PROACTIVE STRATEGIES TO MEDIATE TREE-ROOT DAMAGE TO SIDEWALKS

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Tree-root damage to sidewalks along urban streets is a pervasive problem. To meet the desires of their residents for shade and aesthetics, cities have traditionally lined their streets with trees. This practice has received strong endorsement from the residents as well as the nursery industry.

As trees mature, they frequently cause insidious but widespread destruction to adjacent sidewalks. Contrary to popular belief, the soil environment beneath sidewalks apparently favors tree-root growth. The sidewalk, made of concrete, functions as a barrier against soil moisture loss by either evaporation or transpiration. In addition, the high moisture content of the soil, compared to the concrete, confers upon the soil a high specific heat. When the sidewalk warms, some of the heat radiates to the soil beneath it. Conversely, when the sidewalk cools, the temperature drops more rapidly than the soil, and the underside of the sidewalk becomes a surface for condensation of soil moisture which subsequently percolates back into the soil.

Tree roots tend to grow where the soil environment is most favorable and, therefore, often grow at very shallow depths as they extend under a siewalk. These shallow roots, which, like all roots, enlarge radially, eventually may cause upward displacement of adjacent sidewalks. Typically, the displacement is uneven and "lips" may be created where adjoining sections of sidewalk are differentially lifted. Pedestrians, failing to see these lips, may trip over them and be injured. Replacement by cities of displaced sections of sidewalk becomes necessary to prevent pedestrian accidents and litigation by injured victims. Yet, like ocean waves repeatedly pounding a beach, the roots which are cut back during sidwalk replacement, invariably regenerate and repeat their destruction, necessitating cyclical sidewalk repair.

Besides the foregoing strategy in dealing with the problem, various types of plastic barriers have become available but their longterm benefit is unknown. Another practice, often advocated, is thorough watering of young trees to prevent a moisture differential in the soil profile which might favor shallow rooting. Notwithstanding the soundness of proper watering to promote tree survival and growth, I know of no proof that urban trees are, indeed, under-

[1] Trade names and commercial products or enterprises are mentioned solely for information. No endorsement by the USDA Forest Service is implied.

watered. It is possible that shallow rooting is more a manifestation of genetics than environment. Moreover, even if trees are underwatered and shallow rooting the consequence, there is a question of whether enough urban residents could be "reformed" in their tree-watering practices to have a significant impact.

Apart from current practices, there undoubtedly are other ways that would be cost-effective and feasible of implementation to mediate or even prevent this tree root/sidewalk conflict. Much of my research in recent years has been directed towards identifying such remedies. Among the possibilities under study, some that may depend on implementation by the nursery industry are described below.

Species That Best Fit the Space. The problem of sidewalk damage by tree roots occurs mostly along streets where the trees are located in the strip of land that separates a curb and sidewalk. This space, referred to as the treelawn, planting strip, or parking strip, may be from 2 to 8 feet wide, differing markedly among geographic regions (4).

Wagar and Barker (9) found that in the East Bay Area of San Francisco, where 3- and 4-foot-wide treelawns predominate, sidewalk damage was least with smaller tree species, such as cultivars of purpleleaf plum (*Prunus cerasifera*). It was most serious, as expected, with the most abundant, large-sized species, such as the popular sweetgum (*Liquidambar styraciflua*).

Why are the most frequently planted trees often the kinds destined to do the most sidewalk damage and, therefore, the most expensive to maintain during their lifetime? A primary reason seems to be the widespread availability of these kinds of trees and, conversely, lack of trees that are of conservative size.

Among conservative or moderate-size tree species that should be best suited for use in narrow treelawns, few are readily available from nurseries. An example is the durable European hornbeam (*Carpinus betulus*), a species which apparently is adapted to a wide range of environments. Moderate in size, European hornbeam grows at a moderate rather than a rapid rate and so should need no excessive pruning. It has tough wood that withstands strong winds and other load stresses, and it is virtually pest-free. Moreover, its fruit is dry at maturity and so not messy when it falls, as is fleshy fruit.

Any European hornbeam trees available in the past predominately have been selections with narrow or fastigiate crowns. Such trees may be popular as accents in the landscape, but selections with either globular or pyramidal crowns should be better suited for use along streets where shade is a critical feature. Other traits of this species meriting attention while selecting for crown form include autumn instead of late-winter defoliation, absence of fruit (2), trunks free of suckers, and bark resistant to sunburn.

Indeed, genetic improvement of trees to enhance their usefulness in urban areas would be desirable for most tree species. *Tristania laurina*, sometimes called swamp gum but usually known by its scientific name, for example, is another promising, moderate-size species, except for its fruit. Residents of a street lined with this species in Albany, California, object to the unpleasant, musty odor inside their cars when the clove-like fruit from these trees decays after falling into the cars' air vents. Clearly, a non-fruiting selection would be distinctly superior.

A flawed "delivery system" which fails to dovetail production capability with consumer needs, may be the reason why moderate-size tree species or unique selections of them, instead of larger-size species, are not extensively planted in narrow treelawns. Cost can hardly be a reason because a city should easily justify paying a surcharge, if need be, for such trees, with the expectation that this added cost would be offset by lower maintenance costs during the lifetime of the tree.

Since damage to sidewalks is preceded by shallow root growth, keeping roots away from sidewalks, or as deep as possible when they pass under the sidewalk should be a key objective. Among various strategies that may effectively separate tree roots from sidewalks, one strategy is the promotion of extra-deep rooting, given favorable soil conditions (3). Possibilities for promoting deep-rooting include (a) species with inherently deep roots, (b) unique phenotypes with unusually deep roots, or (c) trees whose roots are molded, during nursery production, into a columnar rootball to facilitate planting the roots that are at the bottom of the root ball exceptionally deep.

Deep-Rooted Species. Differences in massiveness and depth of the root systems are common among tree species. Krasilnikov (7) subdivided woody plant root systems into 11 classes according to their usual depth. The morphological extremes of this classification are tap-rooted trees and shallow-rooted trees. Tap-rooted trees would be expected to have the fewest shallow roots and, therefore, when grown along urban streets, do least damage to sidewalks. Unfortunately, for an array of tree species that may be used in cities, there is a paucity of information about their root morphology. The classification of each species into one or more of Krasilnikov's classes, therefore, is dependent on further study of their root morphology.

Unique Phenotypes. Just as trees of a species have variable crowns, so, too, may their root systems differ. Such variation was obvious when I excavated 8 maturing Chinese hackberry (*Celtis sinensis*) trees along a freeway near Davis, California. Within the excavation zone, which was an area 4 feet radius from trunk center and 15 in. deep, the roots of one of the trees were unusually massive, a condition that was not apparent above ground. In contrast, at the other extreme, another tree had relatively few and much smaller roots. Had there been a sidewalk adjacent to these two trees, the probability of its being damaged undoubtedly would be greatest for the tree with the massive roots.

Examining the roots of maturing trees, like the ones mentioned above, to locate promising root systems for vegetative propagation and possible use as clonal rootstock, requires more labor than is practical. An alternative method, used by Bowman (5) and Kormanik (6), is to screen bare-root nursery stock. Using this method, I have observed dramatic differences in the rooting pattern of 2- to 5-year old seedlings of sweetgum, European and Chinese hackberry (*Celtis australis, C. sinensis*), golden-raintree (*Koelreuteria paniculata*), and other species. The significance of some of these differences is being determined by field experiments now in progress. The objective is to determine whether young seedling trees with steeply descending roots develop exceptionally deep root systems in the landscape.

Other field experiments are examining differences in root morphology between tissue-cultured clones of two 35-year-old sweetgum trees. These parent trees, which technically are the ortets of the tissue-cultured clones or ramets, are located about 40 feet apart along a street in Oakland, California, and have contrasting root systems. On one of these trees, there is pronounced trunk flare, or rather a massive part of the root system is exposed above ground, and the adjacent sidewalk has been replaced three times. The other tree has little trunk flare, no roots show above ground, and the adjacent sidewalk has relatively little damage.

Columnar Rootball. An alternative strategy for promoting exceptionally deep rooting of trees may be to set the roots extra deep when the trees are planted. For this purpose, I grow trees in extra-deep containers, as Amling (1) did with pecans. In this sleeve container, which measures 30 inches deep and 7 inches in diameter, I produce columnar rootballs so the lowermost roots of these rootballs can be planted exceptionally deep.

The sleeve containers are constructed from 34-inch sections cut from rolls of extruded 6-mil, 11-inch layflat polyethylene tubing, available from Gemini Plastic Enterprises, Inc., 3574 Fruitland Ave., Maywood, California 90270. Lampblack and another compound included in the formulation inhibits degrada'tion of the polyethylene by ultra-violet radiation. One end of each 34-in. section is heat-hemmed to form a reinforced top and the other end is heat-seamed to form the bottom. Then, using a paper punch, drainage holes are punched into the bottom. A 6-in.-wide Futura Portable Poly Heat Sealer, available from Packaging Aids Corporation, 469 Bryant St., P. O. Box 77203, San Francisco, California 94107, has been used to heat the polyethylene in fabricating the containers.

Growth of tree roots to the full depth of the sleeve container, an initial uncertainty, was confirmed in the first year with the successful production of European hackberry and Chisos cherry (*Prunus serotina* ssp. *virens*), starting with seedling liners, age 2 years. After transplanting the liners into the sleeve containers, the containers are tied upright to a 2-foot-high wooden frame, made by nailing a 1 × 6 in. board onto 2 × 2 in. end stakes, driven securely into the ground. Four of these frames are each spaced 1 foot apart in 20-foot beds.

These and other kinds of trees grown in the sleeve containers and in standard-depth containers are now being tested under field conditions to determine any differences in root/shoot development. Treatment effects will be determined by measuring the cross-sectional root area of each tree, after Lindgren and Orlander (8), and possibly the dry weight of roots within a 1-foot-deep zone around each tree.

DISCUSSION

Trees that may be specially produced in the future to be compatible with sidewalks obviously would be targeted for a particular market, as, for example, municipalities, for planting along their streets. Their cost of production might be substantially more than for conventionally produced trees. A price differential for them compared with trees produced conventionally would have to be justified by improved tree performance as reflected in reduced long-term maintenance cost, particularly less sidewalk damage.

The person who expressed a passion for trees because "they give shade and are pretty" summed up the two basic benefits of urban trees. Discovering management strategies for throttling sidewalk damage by trees, a major and possibly unnecessary cost of their benefits, is the ultimate objective of these investigations. The nursery industry, at the front end of the "delivery system" which links producer with consumer, is a logical implementer of various products or practices which may be found desirable by these investigations.

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SEED COLLECTION AND CLEANING

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Seed collection and cleaning is an aspect of the nursery trade that is not taught in any college, university, or trade school. It is a skill acquired through apprenticeship or trial and error. Involved in the collection and distribution of seeds for 14 years, I have acquired some practical expertise.

Growers depend upon the seedsman to be a reliable and consistent source for seeds and information. Ability to meet grower needs without fault is our reputation.

Collection Sources. Much of the parent stock for regional outdoor ornamentals is available locally. Locations may be fields, nurseries, parks, schools, street plantings, or residences. Best times for locating plant material are often when the plant is highly conspicuous in bloom. Good record keeping and keen observation enable you to catalog an area on file cards and maps. A hand tape recorder allows hands-free data collection while traveling.

Habitat. Seed source should be appropriate for ultimate growing conditions. Collection locality should conform to the final growing habitat. Seedlings introduced into localities from outside their parental climate may lack adequate vigor and form.

Collection sites for cross-pollinating species must be isolated to avoid unwanted hybridization. Good examples are *Agapanthus* and *Eucalyptus*.