Research Note

PRELIMINARY FINDINGS FROM MEASURING STREET TREE SHOOT GROWTH IN TWO SKELETAL SOIL INSTALLATIONS COMPARED TO TREE LAWN PLANTINGS

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Skeletal soils include a group of designed planting media variously called structural soils, or stone matrix soils (Bassuk et al. 1998; Gamstetter 1998; Grabosky et al. 1998; Kristofferson 1998). They have been developed to improve street tree establishment and growth in paved situations. Before pavement is laid, the subgrade and base layers of a pavement section must be compacted to meet engineers' specifications for load-bearing. This often leads to soils that are too dense for root penetration. Skeletal soils, when designed correctly, create a rigid matrix with large pores to allow root growth without sacrificing soil load-bearing capacity.

The discussion about use of skeletal soils, their practicality, and their long-term efficacy has grown over several years. However, there is little long-term data on skeletal soil used in actual pavement systems. Toward that end, trees established in one type of skeletal soil profile (CU Structural Soil®) are being monitored annually to track tree growth response. The chosen installations have trees growing in paved systems and lawn areas for comparison, and replicates were chosen to minimize influence from confounding variables such as levels of use, sunlight, wind, and adjacent building height. This technical note presents preliminary data on two sites being monitored. The two projects were installed in fall 1997. The first project was located on Lorimer Street adjacent to McCarren Park in Brooklyn, New York, U.S. The second project was part of a New York State Department of Transportation street renovation in Ithaca, New York.

MATERIALS AND METHODS

Quercus bicolor and *Q. phellos* trees, 5.1 to 7.6 cm (2 to 2.5 in.) in caliper were planted in the McCarren Park project. The species were planted on either side of the north- and south-running street with the east-side trees planted into a soil tree lawn area of pre-existing sandy soil with a 6-m (20-ft) minimal width. Trees were planted 1.8 m (6 ft) from the sidewalk. The trees on the west side were placed in a 80% by weight 1.9-cm (0.75-in.) granitic crushed stone, hydrogel-stabilized skeletal soil material, based on research at Cornell University (Grabosky et al. 1998). The skeletal soil volume was placed in a 0.9-m (3-ft) deep and 2.1-m (7-ft) wide trench between a 0.9-m-tall park wall and the street curb, representing the entire sidewalk width. The 0.9-m square pavement openings were next to the wall. There were no shadows from neighboring structures shading the site. Trees for the Ithaca project were specified as 5.1 cm (2 in.) in caliper when first installed into a CU Soil based on the same research at Cornell, with 80% crushed gravel 2 to 2.5 cm (0.8 to 1.0 in.). No supplemental irrigation was employed. Field mortality and subsequent replanting has been noted for future analysis.

Species used in the Ithaca project were *Acer campestre*, *Prunus* 'Accolade', *Syringa reticulata*, *Zelkova serrata* (cultivar unknown), and cultivars of *Malus* sp. The installation listing for the crabapples were only by flower color—red or white. The red cultivars supplied were 'Adams', 'Centurion', and 'Prairifire'. The white cultivars were 'Harvest Gold', 'Ormiston Roy', and 'Sugar Tyme'™. Information on cultivar placement was not documented, so the crabapples were visually checked to eliminate flower color as a covariate in the analysis, since there was the potential to have single cultivars placed entirely in one treatment, which would influence the data. Trees were planted over several streets within a 2- to 3-block radius as part of a major street renovation project. Trees were planted in the skeletal soil material and a tree lawn vegetation strip. The 80% (by weight) limestone crushed gravel, hydrogel-stabilized skeletal soil material was placed 0.46 m (18 in.) deep in a continuous 1.8-m (6-ft) wide trench with pavement square openings of 1 m (40 in.). Soil in the 1.8-m-wide tree lawn strips was a sandy loam (Buckstrup and Bassuk 2000). The streets were adjoined by one- to two-story commercial buildings. The Ithaca trees were irrigated bi-weekly during their first year of establishment and periodically thereafter with irrigation bags (TreeGator® Spectrum Products Raleigh, NC).

Trees have been monitored for three years at the time of this report. Of the parameters in consideration, annual shoot extension on three randomly selected exterior shoots from the middle one-third of the Ithaca tree canopy and the top two-thirds of the Brooklyn tree canopy were recorded, measuring the length from the end of the shoot to the terminal bud scars of the previous year. Due to lack of balance in data sets (an artifact of the opportunistic approach and costs associated with streetscape pavement projects), the mean for each tree was tabulated, ranked, and evaluated within species by soil treatment in nonparametric analysis. The medians of shoot length data on each species within each treatment were analyzed with a Mann-Whitney confidence interval test.

RESULTS AND DISCUSSION

Differences in shoot growth between the two planting situations showed either comparable growth between lawn and paved skeletal soil installations or that the trees in the skeletal soil were growing more. Notable differences in the Ithaca set were increased shoot growth in the skeletal soil profile for *Malus* sp. at a level of significance of 0.003 and *Zelkova* at 0.06 (Table 1). At the Brooklyn site, there was an increase in *Quercus bicolor* growth in the skeletal soil treatment at a 0.07 level of significance (Table 1). In addition to the differences observed in the study, the lack of differences in the other species also is important since this was a comparison between a noncompacted lawn and a purposely compacted pavement installation where, in the latter case, one would expect reduced growth.

These preliminary data are consistent with previous observations and conclusions that the skeletal soil strategy is effective in the establishment phase of street tree life; however, the data stand in contrast to earlier field experimental data collected in 1998 at the same post-transplant time frame of three growing seasons in a skeletal soil profile (Grabosky 1999). In the earlier controlled field experiment, shoot growth of *Acer campestre* was over 30 cm, as compared to only 3 cm in the Ithaca street tree project. In the same previous study, there was no difference in shoot growth between *Malus* sp. 'Adirondack' (Grabosky 2001) in a paved versus mulched field-grown control. This is different from the observations on Ithaca street tree planting where shoot growth was significantly increased in the skeletal soil. The earlier study found *Malus* shoot growth in excess of 30 cm, which is comparable to the skeletal soil profile for the Ithaca street tree project (33.1 cm median shoot growth) (Table 1).

The small pavement openings in these installations will become problematic as the trees grow. It is important to consider pavement opening dimensions in skeletal soil installations. Since skeletal soils are designed to safely support unit pavers in wider openings, they can be easily removed as the trunk and buttress roots impact on the pavement. We have observed mower contact with trees during collection of the Brooklyn data, and there have been higher levels of mortality on the tree lawn treatment groups to date. There are several uncontrolled variables inherent in the opportunistic comparison of working installations. Competition from the surrounding turf in the vegetation strip can decrease growth (Green and Watson 1989). The quality of the existing site or soils used on a project can have an influence on the viability of a tree planting as can the construction activities that occur in the placement and construction of the site. Further definition and testing of confounding variables are part of the continued research on these sites.

Table 1. Shoot extension on tree species in two test sites comparing "CU Structural Soil" to tree lawn installations using a nonparametric analysis of medians with Mann-Whitney confidence intervals. Data are from the third year after transplanting for both projects.

Project/species	Median shoot length in centimeters (number of replicates): Tree lawn installation	"CU Structural Soil" installation	Alpha level of significance
Brooklyn, NY			
Quercus bicolor	14.7 cm (16)	25.5 cm (14)	0.07
Quercus phellos	13.3 cm (7)	17.2 cm (10)	0.38
Ithaca, NY			
Acer campestre	7.5 cm (12)	3.6 cm (11)	0.37
Malus sp.	17.1 cm (19)	33.1 cm (25)	0.003
Prunus 'Accolade'	6.1 cm (4)	8.3 cm (4)	0.67
Syringa reticulata	6.0 cm (4)*	7.0 cm (15)	0.65
Zelkova serrata	39.9 cm (4)	85.0 cm (4)	0.06

*Lack of balance reflects heavy mortality of *Syringa reticulata* in the tree lawn between observations in the first and second year.

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