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Salt and Milwaukee street trees

Susan Van Wyck
University of Wisconsin - Milwaukee

Forest Stearns
University of Wisconsin-Milwaukee

SALT AND MILWAUKEE STREET TREES

Trees help to make urban life livable. They improve the physical environment of the city and provide a feeling of security and mental well-being that the urbanite does not find in stone, brick and glass. Yet, despite their apparent strength and the feeling of permanence they give, city trees are subject to many stresses and are relatively short-lived.

Many trees are not well-adapted to the rigors of urban life. Some are highly susceptible to the effects of SO_2. Others, such as the oaks, grow too slowly while cottonwood and horse chestnut for example, good city trees, in most respects, produce quantities of fruit or seeds considered a nuisance by many residents. Trees best adapted to urban life appear to be those native to floodplains such as elm, ash, silver maple and sycamore. These species evolved to survive spring floods, summer droughts and therefore are better suited to the poorly aerated city soils. Since the rapid demise of elms as a result of the Dutch elm disease trees planted most frequently in Milwaukee have been maple, ash, and honeylocust. Many of these trees are now 15-25 years old and are beginning to show the effects of urban life.

The problems of city trees include drought, 'bumper' disease, vandalism, natural gas leakage, herbicide application, 'backhoe root,' air pollution, fungal infections and insect infestations. In northern cities, the effects of deicing salt combined with soil compaction seem to be especially significant.

In the city of Milwaukee alone, 38000 tons of deicing salt were applied in 1976 to the 800 miles of city streets; in 1977, 32,600 tons were applied. The physiological effect of salt in the soil was exacerbated in the spring of 1977 by a prolonged spring drought. The primary effect of salt is to reduce the availability of water to the plant by increasing the osmotic value of the soil solution and making if more difficult for the plant to take in water. In addition, both sodium and chloride ions are absorbed and translocated within the tree, resulting in injury to the leaves such as leaf curl or scorch.

Heavy losses of trees and damage to sugar maple have been seen in several cities in the United States. For several years, this 'decline,' as it is called, has been evident in the northwestern portion of Milwaukee where sugar maple has been planted extensively. At the time of the federal land survey (1833) this area was classed as beech-maple forest; since then environmental conditions have changed drastically so that these species are no longer successful.

Sugar maple appears particularly susceptible to salt damage with reduced shoot growth, the death of terminal buds and a variety of leaf symptoms, summer reddening or yellowing and leaf scorch (Westing 1966). Kotheimer (1967) listed other sensitive species as red maple, basswood, elm and several conifers. Species tolerant of salt are: red cedar, some oaks, white ash, black locust, norway maple and several birches. Other common trees are intermediate in salt tolerance.

This study, begun in the spring of 1977, was planned to examine the effects of road deicing salt on the growth of Milwaukee street trees. (Van Wyck 1978). Particular attention was given the problem of maple 'decline.'

METHODS

Three species, sugar maple, (*Acer saccharum*) Marshall's seedless ash (a variety of green ash) (*Fraxinus pennsylvanica*) and skyline honeylocust (cultivar of *Gleditsia triacanthos*) have been planted extensively in Milwaukee. These three species were chosen for study. With advice from the city of Milwaukee Bureau of Forestry,[1] 10 quarter sections and 5 street transects were selected in the northwestern and eastern sectors of the city (Fig. 1). Between August 8 and August 21, 1977, 228 trees were examined. For each tree, the diameter at breast height, condition of the crown, condition of the bole, distance from the pavement, probable nearby fertilizer or herbicide usage and maple decline symptoms, if present, were noted. Soil samples were obtained around each tree approximately 12 inches from the trunk on each of the four cardinal directions. A soil probe was used to sample to an 8 inch depth; the four samples were combined, air dried and utilized for nutrient and soluble salt analyses. Soluble salt content (millimhos conductivity per centimeter) was measured on 228 soil samples using a Beckman Solubridge Soil Tester. Organic matter content, pH, phosphorus and potassium levels were determined for 139 samples by the UW Soil and Plant Analysis Laboratory. Regression correlation analysis was used to examine relationships between tree growth rate or leaf scorch and soluble salts.

RESULTS

The soluble salt content of the soil proved to be low even along heavily salted streets. Average conductivity was 0.25 mh per centimeter, slightly higher conductivities (0.4-0.6 mh/cm) were found adjacent to parking lots and along several of the major streets while quiet, residential streets often showed an average conductivity of 0.27 mh/cm. The literature suggests that these levels are not sufficient to have any direct biological effects. The soil samples were collected in August 1977; to examine the possibility that the low values resulted from seasonal effects additional samples were collected in April, 1978. The April samples showed conductivity levels equivalent statistically to those taken in August. Westing (1966) suggested that heavy spring rains, runoff from

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1 This study could not have been done without the help of the City Forester, Robert Skiera, and members of the Forestry Bureau. Their assistance is greatly appreciated.

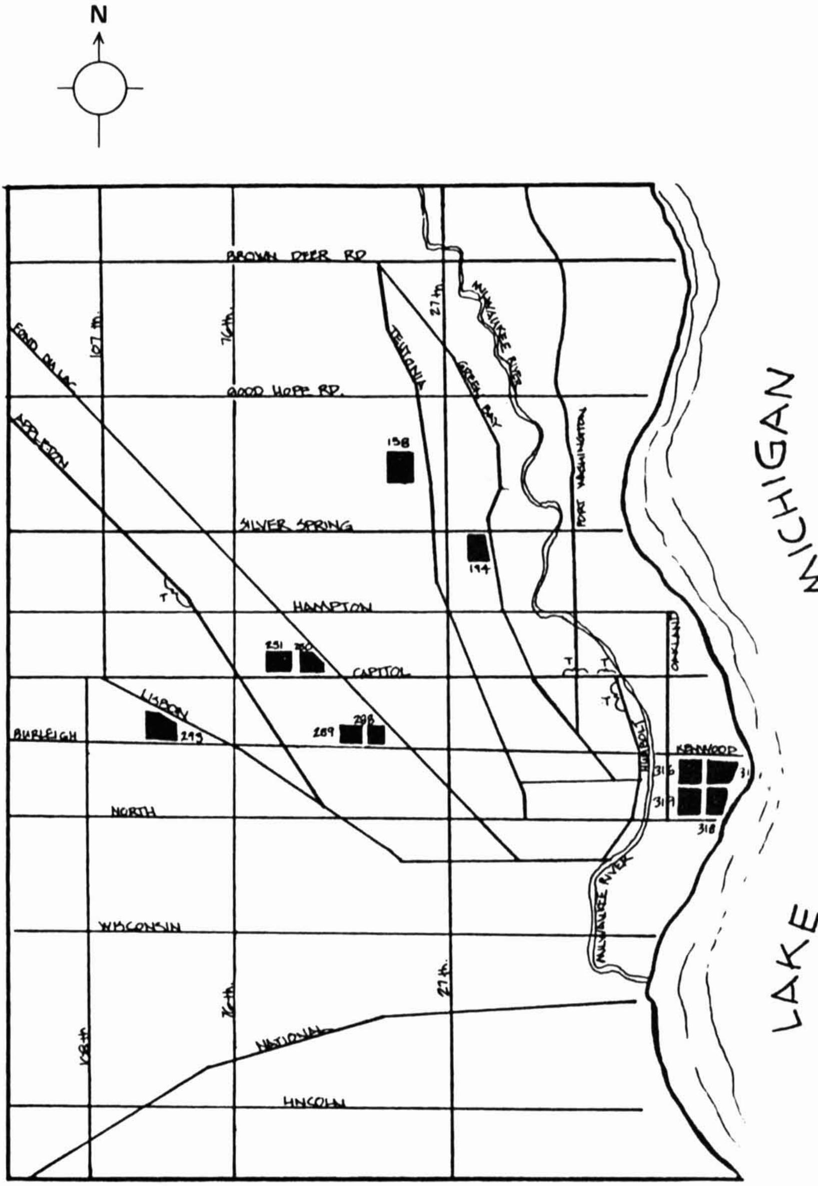

Fig. 1. Location of study sites in the city of Milwaukee. Numbers identify the quarter section and 'T' a transect.

pavement, and impermeable topsoils may prevent accumulation of deicing salts; that appears to be the case in Milwaukee. Nearly all trees studied were growing, whether on natural soil or fill, in clay or clay loam, usually with a clay substrate, characteristic of most Milwaukee urban soils.

Twig length is not the ideal measure of growth rate. It was used because urban residents often object to the use of increment borers to obtain cores from tree trunks – this despite the fact that the city owns the trees and the taking of increment cores rarely causes damage.

Twig length proved to be highly variable (Table 1). Skyline honeylocust showed the greatest yearly growth (17.1 in.), Marshall's ash was intermediate (9.6 in) and sugar maple the least (6.5 in). These values represent the average annual growth of the last three years. No correlations were found between twig length and soil salt content, nor were any correlations evident between the degree of scorch or similar symptoms in sugar maple and soil salt content (Tables 1, 2 and 3).

Exact data on tree age were not available. Sugar maples ranged from 17-19 years of age, a few being older, and honeylocust and Marshall's ash between 15 and 20 years. The average dbh was 5.3 in., 4.3 in. and 4.2 in. for sugar maple, Marshall's ash and skyline honeylocust, respectively.

In addition to possible direct effects on plants, deicing salt may also influence soil characteristics resulting in puddling and the loss of organic matter. An attempt was made to study soil compaction in this study. However, virtually all soils in which these trees grew were found to be exceedingly compact, a result of the fine soil texture and of filling and trampling. Surface soils varied considerably from about 60 pounds sq in (psi) to averages (for several quarter sections) of over 140 psi. Compaction increased rapidly with depth and at the 18" depth, all soils, save those in one area, gave penetrometer readings of 290-300 psi and thus were exceedingly compact.

CONCLUSIONS

Our results indicate that the level of soluble salt remaining after winter in Milwaukee urban soils is probably not high enough to directly influence the growth of street trees. However, the field observations clearly indicate that there is a maple 'decline' problem. The compact heavy clay and clay loam soils reduce infiltration so much salt is removed by surface runoff. Nonetheless uptake may take place and sugar maple has been shown to be sensitive to effects of concentrations of both Cl^- and Na^+ (Kotheimer 1967).

During the study leaf symptoms were observed on maple especially during dry periods. It is probable that the inability to obtain sufficient mositure, for whatever reason, is a major factor in the decline of maple and perhaps of other Milwaukee street trees. Despite an average annual rainfall of over 30 inches, water is in short supply for trees in the city; this must be borne in mind when choosing and planting street trees.

Marshall's seedless ash appeared to be the tree best adapted for Milwaukee planting since it is resistant to drought, grows vigorously and has a desirable form; some trunk cracks were evident. Skyline honeylocust is late to leaf out in

Table 1

Mean annual twig growth and soluble salts in soil by quarter section and transect and correlation between growth and salts				
Quarter section or transect	Species[1]	Annual twig growth[2]	Soluble salt average[3]	Correlation coefficient
194 NW	SM	5.48	0.23	-0.03
158 NW	SM	8.99	0.23	-0.32
251 NW	SM	6.92	0.25	0.24
250 NW	SM	5.13	0.23	0.38
293 E	MA	9.38	0.27	0.47
319 E	MA	9.48	0.21	0.43
318 E	MA	10.77	0.23	0.38
Cap. E	MA	7.60	0.60	-0.20
316 E	MA	9.36	0.18	0.83
317 E	MA	9.68	0.22	-0.65
Cap. E	SL	17.86	0.29	0.40
Hum. E	SL	16.03	0.19	-0.26
App. NW	SL	21.81	0.40	0.46
288 NW	SL	19.16	0.21	-0.17
Lake E	SL	10.56	0.16	0.61

1. SM=sugar maple MA=Marshall's ash SL=Skyline Locust
2. annual twig growth averaged over three years (inches)
3. expressed in millimhos/centimeter

Table 2

Regression Correlation Analysis – Annual Twig Growth Versus Soluble Salts

	Sugar Maple	Marshall's Ash	Skyline Locust
Mean of Soluble Salts[1] (x)	0.24	0.26	0.26
Mean of Annual Twig Growth[2] (y)	6.53	9.63	17.11
Standard Deviation (Soluble salts)	0.08	3.10	0.16
Standard Deviation (Twig growth)	4.14	3.04	6.26
Correlation Coefficient (r)	0.03	-0.10	-0.09
Sample Size (n)	89	83	56

1 annual twig growth, averaged over three years, in inches
2 expressed in millimhos/centimeter

Table 3

Linear regression between leaf scorch symptoms and soluble salts

Leaf Scorch Rating
0-no leaf scorch symptoms 1-leaf tip scorch on a few leaves 2-leaf tip and marginal scorch 3-leaf tip and marginal scorch on most leaves 4-most leaves on tree exhibit scorch affecting most of each leaf, some defoliation 5-most leaves exhibit scorch affecting most of the area of each leaf, considerable defoliation

Regression for Sugar Maple

Average of soluble salts-0.24
(x)
Average of leaf scorch rating-1.8
(y)
Soluble salt deviation-0.30
Leaf scorch rating deviation-1.2
Correlation Coefficient-0.06

spring and has a growth from considered less desirable. It is a tree well adapted for urban planting since it grows rapidly and has proved hardy.

Although this study did not produce direct evidence of the effect of salt damage, it did demonstrate and quantify characteristics of several commonly planted city trees. Further work on the water balance of urban trees and on the fate of road deicing salt is indicated.

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Susan Van Wyck and Forest Stearns
Department of Botany,
The University of Wisconsin–Milwaukee