Tree Transplanting and Establishment

Gary W. Watson

Both experience and research make it clear that almost any size tree of any species can be transplanted. Success depends on the reestablishment of a normal spreading root system. An understanding of how roots grow and take up water can aid the process, even on difficult sites.

Many aspects of transplanting change over time. Modern equipment has made it possible to transplant larger trees with "soil balls" more affordably. Containerized production has grown in popularity for many reasons, including the ability to plant in any season. One thing remains the same—plants must quickly establish or reestablish a normal, spreading root system on the new site to minimize susceptibility to stress and assure survival.

Stress after transplanting, often called transplanting shock, is caused primarily by drought stress. Field-grown trees can lose up to 95 percent of their roots when they are dug from the field. This small portion of the root system has difficulty absorbing enough water to meet the needs of the tree. Plants grown in containers are also subjected to drought stress after planting, not because of root loss, but because water drains out of the light soilless container media much faster after it is planted in the ground than when it was in the pot. To compound the problem, irrigation is typically less frequent than it was in the container nursery. All newly planted trees will be subjected to stress until a normal spreading root system has developed.

When the root ball is planted high to improve drainage, the soil should slope from the existing grade to the top of the root ball.

Planting Site Preparation

Not every site requires extensive preparation before planting. The soil in undisturbed sites and landscapes in older neighborhoods is often of very good quality. Site preparation must be more intensive on disturbed sites or sites with naturally poor quality soils. Soil conditions on urban planting sites can be very difficult for root growth.

Planting site preparation can provide an optimum environment for root growth for only a limited time. Considering that the roots of a tree can normally spread two to three times as far as the branches, the long-term needs of even a small tree cannot be completely provided for at planting time. Long-term survival will depend more on selecting a species that will be able to survive, and thrive, under the existing site conditions.

Planting site preparations should focus on providing the highest quality environment possible for initial root growth during the first year or two after transplanting—possibly longer for trees over 4 inches (10 cm) in caliper. Even in cool northern climates, tree roots with average growth rates may extend 3 feet (1 m) or more from the root ball after two years. Though it would be desirable to prepare a larger area, in most cases it would be impractical.

Planting Hole Size and Shape

Trees are expensive. Planting the tree properly and maintaining it until it is established will protect the substantial investment in the tree. To emphasize the need for adequate site preparation, gardeners often advocate preparing a five-dollar planting hole for every fifty-cent tree.

The primary objective of planting site preparation is to provide a quantity of backfill soil that promotes rapid initial root development and does not restrict root spread beyond the planting hole. Ideally, these objectives should be achieved with a minimum of cost and effort. To prevent settling, the root ball must be supported by undisturbed soil. Since most new roots will grow horizontally from the sides of the root ball, compacted soil at the bottom will not substantially affect overall root growth.

When a deeper planting hole is not an option, widening the planting hole is the only way to increase its size. Most tree roots are concentrated within the top foot of soil. Since the most vigorous root growth is likely to occur near the surface, efforts should be concentrated there. In many compacted urban soils, root growth from the bottom half of a 12-to-18-inch (30-45 cm) deep root ball will be inhibited by inadequate drainage and aeration. In these soil conditions, a wide hole for the entire depth of the root ball may not be as useful or efficient as a hole with sloped, or stepped, sides. With this configuration, the majority of the effort is directed towards surface soils where the new roots will grow most vigorously. A hole with sloped sides will not restrict root spread. Deeper roots will grow towards the surface soils and continue to spread if they are unable to grow into the compacted subsoil (Figure 1).

A planting hole that is two to three times the width of the root ball at the surface, with sides sloping towards the base of the root ball, is optimum for most situations. The root ball can hold less than 5 percent of the original root system. A hole only 25 percent greater in diameter than the root ball will allow the root system to reach less than 10 percent of its original size before poor-quality site soils slow root growth. A hole three times the width of the root ball with sloped sides will allow the root system to grow rapidly to 25 percent of its original size before being slowed by the poorer quality site soil. The well-aerated surface soil is increased up to tenfold by the wide, shallow configuration. This increased volume of high quality backfill soil promotes rapid root growth and will make the tree less subject to severe drought stress than the tree in a smaller hole. Trees transplanted with a tree spade also benefit from a larger planting hole. The tree spade's metal blades dig cone-shaped holes whether extracting a tree or creating its new home. In this situation, cultivation around the root ball after planting may be the only practical method.

Backfill Soil Modifications

The change in soil type at the interface between backfill soil and the surrounding undisturbed soil is often blamed for poor root development in the undisturbed soil, but this stems from a confusion between inability of roots to cross the

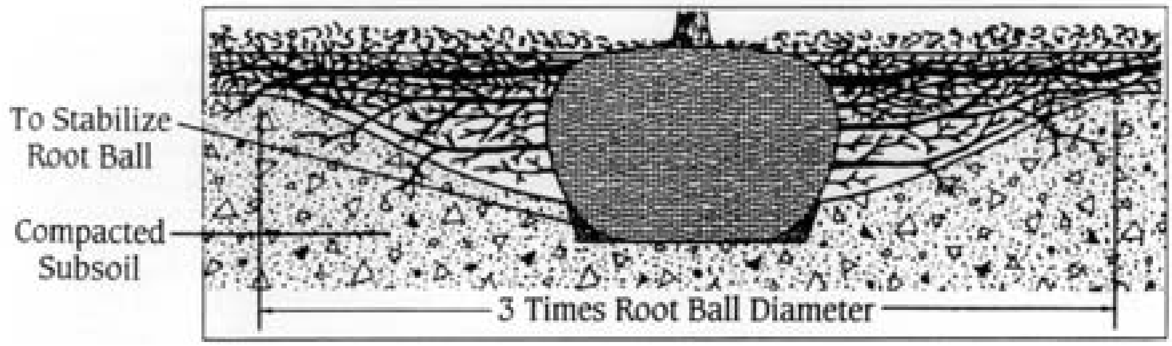

Figure 1. Where roots have difficulty penetrating compacted site soils, sloped sides allow roots to continue to grow vigorously towards the better soils near the surface. Roots that do penetrate the site soil along the sloping interface will probably grow more slowly

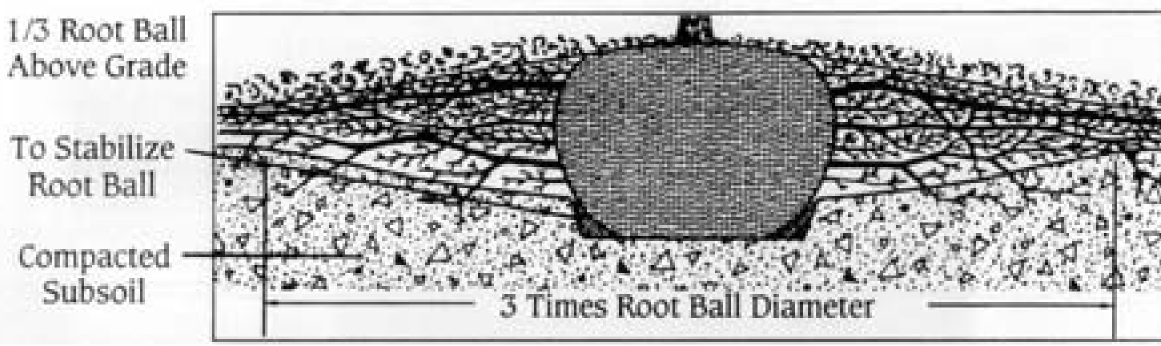

Figure 2. Planting the root ball so that approximately one-third of it is above grade can help to provide better drainage and aeration for roots.

interface and inability of roots to grow vigorously in the soil material on the other side. While the interface can have a major effect on soil water movement, it usually does not affect roots. If the backfill soil has been amended, the abrupt change in soil texture can affect soil properties such as water movement but probably not root growth.

When three types of backfill soils were used on a compacted urban planting site, including unamended soil, there was no difference in root development in any of the backfills. (Note that unamended soil is not the same as unaltered soil.) Root development in the soils outside of the planting hole was lower than in any of the backfill soils, but this appeared to be due to the overall reduced root growth in the compacted clay site soil, rather than an inability of the roots to grow across the interface between the soils.

On moderate sites, amending the soil may be unnecessary, but not harmful. On extremely poor quality sites, soil amendments may be more important, but still probably not as important as digging a large planting hole.

Drainage

Adequate drainage from the bottom of the planting hole is very important for root regeneration. Gravel in the bottom of the planting hole can make drainage worse. Water will not move from the finer textured soil above to the layer of coarse gravel below until the fine-textured soil is completely saturated. This results in waterlogged soil above the gravel.

Drainage tubing may be used to drain water from the bottom of the planting hole if the water can be discharged at a lower level nearby. Planting with the top of the root ball slightly above grade can also increase survival on poorly drained sites. No more than one-third of the root ball should be above grade, and the soil should be gradually sloped between the top of the root ball and the original grade (Figure 2).

Establishment After Transplanting

The establishment period can be defined as the period required for a plant to grow a normal root system. During this period the plant is susceptible to extreme stress. The length of the establishment period is affected by many environmental and cultural factors. Growth rate also provides an indication of stress (Figure 3). Growth will slow immediately after transplanting and recover to pre-transplanting levels as the root system regenerates and stress is reduced.

Plant growth is always limited by something—temperature, light, nutrients, genetics—but after transplanting, water is usually the most limiting factor. Transplanted trees rely heavily on moisture in the root ball throughout the first growing season. For balled-and-burlapped trees, the moisture contained within the root ball represents only a small fraction of the water that was available to the tree before transplanting, and it is small relative to the transpiration demands of the tree. Root ball soil moisture can be depleted very quickly, even while backfill soil just outside the root ball stays very moist, because there are few roots to absorb the water there. The water from the backfill soils is not able to move into the root ball quickly enough to effectively replace what is being removed by the tree. Just two days after watering, the root ball soil can become dry enough to stop new root growth and to reduce the capacity of the existing root tips to absorb water. (In experiments with trees of two-inch caliper transplanted into backfill soil, it took four to five months to develop roots just outside the root ball that were sufficiently dense to allow significant amounts of soil moisture.) It may take several days for growth to resume after watering. With frequent, repeated soil drying, root growth may be halted for long periods.

Calculating the amount of water held in the root zone in relation to usage by the plant is another way to estimate the water needs of new plantings. The supply of soil moisture available to the expanding root system of a recently planted shrub increases more rapidly than does water use by the slower growing crown. Twenty-one weeks after planting, the soil water

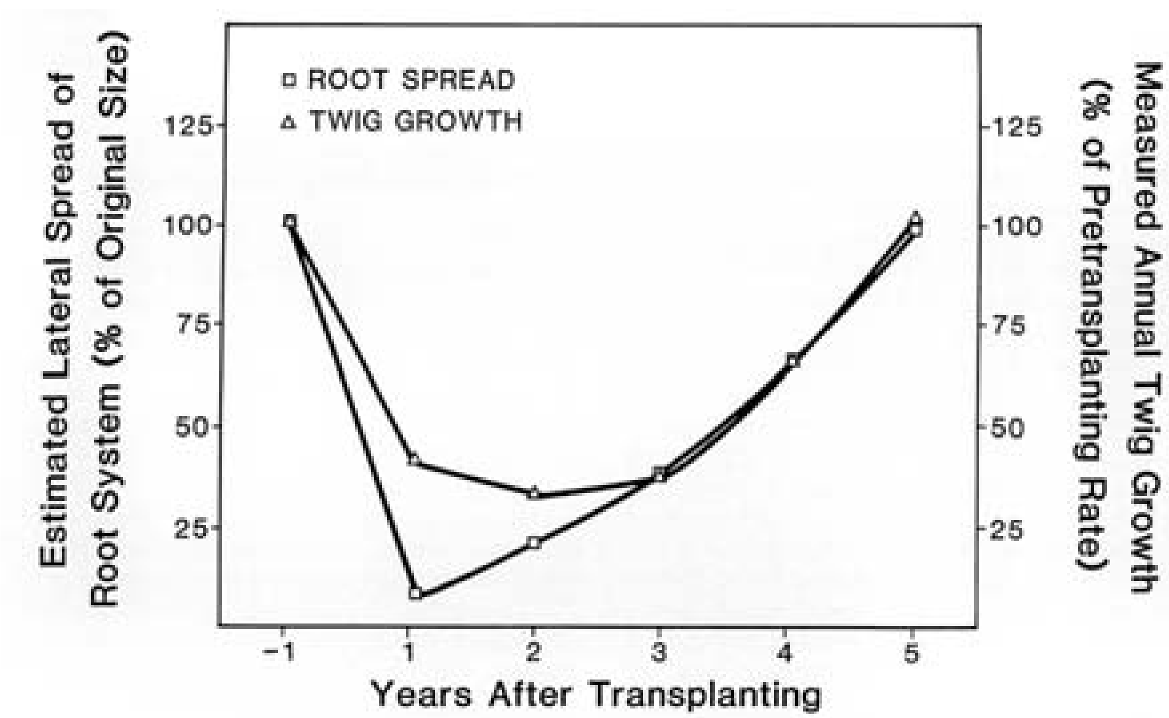

Figure 3. Root loss as a result of transplanting causes a corresponding decrease in twig growth Recovery of twig growth rate is closely related to regeneration of the root system.

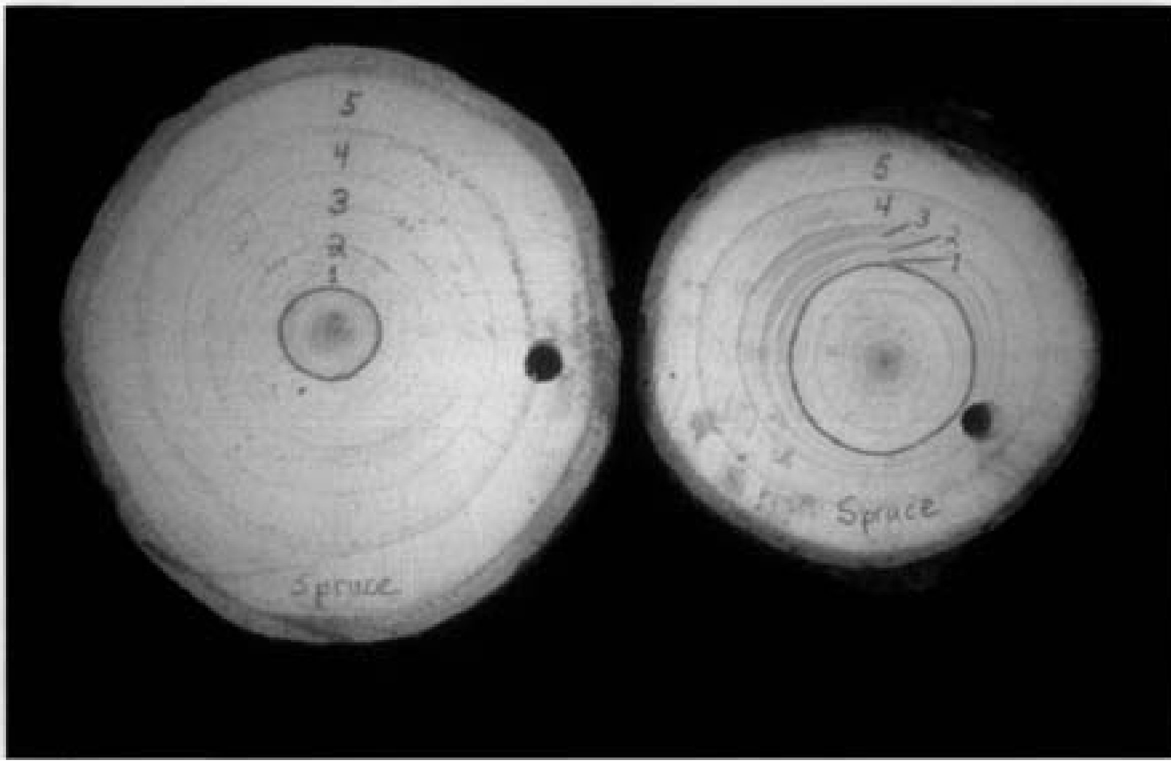

Figure 4 Trunk sections of transplanted spruces (Picea *sp.*) *show that growth of the larger transplanted tree (size at the time of transplanting is shown by the circle) is slowed for several years, while normal growth of the smaller tree resumes more quickly. By the time both of the trees are established, the relative size of the two trees may be equal or reversed.*

supply of small shrubs was only eleven days. Two-inch caliper trees may require two growing seasons before attaining a large enough root system for a similar soil water supply.

Duration of Transplanting Stress

To be considered fully established after transplanting, the tree must develop a full root system on the new site. The partial root system in the root ball, or the confined root system of the container, must develop into a normal spreading root system that can utilize soil moisture and nutrient resources from a large soil volume. This will take several years.

Root establishment takes longer for large trees than for small trees. When standard specifications are followed, the size of the root ball or container is proportional to the size of the plant. Regardless of size, the root ball holds only this same small percentage (4 to 18) of the root system. The root system in container plants is likewise confined to a proportionately small soil volume. Moreover, root growth rates are similar for large and small trees. What is very different is the distance that roots must grow to develop the full spreading root system necessary for complete establishment. A smaller tree requires fewer increments in annual root growth after transplanting than a large tree in order to replace the original root system. Since the smaller tree recovers vigor faster, it may one day be nearly the same size as a larger tree transplanted at the same time (Figure 4).

Soil temperature also affects root growth after transplanting. In climates where the soils are warm year round, roots will grow faster and plants will become established sooner. In the north temperate climate of the upper midwestern United States, twig growth of a four-inch caliper tree is reduced for four years after transplanting. In other words, the establishment period is approximately one year per caliper inch. In the subtropical climate of northern Florida, where roots grow much faster, trees reestablish at a rate of approximately three months per caliper inch.

During the second half of the establishment period, stress may not be as apparent. Nevertheless, the reduction in growth can be measured. At this time, monitoring should be continued, but it may be possible to limit supplemental watering to periods of drought.

Comparisons Among Growing Methods

Researchers have compared the establishment of traditional field-grown trees with conventional root balls to that of container-grown trees and of trees grown in in-ground fabric bags. Based on data on water stress, trees that were transplanted from field soil or from fabric bags establish more quickly than trees planted from plastic containers. Container plants were smaller and sustained very little root loss at transplanting and yet took longer to establish. Although measurable, the differences were not great enough to warrant avoiding container-grown plants. Adequate irrigation will easily overcome the difference, and container plants have many other advantages. The need for regular watering of all trees cannot be overemphasized. As long as the roots stay primarily confined to the root ball soil, they will be susceptible to rapid drying when irrigation or rainfall is absent for even a short period.

Both periodic and chronic stress can reduce growth in any plant. If a high level of care and a consistent environment is maintained above and below ground, the plant will establish faster. Water stress reduces photosynthesis and root growth and also increases susceptibility to certain disease and insect problems. Adequate site preparation and judicious watering throughout the growing season will do more to assure survival and maximize vigor than anything else, with the possible exception of high-quality, site-appropriate plant material.

The successful establishment of transplanted trees is dependent primarily on the reestablishment of a normal spreading root system on the new site. This process can be slowed by inadequate site preparation and difficult sites. Root growth is naturally slower in colder climates. Larger trees have larger root systems and take longer to regenerate after transplanting. Both experience and research make it clear that almost any size tree of any species can be transplanted. Large and small trees transplanted at the same time may eventually be similar in size. The choice may depend on size of budget and willingness to wait for a small tree to grow.

For Further Reading

Barnett, D. 1986. Root growth and water use by newly transplanted woody landscape plants. *Public Garden* 1: 23–25

Beeson, R. C., and E. F. Gilman. 1992. Diurnal water stress during landscape establishment of slash pine differs among three production methods. *Journal of Arboriculture* 18: 281–287.

Watson, G. W, and G Kupkowski. 1991. Soil moisture uptake by green ash trees after transplanting. *Journal of Environmental Horticulture* 9: 226–227.

Watson, G. W., G. Kupkowski, and K. G. von der Heide-Spravka. 1992. The effect of backfill soil texture and planting hole shape on root regeneration of transplanted green ash. *Journal of Arboriculture* 18 130–135.

Gary Watson is Root System Biologist at The Morton Arboretum in Lisle, Illinois His book *Transplanting Trees* will be published later this year by the International Society of Arboriculture.