STREET TREE DECLINE AND CONSTRUCTION DAMAGE

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Abstract. Construction damage from street widening, and curb and sidewalk replacement were found to negatively affect both tree survival and condition. Trees in narrow tree lawns suffered the greatest reduction in condition from construction damage. Construction damage was found to have a high economic impact on street tree value.

Street trees, sidewalks, and curbs are positive components of the urban infrastructure; however, these features often come into conflict with one another. Tree roots may lead to sidewalk and curb lifting, and potential liability (2).

Replacement of sidewalks and curbs is costly to both taxpayers and trees. In 1975, 22 California cities incurred an average annual cost for sidewalk repair of $27,000 (2). Although some municipalities have professional forestry input during sidewalk replacement, most have no requirement for inspection of repair work by a competent arborist (5,7).

The relationship between injury to tree roots and tree health is known (1). Damage to roots from construction activities such as soil compaction, placing fill over roots, root severing, and drainage pattern changes often causes tree decline and death (6). Reconstruction of city streets, curbs, and sidewalks is often blamed for street tree decline, but the extent of the problem is unknown.

This study assesses damage to street trees from sidewalk replacement, street widening and curb replacement by comparing the survival and condition of these trees to trees on streets where construction has not taken place.

Methods

A partial tree inventory conducted in 1979 by the Bureau of Forestry in Milwaukee, Wisconsin provides a historical record of a street tree population. Of approximately 80,000 trees inventoried in one district of the city, 15% had been subjected to construction related injury from 1981 to 1985.

Construction projects involving sidewalk repair, street widening, and/or curb reconstruction form 1981-1985 were selected for the tree sample population. One hundred projects (20/year) were randomly selected, and one block sections were randomly selected from these 100 projects. Construction damage was prioritized by the level of disturbance in the following descending order: street widening and curb setback; combined curb and sidewalk replacement; curb replacement; and sidewalk replacement. Fifty blocks (10/year) with the highest disturbance levels were selected using the above level of disturbance criteria. Of these, 25 blocks with the greatest species diversity were chosen for the sample. Control trees (undamaged trees) were located on blocks which were the first non-construction block nearest to each construction site. For both construction and control blocks the first 25 trees per block were sampled.

The following data were collected for each tree sampled (control and treatments); diameter at 4.5 ft. above ground level, species, tree lawn width (curb to sidewalk), and Council of Tree and Landscape Appraisers (CTLA) tree condition rating (100, 80, 60, 40, 20, and 0 percent). The type of construction activity was noted for trees affected (treatments). The 1979 tree inventory was examined to determine if each existing tree was a survivor, replacement, or an addition to the tree population after 1979.

Initial analysis used a z-test to compare tree survival from 1979 to 1989 between construction and control blocks for trees. A Chi square test was used to determine if similarity existed between construction and control blocks prior to construction projects, and if differences in tree condition occurred by 1989. Further analyses tested differences between tree condition and tree lawn width, tree species, and tree diameter using Analysis of Variance (ANOVA) one way and two way procedures. Only trees present from 1979 to 1989 were used to test for significant differences, with the exception of the tree survival test. All significant differences are at the .05 except were noted.

Results

A total of 989 trees were sampled from inventory data, with 510 occurring on construction blocks and 479 on control blocks. Of the 989 trees sampled, 670 trees survived from 1979 to 1989, 175 trees had been replaced sometime during the period, and 144 trees were new to the population since 1979. Of 15 tree species found on sample blocks, three were used in the analysis since they represented the majority of the sample (74%) and the street tree population of Milwaukee. These species are green ash (*Fraxinus pennsylvanica*), honeylocust (*Gleditsia triacanthos*) and Norway maple (*Acer platanoides*).

Tree condition and survival. Prior to implementing construction projects, no significant difference was found between tree condition on construction damaged (77.2%) and control (77.7%) trees in 1979. However, a significant difference was found between tree condition on construction (71.1%) and control (76.7%) blocks for trees surviving from 1979 to 1989 (Table 1).

Between the years 1979 and 1989, 81.4% of the control trees and 77.3% of the construction damaged trees survived. These survival percentages were significantly different at the .10 level using the z-test (Table 2).

Tree lawn width. Significant differences were found in tree condition relative to tree lawn width when construction damaged and control trees were compared (Table 3). As lawn width decreases tree condition decreases for both construction and control trees, but it decreases more for construction damaged trees. For construction blocks significant difference occurred between lawn widths of < 8 ft, and > 10 ft using the ANOVA one way procedure. For control blocks significant differences occurred between lawn widths of < 8 ft, and 8 to 9.9 ft. and between 4 - 7.9 ft, and > 10 ft. Lawn widths < 4 ft and > 10 ft. were not significantly different for control blocks. However, a significant difference between < 4 ft. and > 10 ft. for construction blocks was found. The ANOVA two way procedure revealed significant difference between lawn widths (.002) independent of construction or control blocks, and a significant difference between construction and control blocks (.000) independent of lawn width. Two way interactions between lawn

Table 1. Percent tree condition of street trees damaged by construction between 1981 and 1985 versus undamaged trees.

Evaluation date	Percent tree condition: Construction	No construction
1979	77.2a	77.2a
1989	71.2a	76.6b

Means in same row following with a different letter are significantly different (.05% level) using a Chi-square test.

Table 2. Percent tree survival from 1979 to 1989 for street trees damaged between 1981 and 1985 and undamaged by construction.

Tree status	Number of trees 1979	1989	Percent* survival
Damaged	432	334	77.3
Undamaged	413	336	81.4

*Percent survival significantly different (.10% level) using a z-test.

Table 3. Reduction in tree condition percent of construction damaged and undamaged street trees by tree lawn width.

Lawn width (feet)	Tree condition (%): Undamaged	Damaged
<4	75.8ab	66.0a
4-7.9	74.8a	69.6a
8-9.9	80.4c	73.0ab
>=10	78.2bc	74.2b
Average	76.7	71.1

Means in same column followed with a different letter are significantly different (.05 level) using Student-Newman-Keuhl's.

width and construction and control blocks reveled no significant differences.

Tree species. Significant differences in tree condition between construction and control blocks were found using the ANOVA two way procedure for green ash, honeylocust, and Norway maple. No significant differences were found between green ash, honeylocust, and Norway maple in comparing their mean tree condition for both control and construction blocks separately with the one way procedure.

Tree diameter. Tree diameters were grouped into three diameter classes (< 7 in, 7-12 in., and > 12 in.) ANOVA one way procedure analysis resulted in no significant difference in condition between the three diameter classes on construction blocks.

Discussion

Results from this investigation associate street and sidewalk construction projects with reduced tree survival and tree condition. Trees damaged by construction activities had 22.7 percent mortality five to eight years later, compared to a control tree mortality of 18.6 percent for the same time period. Of greater significance is the reduction in tree condition associated with construction damage. Tree condition did not change for control trees, but did decline significantly from 77.2 percent to 71.1 percent five to eight years later for trees damaged by construction.

Width of the tree lawn was found to influence tree condition of both treatment and control trees. Trees on narrow lawns had lower conditions. This is to be expected as narrow tree lawns provide less rooting space. Additionally, trees were found to have even lower condition ratings in narrow lawns where l981 to 1985 construction activity damaged root systems. In recommending the safe distance from the tree trunk to sever root systems in sidewalk and curb/gutter renovation, Harris (3) states you can safely cut at the area where root caliper begins to markedly decrease. He further observed that no large horizontal or sinker roots extend beyond 6-10 feet from the trunk. This is supported by Lyford (4) who found that the central root system of northern red oak (*Quercus rubra*) extends 3.5 to 7 feet from the trunk and consists of main laterals, and numerous vertically and obliquely descending woody and non woody roots. Hamilton (1) observed that a high percentage of water and nutrient absorbing roots are close to the tree trunk and most sinker roots are within four feet of the trunk. Based on these observations sinker root damage maight not occur in lawn widths beyond 8-10 feet. Reduced damage to sinker roots may explain the similar tree condition which occurred on construction and control blocks at the 8-9.9 and >= 10 ft. lawn widths.

While construction damage was found to negatively influence tree condition, this decrease in condition was independent of tree species and tree size.

Economic implications. Assuming an average value of $1,100 per tree in the City of Milwaukee, the population of 200,000 street trees has a value of $220 million. Approximately 3% of the street tree population was subjected to construction projects each year during the study period (1981-1985). Projected to the entire population, this represents 6,000 trees damaged per year with a value of $6,600,000. Subtracting for a condition class reduction of 6.1% (from 77.2 to 71.1%), this translates into a loss of approximately $521,500 per year in tree value. Likewise, mortality associated with construction damage was 4.1 percent higher (81.4% survival versus 77.3 %). A mortality rate of 4.1 percent of 6,000 trees damaged per year is an additional loss of 246 trees per year with a value of $270,600. Assuming 3 percent of the street trees in Milwaukee are affected by construction damage each year, the total annual loss in tree value is $792,100 ($521,500 + 270,600).

Summary

Prevention of sidewalk and curb lifting would save costs associated with repair of these structures, maintain tree condition class (tree health), and prevent decline in tree value of the urban forest. Many methods have been proposed to reduce or prevent lifting including root barriers, herbicide impregnated geotextile fabrics, watering management, and an adequate tree lawn width. Tree lawn widths of ten feet or wider may reduce lifting of sidewalks and curbs. Even if lifting occurs, our investigation indicates that tree condition reduction from construction projects is less with greater lawn widths. Yet even with wider tree lawns, planting the tree too close to sidewalks or curbs will result in greater lifting and damage from the repair process.

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Résumé. Les dommages par les travaux de construction lors de l'élargissement de rues, de la modification de courbes et du remplacement de trottoirs étaient des facteurs considérés comme affectant de façon négative à la fois la survie et l'état de santé de l'arbre. Les arbres sur des terrains étroits souffrent le plus d'une réduction de l'état de santé lors des dommages causés par les travaux de construction. Les dommages par les travaux de construction étaient jugés comme ayant un grand impact sur la valeur immobilière des arbres.

Zusammenfassung. Bauschäden durch Strassenverbreiterung und Bordstein- und Bürgersteig- erneuerungen haben nachweislich negative Auswirkungen auf Überlebensrate und Kondition der Bäume. Bäume in engen Baumpflanzungen erlitten die größten Einbußen an Kondition durch Bauschäden. Bauschäden haben nachweislich einen hohen ökonomischen Einfluß auf den Wert von Strassenbäumen.