Proper Tree Planting Techniques

Trees can be purchased as bare root, containerized, or balled-and-burlapped specimens. Basic planting methods are the same for all specimen types, but handling and special considerations apply, depending on the size and type of tree. A checklist of basic planting guidelines for all tree types, and planting guidelines for special situations is provided below. These guidelines are provided as a handy reference for communities to use as they implement their tree planting programs and develop contract and bidding specifications for tree planting projects.

Basic Planting Guidelines for All Tree Types

Match the tree species to site conditions. Base this on the soil type, soil pH, surface and sub-soil drainage, growing space, exposure factors (e.g., sun, wind, ice and snow, and de-icing salts), and the tree's cold hardiness.

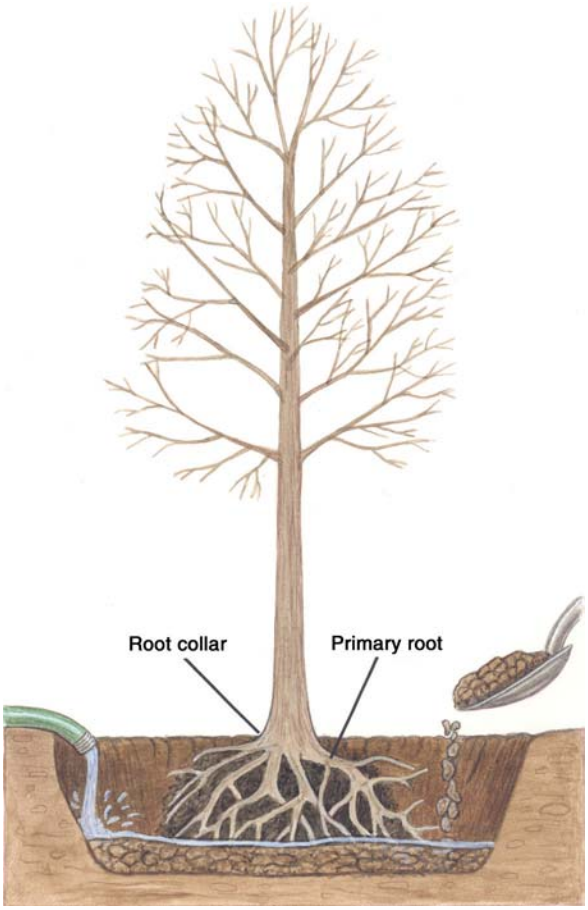

Figure 4.12. *Make sure the root collar (arrow) is at the soil surface or slightly above (e.g., 1-2 inches) when the tree is planted.*

Prepare the site by removing the sod. Loosen the soil by tilling or spading an area three- to five-times wider in diameter than the width of the root system, and only to the depth of the root system.

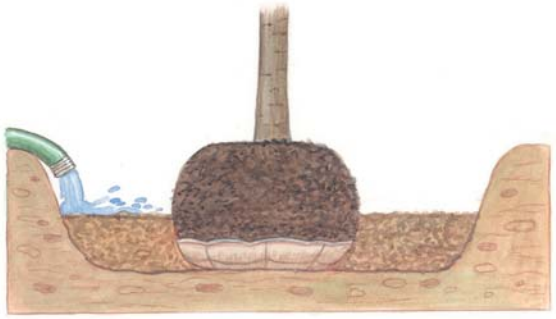

Figure 4.13. *Back fill the planting hole half way with the original soil that was removed and water.*

Dig a hole in the center of this circle that is 1 to 2 feet larger in diameter than the root ball and deep enough so the root collar is at the soil surface when the tree is planted. The root collar is the base of the stem where the primary roots first begin to branch away from the stem (Figure 4.12) The root collar may be buried in balled and burlapped, container grown, or tree spade dug trees. If you find the root collar is buried 3 inches deep in the root ball, dig the planting hole 3 inches shallower than the depth of the root ball.

Maintain undisturbed (not loosened) soil beneath the root ball to prevent the tree from settling.

Carefully place the tree in the center of the hole and gently remove any excess soil to expose the root collar flare. Double-check that the root collar (base of the stem where the primary roots first begin to branch away from the stem) is at the soil surface or slightly above (e.g., 1 to 2 inches). Planting trees at the proper depth, and not too deeply, is a critical step that can help to prevent the development of stem girdling roots and premature tree failure. Stem girdling roots can compress and kill trunk tissue, and cause trees to decline 10 to 20 years after planting or suddenly fail during storms by snapping off at the stem/root compression area.

Backfill around the roots with the soil that was removed. Lightly pack or water the soil during this process to eliminate air pockets (Figure 4.13). Backfill the planting hole to the height of the root collar, but no higher.

Mulch with 4 to 6 inches of coarse wood chips or shredded bark. Pull the mulch back from the trunk to prevent direct contact with the root collar and trunk. Be sure to avoid creating a mulch volcano by applying the mulch too deeply and placing it right up to the stem (Figure 4.14).

Figure 4.14. *Avoid mulch volcanoes. Mulch heaped too deeply and too close to the base of the stem can lead to stem girdling roots and decay.*

Water is very important to a newly planted tree. Newly transplanted trees will benefit from daily watering for the first 1 to 2 weeks, applying approximately 1 to 3 gallons-per-caliper-inch at each watering.

Thereafter, water trees every 2 to 3 days for the next 2 to 3 months and then weekly until established. Newly transplanted trees are absorbing water from a diminished root area. Apply water directly to the root ball at first. Roots must generate and grow into surrounding soils before a larger soil volume can be tapped for moisture. This watering regime should provide the new roots with sufficient moisture without drowning them. Roots need oxygen, too! Adjust the watering schedule accordingly for rain or very dry conditions.

Don't Forget To:
Inspect containerized and container-grown trees prior to planting to see if the roots are pot-bound or encircling. (Avoid the purchase of moderately- to severely-pot-bound plants). If the roots are slightly pot bound, remove the pot and make a vertical slice up each quarter of the root ball to a depth of about 1 inch. Cut an X across the bottom of the soil ball to a depth of about 1 inch. Gently loosen some of

Figure 4. 15. *If the tree is pot bound, score the root ball with a knife to a depth of 1 inch, as shown.*

the roots, then plant (Figure 4.15). If encircling roots are flexible, it may be possible to straighten and orient them in a radiating direction outward from the trunk, rather than cutting them.

Inspect bare root trees for broken or encircling roots, and all trees for broken or damaged branches prior to planting. Remove any broken or encircling roots and broken or damaged branches with a sharp hand pruner. Also, remove crossing or rubbing branches.

Keep all types of root systems moist prior to planting. For bare root trees, placing moist straw or sawdust around the roots works well.

Soak bare root trees in water 1 hour prior to planting.

Sweat bare root trees in a shaded place such as a garage and keep them moist until the buds open. Sweating is a process that creates favorable conditions necessary for bud break and development on certain tree species, such as oaks and hackberries.

Remove all containers prior to planting, including biodegradable, papier-mâché pots. If the roots and soil are loose in the container, then place the container in the planting hole and carefully cut away the container as you backfill with soil.

Be sure all roots extend away from the trunk to prevent future problems with encircling and stem girdling roots.

Remove at least the upper two rungs on wire baskets before completely backfilling. Typically it is best not to remove any portion of the wire basket before the tree is safely placed in the planting hole and is partially backfilled.

Remove the nails holding the burlap together, then cut away as much of the burlap as possible after the plant has been partially backfilled. Never allow any burlap to remain above the soil surface.

Cut and remove all twine and rope from around the soil ball and tree trunk.

Prevent animal damage to young trees, if needed, by placing a 12- to 24-inch-tall cylinder of 1/4-inch mesh hardware cloth around the trunk, leaving 2 to 3 inches between the wire and the trunk.

Provide follow-up care during the establishment period to ensure tree survival and success. Recent research suggests watering frequency is very important to facilitate rapid and successful establishment. See the suggested watering schedule mentioned above. Successful establishment and tree survival rates will decrease total costs of a tree planting project when tree removal and replacement costs are factored into the total budget.

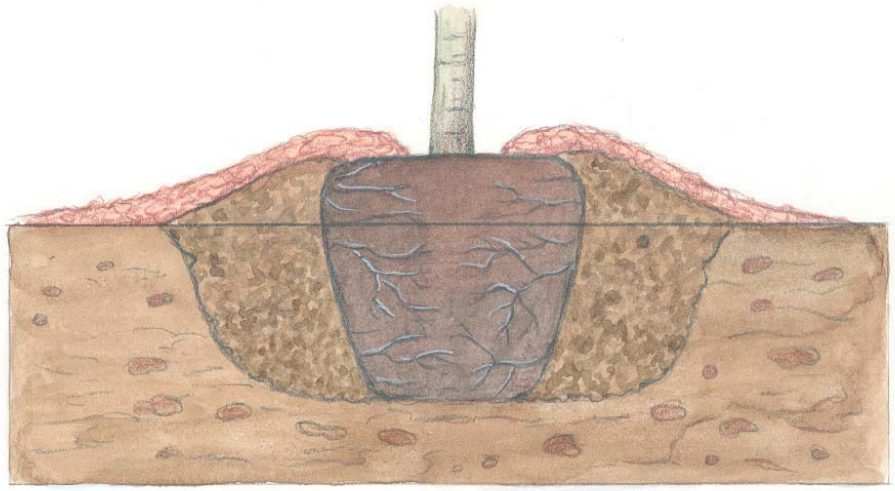

Figure 4.16. *For heavy or poorly drained soils, plant the root collar slightly higher than the soil surface (e.g., 1 to 2 inches), and mound the soil to cover the root ball.*

Planting Guidelines For Special Situations:

For heavy and/or poorly drained soils, plant slightly higher than normal and mound the soil up to cover the root ball (Figure 4.16).

Do not add peat to poorly drained, heavy clay soils, as it can act as a sump and draw water into the root zone.

Do not add rocks or gravel to the bottom of a planting hole to improve drainage unless drain tiles are installed.

When using tree spades, water the trees thoroughly before moving them. Rough up the sides of the planting holes with a shovel or rake, then place the trees slightly higher than the original grade to allow for settling.

If using a weed control barrier, use a porous landscape fabric. Do not use plastic around trees.

Staking is generally not necessary unless the tree is unstable. Stakes and strapping should be applied to support the tree, yet allow the tree to move and sway. Stakes and strapping should be REMOVED within one year. Connect the tree to the stakes with wide (two inches or wider), flexible materials, such as strips of canvas, mesh or burlap or old bicycle inner tubes (Figure 4.17). Avoid ropes, strings or wires in garden hose sections since these materials can compress and girdle stem tissue.

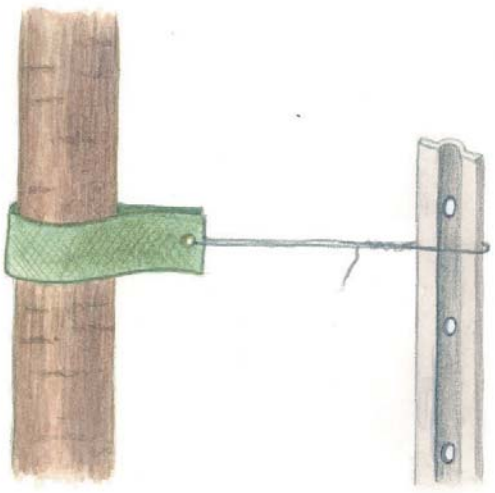

Figure 4.17. *Stake if necessary, for no more than 1 year.*

Proper Tree Pruning Techniques

Sound arboricultural practices will prevent development of many hazardous tree defects. Investing community resources in proper tree pruning techniques is one of the most effective tree risk management strategies. Early formative pruning and ongoing maintenance pruning will prevent the development or eliminate many tree defects that are leading causes of tree failure. Early and regular tree pruning will also reduce the costs of subsequent pruning, tree removal, and replanting.

Industry standards for pruning trees are published by the American National Standards Institute in *The American National Standard for Tree Care Operations - Trees, Shrubs and other Woody Plant Maintenance- Standard Practices: ANSI A300 – 1995* (ANSI 1995). The A300 (Part 1) standards currently address tree pruning practices only, and provide guidelines for young tree, mature tree, and utility pruning operations. The American National Standards Institute has also published a standard reference for safety requirements for workers and the public who are engaged in tree care operations entitled *The American National Standard for Tree Care Operations - Pruning, Trimming, Repairing, Maintenance, and Removing Trees, and Cutting Brush - Safety Requirements: ANSI Z1331.1-2001* (ANSI 2001). The purpose of this standard is to provide safety criteria for workers and the public, and to serve as a guide to federal, state, and municipal authorities in the drafting of their regulations.

These industry standards can help communities develop pruning specifications and safety regulations. Community tree care managers who write contracts and bidding specifications for tree maintenance work projects should be familiar with them. Both publications are available from the American National Standards Institute, National Arborist Association, and the International Society of Arboriculture at their respective websites as follows:

http://www.ansi.org http://www.natlarb.com http://www.isa-arbor.com

Pruning Schedules

Trees should be pruned regularly during their early formative years to improve tree structure and promote tree health. Good structure of primary, scaffold branches should be established while the tree is young. The scaffold branches provide the framework of the mature tree, and properly trained young trees will develop a strong structure and require less corrective pruning as they mature. Early formative pruning is "good preventive medicine" that will help to avoid the development of many tree defects, or eliminate them before they become hazardous to public safety. For example, early formative pruning that removes weakly attached branches will improve tree structure, and can prevent major branch failures in subsequent years. The elimination of codominant stems, early in the tree's life, will prevent the development of defects that could lead to stem failure such as included bark and/or cracks at the stem union.

Many pruning schedules have been published, and the recommended interval between pruning activities varies. The ANSI A300 pruning standards provide guidelines for pruning young trees at the time of planting, 1 to 3 years after planting, and 4 to 6 years after planting. Here are some tips to remember when pruning young trees. These tips incorporate the ANSI A300 pruning standards and recent research findings:

Pruning Young Trees

At Planting

Little, if any, pruning should be needed at the time of planting. This is especially true if high quality nursery stock has been selected for planting. Any pruning performed on newly planted trees should be limited to corrective pruning. Several studies have shown that pruning the crown at planting to achieve a better balance between roots and foliage does not enhance establishment and can actually increase the time required for establishment. This phenomenon occurs because the food manufacturing capacity of the foliage is needed to produce new roots and shoots.

Corrective pruning to be done at planting

- Remove diseased, dead, or broken branches
- Eliminate double leaders (The top of a tree should never be pruned except to remove a double leader)
- Remove branches with included bark in their attachments
- Do not remove lower branches or thin the crown at planting

1-3 Years After Planting

- Never remove more than one quarter of the foliage or live branches of a tree per year
- Remove branches that are dead, broken, or rubbing
- Select primary scaffold branches that are well spaced along the tree trunk as follows:
  - 18 inches apart for tree species that will reach >40 feet at maturity
  - 6-8 inches for tree species that will reach < 40 feet at maturity
- Remove branches with included bark in their attachments

4-6 Years after Planting

- Never remove more than one quarter of the foliage or live branches of a tree per year
- Remove branches that are dead, broken, rubbing
- Selectively thin to promote a structurally sound scaffold branch system and strong branch unions
  - Eliminate codominant stems. Codominant stems are a leading cause of tree failure
  - Remove branches that interfere with proper spacing of scaffold branches
  - Remove branches with weak branch attachments and included bark
  - Retain branches with strong U-shaped angles of attachment
- Prune lower branches to prevent interference with site lines, pedestrian traffic, and other clearance issues

Basic Pruning Methods

Pruning cuts should always follow the guidelines provided in Appendix 3: How to Prune Trees. Proper training and experience is needed, particularly for large limb removal and the removal of highly hazardous trees. Communities should hire experienced and insured arborists, if the public works staff are not trained or experienced in these procedures.

Wound Dressings

Wound dressings are not necessary or recommended for most pruning cuts. Research has shown that dressings do not hasten wound closure or reduce wood decay. The application of dressings can effectively reduce sap flow from wounds, and in this capacity can help prevent the transmission of certain diseases such as oak wilt and Dutch elm disease. If oaks or elms are wounded or must be pruned during active disease transmission periods, use a latex rather than oil-based or asphalt-based paint.

Timing of Pruning

Try to schedule pruning activities during the late dormant season. Pruning in late winter, just before spring growth starts, leaves fresh wounds exposed for only a short length of time before new growth begins the wound sealing process. Pruning trees during the dormant season can help to avoid certain diseases such as oak wilt, Dutch elm disease, and fireblight. Another advantage of dormant pruning is that it is easier to make pruning decisions without leaves obscuring branch structure.

Ideally, it is best to avoid pruning trees when leaves are forming and until they are fully mature. This is true because much of the tree's energy reserves are being used to support leaf expansion and growth, and only limited energy reserves are available for defensive activities like wound sealing and compartmentalization.

Protection of Trees From Construction Damage

Construction activities impact trees and can create or exacerbate hazardous situations. Protecting tree health and mitigating high-risk situations on a construction site is a matter of recognizing the potential impacts of construction activities, and identifying hazardous trees or defects that exist on the site. Avoiding or minimizing construction damage is a critical step in preventing the development of many hazardous tree defects, and eliminates the costs of treating construction damaged trees. Advanced planning and simple mitigation steps can minimize the risks associated with trees during and after construction. These include:

- **Protecting healthy, structurally sound trees**
- **Protecting trees from direct injury**
- **Protecting the structural integrity of trees**
- **Protecting the overall health of trees throughout construction**

Although they are not discussed here, there are significant tree risk management issues that should be considered along with the risk of structural tree failure during and after construction (Johnson 1999). These issues include creating a structure and site that are defensible against wildfire, providing adequate visibility at roadway intersections, and providing visibility for security and surveillance.

Protect Healthy, Structurally Sound Trees – "Save the Best – Chip the Rest"

In areas where trees will impact people and structures, trees should be assessed to ensure that they are healthy and structurally sound. Trees that are unhealthy and/or structurally weak will only get worse following construction activities. No efforts

Steps for a successful tree protection plan:

- Mark construction zone boundaries
- Inventory trees on the site
- Train contractors and sub contractor crews
- Design the site to accommodate construction activities:
  - Vehicle movement and parking
  - Material storage
  - Vehicle cleaning
- Select the trees to be saved
- Protect the trees you plan to save
- Prepare the trees for construction disturbance
- Protect and preserve the soil for future tree planting
- Monitor the construction process and hold periodic meetings with contractors
- Enforce penalties for non-compliance
- Make a final inspection of the site
- Commit to long-term maintenance

should be made to save these trees. A tree specialist can inventory and inspect trees and provide a report of potential problems. The specialist should review construction plans to see if the proposed construction or subsequent landscaping activities will create new target areas. Eliminate or correct hazardous situations, or exclude people from hazardous areas.

Protect Trees From Direct Injury

Trees can be damaged or killed by a wide variety of construction activities. Construction practices can result in obvious damage such as torn bark and less obvious damage to roots. Any injury to the wood or bark of a tree is a potential long-term problem. Open wounds deplete a tree's energy resources and provide entry points for insects, diseases, and decay. Decay is the leading indicator of potential tree failure and is always the result of wounds. The worst damage, however, often remains hidden underground. Roots that lie within the path of construction must be protected because they are so important for anchoring the tree.

Approximately 90 to 95 percent of a tree's root system is located in the top 3 feet of soil, and more than half is in the top 1 foot. Avoid construction activities within the CRR to ensure the tree's root zone is adequately protected.

When you remove a large number of trees, you change the site conditions for the remaining trees. Sudden increases in amounts of sunlight and wind may shock trees. It is not uncommon to find scorched leaves, broken branches, and uprooted trees after a site is cleared. Although some of these problems are temporary, they may compromise tree health when coupled with additional construction damage.

Protect the Structural Integrity of Trees

Trees acclimate to the conditions of the site where they grow. Mature trees have less ability to adapt to changes in the environment than younger trees. Construction activities can change soil moisture, wind exposure, and sunlight, requiring trees to acclimate to new conditions. The shape of a tree's trunk and root system reflect the tree's adaptation to environmental conditions that existed prior to construction. For example, forest or plantation trees have trunks with less taper and few lower branches than open grown and exposed trees. Collectively, they protect each other from most wind damage. Once exposed along the edges of openings created by construction activities, individual trees may not have the strength to withstand increased wind. This problem can be mitigated by selectively thinning the woodland or plantation several years prior to construction activities. You can avoid sun and wind stress and improve tree survival by preserving trees in groups rather than as individuals.

Root loss not only affects the health of trees but also their condition and stability. Any tree that experiences significant root loss will have a different center of gravity as a result. This shift in balance often results in less stable trees especially the large, mature trees and leaves them more vulnerable to toppling over, especially during high wind. Construction activities that sever more than 40 percent of roots located within the CRR will result in a tree that is in imminent danger of falling over, with or without the help of wind. Trees growing in tree lawns or near streets typically have an unbalanced and restricted root distribution. Therefore, any root removal or damage during construction is a more significant loss to trees growing in tree lawns as compared to trees growing in more open areas.

Protect the Overall Health of Trees Throughout Construction

In addition to protecting the CRR, there are other ways in which you can reduce the impact of construction activities on your trees. Some of these are relatively simple; others are complex and expensive. Carefully consider the importance of each tree to the future appearance of the site and consult a tree specialist before deciding whether protective measures are worth the cost.

Soil compaction is the single largest killer of trees in construction areas. Tree roots need loose soil to grow, obtain oxygen, and absorb water and nutrients. Stockpiled building materials, heavy machinery, and excessive foot traffic all damage soil structure. Lacking good soil aeration, roots suffocate and tree health declines. Prevent soil compaction by establishing storage areas and traffic routes safely away from the CRR of trees, and installing protective fences and signs. If traffic cannot be rerouted, apply several inches of protective mulch (6 inches or more) within the CRR of affected trees to reduce soil compaction. Mitigating existing soil compaction problems is rarely effective, so careful planning will help avoid the expense and labor of corrective treatments or removal of damaged trees.

Improper handling or disposal of materials used during construction also can harm roots. Fill gas tanks, clean paintbrushes and tools, and repair mechanical equipment well outside the CRR of trees to prevent chemical spill damage. Finally, avoid changes to native soil pH by not cleaning out concrete mixers or mortar boxes on site or burying concrete materials within the CCR of existing trees or in areas where future plantings are planned. Alkaline clays or limestone should not be used for fill or paving.

Grade changes within the CRR usually kill a tree. This happens either directly, or by changing soil moisture and oxygen availability within the root zone. Except where absolutely necessary, avoid disruptions to the natural contour of the site or shift them well outside the CRR. Mitigate disruption to the CRR with techniques such as use of porous fill, mulch and non-turf groundcover, and constructing retaining walls at or beyond the CRR.

As much as 40 percent of a tree's root system can be cut during the installation of a nearby utility line. This reduces water and nutrient uptake and may compromise the stability of the tree. If it is not possible to relocate the utility line outside the tree's CRR, you can reduce root damage by tunneling under the tree's root system (Figure 4.18).

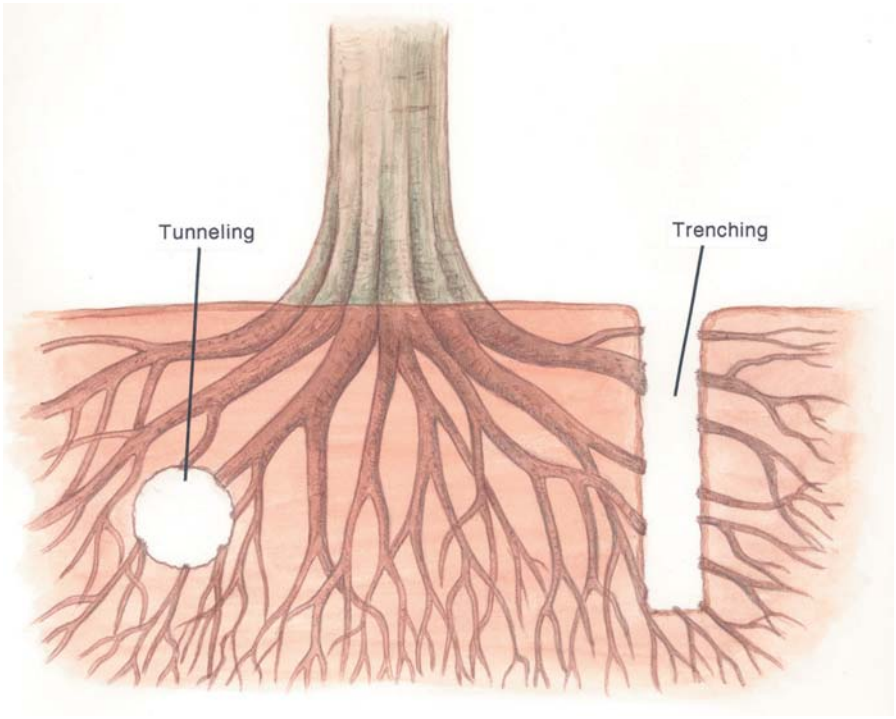

Figure 4.18. *Underground utilities installed via a tunneling system cause less root damage than convention trenching operations.*

Avoid soil tunneling (augering) too close to the tree's stem in order to minimize injury to tree roots. The diameter of the tree can be used as a guide to determine the minimum distance from the tree where tunneling should occur (Table 4.2).

Table 4.2 Minimum distance (feet) from the tree's stem that soil augering/tunneling should occur, based on tree diameter.

Tree diameter (dbh, inches)	Auger distance from tree stem (radius, feet)
0-2	1
3-4	2
5-9	5
10-14	10
15-19	12
> 19	15

Source: Morell 1984

Trenching for building foundations also poses a danger to nearby trees. Posts, pillars, or I-beams sometimes can be substituted for foundation walls and footers on homes. Drilling single holes as opposed to cutting deep trenches saves critical roots.

Street Trees and Construction Damage

Established street trees are subjected to damage from construction activities more frequently than forest trees. The infrastructure of any community (e.g., streets, sidewalks, curbs, and buried utilities) is continually updated, repaired, or expanded, and trees growing in tree lawns (e.g., tree lawns) or close to these public services are vulnerable to construction activities. A community can minimize construction damage to public trees by adopting a tree preservation policy that establishes tree preservation guidelines.

Root loss is the most common type of construction damage that street trees suffer. This is particularly harmful because these trees already are growing in root-limited spaces, and are often less healthy than other landscape trees due to other environmental stresses posed by tree lawns. Stresses include reduced soil volume, poor quality soil, accumulation of de-icing salts, and characteristically drier conditions than other landscape sites.

Minimize root loss to minimize construction damage to street trees. Most healthy trees can tolerate one-sided root cutting and recover from the loss with long-term after care (Johnson 1999). Trees that have roots cut on two sides usually suffer much more damage and are less stable. It is questionable whether to save trees that suffer root loss on three or more sides.

Damage to sidewalks, curbs, and gutters near trees is costly and the damage is frequently listed as a tree problem. In California over $70 million dollars in damage to these grey infrastructure components has been reported (McPherson 2000). Nationally, it is likely then that billions are spent annually repairing damage to curbs, gutters, and sidewalks. But is the tree 100 percent of the problem? Some evidence suggests that defects in sidewalks and natural expansion and contraction of soils account for sidewalk damage. In other cases attempting to grow a tree too close to infrastructure is the problem.

Damage to sidewalks, curbs and gutters becomes less frequent the farther away tree stems are form the edge of these structures. Damage becomes infrequent in tree lawns that are approximately 8- to 10-feet wide or greater. Also, in the cases where damage does occur, the repair process and subsequent damage to tree roots systems on average does not cause any greater tree mortality than normally occurring nor a detectible reduction in tree condition (Hauer et al. 1994).

The amount of root cutting near street trees may be reduced by a variety of methods and compromises:

- Plant smaller stature trees (Remember, doing so will also reduce the ecological benefits that larger stature trees can produce).
- Move the sidewalk away from the tree.
- Plant trees on the sidewalk side opposite of the tree lawn (If this area is private property a green easement could be developed to allow tree planting on private property and future care by a municipality).
- Ramp the sidewalk to minimize trip and fall events.
- Grind down the raised sidewalk to increase the time period before infrastructure replacement is needed and the subsequent root damage will occur.
- Evaluate soil texture when designing sidewalk projects.
- Avoid widening streets or sidewalks when they are replaced.
- Narrow the width of the street when possible to lessen the amount of root damage and provide more area for future root growth.
- Use air or water tools to expose main structural roots to facilitate clean cutting of roots rather than ripping them from soil excavation with a backhoe.
- If curbs are need to be replaced, hand form the curbs adjacent to tree roots, rather than excavating with machinery. Excavation with machinery destroys major branch roots, even if the new curb remains in the same position as the old curb.
- Consolidate utilities into common trenches whenever possible, and tunnel under tree root systems. Laying several utilities in a common trench minimizes the number of trenches and root cuts.
- Avoid regrading the surface of the tree lawn. Although it is not trenching, it still cuts and removes roots, usually the fine roots that absorb most of the water and nutrients for the tree. If regrading must be done and creates a mowing/maintenance problem, consider the installation of retaining walls at the curb line, or remove the turfgrass from the tree lawn and replace it with mulch and landscape plantings.

When tree lawns are greater than 10 feet wide, take steps to plant trees to avoid future damage. Placement of trees in the center of the tree lawn rather near the sidewalk or curb side is important. Simple centering of the tree in the tree lawn in wide tree lawns will help prevent future tree and infrastructure conflicts.

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Literature Cited

American Association of Nurserymen (AAN). 1997. **American standard for nursery stock: ANSI Z60.1- 1996**. Washington D. C.: American Nursery & Landscape Association. 57 p.

American National Standards Institute (ANSI). 1995. **The American national standard for tree care operations - tree, shrub, and other woody plant maintenance - standard practices: ANSI A300-1995**. New York: National Standards Institute. 8 p.

American National Standards Institute (ANSI). 2001. **The American national standard for tree care operations - pruning, trimming, repairing, maintenance, and removing trees, and cutting brush - safety requirements: ANSI Z1331.1-2001**. New York: American National Standards Institute. 22 p.

Bassuk, N.; Grabosky, J.; Trowbridge, P.; Urban, J. 1997. **Structural soil: An innovative medium under pavement that improves street tree vigor.** Ithaca, NY: Cornell University Urban Horticulture Institute. Updated December 12, 2000, <http://www.hort.cornell.edu/department/faculty/bassuk/uhi/article.html>.

Burns, R. M.; Honkala, B. H., tech. coords. 1990. **Silvics of North America. Volume 1, Conifers**. Agric. Handb. 654. Washington D. C.: U. S. Department of Agriculture, Forest Service. 675 p. 2 vol.

Burns, R. M.; Honkala, B. H., tech. coords. 1990. **Silvics of North America. Volume 2, Hardwoods**. Agric. Handb. 654. Washington D. C.: U. S. Department of Agriculture, Forest Service. 877 p. 2 vol.

Demsey, G. 1994. **Notes from hurricane Andrew.** In: Burban, L. L.; Andersen, J. W., eds. Storms over the urban forest, 2nd Edition. Radnor, PA: U. S. Department of Agriculture, Forest Service, Northeastern Area, State and Private Forestry: 105-133.

Gerhold, H. D.; Lacasse, N. L.; Wandell, W. N, eds. 2001. **Compatible tree factsheets for electric lines and restricted spaces.** University Park, PA: Pennsylvania State University, College of Agricultural Sciences. 156 p.

Hauer, R. J.; Miller, R. W.; Ouimet, D. M. 1994. **Street tree decline and construction damage.** Journal of Arboriculture. 20(2): 94-97.

Johnson, G. R., 1999. **Protecting trees from construction damage: A homeowner's guide.** FO-6135-S (revised). St. Paul: University of Minnesota Extension Service. 16 p. (also available at web address: http://www.extension.umn.edu/distribution/housingandclothing/DK6135.html)

Johnson, G. R., Sucoff, E. 1995. **Minimizing de-icing salt injury to trees.** FO-1413. St. Paul: University of Minnesota Extension Service. 8 p.

McPherson, E. G. 2000. **Expenditures associated with conflicts between street tree root growth and hardscapes in California.** Journal of Arboriculture. 26(6): 15-18.

General Reference

Cervelli, J. A. 1984. **Container tree plantings in the city.** Journal of Arboriculture. 0(3): 83-86.

Fazio, J. R., ed. 1988. **Resolving tree-sidewalk conflicts (No. 3)**. Nebraska City: Tree City USA, National Arbor Day Foundation. 8 p.

Fazio, J. R., ed. 1989. **How to save trees during construction (No. 7).** Nebraska City: Tree City USA, National Arbor Day Foundation. 8 p.

Harris, R. W.; Clark, J. R.; Matheny, N. P. 1992. **Arboriculture: Integrated management of landscape trees, shrubs, and vines. 2nd Edition.** Englewood Cliffs, NJ: Prentice-Hall Inc. 687 p.

Hightshoe, G. L. 1988. **Native trees, shrubs, and vines for urban and rural America.** New York: Van Nostrand Reinhold. 819 p.

Kuser, J. E., ed. 2000. **Handbook of urban and community forestry in the northeast.** NewYork: Kluwer Academic/Plenum Publishers. 444 p.

Matheny, N. P.; Clark, J. R. 1991. **A photographic guide to the evaluation of hazard trees in urban areas, 2nd edition.** Urbana, IL: International Society of Arboriculture. 85 p.

Matheny, N. P.; Clark, J. R. 1998. **Trees and development: a technical guide to preservation of trees during land development.** Urbana, IL: International Society of Arboriculture. 184 p.

Miller, F. D.; Neely, D. 1993. **The effect of trenching on growth and plant health of selected species of shade trees.** Journal of Arboriculture. 19(4): 226-229.

Minnesota Association of Soil and Water Conservation Districts Forestry Committee. 1986. **Minnesota tree handbook.** Staples, MN: Adventure Publication. 408 p.

Moll, G. A., ed. 1990. **Community forests get a check up.** Urban Forest Forum 9(6): 10-12.

Perry, T. O. 1982. **The ecology of tree roots and the practical significance thereof.** Journal of Arboriculture. 8(8): 197-211.

Swanson, B. T.; Rosen, C. 1990. **Tree fertilization.** FO-2421. St. Paul: University of Minnesota Extension Service. 4 p.

Urban, J.1992. **Bringing order to the technical dysfunction within the urban forest.** Journal of Arboriculture. 18: 85-90.

Watson, G. W.; Neely, D., eds. 1995. **Trees and building sites.** Champaign, IL: International Society of Arboriculture. 191 p.