# HARDSCAPE DAMAGE BY TREE ROOTS

**by Lawrance M. Lesser**

**Abstract.** Tree root damage to hardscape is a problem for most cities, costing millions of dollars annually statewide for repairs and associated legal expenses. There is a need to systematically identify which tree species are the most often associated with hardscape damage, so that urban tree managers can make appropriate species selections. This study uses TreeKeeper® data to compile a listing of those species most often associated with hardscape damage in three southern California cities, and compares results from another study.

**Key Words.** Hardscape damage; street tree; roots; inventories; species selection.

The damage that tree roots cause to hardscape—sidewalks, curbs and gutters, asphalt, etc.—can be a large problem. Hardscape damage usually occurs as tree roots, mostly developing in the top 15 to 30 cm (6 to 12 in.) of soil, grow into the interface voids between concrete or asphalt and soil. As some roots increase in diameter, the resulting pressure can raise and crack concrete. This creates trip hazards, and local governments must spend a sizeable amount, approximately US$70.7 million annually in California, U.S., alone (McPherson 2000) to repair such damage. Lawsuits from trip-and-fall cases can cost cities much more in attorney's fees. Further, some of the methods used to resolve root–hardscape conflicts, such as root pruning, can harm or kill the tree (Thompson and Ahern 2000). Obviously, it is in everyone's best interests to find ways to reduce hardscape damage by tree roots.

Much of the damage caused by roots is preventable by making the right choices. Two recent surveys of California cities and counties (Bernhard and Swiecki 1993; Thompson and Ahern 2000) cite species selection as the most important method of reducing hardscape damage caused by trees. Simply put, it is generally accepted that some species are more prone to surface rooting and resulting hardscape damage than others. However, since very few studies have systematically identified those species most often associated with hardscape damage, urban forestry decision makers must rely on a combination of informational sources to make appropriate tree-related decisions. These sources include:

**1. Personal experience.** There is no doubt a very wide variety of tree care professionals' experiences that influence species selection; various professionals may have somewhat differing opinions of the same species, depending on their involvement with tree selection and care (Sommer et al. 1992). For example, trees associated with problems in one area may be well-behaved in others, which could lead to conflicting opinions about a species' behavior. Also, a preponderance of one species in an area could generate strong feelings towards it, even though other species may be linked to more problems.

**2. Reference works.** Sources such as the *Sunset Western Garden Book* (Sunset 1995) or the "SelecTree" Web site (Reimer and Mark 2001) offer a rating of trees based on damage potential. Reference works often draw their information from other reference works; for example, the SelecTree Web site notes that its information came from a combination of two sources, one of which is Pacific Gas and Electric's "TreeFinder" database; TreeFinder information, in turn, was culled from a number of other reference works (Dominguez, personal communication).

**3. Anecdotal reports and stories.** Verbally communicated information is notoriously prone to distortion with each retelling; information related to trees, when passed from person to person—even professionals—is no different.

**4. Information provided by other professionals.** Such professionals may, in turn, rely on the sources described above when hard data are not available.

A solid body of research, based upon actual conditions and situations, needs to be amassed to better understand which trees cause the most hardscape damage, and under what conditions, in order for decision makers to make better tree choices. The purpose of this initial study, therefore, was to compile a list of trees most often associated with hardscape damage, as determined by a multiple-city tree inventory.

## METHODS

Municipal street tree inventory data from the southern California cities of Temple City, Monrovia, and Rancho Cucamonga were used in this study. These cities are of similar climate [USDA zone 9, Sunset zones 18–20, characterized by hot summers and cool, wet winters, with 25 to 36 cm (10 to 14 in.) of annual rainfall] and are located in or near the foothills of mountain ranges to the north. Soils in these cities tend to be loamy to sandy, often alluvial in nature, and generally very well-drained.

The data were originally a part of survey data obtained from TreeKeeper® (a tree management software package published by the Davey Resource Group, a division of the Davey Tree Expert Company), as detailed in an earlier paper (Lesser 1996). TreeKeeper data usually include many dimensions of tree data, such as dbh (diameter at breast height) and growing space; data used in this paper were analyzed for species frequency, dbh, and association with hardscape damage (sidewalk and curb/gutter damage).

Trees were initially catalogued by city, species, and dbh. Trees less than 7.6 cm (3 in.) dbh were not included in this study, since trees this size have been considered either newly planted or still immature (Lesser 1996). In either case, small-dbh trees are unlikely to have root systems capable of damaging hardscape. Next, all remaining trees of a species associated with any amount of sidewalk lifting or curb/gutter damage were divided by the total number of trees recorded for that species, yielding a percentage of each species associated with hardscape damage. Approximately 32,000 trees were included as a part of the final inventory. The results of this analysis are listed in Table 1.

## RESULTS

Forty species were included in this study, in order to include the top 25 most common species in inland southern California (Lesser 1996). Table 1 ranks those species by percentage of specimens associated with hardscape damage, from highest to lowest. Median percentage of individuals of a given species associated with hardscape damage is 7.1%; 15 species are ranked as "higher than average," and 25 species ranked as "lower than average."

Contrary to what might be expected, there are only two large-statured species [species with the potential to grow over 18 m (60 ft) in height in southern California, as indicated in the *Sunset Western Garden Book* (Sunset 1995)] associated with greater-than-average hardscape damage. Instead, the majority of those above the median are of medium stature [9 to 18 m (30 to 60 ft)], while 11 out of 25 below the median are large-statured. This suggests that ultimate tree stature is not a good indicator of potential for hardscape damage.

It is also interesting to note that of inland southern California's ten most common street tree species, six species exhibit more than the median amount of damage. Furthermore, only two of the most recently planted species are associated with more than the median amount of hardscape damage (Table 1). These facts do not necessarily mean that deliberately "smarter" species selections are being made, but they may simply reflect current trends in species preferences.

Surprisingly, there are also some palms (which have close-knit, fibrous root systems) and some small-statured trees linked with hardsdcape damage. It is possible that the palms and small trees recorded here are not themselves causing damage, but that the damage is due to other causes (such as older trees removed from the same location).

**Table 1. Species rankings by percentage of specimens associated with hardscape damage. Large-statured trees [over 18 m (60 ft)] are in bold; medium-statured trees [9 to 18 m (30 to 60 ft)] are in plain typeface; small trees [under 9 m (30 ft)] are in italics. "Recently planted rank" indicates ranking of frequency of newly planted trees in inland areas; "inland rank" indicates species frequency ranking in existing inland street tree populations (Lesser 1996). Species above the line are associated with greater-than-average hardscape damage; those below, less-than-average.**

| Recently planted rank | Inland rank | Present study rank | Species | Number of trees | | |
|---|---|---|---|---|---|---|
| | | | | Total | Damaging | % Damaging |
| | | 1 | Acer saccharinum | 883 | 211 | 23.9% |
| | 19 | 2 | **Fraxinus uhdei** | 942 | 222 | 23.6% |
| | 15 | 3 | Ceratonia siliqua | 299 | 61 | 20.4% |
| | | 4 | Fraxinus velutina 'Glabra' | 531 | 98 | 18.5% |
| | | 5 | **Grevillea robusta** | 108 | 19 | 17.6% |
| | 4 | 6 | Cinnamomum camphora | 587 | 100 | 17.0% |
| | | 6 | Ulmus pumila | 230 | 39 | 17.0% |
| 1 | 1 | 8 | Liquidambar styraciflua | 5766 | 836 | 14.5% |
| | 22 | 8 | Brachychiton populneus | 76 | 11 | 14.5% |
| | | 10 | Ficus microcarpa nitida | 492 | 64 | 13.0% |
| | 6 | 11 | Quercus ilex | 713 | 82 | 11.5% |
| | 8 | 12 | Ulmus parvifolia | 1041 | 113 | 10.9% |
| 8 | 3 | 13 | Magnolia grandiflora | 1073 | 113 | 10.5% |
| | | 14 | Ligustrum lucidum | 163 | 14 | 8.6% |
| | 7 | 15 | Quercus agrifolia | 468 | 38 | 8.1% |
| | | 16 | Albizia julibrissin | 404 | 27 | 6.7% |
| | 10 | 17 | Jacaranda acutifolia | 633 | 32 | 5.1% |
| 7 | 11 | 18 | *Cupaniopsis anacardioides* | 1243 | 53 | 4.3% |
| | 25 | 18 | Pinus halepensis | 821 | 35 | 4.3% |
| 5 | 16 | 20 | Liriodendron tulipifera | 433 | 15 | 3.5% |
| | | 21 | Fraxinus velutina 'Modesto' | 254 | 8 | 3.1% |
| 3 | 9 | 22 | **Platanus × acerifolia** | 1884 | 39 | 2.1% |
| 9 | | 23 | Pinus brutia | 151 | 3 | 2.0% |
| 4 | 18 | 24 | **Alnus rhombifolia** | 1202 | 23 | 1.9% |
| | | 24 | Pinus thunbergiana | 420 | 8 | 1.9% |
| | | 24 | *Prunus cerasifera* | 316 | 6 | 1.9% |
| 2 | 2 | 27 | *Lagerstroemia indica* | 1327 | 24 | 1.8% |
| | 14 | 28 | Washingtonia filifera | 490 | 8 | 1.6% |
| | 20 | 29 | **Platanus racemosa** | 558 | 8 | 1.4% |
| | 24 | 30 | **Eucalyptus sideroxylon** | 571 | 7 | 1.2% |
| | | 30 | *Callistemon citrinus* | 333 | 4 | 1.2% |
| | 12 | 32 | Pinus canariensis | 1072 | 8 | 0.7% |
| | | 33 | **Cupressus sempervirens** | 327 | 2 | 0.6% |
| | 5 | 34 | **Washingtonia robusta** | 855 | 4 | 0.5% |
| | 13 | 35 | **Eucalyptus globulus** | 2738 | 5 | 0.2% |
| 6 | 17 | 36 | **Eucalyptus camaldulensis** | 1522 | 2 | 0.1% |
| | | 37 | **Eucalyptus maculata** | 467 | 0 | 0.0% |
| | 23 | 37 | Phoenix canariensis | 199 | 0 | 0.0% |
| 10 | | 37 | **Eucalyptus cladocalyx** | 169 | 0 | 0.0% |
| | 21 | 37 | Tristania conferta | 143 | 0 | 0.0% |
| | | | **Total trees:** | 31,904 | 2,342 | |

## DISCUSSION

Given these results, how does this inventory compare or conflict with other studies that explore rooting problems? Few published studies have actually examined which species are linked with hardscape damage, and to what degree; possibly the only other study in the western United States comparing damage by species was conducted in the San Francisco, California, area (Wagar and Barker 1983). Table 2 compares the result of that study, which included only ten species, with the present one. There is no direct agreement in ranking of species between these two studies. Sample size, which could generate skewed data depending on where one collects it, could be the primary explanation for the differences in these two studies; Wagar and Barker (1983) sampled only 763 trees, whereas the present study used almost 32,000 trees. In spite of this, however, it is interesting to note the species common to both studies, and generally ranked as having a high association with root-sidewalk problems: *Liquidambar styraciflua, Magnolia grandiflora,* and one or more *Fraxinus* species.

**Table 2. Comparison of species rankings by degree of hardscape damage from the current inventory and a case study. Large-statured trees are in bold; small trees are in italics. Numbers next to species in the case study are that species' rank in the present study.**

| Rank | Inventory (present study) | Case study (Wagar and Barker 1983) |
|---|---|---|
| 1 | Acer saccharinum | Liquidambar styraciflua (8) |
| 2 | **Fraxinus uhdei** | Morus alba |
| 3 | Ceratonia siliqua | **Fraxinus uhdei** (2) |
| 4 | Fraxinus velutina 'Glabra' | Fraxinus velutina 'Modesto' (21) |
| 5 | **Grevillea robusta** | Ulmus parvifolia (12) |
| 6 | Cinnamomum camphora | Magnolia grandiflora (13) |
| 7 | Ulmus pumila | **Platanus × acerifolia** (22) |
| 8 | Liquidambar styraciflua | Ligustrum lucidum (14) |
| 9 | Brachychiton populneus | Myoporum laetum |
| 10 | Ficus microcarpa nitida | *Prunus cerasifera* (26) |

Of course, many factors may contribute towards tendencies to surface root, such as 1) genetic tendency of a species towards shallow rooting, 2) watering regimes (shallow watering encourages surface-rooting), 3) small planting spaces and/or proximity to hardscape (Francis et al. 1996), and 4) site-specific conditions (such as excessive soil compaction) that impede root growth and contribute to surface rooting. The genetic potential of the rootstocks of grafted trees should also not be overlooked. It should be noted, however, that both Wagar and Barker (1983) and Costello et al. (2001) determined that there is a small to negligible effect of soil type on sidewalk damage by roots; therefore, soil type could be eliminated as a factor in surface rooting. It is also possible that more "tree-progressive" cities may make better species selections, or take other measures to reduce root damage potential (such as better preparation and design of planting spaces), ultimately skewing data collected through inventories; this is an interesting topic for future research.

## CONCLUSIONS

This study is but one step toward amassing hard data regarding which species actually cause hardscape damage. Also, given the possible causes for hardscape damage, the data presented here should be evaluated critically and not be used as a clear-cut guide for selecting street trees based on hardscape damage potential. A future study is planned that will examine the top species associated with hardscape damage by dbh and growing space, and may provide more detailed (and useful) data.

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**Résumé.** Les dommages par les racines d'arbres aux infrastructures de rues sont un problème pour la plupart des villes et qui coûtent des millions de dollars annuellement pour l'ensemble de l'état en réparations et en frais légaux inhérents. Il y a un besoin pour identifier systématiquement quelles sont les espèces qui sont le plus souvent associées à des dommages aux infrastructures, et ce afin que les gestionnaires d'arbres en milieu urbain puissent faire une sélection d'espèces appropriées. Cette étude fait usage de données provenant du logiciel TreeKeeper® pour compiler une liste des espèces les plus souvent associées à des dommages aux infrastructures dans trois villes du Sud de la Californie et ensuite pour comparer ces résultats avec ceux d'une autre étude.

**Zusammenfassung.** Für die meisten Städte sind die Schäden an Straßenbelegen durch Baumwurzeln ein großes Problem, welches jährlich bundesweit Millionen Dollar für Reparaturen und Verwaltungskosten verschlingt. Es besteht der Bedarf, diejenigen Baumarten zu identifizieren, die überwiegend mit den genannten Schäden assoziiert sind, so dass die Grünflächenämter entsprechende Auswahlen treffen können. Diese Studie verwendet TreeKeeper® data, um die fraglichen Baumarten, die mit Schäden in drei südkalifornischen Städten in Verbindung gebracht werden, zu erfassen und die Ergebnisse mit anderen Studien zu vergleichen.

**Resumen.** El daño de las raíces a la infraestructura es un problema para la mayoría de las ciudades, costando millones de dólares anualmente su reparación y gastos legales asociados. Existe la necesidad de identificar sistemáticamente cuáles especies de árboles son las más frecuentemente asociadas con estos daños, con el fin de que los planificadores urbanos hagan las selecciones apropiadas. Este estudio usa los datos de TreeKeeper® para compilar una lista de estas especies asociadas con daños en tres ciudades del sur de California y compara los resultados de otros estudios.