ENVIRONMENTAL FACTORS AFFECTING TREE HEALTH IN NEW YORK CITY

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A major problem facing the arborist is choosing tree species suitable for urban plantings. A wide variety of biologically important stresses limit tree growth in cities. Because metropolitan tree planters tend to choose only those species commonly known to be tolerant of urban stresses only a few species of trees are found in cities.

Urban areas are very heterogeneous, and different stresses or different degrees of stress may be present even at adjacent planting sites. For example, a tree beside a wide, heavily travelled city street may be subjected primarily to high salts and high winds while around the corner, on a street with less vehicular traffic, soil compaction may be more critical. The disturbed nature of urban soils, with fill, concrete, refuse, and other artifical factors, also contributes to the highly variable environment, even on the same city block.

Greater plant diversity can be maintained if trees are selected for tolerance to stresses present at a specific site, rather than for tolerance to all urban stresses. But, tailoring trees to the site is difficult in light of the variable conditions and because little information concerning responses of trees to specific urban stresses is available.

Research is needed to identify the most common urban stresses and also to evaluate the relative tolerance of tree species to specific stresses. However, scientifically designed experiments testing tree responses to urban stresses are rare because the costs and space requirements are prohibitive, and because planners are relucant to compromise their landscape designs for research purposes.

There is a growing trend for municipalities and private companies with large numbers of amenity trees to monitor their trees with computer inventories. These systems are useful for budgeting funds and labor, and planning long-term maintenance needs. Because such systems are management, rather than research oriented, they generally include only minimal information on biologically important parameters. Typically these systems record tree location, size, and health and site characteristics (5). Biologically important parameters (eg., soil moisture, soil type, and nutrient levels) are generally not included as site characteristics. Instead they include management-oriented variables (eg., proximity to street signs or the size of the planting space). Because stress-related information is not emphasized, these surveys offer only limited information on stress tolerances of urban tree species and varieties.

Our Study

Three years ago, as part of a larger environmental research effort, a tree inventory system was developed for the Consolidated Edison Company of New York. In 1980, about 1,000 street trees were planted around their facilities which are located throughout the five boroughs of New York City. The majority of these trees, representing some 11 species, were 3-3½ inch diameter trees in pits covered with porous paving blocks. Development of the tree inventory system provided a detailed management system that yielded not only valuable management information, but also data on the relative importance of various environmental factors to tree health. Over 80 variables of 5 different types were recorded for 375 trees during the summer this system was first implemented. This paper summarizes the preliminary findings.

The five categories of variables included those that identified the individual tree, evaluated tree health, recorded relationships between the tree and its physical environment, noted care needed or received by the tree, and quantified biologically important site parameters. Data were collected in the summer of 1982 by two-person crews, recorded first on data sheets and then stored on diskettes using a microcomputer (Apple II with

Datastar). It was then uploaded to a main-frame computer for statistical analysis (SAS, SAS Institute Inc., Cary, North Carolina).

The 375 trees inspected in the first year were distributed among three of the New York City boroughs, but were concentrated in Manhattan. They were located at sites where tree establishment has proven difficult in the past and represent some of the most heavily populated areas in the world. Eleven species were represented in the sample, but by far the largest percentage were of four: Norway maple (28%), sycamore maple (17%), pin oak (16%), and lindens (21%).

Indicators of Tree Health

The health of all trees was evaluated using a number of different variables. These included vigor, twig dieback, twig growth, and amount and severity of leaf chlorosis and leaf scorch.

The vigor rating was a subjective evaluation of health; trees were classified as excellent, mediocre, poor, or dead. This evaluation was fairly repeatable in spite of its subjective nature. On the several occasions when groups of trees were evaluated twice, over 90% of the trees received identical ratings.

Twig dieback was an evaluation of the percentage of small branches that were dead. This variable was also repeatable and, because of its more subjective nature, was more valuable for comparing widely separated trees. Twig growth was a measure of the current years growth on "normal" mid-to-upper-crown branches. Sprouts and lower crown branches were not included because they were often abnormally long. Trees were classified into three groups: 0-5 inches, 5-10 inches, or more than 10 inches of twig growth.

Amounts of leaf scorch and chlorosis were evaluated near the end of the growing season. Severity of symptoms was recorded on a scale of zero to three (0 = none, 3 = severe). Percentages of leaves affected were also recorded, and the two figures multiplied to come up with a scorch rating and a chlorosis rating for each tree which could range from 0 to 300.

Environmental Factors Affecting Tree Health

Soil moisture was probably the single more important environmental factor contributing to the decline of trees. When individual trees in poor health were examined closely, their root balls were often saturated with water. Soil moisture of all trees was measured in late spring using a moisture-sensing probe (Aqua Probe, H.S. Crane, Inc., Oneida, N.Y.) which registered between 0 (very dry) and 10 (very wet). Statistical tests (Chi-square tests of independence and Spearman's ranked correlation coefficients) indicated that soil moisture was related to several tree-health-indicator variables. Trees growing in wet soils tended to be in lower vigor classes, have more twig dieback, and have less twig growth than those growing in drier soils.

It is popularly believed that drought stress, rather than wet soil, is an important problem for city trees. However, we did not find this to be the case. Even in late summer, soil moisture levels for all 375 trees were more than adequate. Although

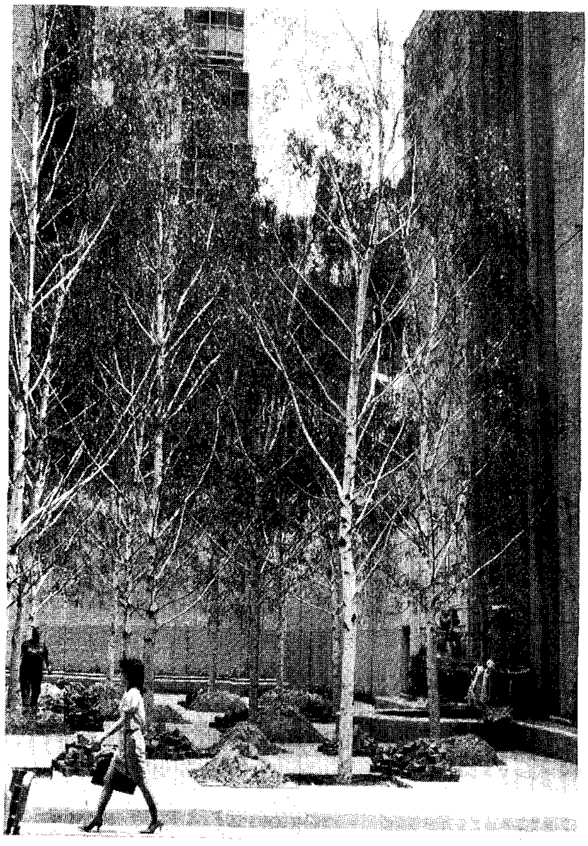

Figure 1. Silt-clogged drainage tiles resulted in water-logged soil and a rapid decline in vigor for these birches.

the general public does not perceive excess soil moisture to be a problem, practitioners in cities as widely scattered as Milwaukee (personal communication from Robert Skiera, City of Milwaukee, June 1984), Washington D.C. (2), and San Francisco (3) have reported similar findings. Part of the reason excess soil moisture may be mentioned only rarely is that above-ground symptoms of excess soil moisture (chlorosis, leaf scorch, premature leaf drop, and twig dieback) are similar to those of drought. Levels of oxygen in water-saturated soils can decrease to the point where root injury occurs (7) and the resulting reduction in water uptake can cause wilting of leaves even though the soil is wet.

Soil samples were collected from each tree and analyzed for pH, salts, chloride, nitrates, ammonium, and potassium. Among these variables, soil salts were most commonly related to tree health. Trees growing in soils with high salt levels tended to have more twig dieback and less twig growth than those growing in soils with lower salt levels. Numerous researchers have reported similar negative effects of soil salts on tree health (4, 7, 9).

Figure 2. Excavation of tree pits that appear dry on the surface can reveal extremely wet conditions. Pin oak was unable to survive in this soil.

Figure 3. The first major roots on this dying Norway maple were buried under 13 inches of soil. The arrow marks the top of the root ball. This problem was traced back to a nursery practice of mounding soil around trees to control competing vegetation.

High soil salts and wet soils tended to occur together. This was not surprising as poor drainage restricts the normal leaching of soil salts. Like excess soil moisture, high soil salts tend to limit the availabilty of soil water to the leaves. Thus it was difficult to separate the effects of these two stresses.

When a group of 60 Norway maples growing in an area where dramatic differences in scorch were observed was analyzed separately, soil chlorides and salts were found to be associated with leaf scorch. However, this relationship was not strong enough to be significant when all trees in our study were analyzed.

Soil potassium levels were related to tree vigor. Trees growing in soils with higher levels of potassium tended to be in poorer vigor classes. This was surprising since potassium is a required nutrient, and potassium-containing fertilizers are known to improve tree growth on many soils. Since potassium levels are significantly associated with nitrate and salt levels, this could be due to contamination of the soil samples by buried fertilizer packets. However, a similar study with older, unfertilized trees also showed a relationship between potassium levels and tree vigor (1). It is known that dog urine contains large amounts of potassium (6). Dr. Pirone, a retired plant pathologist at the New York Botanical Garden, has long maintained that dog urine is responsible for many of the tree health problems in New York City.

It was not possible, using these data, to identify differences among species in response to environmental factors. However, additional trees have been evaluated and we are analyzing our expanded data set to see if species or cultivar differences can be detected.

A final point about these environmental factors is their heterogeneity in the urban environment. We often saw sizeable fluctuations in soil moisture, salts, and nutrients within a single block of a city street.

Aspects of Tree Planting Affecting Tree Health

Tree health was significantly affected by the design of the planting site. Trees growing in large tree lawns were likely to be more vigorous and have a longer current year's twig growth than those growing in either pits or small tree lawns. Trees in planting sites with bare earth or mulched surfaces were more likely to be in excellent vigor class and have faster growing twigs than those in areas covered with paving blocks. Unfortunately it was not possible to separate the effects of site type from those of site surface because the two factors were closely associated in our sample. Trees in open areas would have more soil volume available for root exploitation and ones without paving blocks would enjoy better soil aeration. These factors would allow more efficient uptake of water and nutrients.

Aspects of tree planting that were not part of our data set, but were observed while evaluating problems of individual trees during the summer, also affected vigor and survival. For example, excavation of dying trees revealed in some cases

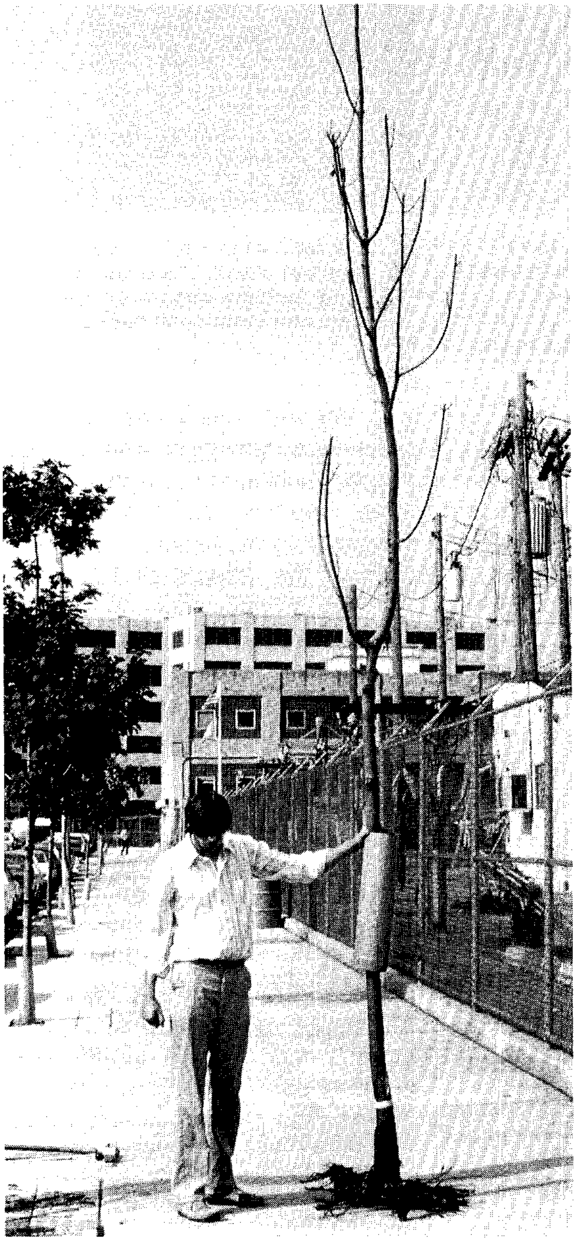

Figure 4. The root system on this sycamore maple was too small to support the crown, even though the root ball size met American Association of Nurserymen's standards. We recommend increasing the root ball sizes.

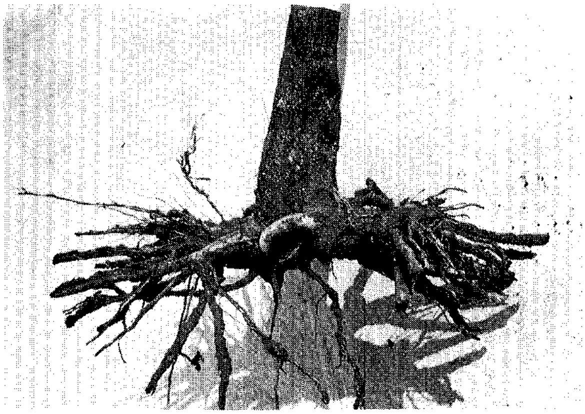

Figure 5. This is a close-up of the root system we found on the sycamore maple in Figure 4. This tree died two years after planting. This root system could not provide adequate water uptake for the crown. Note that few small "feeder" roots are present.

that the abrupt flare of the tree's trunk, which is found just above the soil and the first major roots in nature, was as much as 10 to 15 inches below the soil surface. Close examination indicated that although the root ball had been placed in the tree pit at the correct depth, the roots themselves were in the lower part of the root ball. This is due to the nursery practice of mounding soil at the base of trees to control weeds.

Another problem we encountered when excavating dead and dying trees was very low root to shoot ratios. Although root balls were dug in accordance with recognized standards, they are often too small in comparison to the above-ground portion of the tree. Since few nurseries root prune anymore, a large proportion of the fibrous "feeder" roots are lost in final digging. Watson and Himelick (1982) showed that up to 98% of the root system is lost during modern transplant procedures. This problem was aggravated by the mounding of soil in the nursery discussed earlier. In addition to the effect discussed earlier, this practice further reduces the effective size of the root balls.

Summary

This paper is a preliminary report of a larger study examining environmental conditions of trees along streets in New York City. Excessive soil moisture and the mounding of soil on roots in nurseries, two factors which have not been widely described in the literature, were found to have important effects on tree health. In addition, our study corroborated earlier studies demonstrating the importance of soil salts and root system sizes on tree health. The need for larger root systems in proportion to tops was stressed.

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