JOURNAL OF
ARBORICULTURE

February 1985
Vol. 11, No. 2

TREE SIZE AFFECTS ROOT REGENERATION AND TOP GROWTH AFTER TRANSPLANTING[1]

by Gary Watson

Slow growth of trees over 4 inches dbh, following transplanting, is often a source of concern for arborists and landscape contractors. Growth of these trees is often stagnant for several years. Smaller 1- to 3-inch trees, transplanted at the same time, will often equal in size or surpass them before larger trees regain their pretransplanting vigor. In spite of these difficulties, larger trees continue to be transplanted for the immediate advantages they can provide in landscape design.

All newly transplanted trees are subject to an initial period of reduced vigor, but the duration of this period varies. This period is often referred to as transplanting shock. Neither researchers nor practitioners have been able to identify any single, specific cause for the prolonged period of transplanting shock experienced with large transplanted trees. Various physiological stresses are often implicated. All transplanted trees are subject to varying degrees of water stress because the root system is drastically reduced (Watson and Himelick, 1982a). Water stress can reduce photosynthetic activity (Kozlowski and Keller, 1966), potentially diminishing carbohydrate reserves and reducing growth. Recent work has shown that levels of carbohydrate reserves are not reduced in transplanted trees when they are watered adequately following transplanting (Watson and Himelick, 1982b), and may only play a role in cases of severe or prolonged water stress. Stressed trees are often susceptible to a wide variety of insect and disease problems which can result in reduced vigor, distortion of shape, and death (Schoeneweiss, 1981). The causes of transplanting shock are complex and relate to the reduced size of the root system of the transplanted tree. The root-shoot imbalance created by transplanting appears to be the primary cause of transplanting shock with other physiological and pathological problems acting as secondary agents. Until the natural root-shoot balance of the tree is restored, some degree of transplanting stress will exist.

It is the intention here to show the relationship between the duration of stress from transplanting and the length of time necessary to replace that portion of the root system lost during transplanting. When standard nursery practices are used to determine the size, the root ball is proportionate to the crown for both large and small trees (Himelick, 1981). It is important to remember that as the size of the tree increases, the lateral spread of the original root system increases. Although a consistent percentage of the root system is left behind, a greater mass and length of roots is lost from the large tree and these must be replaced at the new site. If the roots of both the large and small trees grow at the same rate, the root system of the larger tree will take much longer to regenerate. This point is illustrated in the following model.

Figure 1 illustrates a model of a small (4 inches dbh) and a large (10 inches dbh) transplanted tree of the same species transplanted at the same time. It shows the reduction in the root system at the time of transplanting and the regeneration of the root system during the succeeding years. The model incorporates several aspects of root development which should be thoroughly

1. This work supported in part by the Theodore Brickman Company, Long Grove, Illinois.

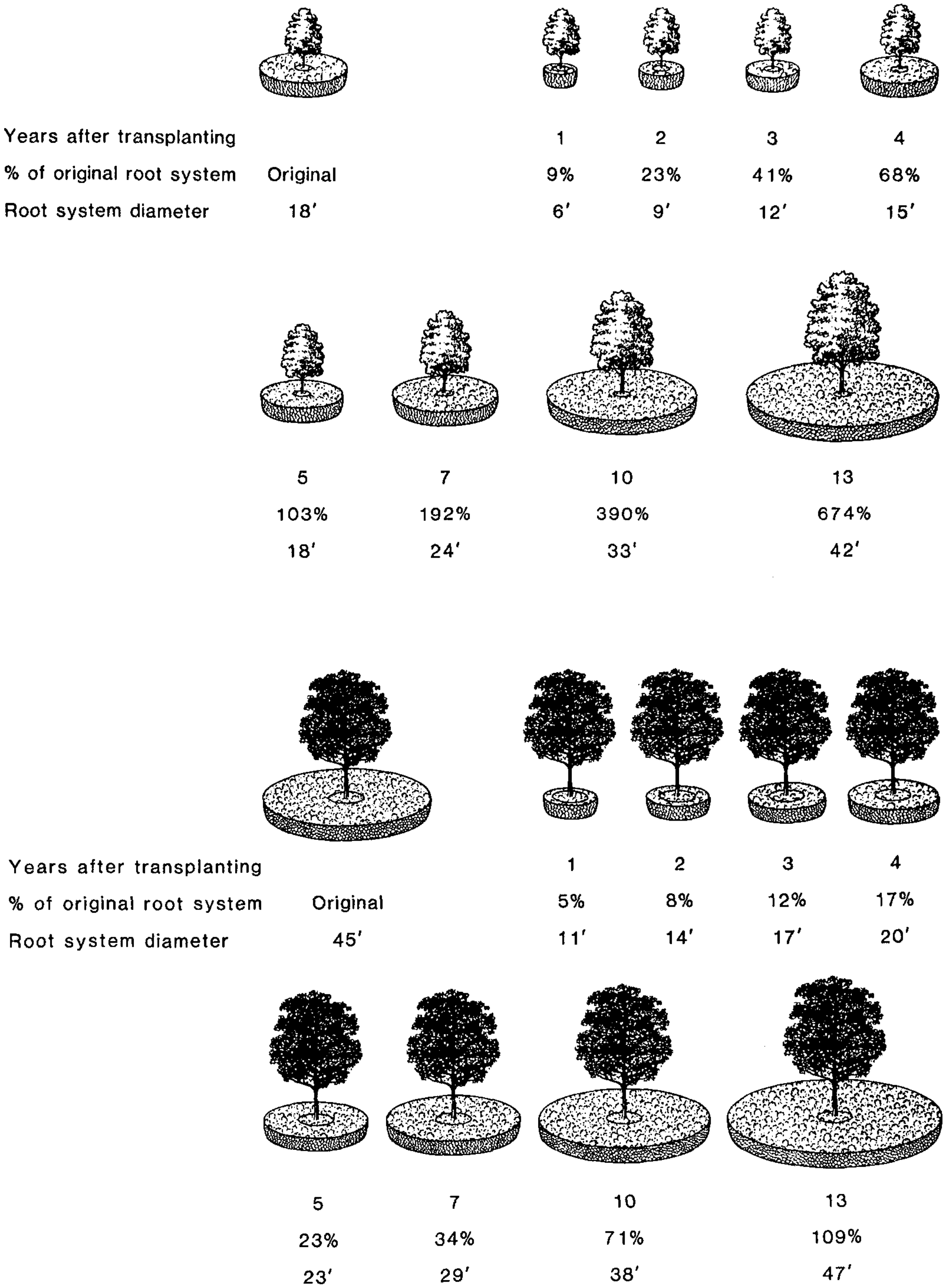

Figure 1. The relationship between root growth and top growth of transplanted trees of 4- and 10-inch dbh at the time of transplanting. The larger tree grows very slowly for many years, while the smaller tree resumes a normal rate after only a few years. Eventually, the two trees are nearly equal in size.

understood in order to fully comprehend the model:

1. The natural root distribution of shade trees is very shallow and widespread. Little, if any, root growth occurs below 48 inches in most soils. Fine roots are heavily concentrated in the top 4-12 inches of soil. Structural or sinker roots penetrate deeper, but seldom below 48 inches. Tree taproots are rare or absent for most tree species. Actual depth of the roots is highly influenced by soil type at the site.

2. Root regeneration occurs laterally from the perimeter of the root ball. The rate of growth of regenerated roots is essentially the same for both large and small trees of transplantable size, if unstressed. Lateral growth out from the soil ball of 18 inches per year is average for a well-maintained tree transplanted in friable, well drained soil. In previous studies, lateral root growth ranged from 12-27 inches per year (Watson and Himelick, 1982b).

3. As roots grow, exploitation of the soil by the fine roots is uniform throughout the lateral spread of the root system. Seldom are there large areas of soil in which roots do not grow unless the soil conditions are unfavorable.

The model is based on the concept that as long as the roots and aerial portions of the tree are out of balance, the vigor of the tree will be reduced. The roots cannot supply sufficient quantities of water and mineral nutrients to the upper portions of the tree for vigorous growth until the natural balance has been restored. The greater the imbalance, the slower the resultant growth. In the model, the root system of the 4-inch tree had a diameter of approximately 45 feet before transplanting. The above- and below-ground portions of the tree were in natural balance. During transplanting this balance is grossly distorted and the root system may be reduced by as much as 98 percent (Watson and Himelick, 1982a). New roots are initiated from callus formed near the cut end of the roots at the edge of the root ball. This occurs soon after transplanting. By using 18 inches per year as an average annual root growth, the smaller tree will replace its original root system in less than 5 years. Since the top of the tree has continued to grow slowly during this period, it may take slightly longer to restore the original root-shoot balance. After 5 years, the regenerated root system of the 10-inch tree will be only about 25 percent of its original size, and the tree remains stressed. As Figure 1 illustrates, a period of 13 years or more is required to restore the original balance of the 10-inch tree. At this time, the root system of the smaller tree is nearly as large as that of the larger tree. Since the root systems are nearly equal in size, it follows that the above-ground portions are also nearly equal. Since the small tree has been growing vigorously for several of the 13 years while the larger tree has been under at least some degree of stress, it is possible for the original 4-inch tree to be larger than the 10-inch tree by this time.

The model can be used to understand the concepts involved in root regeneration and transplanting shock, and to predict the timing of events. It is difficult to model all of the factors that influence root regeneration. Roots of different tree species grow at varying rates. Soil conditions have a profound effect on root growth rates. Promoting vigorous root growth is the best way to minimize the severity and duration of transplanting shock for trees of any size.

The soil environment must be favorable for optimum root growth. Most importantly, moisture, aeration, and nutrient levels must be favorable. When used as backfill, heavy, compacted soils should be modified to improve drainage and aeration. Soil conditions are usually most favorable for the fine root development in the top 4-6 inches of soil, especially in the disturbed clay soils often encountered in urban areas. The deeper soil layers are often waterlogged and oxygen deficient. Modification of this surface soil around the root ball would promote more rapid root regeneration in the early years following transplanting. A large planting hole with the sides sloping at a shallow angle would accomplish this and also provide a large interface between the backfill and the native soil. Only in unusual circumstances should there be difficulties as the roots grow through the interface between the ball and the native soil (Whitcomb, 1979). Mulching the surface would further improve the rooting environment and increase root growth. Litzow and Pellett (1983) have published a review on this subject. Rooting hormone treatments may also be useful in increasing root regeneration during the initial period of establishment (Prager and Lumis, 1983; Lumis, 1982).

Summary

The model shows why large transplanted trees are likely to have reduced growth for many years following transplanting due to the length of time required to regenerate the roots lost during the transplanting process. The above-ground portion of the tree must be in balance with the root system for proper growth. The size of the above-ground portion of the tree is controlled by the size of the root system. When the root system is reduced or restricted, the growth of the trunk and branches will also be reduced. Since the spread of the regenerated root systems of the large and small transplanted trees differs only by the relatively small difference in size of the original root balls, it follows that the growth of the above-ground portions of the trees must eventually be similar if the root-shoot balance is to be maintained. Trees transplanted into poor sites may never regain proper root-shoot balance and normal vigor.

Literature Cited

Himelick, E.B. 1981. Tree and Shrub Transplanting Manual. International Society of Arboriculture, Urbana, IL.

Kozlowski, T.T. and T. Keller. 1966. *Food relations in woody plants.* Bot. Rev. 32: 293-382.

Lumis, G.P. 1982. *Stimulating root regeneration of landscape-sized red oak with auxin root sprays.* J. Arboric. 8: 12-13.

Prager, C.M. and G.P. Lumis. 1983. *IBA and some IBA-synergist increases of root regeneration of landscape-size and seedling trees.* J. Arboric. 9: 117-123.

Schoeneweiss, D.F. 1981. *Infectious diseases of trees associated with water and freezing stress.* J. Arboric. 7: 13-18.

Watson, G.W. and E.B. Himelick. 1982a. *Root distribution of nursery trees and its relationship to transplanting success.* J. Arboric. 8: 225-229.

Watson, G.W. and E.B. Himelick. 1982b. *Root regeneration of transplanted trees.* J. Arboric. 8: 305-310.

Whitcomb, C.E. 1979. *Factors affecting the establishment of urban trees.* J. Arboric. 5: 217-219.

MSU-DOE Plant Research Laboratory
Michigan State University
East Lansing, Michigan 48824

DISTRIBUTION TREE CLEARANCE PROGRAM AT BALTIMORE GAS AND ELECTRIC[1]

by Thomas D. Mayer

Abstract. The Baltimore Gas and Electric Company's tree-clearance policy is to provide for the safe and reliable supply of electric energy in an economic manner which is compatible with the environment. To that end, the Distribution Tree Clearance Program utilizes many methods and techniques to trim trees and shrubs and to maintain line integrity. Natural trimming is preferred, as is selective clearing with appropriate treatment with an EPA-approved herbicide. Following the introduction of an aggressive "Think Cut Down" program, more trees are being removed from the system, thus reducing future maintenance time. Often, where undesirable tree species are cut down, an aesthetically pleasing grass-herb-shrub-desirable tree species community becomes established.

The Baltimore Gas and Electric Company (BG&E) is an investor-owned utility serving an area of approximately 2,300 square miles in Northern and Central Maryland. The service area is bordered on the north by the State of Pennsylvania, on the east by the Chesapeake Bay and the Susquehanna River, on the south by parts of Calvert and Prince George's Counties, and on the west by portions of Montgomery and Carroll Counties. The BG&E service area experiences about 43 inches of rainfall annually. The climate of

1. Presented at the annual conference of the International Society of Arboriculture in Quebec City, Canada in August 1984.