Selection and Propagation of Deep-Rooted Ornamental Trees for Urban Environments

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Ornamental trees in urban environments provide myriad biological, physical, economical and sociological benefits. Trees:

- provide a habitat for a wide range of animal life
- function as a cleansing mechanism for polluted air
- shade houses and other structures, thus reducing the need for electrically powered air conditioners during the summer
- provide an environment in which human beings can connect with nature

Some trees, however, have root systems that cause damage to sidewalks, curbs and gutters (Figure 1). This damage is the result of planting trees in planting areas that are too small or too narrow and/or the tree's inherent tendency to have shallow, horizontally developed roots. As these shallow roots produce secondary thickening growth, they tend to upheave pavements around them.

Several popular tree species have been associated with sidewalk and curb upheaval. They include: *Liquidambar styraciflua*, *Morus alba*, *Fraxinus spp.*, *Ulmus spp.*, *Magnolia grandiflora*, *Prunus*, Monterrey Pine, Blue Gum eucalyptus, and camphor (Hamilton, 1984a).

This problem is of major proportions in many cities in California (personal communications with Sacramento and Davis city arborists). In a survey of cities in the Bay Area in 1974, 60% of the street trees were estimated to have caused some or severe damage (Hamilton, 1984a). A more recent survey of sidewalks in San Jose, California found the estimated repair cost for tree related damage to be $14.3 million and annual concrete repair costs attributed to tree damage to range from $0.18 to $13.65 per tree (Peper and McPherson, 1995). It's quite apparent that even a partial solution to this problem would result in substantial savings for city governments.

Severe sidewalk and curb damage due to shallow tree roots and narrow planting strip. (Fig. 1)

Suggested and/or attempted solutions to this problem are myriad (Hamilton, 1984b). Most of them focus on management practices of one sort or another and include: careful water applications, growing trees in wider planting strips (Figure 2), increasing soil aeration, root pruning, root barriers, copper screening placed in trenches, avoidance by redirecting sidewalk paths (Figure 3), deep planting, and tree removal.

None of these mitigation steps alone has proved to be a satisfactory solution. The one approach that has not been taken is to identify, select and propagate trees that naturally have deep, vertically oriented root systems. This approach would involve the identification of existing non-troublesome individuals of tree species. Rooting depth and growth habit is a heritable trait and we are confident we can exploit this naturally occurring characteristic (Bowman, 1941). Variability has been shown in the form and in the primary and secondary growth of tree roots (Barker, 1987; Barker and Wagar, 1987; Coutts, 1987) and in the response of individual trees to root barriers (Harris, 1994). Furthermore, it has been stated that tree rooting characteristics should be taken into consideration in solving the upheaval problems and that the long term solution to root damage should include the selection of better species (Harris, 1994).

Sidewalk upheaval adjacent to a wide planting strip, due to shallow tree roots. (Fig. 2)

Phase I Objective

The objective of Phase I of the tree root study was to determine the 3-5 tree species in selected Bay Area and Central Valley cities that were responsible for causing the most damage to curbs and sidewalks in urban and residential areas due to invasive root systems. In the process of observing the damage caused by these species, we hoped to identify individual trees that exhibited the least damage which could then potentially be used as a source of propagation material (cuttings or seeds).

Six cities were visited between November, 1996 and February, 1997. Currently, these cities have active programs focused on curb and sidewalk replacement necessitated by aggressive growth of tree roots. Strategies to correct or avoid tree-related problems varied among cities and involved root pruning, use of barriers or tree removal followed by replacement with the same or, in some cases, smaller and less problematic tree species.

The following is a summary of the specific findings for each city. The lists of trees we observed were recommended by each city arborist:

Sunnyvale - Leonard Dunn: Tree species observed were *Fraxinus velutina 'Modesto', Liquidambar styraciflua, Pistacia chinensis*, and *Magnolia grandiflora*. Trees were planted in open and closed planting strips of varying widths (usually 4') in residential areas. Planting depths varied, making it difficult (especially in *Liquidambar*) to verify whether perspective candidates were grafted onto rootstocks or were growing on their own roots. Planting depth may also play a role in rooting behavior (*F.v. 'Modesto', Liquidambar*). Good candidates for future propagation were identified for *Pistacia* and possibly *Magnolia* and *Liquidambar*.

Redwood City - Bob Mullins: Tree species observed were *Liquidambar styraciflua, Fraxinus velutina 'Modesto'*, and *Platanus* spp. Trees were located in planting strips of varying widths (2' to 7.5') in residential areas. Several good candidates were identified for all species observed.

Modesto - Allan Lagarbo: Tree species observed were *Liquidambar styraciflua, Fraxinus velutina 'Modesto', Fraxinus angustifolia 'Raywood', Zelkova serrata, Celtis* sp, and *Gleditzia triacanthos*. Trees were planted in 4' strips as well as monolithic situations in residential areas. Good candidates were identified for *Liquidambar, Pistacia*, and *Zelkova*.

Palo Alto - Eugene Segna: Tree species observed were *Cinnamomum camphora, Magnolia grandiflora, Liquidambar styraciflua, Platanus* spp, and *Fraxinus uhdei*. Trees were planted in 4' strips or monolithic situations in residential areas. *Platanus* exhibited the least amount of damage, although *F. uhdei* exhibited relatively little damage considering the size of the trees (+/- 38" dbh). Rootstock identification will be necessary if this tree is chosen for long-term studies.

Two additional cities were visited to observe a single species. *Liquidambar styraciflua* was assessed along Rose Blvd. in Berkeley and *Zelkova serrata* was assessed in Sacramento on the CSU-Sacramento campus (in residence hall parking lots and along perimeter roads).

Based on these survey results, three species, *Fraxinus uhdei, Pistacia chinensis* and *Zelkova serrata,* were chosen as target species for continued research. Fifty seed-propagated liners of each species were planted in Spring, 1997 in field plots in Davis, California. After 18-24 months, the root systems of these trees will be exposed using hydroexcavation or similar technologies. The root systems will be photographed and modeled in three dimensions using computer software (PhotoModeler Pro 3.0, Eos Systems, Inc.). Those individuals with vertically oriented root systems will be selected, vegetatively propagated and planted out for below-ground analysis to see whether their characteristic root architecture is stable.

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Avoiding shallow tree root damage by redirecting the sidewalk path. (Fig. 3)