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SPACE WARS

Can Trees Win the Battle with Infrastructure?

By E. Gregory McPherson, Laurence R. Costello, and David W. Burger

A symposium was held March 31 through April 1, 2000, at the University of California, Davis, to explore strategies to reduce conflicts between tree roots and infrastructure. Fifty participants shared current research findings, identified research and development needs, and developed the basis for a multidisciplinary approach to solve the problem. This article describes highlights of the symposium and future directions of an emerging research and education program. All references cited below are from the symposium proceedings, *Strategies to Reduce Infrastructure Damage by Tree Roots* (Costello et al. 2000), available for $12.50 from ISA's Western Chapter. To order, call (530) 892-1118 or go to www.wcisa.net. All proceeds go to the ISA Research Trust.

The data are in: Trees are losing the battle for space along city streets. Confined to ever-smaller cutouts and planting strips, it's no wonder that roots carve out their space at the expense of sidewalks, curbs, and driveways. Conflicts between tree roots and infrastructure create trip-and-fall hazards for pedestrians, and conflicts can cause large, stately trees—those that provide the greatest benefits—to be removed only because their roots have repeatedly heaved sidewalks (Figure 1). When this happens, trees lose and cities lose (Figure 2).

RECENT RESEARCH FINDINGS

Approximately $71 million is spent annually by cities in California due to conflicts between tree roots and hardscape. One-third of this amount is spent on sidewalk repair and, surprisingly, $2.26 is spent on legal remedies for every $1 spent on mitigation (root barriers, root cutting, etc.). Managers reported that restricted planting space and poor tree species selection were the most frequently occurring causes of conflicts (McPherson and Peper).

Field assessments in Modesto, California, found that soil characteristics and tree size alone were not good predictors of sidewalk damage. Rootstock variation among different species of ash (*Fraxinus* spp.) appeared to be important, but more detailed investigation is needed. Results from Modesto's uniform, sandy loams may not apply where soils differ (Costello, Perry, and Kelley).

Root depth and growth pattern are inheritable traits. Research with three species (Shamel ash [*Fraxinus uhdei*], pistache [*Pistacia chinensis*], and zelkova [*Zelkova serrata*]) uses the latest technologies to identify and propagate deep-rooted individuals. Roots are tenderly excavated with a supersonic air spade, marked and photographed at several angles, scanned, and imported into a three-dimensional modeling program that aids visualization of rooting patterns (Figure 3). Individuals with vertical roots have been vegetatively propagated for field trials (Burger).

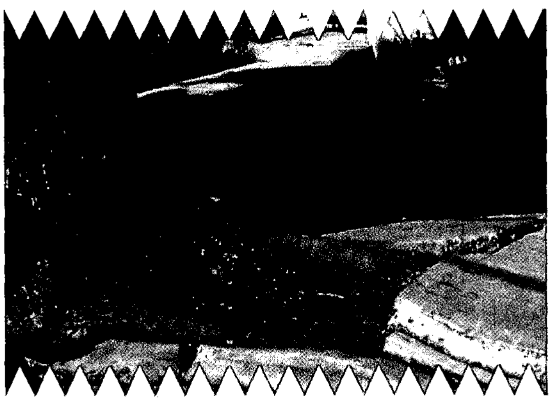

Figure 1. Trees that win the battle for space often pay with their lives later.

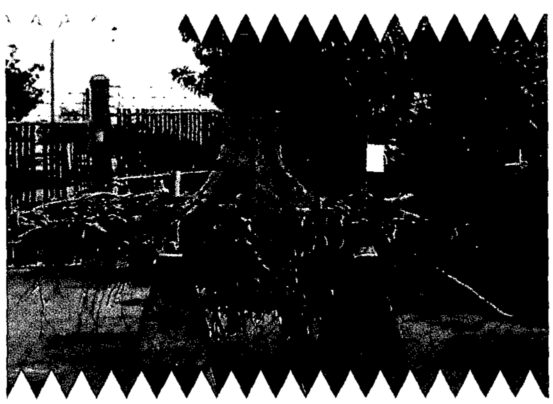

Figure 2. This excavated ginkgo (*Ginkgo biloba*) tree root system illustrates that healthy trees need a substantial amount of underground space (from Dunn).

A survey of tree root expenditures associated with Danish municipal sewers found that roots are not perceived as a major problem. Annual tree-related expenditures were only 1.2 percent of total sewer system costs, and roots were only in sewers laid before 1980. As older sewer systems are renovated, the problem will decrease further (Randrup). In England, the impacts of trenching on tree roots have been severe. To counter the problem, new specifications call for the use of hand-digging or trenchless technology, retention of roots greater than 1 inch in diameter, and careful backfilling around roots (Jackson, Smith, and Roberts).

Relatively little is known about the physiology of root impedance. The pressure exerted by roots axially and radially is substantial (Feldman). For instance, a 15-inch segment of root 1 inch in diameter exerts 175 psi, and this force can lift a sidewalk slab 10 feet long and 4 feet wide (Dunn).

STRATEGIES

Root barriers are commonly used at time of planting and as a retrofit measure to obstruct root growth following root cutting. ►

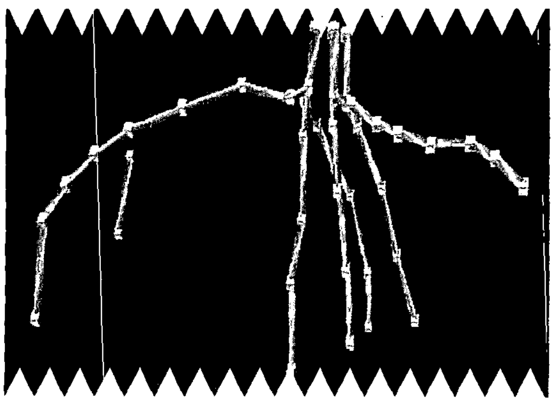

Figure 3. Three-dimensional model of an excavated root system (from Burger).

Studies indicate that they direct roots downward and buy time before roots return to more favorable conditions near the surface. Effectiveness depends on correct installation, soil conditions, and tree rooting patterns (Gilman). Linear root barriers (12 inch) are placed in trenches parallel to the sidewalk where roots are cut. Several inches of backfill between the barrier and walk provide room for root expansion (Dunn). In Modesto, after sidewalks are removed, the concrete is repoured to a depth of 12 inches adjacent to the cut tree roots. This concrete root barrier delays subsequent damage (Gilstrap).

Structural soils developed at Cornell (Bassuk and Grabosky) are being evaluated in California cities such as Palo Alto, Davis, and Santa Monica (Warriner). They provide the structural stability required for compacted base material under pavement, and at the same time have sufficient pore space for root growth. With compaction, the angular aggregate (¾ to 1½ inch) locks into place and creates voids with water, oxygen, and soil for root nutrition. The clay loam soil stays attached to the stone with a binder.

Heroic efforts are made to save mature trees from the chain saw when roots cause hardscape damage. Retaining large anchor roots is necessary if root cutting threatens tree stability. In Sunnyvale, concrete is poured over roots sandwiched between two 10-gauge steel plates (Dunn). The bolted plates force the root to expand laterally instead of vertically, thereby reducing upward pressure on the sidewalk. In other cases, foam and sand backers are used between the root and concrete to absorb upward pressure from radial expansion of the roots. Sidewalks gradually ramped or elevated on piers also are used to preserve large roots (Seegebrecht).

Alternate paving strategies are yet another means of reducing costs associated with tree root growth and sidewalk repair. Interlocking or unit pavers are more flexible than concrete and less costly to repair. Asphalt and decomposed granite are acceptable substitutes for concrete in certain situations (Mason). Modifications such as these must meet Americans with Disabilities Act standards for accessibility.

Many cities narrow or meander sidewalks around the trunks of large trees after the trees have outgrown their space. Sometimes sidewalks are designed and installed to provide additional space for each street tree (Figure 4). In some cases, curbs are moved out into the street when it is the only tree preservation alternative (Mann).

Figure 4. This walk in Redwood City was initially designed to accommodate anticipated tree root growth (from Mann).

Other root and soil management strategies include

- creating gravel-filled trenches that lead roots under walks (Urban)
- waterjetting to increase soil moisture at depth and thus promote deep rooting (Gilstrap)
- using chemical treatments such as allelopathic chemicals and root toxins
- injecting gel or other materials between the sub-base and concrete to reduce oxygen for root growth (Gamstetter)
- modifying the temperature at the interface to repel roots
- using glass block or optical fibers in concrete to increase light at the interface and thus repel roots.

In Redwood City, where City Council policy frowns on planting small "toy trees," parkways as narrow as 2 feet are being retrofitted with large-statured shade trees (Figure 5). Trees are planted at the edge of the sidewalk using half of a grate ($250). This design provides adequate space for the tree to grow and commits the city to widening the sidewalk as the trunk expands (Mann).

Other cities are experimenting with different materials and engineering practices. Alternatives include flexible paving, compressible subgrades, and reinforced concrete (Urban). A new tool for detecting tree roots below pavement is ground-penetrating radar (impulse radar). Tree roots produce a distinctive signature that can be used to determine depth and size prior to excavation (Seegebrecht).

Planning and design strategies have potential to eliminate tree root–hardscape conflicts when they are incorporated into the development process up front. Unfortunately, trees are regarded as "flexible" design components and inserted in the space not occupied by utilities or paving at the end of the process (Sealana). The life expectancy of most sidewalks is 20 to 30 years, while street trees can live 40 to 60 years or longer (Gamstetter). There is need to study the cost effectiveness of designing hardscape to match the life cycles of trees.

Good details and specifications are essential to tree survival and health in restricted growing space. Deep planting, along with pea-gravel mulch is one strategy to reduce shallow rooting (Figure6).

Figure 5. Large-statured trees planted in a narrow parkway in Redwood City "borrow" space from the sidewalk (from Mann).

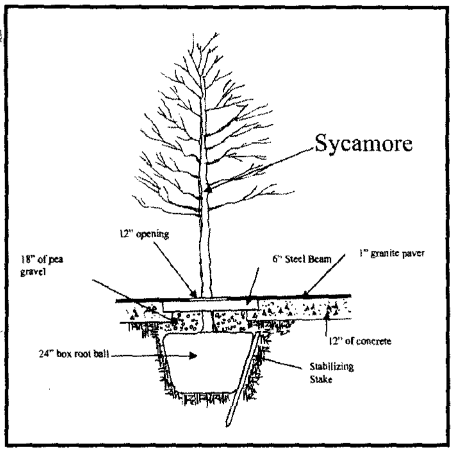

Figure 6. Planting trees below grade has reduced root– hardscape conflicts in San Jose (from Beaudoin).

Specifications should cover everything from root pruning to sub-base preparation for sidewalk construction on a variety of soil types (Beaudoin).

Several cities have achieved better sidewalk and tree management by combining staff into a single department. Santa Monica's Community Forest Management Plan increased awareness and coordination among city departments. Now money is budgeted up front for tree relocation when improvement projects threaten street trees. Arborists review site plans and are consulted before tree roots are removed, and tree protection zones are defined and enforced (Warriner).

NEXT STEPS

The symposium was a first step to developing solutions by involving researchers and practitioners. The symposium spawned its own Web site (telework.ucdavis.edu/treeroots) and a structural soils Listserv (contact Nina Bassuk to subscribe, nlb2@cornell.edu). Priorities were identified for

- new research and development
- communication and outreach
- field testing and follow-up research
- policy, economics, and education

With assistance from symposium participants and others, Larry Costello, Katherine Jones, and Greg McPherson are developing the *Compendium of Practices to Reduce Infrastructure Damage by Tree Roots*. Due to be published in 2002, the compendium will document the application and effectiveness of state-of-the-art strategies. Funding for the compendium is from the Forest Service's Center for Urban Forest Research. Future funding for research on this problem may be spurred by results from the ISA Research Trust's current efforts to develop a new agenda for urban forest research (Watson).

The need to manage risk associated with tree-related trip-and-fall hazards makes finding solutions to tree root–hardscape conflicts a priority. Because space for trees in cities continues to diminish, there is an urgent need for science-based solutions. "Smart Growth" policies encourage more compact development, while an increasing number of underground utilities vie for limited space. Too often, developers, planners, and engineers fail to integrate trees into infrastructure design up front. In existing ►

development, there is public pressure to retain existing trees that have created trip-and-fall hazards, but very little is known about the relative effectiveness of mitigation strategies. Given the large amount of money spent on root–hardscape conflicts, a broad-spectrum research and education program will produce savings for municipalities that will more than pay for itself. There is hope for thriving trees if we work together to defeat the "Space Wars" problem. AN

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