systems before planting.

To help reduce transplant stress, **anti-desiccant** materials may be applied to trees and shrubs planted at less favorable periods in summer or late fall. A second application will be necessary to ensure that the protective benefit of the material remains throughout the winter months (for further discussion of anti-desiccants, see page 16).

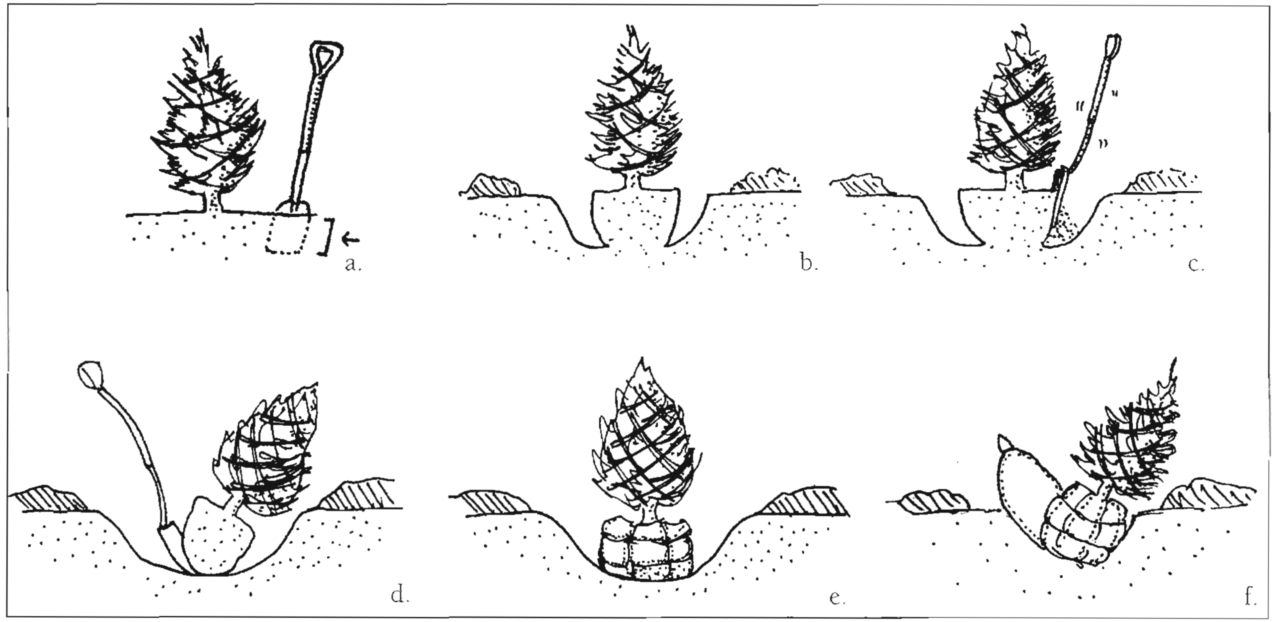
Late Summer and Fall Planting

Why are late summer and fall a good time to plant in some milder regions of New York State? Most woody plants require less moisture later in the growing season than during spring when succulent new growth is present. By late summer and early fall, many of the highly hydrated cells, characteristic of most cells present in succulent spring shoot growth, have either died or become heavily **lignified** or both. These changes in the internal tissues of woody plants contribute to the overall **hardening** of plants. Because woody plants have a lower demand for water during late summer and early fall, plants installed at that time are less subject to acute moisture stress. Moreover, the shorter days, lower air temperatures, and greater amount of rainfall provide an environment conducive to plant establishment.

Shoot growth of most woody plants has either slowed considerably or stopped altogether by late summer or early fall. Leaves, however (even deciduous ones), undergo **photosynthesis** well into the fall. A large proportion of the products of photosynthesis is available for root growth because active shoot growth is very slow or nonexistent. Root growth of many woody

Steps in Transplanting

1. Measure 2 to 4 inches (depending on ball size) beyond original root prune dimension; this will be the outside perimeter of root ball to be dug.
2. Drive a sharp spade into ground to a depth of at least 12 inches, cutting all the way around plant.
3. Carefully remove sod, mulch, or loose soil from around plant. Avoid disturbing first major roots, which should be within about 1 inch of root ball surface.
4. Dig a trench, spade depth, outside of this cut at least three-quarters depth of final root ball.
5. With back of spade toward plant, shave off enough soil from root ball to reduce it to its final, originally determined diameter, rounding top edge and tapering sides uniformly.
6. Cut beneath roots, rounding bottom of soil mass into a ball.
7. Carefully tip soil ball to one side and place rolled burlap underneath on opposite side with burlap unrolled on open side.
8. Tilt ball back over open burlap and unroll portion underneath.
9. Tie burlap or lift corners (this requires at least two people), taking plant out of hole. Tightly secure burlap once plant is out of hole.



Figures 7a–f. Tying in branches, measuring ball circumference, digging, trimming the ball, and removing small trees and shrubs from the hole.

a. Tie branches with rope or heavy twine. Determine and outline proper ball size.
b. Dig the trench all the way around the plant and down to the ultimate depth of the ball.
c. Shave off additional soil from the root ball, at the sides, to the originally determined diameter of the ball.
d. Undercut beneath the roots and shave off any additional soil.
e. Once the burlap is placed under the tipped plant, unroll and tie it securely to the top of the ball.
f. Move the balled and burlapped plant onto a snow tray or other type of skid to get it out of the hole.

plants remains active as long as soil temperatures remain above 40 to 45°F. Thus, woody landscape plants that have functional leaves should establish in a new landscape environment if planted early enough in the fall to allow sufficient time for root regeneration into the new surrounding soil. Some conifers and many broad-leaved evergreens benefit from an earlier start to planting of late summer/early fall as compared to most deciduous and very hardy evergreens.

How long does it take for landscape plants to develop new roots during fall to avoid the risks associated with winter? Research suggests that hardy species can be planted up to late October on Long Island or September to early October in upstate areas without additional risk of winter injury, as compared with plantings made earlier in the season. Plantings made after these dates may be more vulnerable to winter injury.

One disadvantage of fall planting is that regeneration of roots is highest during the spring months, much lower in the summer, and only moderate in the fall. Thus, post-planting performance is usually enhanced when planting is done in the spring. However, when properly timed and planted in the fall, even moderate root growth is sufficient to guarantee good establishment before the onslaught of winter.

Do these suggestions apply to all landscape plants? Plants that are marginally hardy in a particular area or unusually difficult to transplant may be exceptionally difficult to establish if planted in the fall. This is especially true in areas with extreme exposure or problem soils. The following genera have been documented as poor establishers following fall planting:

Abies (Fir)
Acer rubrum (Red Maple)
Betula (Birch)
Carpinus (Hornbeam)
Cercidiphyllum (Katsura Tree)
Cornus (Dogwood)
Crataegus (Hawthorn)
Fagus (Beech)
Ginkgo biloba
Halesia (Silverbell)
Koelreuteria (Golden Rain-tree)
Laburnum (Golden Chain-tree)
Liquidambar (Sweet Gum)
Liriodendron (Tulip Tree)
Magnolia
Nyssa (Sourgum, Tupelo)
Ostrya (Hop Hornbeam)
Oxydendrum (Sourwood)
Pyrus calleryana (Callery Pear)
some *Quercus* species (Oak)
Sassafras albidium
Sorbus (Mountain Ash)
Taxodium (Bald Cypress)
Tilia tomentosa (Silver Linden)
Tsuga (Hemlock)
Zelkova serrata

Managing Drainage

Poor drainage is a common cause of unsatisfactory plant establishment. The soil associated with poor drainage is either too wet or too dry for all but the toughest plants. In an urban environment, construction is usually the cause of drainage or compaction problems. Even the best prepared planting hole in a poorly drained area with clay soils will act like a dish and hold water (Figure 8). Oxygen levels will be extremely low in the bottom of the hole, which is not conducive to root growth. This situation can be resolved by establishing raised planting beds or using subsurface drainage techniques.

To determine how well your soil drains, dig several post holes to a depth of 18–24 inches to reveal texture and soil structure (i.e., clay, loam, sand, or gravel). Mottled gray coloring often indicates unsatisfactory drainage. The rate at which water disappears from a test hole indicates good or poor internal drainage. If you suspect poor drainage, fill the test hole with water and record how long it takes for water to disappear. Repeat this procedure. Measure the percolation rate after the second fill of water; if the water drops more than 1 inch per hour, the drainage is acceptable. If less than an inch drops, either the drainage must be improved or species that tolerate poor drainage need to be planted. If water remains in a test hole overnight, drainage should be improved by installing tile or using raised-bed plantings for trees and deep-rooted plants. If water remains within 1 foot of the soil surface for a week or more, grass and annual flowers are more likely to survive than trees and shrubs. For raised-bed planting, see Figure 9.

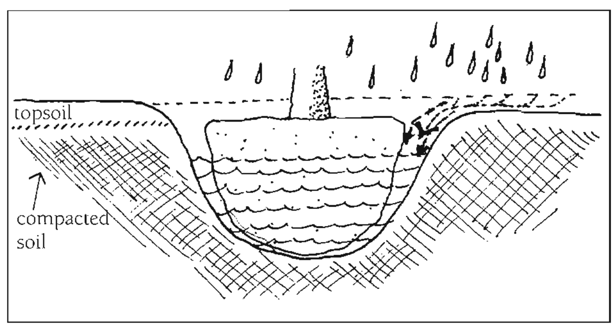


Figure 8. Water is unable to penetrate compacted soil and flows laterally to the lowest point, the planting hole. Root systems then drown.

Plantings can be made in raised areas, or **berms**, for design purposes and to improve drainage. If this is being done, build up a layer of well-drained loam or use a mixture of equal parts soil and compost (or peat moss) to make a bed of loam 2 feet or more deep for shrubs and more than 3 feet deep for trees. If you are using topsoil alone or in combination, try to match it to resemble the soil on the site. Before adding the amended mixture, roto-till or hand spade the existing soil. This will reduce the problem of soil **interface**, where water resists penetrating layers of different soil types. Put half of the prepared mix over the roto-tilled area and till it in place. Follow with the second layer and make the final pass with the tiller.

If, when planting trees, the parent soil is only 1 foot deep over rock, hardpan, or wet soil, adding 2 or more feet of a well-drained loam will provide enough depth for normal root function and vigorous growth. (Loosen the existing soil before adding the new loam.) For shrubs, the bed should be 4 or more feet wide; for trees, 8 to 15 feet or more. Set the plant in the raised bed rather than on the original ground. For a single plant, place a wall around the raised bed to prevent erosion. For groups of plants or for large areas, slope the edges of the bed down to the original level of the soil.

When creating raised planting areas, or berms, be sure that soil mixtures do not become unduly compacted. A hole dug in compacted soil will have a water-holding "teacup" effect. Compaction can cause new aeration problems and impede drainage even if the areas are above normal ground level. Avoid moving soils that are wet from rainfall or overwatering when building raised planting sites.

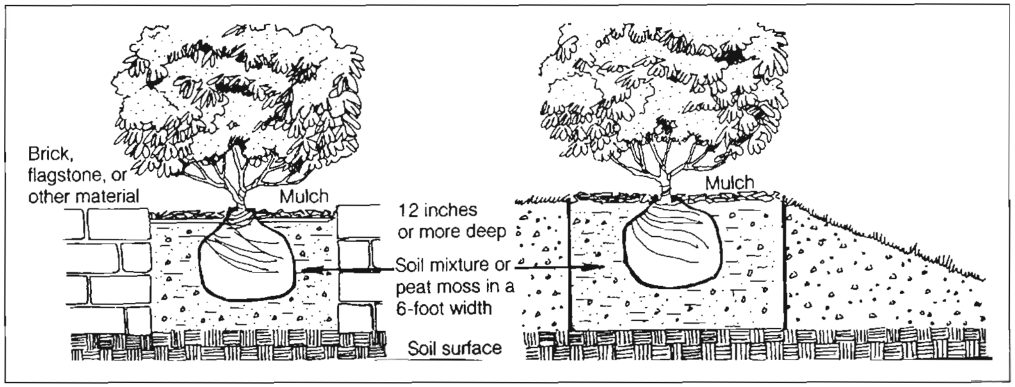


Figure 9. Two examples of raised beds for soils of poor drainage or structure.

If the construction of a raised bed is not an option, you will need to install **drainage tiles**. When using French or tile drain, be sure the drain slopes downhill at a 2 percent minimum grade and that an outlet exists on the downhill side. When setting plants, place them about one-quarter higher than generally recommended, and very gradually slope the soil from the top of the root ball down to the original grade. If neither of the above works because of cost or other reasons, try incorporating compost by deep spading or **sub-soiling** the large bedded area to be planted. Set the plant somewhat higher in the planting hole. In any case, the root ball should always be supported by firm, undisturbed soil underneath to prevent later settling. The careful selection of woody ornamental plants in such situations is extremely important even though the choice of species is limited.

In-Ground Soil Preparation and Planting

The Planting Hole

The planting site should be the highest-quality environment for the best possible initial root growth during the first year or two after planting (longer for trees whose caliper is 4 inches or greater).

Heavy subsoils and excessively well drained sandy ones need to be improved before they are suitable for growing plants. Usually these soils lack sufficient organic matter and can be improved by incorporating compost (see "Very Sandy Soils," page 11).

When planting an individual tree or shrub in good soil, the rule for **backfilling** should be "what comes out goes back in." This allows the upper layer of soil to mix with the subsoil and, at the same time, the cultivation/digging process loosens the soil structure.

> It is helpful to place a sheet of plastic, canvas, or plywood on the ground adjacent to ease the mixing process and simplify cleanup.

A current trend in landscape design is to plant trees and shrubs in large beds or tree islands. This practice helps alleviate soil compaction throughout the area in which roots must grow, which aids in the lateral spread of developing roots. In an area being prepared for multiple plantings, add at least a 2- to 3-inch layer of organic matter and incorporate it into the top 12 inches of soil. (This is equal to about 4 to 5 cubic yards per 1,000 square feet of bed area.) When planting each individual tree or shrub in the prepared bed, dig a single hole large enough to hold the plant and backfill accordingly.

If possible, always install plants as soon as they are brought to the site; otherwise, hold them in a shady spot and keep them properly irrigated.

Normal Well-Drained Soils or Somewhat "Heavy" Soils

Dig the hole as deep and at least three times as wide as the root mass of the plant you wish to install. This will allow the root system to grow in the first one or two years to within about 25 percent of its original spread before the new roots extend into the more compacted soil beyond. Most of the digging should be done near the surface, where most of the vigorous root growth occurs. For a hole with sloped sides (Figure 10), the majority of the digging effort is in excavating more soil nearer the surface and less below. This is where most

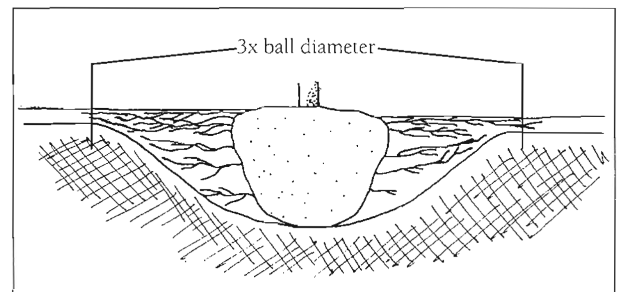


Figure 10. Slope the sides of the planting hole since most of the roots are concentrated in the upper part of the ball and subsequently develop in that area of the hole.

root growth will occur before being affected by the more compacted soil further out from the planting hole. If the backfill has not been amended, the best way to fill in the hole once the root ball is in place is to break down the sides with a spade or fork (Figure 11), thus creating the preferred sloped sides. This helps to avoid soilless air pockets around the perimeter of the hole as

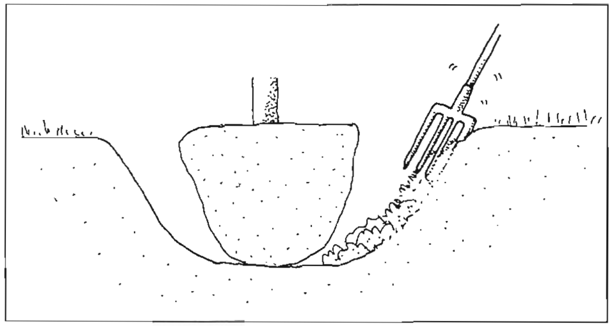


Figure 11. Use a garden fork to break down the sides of the hole and thus eliminate glazing.

it is being backfilled. Eliminating air pockets lessens the chance of roots losing contact with the soil and thus drying out. To help further in lateral root spread at the planting of an individual tree or shrub (when not in a large bed or tree island, as described earlier) and if turf will not be damaged, loosen the soil another few feet out from the original hole with a garden fork.

If you are using a tree spade or auger to dig the hole, glazing of the soil is an even greater possibility. Before inserting the tree, score the sides of the new hole and/or sides of the machine-dug ball to at least an 18-inch depth to allow for better new root growth and penetration into the surrounding soil.

When soil tests indicate the need for additional limestone, phosphorus, or potassium, recommended rates of the needed ingredients should be thoroughly incorporated into the soil to be used in backfilling. Soil tests can be done at many county Cooperative Extension offices. If other fertilizer elements are called for at planting, always use a slow-release, low-salt material (at the recommended rates) to avoid damaging new roots. Elements, including nitrogen, incorporated as soluble, inorganic sources of nutrients can damage roots, thus leading to plant failure.

Notice that no **complete fertilizer** containing nitrogen was added to the planting hole or backfill. If complete fertilizers containing nitrogen are added around the plant roots, readily available nutrients can injure the young expanding roots and may lead to the death of the plant. Superphosphate and limestone applied at recommended rates will not injure roots and can be added safely during planting.

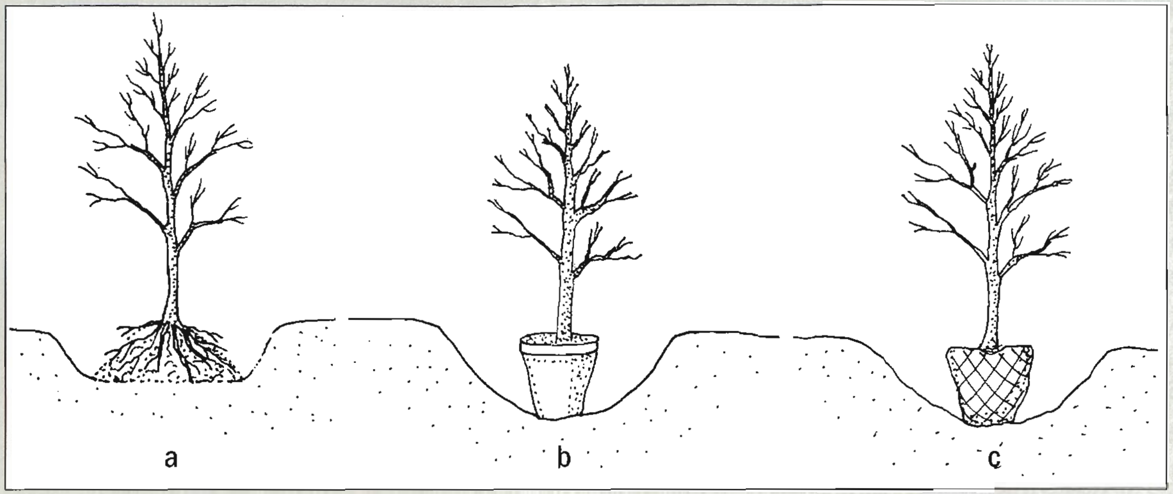
Very Sandy Soils

Light and excessively drained sandy or gravelly soils and shallow soils (less than 2 feet deep) are unsatisfactory for shrubs and trees unless the soil is adequately prepared. Otherwise, restrict plantings to the limited varieties that survive in soils of this type in New York State.

A very sandy soil is like a mass of tiny stones, with too few particles of soil between the sand grains that are capable of holding water and fertilizer materials. Plants cannot flourish with too little water or essential nutrients.

If the shrub or tree is a bare-root plant, dig a hole or pocket large enough to allow the roots to spread completely. For balled and burlapped and container-grown plants, dig the hole up to three times the diameter of the soil ball. Soil is excessively drained if water drains away repeatedly in less than 3 minutes from a posthole 2 to 3 feet deep. To create backfill around the plant and to enhance the water-holding capacity, use a soil mixture of one-third (by volume) of a loamy soil, one-third compost (or sphagnum peat), and one-third the original sandy soil. Firm the soil and make a raised cup-like area or ring of earth on top so that water will flow in toward the original plant ball. Water the soil and spread a 2- to 3-inch layer of mulch over the entire root ball area and beyond. Taper the mulch from the outside edge to within 3 to 4 inches of the trunk or crown.

If the **ecosystem** of a proposed landscape site has been significantly modified, is in poor condition, or the **inoculum** from mycorrhizal fungi and other such beneficial organisms is lacking, it may be worth incorporating one of these **biostimulants** into the backfill at planting. These fungi grow symbiotically with plant roots and aid them in water and nutrient uptake as well as protecting roots against soil pathogens. When roots are colonized with **mycorrhizae**, they have an enhanced surface area for absorption.



Figures 12a, b, c. Bare root, container, balled and burlapped (B & B)

Bare-Root Material

1. Dig holes before shipment arrives or before unpackaging. (Do not accept or plant if any succulent, new growth is emerging from buds.)
2. Remove plant from package.
3. Soak plant in water up to one day in cool, shaded environment.
4. Modify hole depth and width for proper root spread. Mound a small cone of soil in center of hole and place roots immediately over it.
5. Prune any broken or damaged roots.
6. Spread roots (to their natural position) over soil cone, making sure trunk depth is correct at original level.
7. Fill hole approximately half full with backfill, and water in (so soil has consistency of a slurry).
8. Gently raise and lower plant to allow soil to fill in between roots. (Large pockets of air around roots cause them to dry out.)
9. Add rest of backfill. Water again.
10. Gently firm soil with your feet. This will give it a foundation so plant can better withstand wind until roots become established.
11. Apply mulch 2 to 3 inches deep, but do not allow it to touch trunk or crown. Spread mulch to drip line of the plant.
12. Stake or guy trees more than 4 to 5 feet tall if site is windy.
13. Remove all tags or labels to prevent trunk or branch girdling.

Container-Grown Plants

1. Handle plant only by container.
2. Dig deep and wide enough (two to three times) to accommodate width of ball.
3. Remove containers carefully and completely, including those made of fiber materials. Plastic or tapered metal containers can be removed by turning plant upside down and giving rim a sharp tap on a hard, raised surface.
4. **Tease out** roots. If you can't pull them apart, use a sharp knife or hand cultivator to make four to five vertical slashes in root ball (roots should never be allowed to grow in a circle) to hasten establishment of plant.
5. Be sure soil ball is at proper level. If plant sinks, inadequately functioning adventitious roots develop (Photo 2).
6. Fill hole about half full with backfill and fill with water to settle in. (Alternatively, gently tap ground with a shovel handle to settle in backfill.)

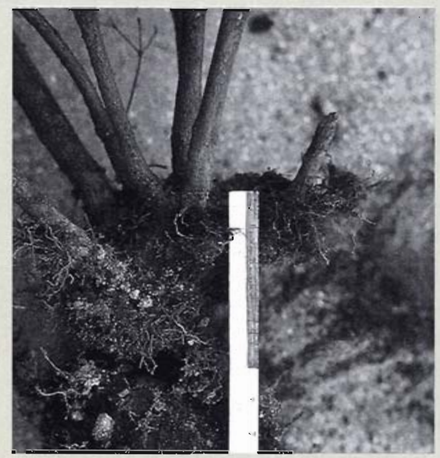


Photo 2. Shrub (azalea) planted too deeply, showing a superficial root system that developed later, above the original one.

7. Add rest of backfill.
8. Construct a 4- to 5-inch-tall saucer-like berm of backfill at outside edge of root ball to hold water.
9. Water again, letting water trickle slowly from hose into saucer for about an hour. This allows plant's existing root system to become thoroughly soaked.
10. Apply mulch 2 to 3 inches deep.
11. Remove all tags or labels to avoid possibility of trunk or branch girdling.

Balled and Burlapped (B&B) Plants

1. Handle plant ball carefully and only by ball. It can be fatal if soil ball breaks.
2. Dig deep and wide enough for ball, approximately two to three times width of ball.
3. Be sure ball is at proper level. Depth should be same as ball. As long as ball is on solid ground, plant can't sink as soil settles (Photo 2).
4. If plant is in a wire basket, cut and remove at least top half of wire.
5. Leave burlap on, then cut off and remove top half or tuck burlap down into hole. Cut and remove rope or string at stem or trunk. If synthetic burlap is used, try to remove it completely. Otherwise, cut away all of what is on side. (If you're unsure it's synthetic, burn a small piece. Synthetic melts but does not burn.)
6. Fill hole approximately half full with backfill. Fill with water to settle in. (Alternatively, gently tap ground using handle of spade or shovel to settle in backfill.)
7. Add rest of backfill.
8. If tree trunk is wrapped, remove and inspect for any wounds and/or insect damage.
9. Construct 4- to 5-inch-tall saucer-like berm of backfill at outside edge of soil ball to hold water.
10. Water again, letting water trickle slowly from hose into saucer for about an hour, so the plant's existing root system is thoroughly soaked.
11. Apply mulch 2 to 3 inches deep.
12. Remove all tags and labels to reduce possibility of trunk or branch girdling.

Precautions

1. Periodically, B&B stock comes as machine-made or "manufactured" balls, meaning soil has been pressurized around bare-root material and then wrapped in burlap to look like actual B&B. A **process-balled** tree costs less but will have experienced major root disturbance following bare root digging in the field.
2. Often, in production, and as a result of repeated cultivation, piling up soil against tree trunk makes soil surface of ball much higher than original soil line. If trunk flare is not evident, be suspicious and carefully scrape off a little soil at surface of ball, especially if it is loose (Figure 1). Then look for root/trunk flare and any soil that is visibly different. This will indicate original proper soil surface level of tree or shrub and level at which it should now be planted.

Tasks Immediately Following Planting

Watering

Too much or too little water can kill newly transplanted trees and shrubs. At planting, make an initial heavy application of water to settle the soil around the trees and shrubs into place. This will eliminate air pockets through which newly developing roots would be unable to grow. Water will also move more uniformly from the soil surface, through the root ball, and into the surrounding backfill. Even if, after all the appropriate modifications, the existing soil is not well drained, you must not *overwater*.

The amount of water that should be applied depends on rainfall, temperature, wind conditions, moisture retention of the soil, and drainage. As a general rule, 1 inch every five to seven days should be adequate during the first growing season (if less than 1 inch of rain has fallen that week). For individual trees whose caliper is around 2 1/2 inches, this is about 10 gallons applied twice per week and should be sufficient to properly wet a 20- to 24-inch diameter root ball. The time required to deliver this same amount of water with a hose can be measured easily by filling a similar-size container. Note, however, that on sandy, well-drained soils during drought periods following spring planting, two 1-inch applications per week may be necessary. This is also true for container-grown plants that have masses of roots initially contained in a limited area of a soilless mix. If rainfall is insufficient during the first fall, continue supplemental watering until the ground freezes. Always apply water slowly so that it percolates deeply and distributes uniformly (Figure 13), especially in the root ball. If water is not concentrated toward the root ball, this area can dry too quickly while the surrounding backfill soil remains moist. Application of more water than the soil can absorb will lead to wasteful runoff. Moisture in the backfill is unable to move into the root ball quickly enough to replace what is being removed by the roots still in the ball.

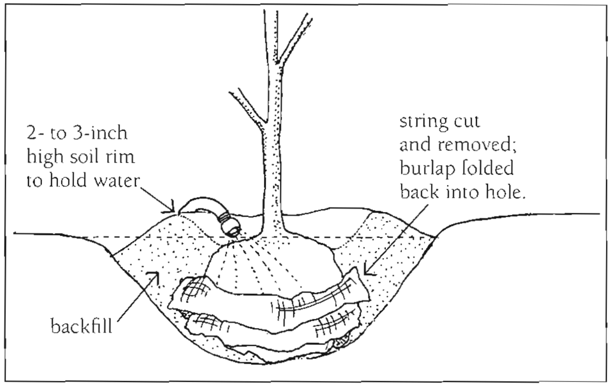


Figure 13. General practices used in the planting process. In this illustration a balled and burlapped tree is shown.

For residential sites or areas where only a few plants have been installed, the most effective and efficient methods are hand watering, a root-watering needle, Gator Bags, Rain Rings, or some other plastic dripping unit or saucer. When supplemental watering is needed, run a light stream of water from a hose at the base of the tree or shrub for an hour or so to saturate the soil completely. For large root balls, the hose or needle may need to be moved to several locations within the saucer or additional Gator Bags installed. Generally during the first year of installation, the plant will rely on water provided in the original root ball, as roots are just beginning to extend out into the backfill. For larger plantings, a drip irrigation system, soaker hoses, or a "leaky pipe" are most efficient because they provide a controlled flow of water directly to the root zone area. A timer should be incorporated into the system to turn the water off at a preset time.

Photo 3. Gator Bags

Never use frequent, light waterings because the roots will grow to the surface to obtain water. Even a brief rain shower of 1/4 to 1/2 inch should be supplemented by additional watering. If you are using a lawn sprinkler to water multiple plantings in a large bed area, place a can or rain gauge near the plants to be watered, and irrigate slowly twice weekly so that the can contains 1/2 to 1 inch of water with each application.

Mulching

Mulching at planting time helps retain moisture, suppress weeds, moderate extremes in soil temperature, and lessen the chance of damage from lawn mowers and string trimmers (Table 3). Mulching can also increase fine root development in the top 6 inches of soil, partly because grass is eliminated. Aboveground growth is also increased by mulching. Some lawn grasses, in fact, reduce growth of trees and shrubs. This suppressive effect is known as **allelopathy**. For example, the chemicals produced by fescues will stunt the growth of Southern Magnolia, Sweet Gum, and Black Walnut.

Apply a mulch immediately after planting within the area enclosed by the water basin (but away from the trunk or stems) and past the crown of the plant, if possible. For large landscape trees up to 3 inches in caliper, a 6- to 9-foot-diameter circle is recommended. Before applying the mulch beyond the water saucer, till the soil to create an even larger area for better root growth. If semi-hardy plants are planted later in the fall, delay this mulch application until a hard frost has occurred. Apply recommended materials 2 to 3 inches deep; oak leaves can be added to a greater depth because they not will settle by season's end (Tables 2 and 3).

Table 2. Bag mulch coverage chart

	Will cover	Depth of mulch (inches)
3 cu.ft. bag	36 sq. ft.	3
	54 sq. ft.	2
	108 sq. ft.	1
1 cu. yd.*	324 sq. ft.	3
	486 sq. ft.	2
	972 sq. ft.	1

*equals nine 3-cubic-foot bags

Depths greater than 3 inches will reduce gas exchange, i.e., the root's ability to respire or breathe (Greenley 1994). Always apply mulch evenly, avoid building a **volcano** around the tree's base, and never place the material up against the trunk or crown (Photo 4). Mulches derived from crushed stone, marble chips, and gravel can be used but do not break down to provide beneficial organic matter and may disperse and thus become maintenance problems. Black plastic and synthetic cloth or fiber-type **geotextile** mulches are alternatives but have numerous horticultural disadvantages, including aesthetics. If a light covering of organic mulch is used to camouflage plastic, as it decomposes it can serve as a germination medium for

Photo 4. Mulch applied incorrectly in a "volcano" fashion

Table 3. Organic mulches

Organic Mulch	Long lasting	Readily available	Attractive	Inexpensive	Winter mulch	Comments
Leaves		•		•	•	Must be chopped or shredded with lawn mower or leaf shredder. Most leaves (except oak) pack down and prevent water penetration.
Cocoa or buckwheat hulls	•		•			Very lightweight; are dispersed easily in wind. Fine texture very attractive. Dogs should be kept from areas where cocoa is applied.
Compost		•		•		Replenish annually. Will improve soil.
Evergreen boughs		•	•	•	•	Excellent plant protection in winter. Discarded Christmas trees are widely available (and free) after December.
Grass clippings		•		•		Ideally, leave clippings on lawn where they add organic matter and reduce need for fertilizer. If using as mulch, be sure the lawn has not recently been treated with an herbicide. Decomposes readily.
Peat moss						Do not use as a mulch!
Pine bark nuggets	•	•	•			Mini-chips retain moisture, stay in place better, and are more attractive than large chips. They do not decompose readily.
Pine needles	•	•	•	•		Weed free. Readily available where pine trees are growing. Stays in place in windy areas.
Salt hay, straw					•	Very useful in vegetable gardens. Use only salt hay and straw, which do not have seed heads. Flammable in dry areas. Decomposes quickly. Coarse texture is visually detracting in small gardens.
Sawdust		•		•		Extremely fine texture can lead to matting and poor water penetration. Apply no more than 1 inch deep. Can temporarily deplete soil of nitrogen. Use sawdust from non-CCA-treated wood only.
Shredded bark	•	•	•			Can be difficult to rewet once mulch and soil below dry out. Easy to apply. Weed free.
Wood chips	•	•		•		Know the source. Do not use wood from diseased trees. If not partially decomposed, wood chips can temporarily deplete soil of nitrogen.

weed seeds that are blown or physically carried into the area. This potential development of weeds negates the weed suppression normally anticipated with mulches. The roots of these weeds can penetrate the fibrous material of the geotextiles and extend into the soil beneath. In addition, if installed on a large area, plastics will restrict water movement into the soil unless punctured.

Staking

Researchers in California found that staked trees in a nursery had poor caliper development and less taper than did unstaked trees. The data suggest that staking, if necessary, should never be done rigidly but left slightly slack to allow the tree to move in the wind and thus develop a stronger trunk. We recommend staking only if the risk of blowing over is great; usually only trees greater than 1/2 inch in caliper require staking.

A tree should be stabilized with guys to hold it in an upright position and prevent loosening of the soil around the roots as the plant moves in the wind. On small trees a single stake is often used, placed on the side of the prevailing wind. Two stakes are usually preferred for trees 3 inches or less in caliper. Larger trees generally require a triangular system of three guy wires attached to stakes driven into the ground (Figure 14). Whichever method is employed, be sure the stakes are driven into the ground outside the perimeter of the planting hole and that the wire is encased in a piece of old garden hose or that flexible straps are connected to the trunk where it comes in contact with the bark of the tree. Once the staking has been accomplished, examine it occasionally to be sure the wires are not excessively loose or taut and that the trunk is not being injured. Generally, after the end of the first entire growing season, it is important to remove the supports to avoid girdling.

In addition to providing support, staking can help prevent mechanical damage to the trunk. Conversely, staking can be a liability if the guy wires are not clearly flagged to prevent human contact.

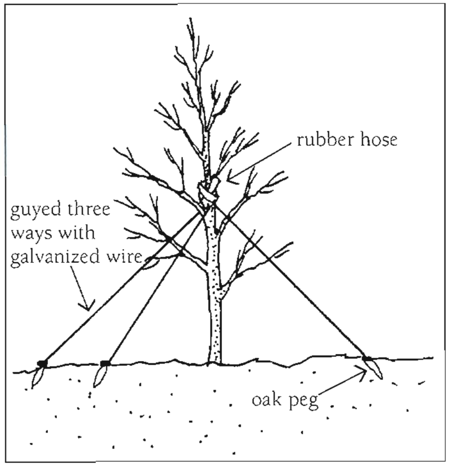


Figure 14. An example of three-way guying.

Wrapping and Other Protection

Although wrapping is no longer recommended, a shelter may be desirable during the first winter or summer following planting to protect very young or tender trees and shrubs against weather extremes. Burlap, snow fencing, or other physical barriers may be installed as windbreaks.

In areas frequented by rodents, rabbits, and deer, the lower portions of tree trunks should be protected with a cage of hardware cloth, chicken wire, or metal fencing. The height will depend on which animal is attacking.

Plastic tree guards (or flexible plastic drain pipe that has been slit down the middle) can offer protection against mechanical injury from mowers and string trimmers. (These protective devices should not be considered a substitute for mulching, however.)

Pruning

If your tree or shrub has been dug carefully and handled properly, pruning will be needed only to remove branches that are broken or those that rub other branches. More pruning than this will reduce photosynthesis, which can reduce root growth that is vital to the reestablishment of transplanted plants. This recommendation refutes past practices of trimming the crown to correct the root/shoot imbalance. Ranney et al. (1989) concluded that top pruning reduced both shoot and root development after transplanting.

If the terminal leader on a tree has been accidentally broken during planting (*never buy a tree that has no terminal*), prune it out and select a strong lateral twig to form the new upright terminal. A small stick can be used as a splint to tie the new leader in position (Figure 15).

Branches are often left on the lower portion of a tree in the production nursery but are undesirable in the landscape. If they are still present, leave them intact for the first few years after planting because they help to develop a strong trunk during the initial establishment period.

Fertilizing

Newly planted trees and shrubs do not need to be fertilized the first (and quite often the second) year that they were planted.

Applying Anti-desiccants

Research has shown anti-desiccants to be variably effective depending on the material, timing, plant species, and environmental conditions. They seem to be most advantageous on deciduous and evergreen plants that must be transplanted when in active growth during the summer. Anti-desiccants can minimize the development of moisture stress in transplanted plants.

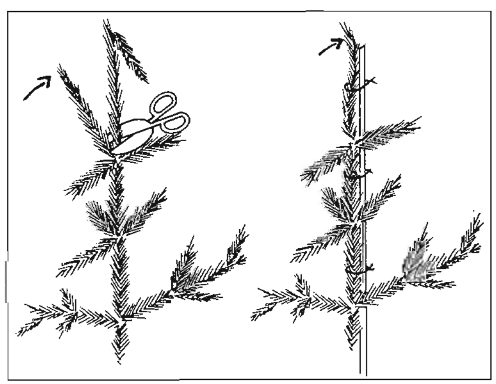


Figure 15. Pruning and use of a splint to train a replacement leader in an evergreen tree.

Regular Maintenance Practices

Whether a transplanted tree or shrub will establish quickly and thrive depends highly on the post-transplant procedures and care given the plant over the succeeding two to three years. For trees of over 3-inch caliper, this special care and inspection period will be extended. (The company installing the plant should pass this information along if they are not being contracted for follow-up maintenance.) It is important to monitor the installation periodically and carefully to ensure progress. Generally, if a tree or shrub establishes well after two to three consecutive summers, it will survive.

Mulching

The benefits of mulching have been described earlier. Because organic mulches (Table 3) decompose, they should be reapplied every two to three years. Lightly rake the old mulch and add new mulch to a total depth

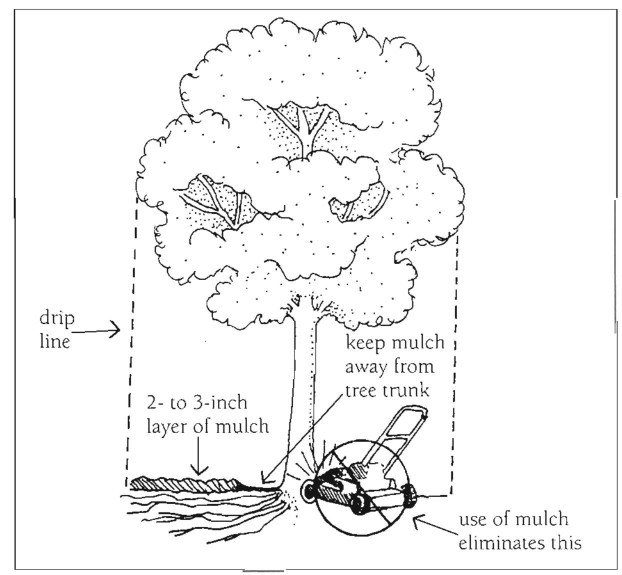


Figure 16. For the first 10 years, if not longer, a mulch is the best alternative to turf around trees, and its use eliminates competition from grass or ground covers. Furthermore, the potential for "mower blight" or string trimmer damage to bark is eliminated.

of 2 to 3 inches. Keep the mulch several inches away from the trunk and stems of trees and shrubs, and never pile it in a cone or "volcano-like" fashion around the crown. The latter practice creates continuous moisture that bark cannot tolerate. As new root systems grow out, the mulched area should be extended further out toward the **drip line** to encourage roots to expand outward.

Watering

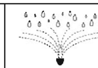
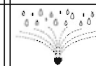
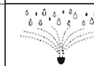
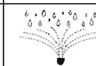
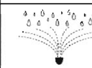
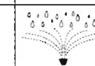
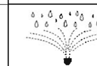
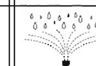
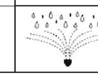
The length of time a plant must be watered after being put into the ground depends on how long it takes the plant to become established in a landscape environment. In a site that has well-drained, rich soil and adequate fertility, a plant will establish readily and have a significant buffer to the drying-out of the root zone. On a more droughty soil, however, the plant will need supplemental watering for three or even four years following planting.

After the first year of planting, a tree or shrub will need water during any drought period that occurs in the next two or three seasons (Table 4). Thereafter, unless the growing seasons are very dry, supplemental watering should not be required.

A plant must always enter the fall and winter season with ample moisture in its system. Research has shown that mid-August through September is the most important time to prepare a plant to tolerate winter stress. Once winter arrives and the ground freezes, water lost because of transpiration by sun and wind cannot be replaced in the plant.

Although established plants require extra watering infrequently, water must percolate sufficiently to force roots to grow deeper (and more laterally) through the soil in search of water. One inch of water will normally penetrate to a 10- to 12-inch depth in a sandy loam and 6 to 8 inches in a heavy clay soil. Always use a rain gauge to measure the amount of water added.

Table 4. Frequency of watering during dry periods.

	first year after planting			second year after planting			third year after planting		
Water needed once every	*Spring*	*Summer*	*Fall*	*Spring*	*Summer*	*Fall*	*Spring*	*Summer*	*Fall*
Two weeks									
Three weeks									
Four weeks									
Five weeks									
Six weeks									
Seven weeks									
Eight weeks									

Pruning

Two or three years following planting, when many branches can still be reached from the ground, trees can be pruned to enhance their structural framework for later years. (Some nurseries may have already done some pruning during the production process.) Pruning may include removing weak, narrow-crotched (less than a 45-degree angle) branches; a co-dominant terminal; and too many branches emanating from a single point on the trunk (Figure 17).

Pruning may also be done to develop an alternate branching pattern so that remaining branches radiate out in different directions from the trunk. Any branches below the first major **scaffold** branch (it is important to choose key scaffold branches while the tree is young) should be removed before they attain a diameter greater than one-half inch to avoid larger wounds. Likewise, any branches growing directly above one another (less than 3 feet apart) should be removed. This process can be done over several years. Any branches that are considerably longer than others should be pruned back to a lateral or outward-facing bud.

For more detailed information on pruning, consult Cornell Information Bulletin 23, *Pruning Ornamental Trees and Shrubs*.

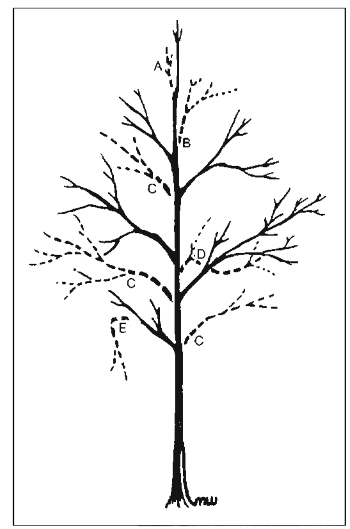


Figure 17. Pruning a deciduous tree after planting to (a) remove a competing terminal, (b) eliminate narrow, weak crotches, (c) remove branches for a more open appearance, (d) eliminate crossing or rubbing branches, (e) remove broken, damaged, or diseased branches.

Fertilizing

When applied at the correct rates, fertilizers can improve the appearance and condition of ornamental trees and shrubs and enable them to resist specific diseases and insects. Response to fertilizer varies with the plant as well as the environment. Soil fertility, aeration, drainage, exposure to sun and wind, temperature of the site, and proximity to buildings, walkways, and streets influence plant growth. Best growth depends on the use of the plant in the landscape, and fertilizers are no substitute for the **wrong plant in the wrong place**.

The extent to which fertilizers are applied for established plants depends on the fertility of the soil and the desired growth. If plants are growing well and look good, you may choose not to fertilize. Add fertilizer where malnutrition is evident, as indicated by poor foliage color and short, weak growth not caused by lack of moisture, fungus, or insect attack. Excessive nutrients can result in unattractive, overabundant shoot growth that is vulnerable to winter snow damage and pests that thrive on the nutrient-rich fluids in the plant tissue.

General Nutrient Needs

Several chemical elements, each with a different function, are deemed essential for plant nutrition. Those required in the greatest quantity (macronutrients) are nitrogen, phosphorus, potassium, and calcium. Certain others, although required in far smaller amounts (micronutrients), are no less essential. These trace or minor elements include zinc, copper, molybdenum, magnesium, iron, sulfur, manganese, aluminum, chloride, and boron. Both macro and microelements come from the soil and from applied nutrients. Carbon, hydrogen, and oxygen are obtained from the air or through the soil.

Before you decide what nutrients a plant needs, have your soil analyzed. A soil analysis will show which nutrients are deficient, so that only those elements that are missing need be applied at the rates necessary to satisfy plant needs. Keep in mind that a large proportion of plant problems, such as poor drainage, are related to soil. Fertilizer will not help plants in this situation. Unfortunately, soil testing is often not done at all or is done incorrectly, and people overfertilize plants that are doing poorly. This practice results in more harm than good.

Fertilizers for Woody Plants

For convenience and adequate fertilization of most woody ornamental plants, home gardeners use a complete fertilizer, one that contains all three major fertilizer materials. The law requires that every package of fertilizer be labeled to show the guaranteed minimum percentages (or grade) of the three major fertilizer nutrients. For example, a 10-6-4 fertilizer contains at least 10 percent nitrogen (N), 6 percent phosphoric acid (P), and 4 percent potash (K). Many grades of complete fertilizers are available (Figure 18).

Inorganic fertilizers. Many complete fertilizers are composed of simple chemicals that are quickly absorbed by plants. These inorganic fertilizers, which are readily soluble in water, are the least expensive and can be bought at any farm or garden supply store. Inorganic fertilizers require care for safe application during the growing season. Some soluble fertilizers are high-analysis (20-20-20), dry, concentrated inorganic sources of nutrients. A specified number of ounces or teaspoonfuls is dissolved in a particular volume of water. Readily soluble fertilizers can be applied safely to plants if the recommendations are followed. In borders, the ease of application of nutrients in liquid form is a major advantage because it allows for more uniform distribution of the fertilizer than is possible using dry materials. Complete liquid fertilizers are similar to readily soluble, inorganic fertilizers and can be used in the same manner. Usually a small amount of the nutrient concentrate is diluted in a larger volume of water to make a working solution. The manufacturer's recommendation should be followed carefully to avoid plant injury.

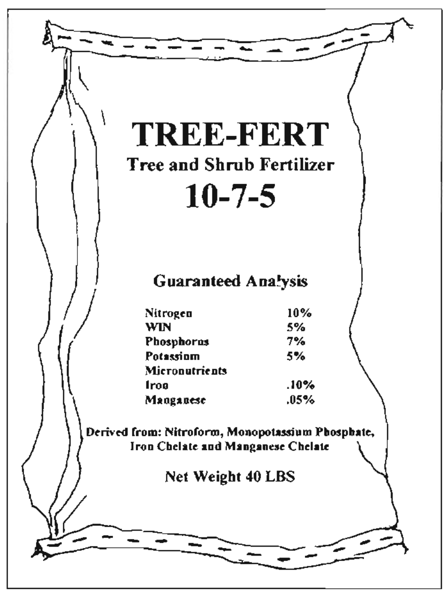


Figure 18. Sample label from a bag of all-purpose granular fertilizer.

Organic fertilizers. Natural organic and organic synthetic fertilizers such as **urea-forms** and **IBDU** release nitrogen more slowly than inorganics. Thus the nitrogen contained in them is less subject to **leaching** during a major precipitation event or frequent irrigation. Many organic or synthetic forms are incorporated in other all-purpose fertilizers, which are widely available. These forms appear on the label as a percent of total nitrogen, expressed as **water-insoluble nitrogen (WIN)**. Urea-forms and IBDU are examples of synthetic organic formulations included as the WIN component of these fertilizers. Such fertilizers are more expensive, but the danger of burning plants is reduced provided recommendations on the package are followed explicitly. Natural organic sources of nutrients such as barnyard manure are relatively low in nutrients and usually contain many weed seeds. Weed-free fertilizers are preferable even when manure is available free of charge. Commercially dried manures are very expensive for the benefits received.

Foliar fertilizers. Foliar applications of readily soluble fertilizers are convenient and easy. They can induce a "green-up" of yellow, nutrient-deficient foliage. Foliar-applied nutrients may improve the appearance and growth of plants that do not receive an adequate nutrient supply through the roots. However, foliar applications should generally be used as a supplement, not a substitute, for soil applications of fertilizers because it is generally not economical for homeowners to attempt to provide all the nutrient requirements of a plant through the foliage.

The disadvantages occasionally associated with foliar applications usually result from not following the manufacturer's directions. Only those materials that give specific recommendations for use as a foliar spray should be used, and directions should be closely followed. Failure to follow the manufacturer's directions may result in plant injury. Spray on cloudy days or in the evening.

Chelates. The application of **chelated** iron or other chelated plant micronutrients to the soil produces a longer-lasting effect than spraying the foliage. Repeated applications are often necessary to maintain attractive green foliage. The addition of chelated iron is supplemental to regular fertilizer practices for certain plants. Chelated microelement formulations are now available in garden stores. Follow the manufacturer's recommended application rates carefully. Spray on cloudy days or in the evening.

Methods, Rates, and Timing

Trees and shrubs may be fertilized in several different ways: broadcasting the dry or liquid fertilizer on the ground, applying either granular or soluble fertilizers below ground in the root zone of plants, or injecting soluble formulations into plants.

Broadcasting. This method is least expensive and, in certain instances, can be just as effective as subsurface techniques. Broadcasting is most commonly used for fertilizing shrubs or small trees. Where lawn areas surround the tree to be fertilized, apply the fertilizer over the entire lawn area to stimulate and improve both lawn and tree. (*Never* use combination-type lawn fertilizers that contain selective broadleaf weed killers over the root systems of trees and shrubs.) In areas with adjoining shrubbery borders or ground cover plantings a broadcast application of a granular fertilizer in the border can also be made. Complete fertilizers, of such composition as 10-6-4 or 5-10-5, can be used effectively for the general range of trees and shrubs on soils that are neutral to acidic in reaction. These fertilizers should be broadcast at the following rates:

For shrubs: At the first signs of growth in spring, and if warranted by the results of a soil test, apply 5-10-5 at 2 to 3 pounds per 100 square feet or 10-6-4 at 1 pound per 100 square feet to the soil surface around the shrubs.

If shrubs are growing in a lawn, the grass must be dry at the time of application; water the lawn thoroughly immediately after the fertilizer is spread.

For trees: Measure the trunk diameter of the tree 4 1/2 feet above the ground. Then apply fertilizer, starting 2 1/2 feet away from the trunk extending to 25 to 30 percent beyond the spread of the branches. Use the following amounts: [Trees up to 3 inches in diameter] 5-10-5 at 2 pounds per inch of trunk diameter or 10-6-4 at 1 pound per inch of trunk diameter. [Trees over 3 inches in diameter] 5-10-5 at 5 pounds per inch of trunk diameter or 10-6-4 at 3 pounds per inch of trunk diameter. If a rate is indicated in excess of 20 pounds of 5-10-5 in 1,000 square feet or 10 pounds of 10-6-4 in 1,000 square feet, the fertilizer should be divided into two or more portions and applied at four- to six-week intervals. Where roads, patios, and sidewalks take up a large proportion of the space under the trees, the area to which fertilizer can be applied is reduced. Rates of application should not exceed 20 pounds of 5-10-5 or 10 pounds of 10-6-4 per 1,000 square feet at any one application.

For subsurface applications to trees. This method is recommended over broadcasting when limited space results in rates of fertilizer applications greater than can be tolerated by ground-covering plants, where slope areas foster the runoff of fertilizers applied to the surface of the soil, or where large trees are present. The crowbar method involves placing granular fertilizer in holes that are punched at 18-inch intervals, to a depth of 8 to 12 inches for deciduous plants (8 inches for evergreen plants), starting at 2 1/2 feet from the trunk and extending about one-third of the distance beyond the branch spread (drip line) (Figure 19). Pour about a cupful of 5-10-5 fertilizer or one-half cup of 10-6-4 in each hole; then fill each hole with water. After the water drains away, fill the hole with good topsoil.

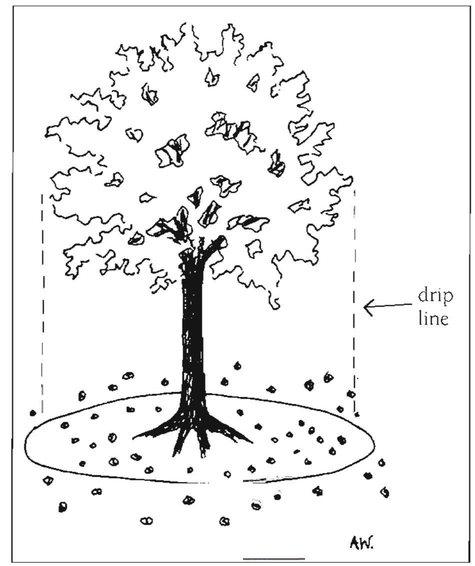


Figure 19. Deep root/crowbar method of fertilization

Commercial firms that manage trees inject solutions containing fertilizers beneath the soil surface. These solutions usually contain soluble fertilizers and **controlled-release** forms of nitrogen suspended in solution. Such combinations provide both immediately available nutrients as well as those that gradually will become available over an extended period of time. Fertilizers used in this manner now are available from horticultural supply firms and should be used according to the manufacturer's instructions. (A standard recommendation is to inject the appropriate liquid fertilizer 6 to 12 inches into the soil at 150 to 200 psi in a grid pattern every 2 1/2 to 3 feet throughout the root zone area.)

Subsurface applications of fertilizer by either means should be made at the first signs of growth in the spring. If such applications are made at other times of the year, it is advised that a major portion of the nitrogen be of a controlled-release nature. This would avoid forcing late plant growth as the result of applications of totally soluble forms of nitrogen; it also reduces the risk of leaching of nitrogen during late fall and winter.

Trunk injection. This technique is employed by commercial firms as treatment in extraordinary situations (e.g., **chlorosis** in pin oaks or in extremely limited growing areas where it is difficult to make above- or in-ground applications of fertilizer). Observations to date indicate varying degrees of success with **trunk injection**, but recent advances have a major impact on the successful use of this technique. Training in the use of injection techniques is necessary and usually is available from the manufacturers of these products.

Fertilizers and the Environment

Although fertilizers are a necessary input for landscape plantings, the nutrients they contain may damage the environment if applied in excess or improperly. Nutrients escape from the plant/soil system in various ways depending on the chemical and biological nature of the element.

Nitrogen, regardless of the chemical form added, converts to nitrate and is lost by leaching via the downward movement of soil water or by erosion of the soil. Thus, nitrogen as well as other nutrients may be a problem in both ground and surface waters.

Phosphorus is usually bound tightly to the soil particles and is present only in very small amounts in the soil water. It may also occur in organic materials, some of which are water soluble. Thus phosphorus is lost by both surface runoff and erosion of soil.

Several techniques help prevent loss of nutrients to the environment. The most effective method is to add the amount of nutrients needed but never to overfertilize. Remember, when fertilizing a large planting bed or major specimen tree(s), always have a soil analysis done. The second method is to apply the fertilizers to achieve efficient plant uptake. Remember the significance of not "pushing" new growth into the fall—do not fertilize between July 1 and October 1. Last, according to the American National Standards Institute for Tree Care Operations, fertilizing is not always the answer for sick trees or shrubs; in certain situations fertilizer can increase pest problems and, for mature trees, maintenance of satisfactory rather than accelerated growth may be the best management objective.

Protecting Trees During Construction

A large, healthy, established specimen tree can decline when growing sites are altered by humans (Figure 20). Even minor compaction, ground-level changes, or any form of root disturbance or cutting can harm a tree's health and long-term vigor. Before any site alteration or construction is done in the vicinity of valued trees or shrubs, be sure to erect appropriate barriers well outside of drip line areas.

Importance of Monitoring Insect and Disease Problems

No tree or shrub, whether newly planted or long established, is immune to problems caused by insect and disease attack. The best defense against pests is to keep plants in good, vigorous condition. Being aware of present and potential problems that affect plants is extremely valuable to the home gardener and professional horticulturist alike.

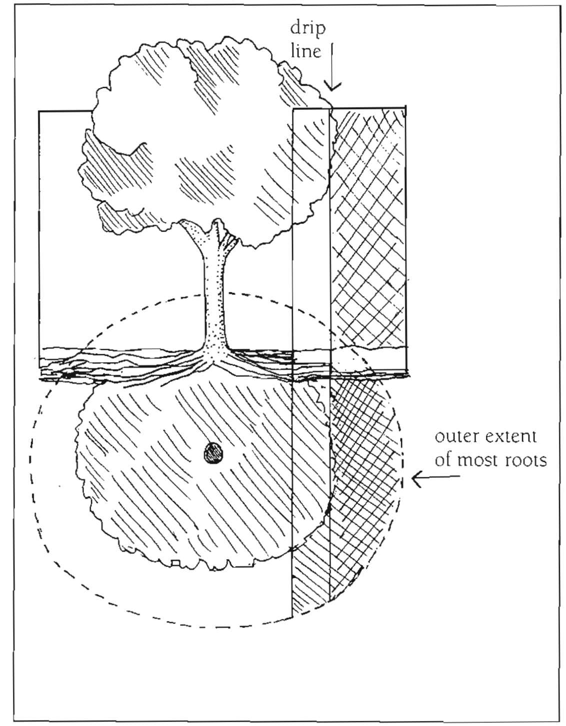


Figure 20. During construction, if the soil is lowered back to the drip line on one side of the tree, 20 percent of the roots would be removed. Conversely, if the grade was lowered halfway to the drip line to the trunk on this same side, approximately 35 percent of the roots would be lost.

Bibliography

American National Standards Institute (ANSI). *American National Standard for Tree Care Operations—Tree, Shrub, and Other Woody Plant Maintenance—Standard Practices (Fertilization) (A300, Part 2)*. New York: ANSI.

American National Standards Institute (ANSI). *American National Standard for Nursery Stock (Z60)*. Washington, D.C.: American Nursery/Landscape Association

Bassuk, N. L., D. F. Curtis, B. Z. Mawanea, and B. Neal. 2003. *Recommended Urban Trees: Site Assessment and Tree Selection for Stress*. Urban Horticulture Institute. Ithaca, N.Y.: Cornell University, Department of Horticulture.

Bassuk, N. L. 2003. *Creating the Urban Forest: The Bare Root Method*. Urban Horticulture Institute. Ithaca, N.Y.: Cornell University, Department of Horticulture.

Bruce, H. 1982. Preparing Transplants for Planting. Plants and Gardens. *Brooklyn Botanic Garden Record* 38 (1), Spring (May), 10.

Childers, N. F., and J. M. Beattie. 1954. Trees for the home grounds, in *The Care and Feeding of Garden Plants*. Washington, D.C.: American Society for Horticultural Science and the National Fertilizer Association.

Davis, R. K. 1984. Transplanting Shock: Large vs. Small Trees. *American Nurseryman*, November 1: 79.

Feucht, J. R., and J. D. Butler. 1988. *Landscape Management*. New York: VanNostrand Reinhold.

Gilman, E. F. 1990. Tree Root Growth and Development II. Response to Culture, Management and Planting. *J. Environ. Hort.* 8:220–227.

Gilman, E. F. 1997. *Trees for Urban and Suburban Landscapes*. Albany, N.Y.: Delmar Publishers. 172 pp.

Goodwin, C., and G. Lumis. 1992. Embedded Wire in Tree Roots: Implications for Tree Growth and Root Function. *J. Arboric.* 18:115–123.

Greenly, K. M., and D. A. Rakow. 1994. The Effect of Wood Mulch Type and Depth on Weed and Tree Growth and Certain Soil Parameters. *J. Arboric.* 21:225–232.

Harris, R. W., J. R. Clark and N. P. Matheny. 1999. *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines*. Upper Saddle River, N.J.: Prentice Hall.

Harris, R. W., A. T. Leiser, and A. Matheny. 1982. *Urban Tree Manual*. Washington, D.C.: Forest Service, U.S. Department of Agriculture.

Harris, R. W., A. T. Leiser, and W. B. Davis. 1978. *Staking Landscape Trees*. Davis, Calif.: University of California Division of Agricultural Sciences Leaflet No. 2576. 13 pp.

Hartman, J. R., T. P. Pirone and M. A. Sall. 2000. *Pirone's Tree Maintenance*. New York: Oxford University Press.

Hudler, G. *Salt Injury to Roadside Plants*. Information Bulletin 169. Ithaca, N.Y.: Cornell Cooperative Extension.

Lloyd, J., ed. 1997. *Plant Health Care for Woody Ornamentals: A Professional Guide to Preventing and Managing Environmental Stresses and Pests*. Champaign, Ill.: Cooperative Extension Service, University of Illinois at Champaign-Urbana and International Society of Arboriculture.

Maleike, R., and R. L. Hummel. 1992. Planting Landscape Plants. *J. Arboric.* 16:217–226.

Rakow, D. A., and R. Weir, III. 1996. *An Illustrated Guide to Pruning Ornamental Trees and Shrubs*. Information Bulletin 23. Ithaca, N.Y.: Cornell Cooperative Extension.

Ranney, T. G., N. L. Bassuk, and T. H. Whitlow. 1989. Effect of Transplanting Practices on Growth and Water Relations of 'Colt' Cherry Trees During Reestablishment. *J. Environ.* Hort. 7(1):41–45.

Trowbridge, P. J., and N. L. Bassuk. 2004. *Trees in the Urban Landscape*. Urban Horticulture Institute, Department of Horticulture, Cornell University. New York: John Wiley and Sons.

Watson, G. 1985. Tree Size Affects Root Regeneration and Top Growth After Transplanting. *J. Arboriculture* 11(2):37–40.

Watson, G. W. 1992. *Selecting and Planting Trees*. Lisle, Ill.: The Morton Arboretum.

Watson, G. W., and E. B. Himelick. 1983. Root Regeneration of Shade Trees Following Transplanting. *J. Environ. Hort.* 1:52–54.

Watson, G. W., and E. B. Himelick. 1997. *Principles and Practices of Planting Trees and Shrubs*. Champaign, Ill.: International Society of Arboriculture.

Two periodicals, primarily for commercial audiences:

American Nurseryman. American Nurseryman Publishing Company, 111 North Canal Street, Chicago, IL 60606.

Journal of Arboriculture. International Society of Arboriculture, Box 71, Urbana, IL 61801.

Check these helpful web sites for other useful publications:
www.gardening.cornell.edu/pubs.html
www.cce.cornell.edu/store/customer/home.php
www.hort.cornell.edu/uhi/

Glossary

Adventitious appearing in an abnormal or unusual position or place; usually associated with roots and buds.

Allelopathy the adverse effect of one plant on another. A term denoting, but not limited to, the negative effect of substances produced by a plant on neighboring plants.

Anti-desiccant a substance that, when applied to plant tissue, reduces water loss from this tissue to the air external to the plant so treated.

Backfill the application of soil, including any amendments to it, around the root zone of a plant being transplanted.

Berm the mounding of soil as a functional design element in the landscape.

Biostimulants organic substance- and/or microorganism-based products that may have a beneficial effect on plant health and growth.

Caliper the diameter of a tree truck or other tree parts such as branches or roots.

Chelates, chelated large organic molecules that can "hold" ions (charged particles) of mineral nutrients in a manner that renders them available to plants when applied to the soil or foliage.

Chlorosis yellowing of plant foliage due to the lack of an essential nutrient.

Complete fertilizer a fertilizer that contains nitrogen, phosphorus, and potassium.

Controlled-release fertilizer a formulation of fertilizer that releases a nutrient (or nutrients) in a slow, consistent manner over an extended period of time.

Desiccation drying of plant parts owing to the loss of water from organs or tissues that comprise a plant.

Drainage tiles a system of underground piping (usually perforated plastic tubing or pipes) that facilitate the movement of soil water to an off-site drainage area.

Drip line the outermost circumference of a tree canopy.

Ecosystem the environment that typifies a specific location.

Geotextile a petroleum-based, cloth-like material that is used to cover the soil surface to prevent erosion or manage weeds as a "mulch."

Girdling roots roots that grow in a manner (encircling) that result in the compression of root tissue against that of the tree trunk or other major roots.

Glazing the compaction of a thin, impenetrable layer of soil that surrounds a hole dug for planting a tree or shrub.

Hardening the conditioning of a plant or plant part that enables both to tolerate a more rigorous environment.

"Heavy" a horticultural term that denotes "largeness" in reference to size in diameter or thickness. A particularly heavy secondary branching system; a heavy root system; and a heavy grade of plant are all common uses of the word heavy in this instance. Also indicates a negative soil condition in which disproportionate amounts of clay and/or silt particles predominate in a soil.

IBDU isobutylidene diurea; a synthetic, organic, controlled-release source of nitrogen fertilizer.

Included bark when an obvious connection of bark is not visible at the union (crotch) of a branch with another branch or tree trunk.

Inoculum biological mechanism by which diseases spread and infect plants.

Interface zone between disturbed soil (such as a dug area in transplanting) and undisturbed soil or between the immediate root zone of a transplanted plant and the backfill placed around it.

Leaching the removal of substances from a medium such as soil by water or other liquids flowing through that medium.

Lignification the process by which plant tissues become woody.

Microclimate a small, limited area whose climate differs from that of the surrounding region.

Monoculture the planting of a species, cultivar, or variety in numbers that far exceed any others in the landscape.

Mycorrhiza(e) a fungal association with plant roots that benefits both organisms.

pH concentration of hydrogen ions in the soil solution; a reflection of the acidity or alkalinity of soil.

Photosynthesis, photosynthetic ability of plants to combine water and carbon dioxide in the presence of light, chlorophyll, and certain enzymes to produce sugars.

Process-balled when media are placed around the roots of a bare root plant to simulate a soil root ball dug with a plant.

Progeny descendants of plants and animals.

Provenance the origin or source of a plant.

Root collar the transitional area where roots join at the lower trunk or stem of a perennial woody plant.

Root pruning the cutting of root systems in soil to promote a dense, more compact root system.

Scaffold limbs, emerging from tree trunks, that support subsequent shoot development and growth that give a mature tree its ultimate shape and character.

Sub-soiling breaking up of impervious layers of soil beneath the soil surface.

Tease out to pull encircling roots out of a compact root ball (container plants) to increase the contact between the roots and backfill during transplanting.

Transpiration loss of water vapor from leaves and stems via stomata and lenticels, respectively.

Tree spade mechanical device with a series of hydrolically driven spades for digging plants with a ball of soil.

Urea-form synthetic, organic source of fertilizer nitrogen (N) that serves as a controlled source of N. Requires, in part, microbial breakdown of carbon-based portion of most molecules to release N.

Volcano mulching the excessive mounding of mulch around the trunks of trees and canes of shrubs to resemble the shape of a volcano.

WIN (water insoluble nitrogen) the portion of the nitrogen content of fertilizer that is insoluble in water at the time of application but that gradually releases the "insoluble N" over a period of time in a controlled-release manner.

Appendix. Site Assessment Checklist

Site location____

PART I—Features of the Land and Soil

Climate

USDA Hardiness Zone

__7a __6a __5a __4a __3a
__7b __6b __5b __4b __3b

Microclimate Factors

__ Frost pocket __ Wind __ Accumulated heat

Surface Soil

Texture

__ Clayey
__ Loamy
__ Sandy

pH

__ Above 7.0
__ 6.0 to 7.0
__ 5.0 to 6.0
__ Below 5.0

Subsoil

Texture

__ Clayey
__ Loamy
__ Sandy

pH

__ Above 7.0
__ 6.0 to 7.0
__ 5.0 to 6.0
__ Below 5.0

Drainage Characteristics

__ Mottled, clayey soil
__Low-lying area

Indicator plants suggest site drainage is:

__wet __well-drained __dry

Percolation test results (in./hr.)

__poorly drained (<4 in./hr.)
__moderately drained (4–8 in./hr.)
__excessively drained (>8 in./hr.)

Compaction Levels

__Severe __Moderate __Uncompacted

Past/Recent Treatment

__Wooded/native state
__Existing landscape
__Excessive machinery resulting in compacted soil
__Presence of construction debris
__Undisturbed meadow/field
__Eroded hillside/slope
__Evidence of recent construction
__Evidence of excessive road salt

Part II—How These Features Affect Site Conditions

Depth Favorable to Roots

	Soil overlies	
	Pan*	Bedrock
Variable, shallow to deep within short distances		__
Very shallow (0–10 in.)	__	__
Shallow (10–20 in.)	__	__
Moderate (20–30 in.)	__	__
Deep (30–48 in.)	__	__
Very deep (>48 in.)	__	
Upper bedrock more or less solid		__
Upper bedrock scattered		__

Access Limitations

__None to slight __Moderate __Severe

Sunlight and Irrigation Levels

__Full sun (6+ hours)
__Part sun or filtered light
__Shade
__No supplemental irrigation
__Automatic irrigation system
Frequency and amount ______________

Structural Factors

Limitations to aboveground space

__Overhead wires __Nearby buildings and structures __Other

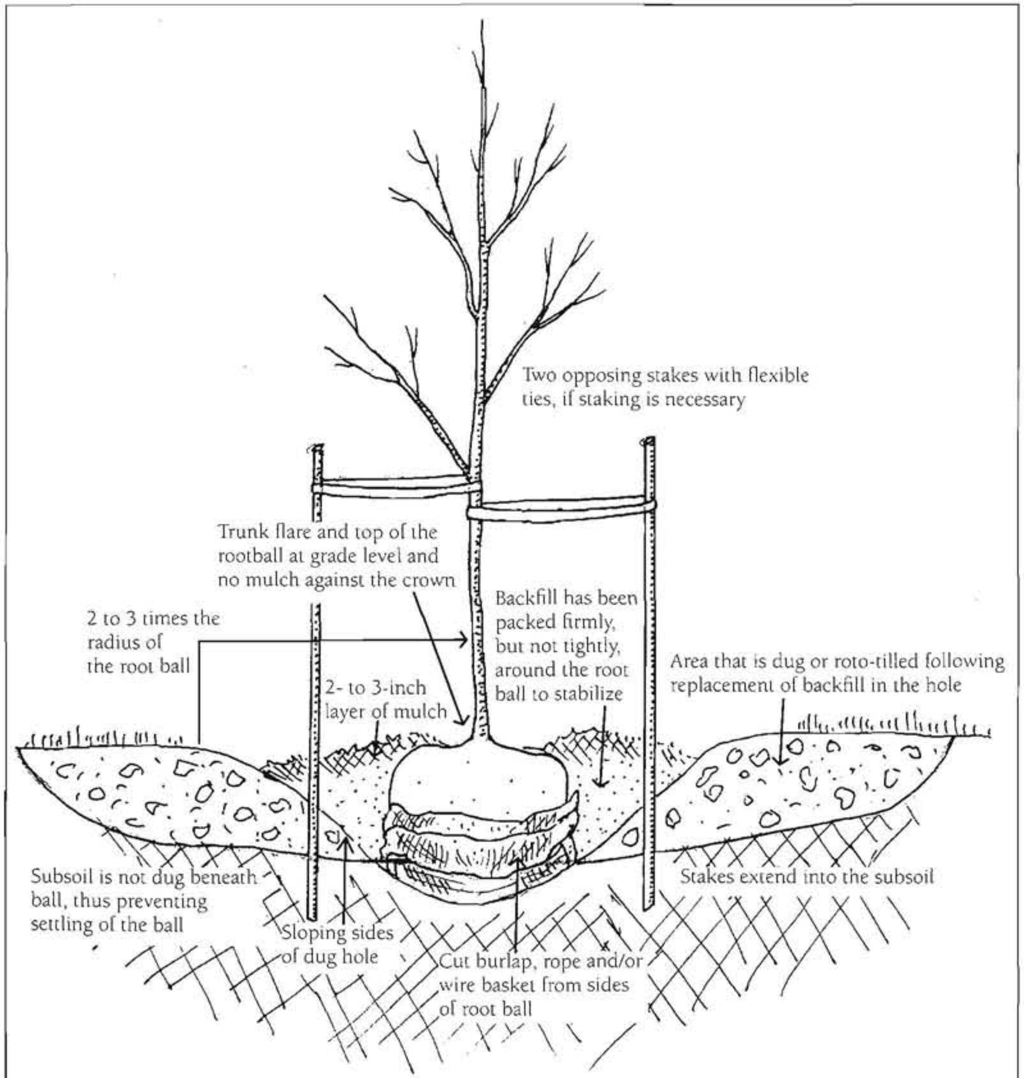
Limitations to below-ground space

__Underground utilities
Approximate rooting volume for site
__Length __Width __Depth

Marked Hazards to Survival and Early Growth

__None
__Wetness (poor aeration)
__Frosts
__Invasive weeds/plants
__Other
__Surface flooding
__Drought
__Heavy grass/brush competition
__Active erosion

*Pan refers to a hardened clay layer caused by cementation of soil particles.



If a tree is planted correctly, it will establish quickly, grow twice as fast, and live much longer than one that is incorrectly planted.

Cornell University
Cooperative Extension

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Most original artwork by Marcia Eames-Sheavly. Drawings of fertilizer bag and deep root fertilization (pages 18 and 19) by Abby Weir.

The previous edition of Information Bulletin 24 was co-authored by Arthur S. Lieberman and Richard Weir, III.

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As a benchmark text for professional horticulturists and homeowners alike, this 25-page manual offers practical information, with clear, easy-to-follow instructions for successful planting and maintenance of trees and shrubs. The information in this guide is drawn from decades of Cornell research, extension demonstrations, and practical landscape and garden experience. Beginning with reliable tips for properly selecting plants from nurseries, readers progress with guidance in appropriate site selection, transplanting processes and schedules, drainage management, and soil preparation. Important tasks immediately following planting—from watering, mulching, staking, and wrapping, to pruning, fertilizing, and anti-desiccant application—provide professionals and hobbyists with knowledge to ensure their trees and shrubs flourish and thrive. Regular maintenance practices, including tips for protecting plants during construction, and the importance of monitoring for insect and disease problems round out this useful and informative publication. Twenty drawings, four tables, and a glossary of important terms serve as valuable supplements to the text.

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