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STREET TREE ASSESSMENT BY A SURVEY SAMPLING PROCEDURE[1]

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Abstract. The structure and composition of street tree populations in Rochester and Syracuse, New York were characterized by survey sampling procedures. Over 7000 trees on 205 streets were censused. Systematic sampling was shown to provide unbiased estimates of the true census population parameters. It was used to identify trees of more frequently occurring species for measurement of 24 size and health traits and 8 physical environmental factors. All trees of less common species were measured. Ten species comprise over 90% of the older trees in each city, with Norway, silver and sugar maple, 75% of them. A much greater species diversity occurs among the younger trees, and none dominates this population. Preliminary comparisons of tree size and major health problems in maple populations in the two cities show few differences between the cities, but species differences are noted. Multivariate analyses now in progress should provide information on the relationship of factors of stress in the urban environment to the growth and health of street trees. The use of survey methods in urban tree management planning is discussed.

In the past 15 to 20 years the American elm (*Ulmus americana*) has suffered a near or total elimination in towns and cities of northeastern United States due to Dutch elm disease. In that same period in Syracuse, New York the mortality rate for sugar maple (*Acer saccharum*) has been estimated to have doubled (Miller, personal communication). This is in part due to a decline of complex cause that has become so widespread, healthy sugar maples have become relatively scarce. If street trees are to continue as prominent features of the urban landscape, nursery stock better adapted to harsh city conditions must be developed.

About three years ago, we initiated two research programs concerned with urban trees. These are: (1) the improvement of urban Norway maple (*Acer platanoides*) and sugar maple through selection and breeding of trees that have survived at least one generation in the urban environment, and (2) the assessment of environmental and biotic factors associated with declining maples, including silver maple (*Acer saccharinum*) in addition to the other two species. These species were chosen because they are important components of the urban forest communities in northeastern cities and because in recent years, major problems have developed that are thought to be associated with stress in the urban environment. If they are to remain among the shade tree species favored for our streets, improved nursery stock and rootstocks for the many cultivars of these species must be developed.

Information we felt important for planning and developing a breeding program for the improvement of urban maples includes: 1) the establishment of a base of information and understanding of urban tree communities and their problems, which is especially important for us since we are novitiates in arboriculture, 2) the identification of traits of importance to the growth and health of the trees and to anticipated uses in the urban landscape, 3) the identification and characterization of the phenotypic variability available for a selection program, and 4) the elucidation of the nature of genetic control systems for these traits. As we acquire this information, breeding plans can be formulated and the program initiated.

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An initial question that had to be answered was, What method should be used for studying urban street tree communities? A complete street tree census would be expensive and probably not feasible for large urban centers. An alternative would be a survey sampling method, but we were not aware of a sampling scheme for street tree populations. Our first problem, therefore, was to develop a survey sampling procedure for characterizing the structure and composition of urban street tree populations. This was undertaken by computer simulations of survey sampling methods using data for the complete street tree population of Poughkeepsie, New York. The data from a 1974 census of Poughkeepsie street and park trees, conducted by Dr. Elias and his staff at Cary Arboretum, were kindly made available to Mr. Paul Mohai and Mr. Lowell Smith for analyses.

A sampling design for street tree populations

A survey sampling scheme was developed by Mohai et al. (1977) for estimating variability in street tree populations. Their work will be briefly reviewed here. The Poughkeepsie data included the location of each tree by street and lot number, the tree height, and stem diameter at breast height (d.b.h. = 4.5 ft). Comparisons of the more common species in areas of the city zoned for different land uses showed only minor differences, so all data were pooled for subsequent analyses. Because the distribution of the various species and cultivars could affect a survey sampling scheme, this was also part of an initial study of these data. It revealed a dispersion of trees of the same species in small groups along one or both sides of the street, even for less common species with incidences as low as 2.5%. The least common species (incidence $\leq$ 1%), however, tended to occur as widely scattered single trees. Such a non-random distribution of trees of the more common species could also result in a non-random distribution of variability for those species. The variation among the trees comprising a clump along a street is likely to be small since the trees are most likely about the same age, share similar environments, may be of common origin from the same nursery or natural population, and may be related. Differences between trees from different streets, however, are most likely larger since one or more of these conditions would not be shared. Therefore, the sampling method must accommodate a possible non-random distribution of variation.

Computer simulations of various sampling survey schemes were used to determine an efficient, reliable method for estimating the population variation for tree height and stem diameter. The true population variances (σ^2_H and σ^2_D, respectively) were calculated from the census data for comparison with the variance estimates of sample populations obtained by the computer simulated surveys. Limitations imposed upon the survey methods were that the computer simulated procedure must mimic ones feasible for a survey crew measuring trees along a street and recording their observations. And, secondly, in the survey design consideration must be given the actual structure of the Poughkeepsie population since the success of the scheme and the accuracy and precision of the variance estimates are dependent upon the species' frequencies, their dispersion pattern, and the distribution of their variability.

The most promising schemes tested represent a combination of cluster and systematic sampling. The "clusters" are streets randomly selected for the survey. The number of streets, designated m, was varied to determine the effect this had on the estimates of the true population variances for tree height and stem diameter. The systematic sampling portion of the sampling scheme determines which trees along the street are to be included in the survey sample population. Only a portion of the more commonly occurring species need be sampled, but the system of sampling is predetermined. For example, Norway maple ranks first among the older street tree species in Syracuse, with an incidence of 42%. Obviously every Norway maple need not be included in the sample, but rather perhaps only every fifth or seventh Norway maple encountered along the street need be included. This is called the sampling interval (k), and the systematic sampling scheme would be k = 5 or k = 7 for Norway maple depending upon which interval was chosen. A systematic sampling interval for the more common species is an efficient procedure for estimating population variance in situations such as this, in which the variation within streets is most likely small compared to differences between streets. It provides a good estimate of the variation in the total population, based upon a minimal sample of trees. Hence, it saves time and money without sacrificing accuracy.

A total of fifty-four sampling schemes, representing various numbers of streets (m) and various sampling intervals (k), were tested for the five most common species among the older trees in Poughkeepsie. These included Norway maple, sugar maple, silver maple, red maple (*Acer rubrum*), and basswood (*Tilia americana*). The optimal scheme would minimize the number of trees of a particular species to be sampled (n) that would still provide a good unbiased estimate of the true population variation, indicated by the standard deviation (s) of the variance estimates. A statistic called the Coefficient of Variation, which is a measure of relative variability, was used to arrive at their recommendations for a sampling scheme for urban street tree assessment. Examples of changes in the coefficient of variation representative of what they obtained are given in Figure 1. The decrease in the coefficient of variation associated with increases in the number of streets surveyed (m) exhibited by all five species reflects the increase in the precision of the variance estimates. Note that only one value, that for basswood and m = 30, exceeds the 50% acceptable limit, the limit suggested by Namkoong and Roberds (1974). This was exceeded in other sampling schemes as well and was associated with small numbers of sample streets and/or large sampling intervals, both of which would result in a decrease in sample population size $\bar{n}$ and an increase in the variability in the variance estimates (s). They concluded that a range of 50 to 100 streets would suffice for a sample survey of urban streets. Further increases in precision of the variance estimate due to increases in the number of streets surveyed were not considered worthwhile when weighed against increased costs due to the additional time required. The sample

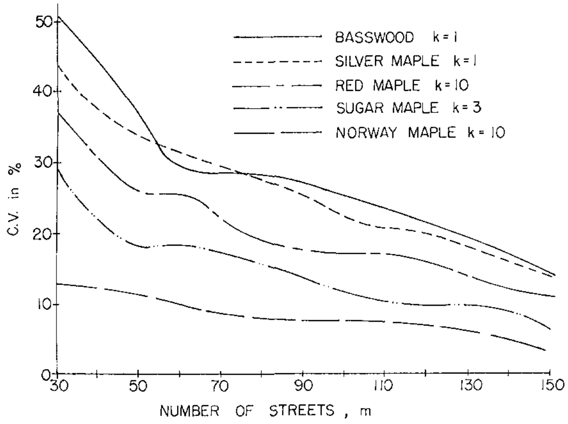

Figure 1. Changes in the Coefficient of Variation (C.V.) of the Stem Height Variance Estimates (s_H^2) with Changes in the Number of Streets Surveyed (m) for the Five Most Common Older Street Tree Species in Poughkeepsie. Sampling Intervals (k) are fixed.

size needed to achieve this degree of precision is surprisingly small. The average sample sizes for the simulated surveys with 50 sample streets in Figure 1 are: basswood 31, silver maple 27, red maple 18, sugar maple 70 and Norway maple 113. Obviously a relatively small sample population of trees located on a rather small number of randomly selected streets will provide a reasonably precise estimate of true population variances.

The recommended survey sampling procedure is a combination of cluster and systematic sampling, with streets the clusters and the sampling interval the systematic sampling scheme. The specific guidelines are:

1) The sample population size (n) should be about 100.
2) The number of randomly selected streets to be surveyed (m) should be at least 50 but need not exceed 100.
3) A length of two to three city blocks should be surveyed on each street (this is based upon the fact that the average number of blocks per street in Poughkeepsie was 2.5).
4) The sampling interval (k) per species should be based upon its incidence so that a sample population size of 100 is achieved.

As a final test of the recommended survey sampling scheme, Mohai et al. (1977) simulated the procedure for the same five species with 100 randomly selected streets and sampling intervals based upon species incidence. Comparisons of the variance estimates for tree height and stem diameter from these computer simulated surveys to the true population variances (σ^2_H and σ^2_D) revealed small differences except for red maple and for stem diameter for basswood. The discrepancies for red maple were thought to be due to excessive grouping of this species along certain streets, and that for basswood attributed to chance. They concluded that the estimates in general were acceptable.

Street tree assessment in Rochester and Syracuse

Extensive sample surveys of the older street tree communities in Rochester and Syracuse, N.Y. were conducted in 1976. Specific objectives were (1) to characterize species composition and incidences, (2) to estimate the population variability for a variety of physical characteristics and measures of health for each of the more common species, (3) to determine tree variation distribution patterns in each city, and (4) to characterize physical environmental factors that might affect the growth and health of each tree.

Survey Sampling Procedure. The sampling procedure recommended by Mohai et al. (1977) was modified slightly to provide information on the distribution pattern of the natural variation among the street trees in the cities. Random procedures were used to select 29 sample plots in sections of each city with a medium to high density of older trees. Aerial photographs and ground surveilance were used to identify these parts of the cities. The sample plots serve as the "primary sampling units" or clusters. In each plot approximately six to nine blocks of adjoining or near-adjoining streets were randomly selected for survey. Each street, in this survey procedure, is a "secondary sampling unit." A census that included the identification of every tree on these portions of the 105 surveyed streets in Rochester and 100 in Syracuse was taken. In addition, the street and lot location and stem diameter (d.b.h.) were also recorded for each tree. Systematic sampling procedures were employed for the more common species to choose those trees that would be intensively measured as part of the sample population. Every tree of the less common species and cultivars, however, was intensively measured. The sampling intervals (k) in Syracuse were 8 for Norway maple, 6 for silver maple, and 2 for sugar maple and in Rochester were 8 for Norway maple and 3 for silver maple. Every tree of the remaining species was sampled. It should be noted that the initial sampling intervals for Rochester had to be changed because the original estimates of species incidences for these two species proved to be too small. Therefore the final sample populations are larger than necessary.

Survey Format. The data acquired for each sample tree are shown in Table 1. Three general categories were included, namely seven physical characteristics; seventeen measures of health for foliage, stem, limbs and roots; and seven factors of the physical environment. Rating measures for many of these factors and conditions provide considerable detail for each tree and its environment.

Survey Results. Only a portion of the results from these surveys will be presented here as the analyses of the data are still in progress. The composition of the more common species and/or cultivars among the "older" trees, i.e. with a d.b.h. $\geq$5 inches, and their frequencies are given in Table 2. This includes the estimates of the species composition and their incidences in the true street tree populations in Rochester and Syracuse based upon the survey populations along with the same information for the total Poughkeepsie street tree population. Note that in all three cities Norway maple is by far the most common species, with silver and sugar maples ranked second or third. Only one more species, white ash, occurs at a frequency of 1% or greater in all three cities. These four species alone comprise about 80% or more of the older tree populations in these three urban centers! No other consistency in species preferences among the cities is obvious, even though two species, red maple and honeylocust, and the combined London plane/sycamore group are common to the listing for two of the three cities. It is evident that only a few species were preferred for street planting about 25 or more years ago.

Table 1. Summary of urban street tree survey data acquisition

Tree physical characteristics

- height
- diameter breast height (=4.5 ft.)
- crown width
- crown shape
- crown density
- crown competition
- fall coloration

Physical environmental factors

Site conditions:	impermeable surfaces
	turf
	ground/street disturbances
crown disruptions	
street lighting	
traffic volume	
salt load	

Measures of Health

Foliage:	general condition
Problems:	necrosis
	chlorosis
	discoloration
	distortions
	holes
	surface defects (biotic)
	wilting
	leaf angle
Stems and limbs:	general condition
	dead limbs
Problems:	cankers
	decay
	insect damage
	wounds
Roots	exposed
	girdling

Table 2. Common trees (incidences $\geq$ 1%) among older street trees (d.b.h. $\geq$ 5 in.) in three New York urban centers.

Poughkeepsie		Rochester		Syracuse	
Species	%	Species	%	Species	%
Norway maple	71	Norway maple	56	Norway maple	42
sugar maple	14	silver maple	14	silver maple	27
silver maple	3	sugar maple	5	sugar maple	13
red maple	3	green ash	4	red maple	3
basswood	3	linden	4	box elder	3
white ash	1	white ash	3	cottonwood	3
		honeylocust	3	white ash	2
		London plane	2	honeylocust	1
		blue spruce	1	American elm	1
others	5	others	8	others	5
Total pop.	5547	Sample pop.	2880	Sample pop.	2157

Table 3. Common trees (incidences $\geq$ 1%) among younger street trees (d.b.h. $<$ 5 in.) in three New York Urban centers

Poughkeepsie		Rochester		Syracuse	
Species	%	Species	%	Species	%
Malus spp.	47	Norway maple	22	Norway maple	24
Norway maple	23	linden	15	*Malus* spp.	13
pin oak	5	green ash	11	green ash	9
linden	5	honeylocust	9	London plane	5
green ash	5	*Malus* spp.	7	linden	5
red maple	2	J. pagoda tree	5	Zelkova	4
Prunus spp.	2	London plane	5	red maple	4
sugar maple	2	sugar maple	4	honeylocust	4
golden-rain tree	2	pin oak	3	silver maple	4
hawthorn	1	cork tree	2	sugar maple	3
		ginkgo	2	tuliptree	2
		red oak	2	white birch	2
		white ash	1	ginkgo	2
		Prunus spp.	1	Ky. coffeetree	1
		silver maple	1	box-elder	1
		Eur. mtn. ash	1	hawthorn	1
				American beech	1
				hackberry	1
others	6	others	9	others	14
Total pop.	1824	Sample pop.	1578	Sample pop.	548

The composition of the "younger," more common species and cultivars with d.b.h. $<$ 5 inches and their frequencies are given in Table 3. For this table "more common" again represents an incidence of 1% or greater. It is immediately apparent that a greater diversity of species and cultivars has been planted in recent years. In fact, twice as many occur in these listings for the younger tree populations as were given in Table 2 for the older tree populations. Five species occur commonly in all three cities (*Malus* spp., Norway maple, green ash, linden/basswood, and sugar maple), but they do not overwhelmingly dominate the populations except for Poughkeepsie. In Rochester and Syracuse, however, they constitute only a little more than half of the younger trees. It would appear that the pattern of planting in recent years has included many more species and cultivars at higher frequencies so that one or two species do not dominate the population. It should be noted that all cultivars were lumped by species for this presentation, but the survey data identifies them by cultivar name.

Certain differences between Poughkeepsie and the other two cities are likely due to differences in the populations represented by these data. The total street tree population for Poughkeepsie is given. This includes the older central part of the city, formerly dominated by the American elm but now by younger trees, with *Malus* spp. the most common choice as a replacement. Comparable areas in Rochester and Syracuse were mostly excluded since sample plots were selected only from sections of the cities with medium to high densities of larger trees. This resulted in the exclusion of the older, central areas of both cities in our surveys.

Population Parameters for Stem Diameter and Tree Height. The preliminary results of the stem diameter and tree height analyses for the Rochester and Syracuse populations of the more common species will be presented so that inferences on the reliability of the survey procedure can be made and the populations in the two cities compared.

The accuracy of the estimates of the true survey population means obtained by systematic sampling of the three most common species in each city can be determined by comparing the estimates of the mean stem diameters with the true survey population means. This is possible since the d.b.h. was recorded for all trees in the survey. The results of these analyses are given in Table 4. The confidence interval indicates the range in which the true mean stem diameter lie unless a 5% mischance in sampling has occurred. It should be noted that for all species in both cities, the estimate of the population mean ($\bar{x}$) is nearly the same as the true mean, and, the true mean (μ) does lie within the 95% Confidence Interval for each population. This permits us to conclude that the estimated mean ($\bar{x}$) is an unbiased estimate of the true survey population mean. The use of systematic sampling for characterising the more common species in urban street tree populations, therefore, results in a considerable saving of time and money without loss of precision.

Table 4. Comparisons of the estimated mean stem diameter ($\bar{x}$) and its 95% confidence interval for the systematic sample populations of the most common maple species to the true mean stem diameter (μ) of the survey populations.

Species	Pop. size N	est. mean x	95% confidence interval	true mean μ
	Rochester			
Norway maple	305	16.95	16.22-17.68	17.22
Silver maple	295	26.52	25.79-27.25	26.55
	Syracuse			
Norway maple	160	16.96	16.18-17.74	17.21
Sugar maple	167	20.25	19.29-21.21	20.85
Silver maple	138	25.51	24.15-26.87	24.44

Estimates of population variability for traits of interest to the tree breeder can serve as "yardsticks" for the selection of trees judged to be superior for the composite of important traits. The results of the analyses of population variability for stem diameter for Rochester and Syracuse trees are presented in Table 5. Two parameters characterize these populations, the mean ($\bar{x}$) or average diameter of all sample trees and the standard deviation (s), an index of the spread or the range of the variation. For example, approximately 95% of all individuals in a population with a normal distribution occur within two standard deviations of the mean. The third statistic, the coefficient of variation, is a measure of the relative amount of variation available for selection.

Average stem diameters are about the same for each species in the two cities except for sugar maple. The larger average d.b.h. of 20.25 inches for the Syracuse trees compared with 15.30 inches for Rochester suggests an older sugar maple population in Syracuse. The greater variability exhibited by the Rochester population (c.v. = 47% compared with 31% for Syracuse), however, clearly indicates a much greater range of diameters. A computer printout of the distribution, however, revealed a bimodality in this population, hence the greater variation. These two groups of sugar maples of different diameter classes that occur in Rochester are probably due to differences in age. This suggests that large numbers of sugar maple were planted in Rochester at two different times, probably coincident with major periods of urban expansion. Some differences in variability are present for the other species, with the Rochester population more variable for certain species and Syracuse for others. The important information about these populations revealed by the coefficient of variation is that a fair amount of variation does exist and could serve as the base for a selection program.

Comparable results from the analyses of tree height are given in Table 6. The pattern of differences in tree height for each species in the two cities is similar to that observed for stem diameter, but the differences are larger. Norway, silver and red maple are on the average taller in Rochester than in Syracuse; white ash is about the same in both cities; and sugar maple is smaller in Rochester. The relative amount of variability, however, is generally smaller than observed for stem diameter, but the pattern of differences for each species in the two cities is about the same as for stem diameter. Reasons for these differences are not apparent from these results, but analyses now in progress that relate the various physical characteristics of each tree to its biotic and physical environment may provide information to help explain these differences.

Major Stem and Foliage Problems. A summary of the frequencies of major stem and foliage problems for Norway, silver and sugar maple in Syracuse is given in Table 7. Results from the Rochester survey are similar and so will not be reviewed here. In general, silver maple is relatively healthier than either of the other

Table 5. Estimates of population parameters and relative variability of stem diameter (inches) for the more common older street tree species in Rochester and Syracuse.

	Rochester				Syracuse			
Species	Pop. size N	Mean $\bar{x}$	Standard deviation s	Coeff. of var. c.v.	Pop. size N	Mean $\bar{x}$	Standard deviation s	Coeff. of var. c.v.
Norway maple	305	16.95	6.48	38%	160	16.96	5.06	30%
sugar maple	146	15.30	7.13	47%	167	20.25	6.34	31%
silver maple	295	26.52	6.42	24%	138	25.51	8.13	32%
red maple	17	19.53	9.07	46%	75	17.20	8.41	49%
white ash	101	20.11	6.94	35%	37	20.68	5.79	28%

Table 6. Estimates of population parameters and relative variability of tree height (feet) for the more common older street tree species in Rochester and Syracuse.

	Rochester				Syracuse			
Species	*Pop. size N*	*Mean $\bar{x}$*	*Standard deviation s*	*Coeff. of var. c.v.*	*Pop. size N*	*Mean $\bar{x}$*	*Standard deviation s*	*Coeff. of var. c.v.*
Norway maple	305	47.38	13.77	29%	160	45.80	11.62	25%
sugar maple	136	46.99	14.51	31%	167	56.34	13.82	25%
silver maple	295	69.32	13.83	20%	138	61.11	13.96	23%
red maple	17	55.24	20.63	37%	75	46.85	19.68	42%
white ash	101	61.20	14.43	24%	37	61.92	15.94	26%

species. This is revealed not only by comparisons of the incidences of these various stem and foliage problems, but also by the average ratings for stem and foliage conditions for these species given at the bottom of the table. In these ratings, the smaller the value, the better the tree. Branch breakage has long been considered the major shortcoming of silver maple, but note that its incidence isn't that much greater than in the other two species. Branch stubs due to breakage and improper pruning are common in all three species. Since they serve as entry ports for various pathogens causing heart rot that weakens the tree, major stem breakages and property damage are likely consequences. Good management pruning and shorter rotation would alleviate this problem. Stem seams are also associated with heart rot and are quite common in these Norway and sugar maple populations.

Table 7. Major stem and foliage problems in Norway, silver, and sugar maple street trees.

Condition	Norway maple	Silver maple	Sugar maple
	Incidence in Percent		
Stem problems—Syracuse			
large wounds	12	7	8
broken branches	3	8	5
broken branch stubs	38	32	29
pruning branch stubs	25	22	15
Nectria cinnabarina	2	0	0
target nectria	0	0	2
Eutypella parasitica	2	0	3
heart rot	25	28	34
sap rot	13	3	5
seam	20	9	14
Foliage problems—Syracuse			
scorch	17	2	24
necrotic fleck	12	0	4
chlorosis	25	33	38
chlorotic fleck	15	6	8
interveinal chlorosis	1	28	8
chlorotic, tufted and small	6	0	7
wilted	20	7	28
fall coloration	3	8	13
mites	0	20	0
aphids	19	0	1
None, normal foliage	10	16	6
	[1] *Ratings: 0 to 9*		
Average stem condition			
Syracuse	2.0	1.5	2.2
Rochester	1.6	1.4	1.4
Average foliage condition			
Syracuse	2.1	1.5	1.9
Rochester	1.5	1.0	2.5

[1] Varies from good (0) to bad (9).

Differences among the three species in foliage problems are even greater than for stem problems. Silver maple exhibits considerably lower incidences for most problems, with the exception of mites and interveinal leaf chlorosis. Mites cause abnormalities in leaf growth and color but probably do little serious damage. Chlorosis is a common urban problem, probably due to the impaired ability of disrupted roots to supply needed nutrients. Wilt and scorch are of common occurrence in Norway and sugar maple, especially in August when these data were taken. Verticillium accounts for some of the wilting, but others are caused by canker girdling of branches and environmental factors. Aphids are a major nuisance problem on Norway maple, but selection for resistance to aphids has been successful in agronomic crops, hence holds promise for Norway maple.

These data on stem and foliage problems represent the presence or absence of each condition for each tree surveyed. The degree of the symptom expression or condition was also noted in our surveys so that when these quantitative differences are taken into consideration, further differences among the species and perhaps between the cities may be revealed. These results, however, do indicate that real differences do exist in these populations since a fair proportion of each species exhibits no foliage problems. It would therefore appear that these populations could serve as a yardstick for the measurement of health problems and for genetic improvement through selection.

Discussion and Conclusions

The application of survey sampling procedures for characterizing street tree populations appears to be an effective method for urban tree assessment. It can provide accurate, unbiased estimates of the variability in these populations at a minimal cost. The combination of cluster and systematic survey procedures developed by Mohai and co-workers for a small urban center (i.e. Poughkeepsie, New York with a population of about 32,000 and an area of four square miles) appears suitable for use in relatively large metropolitan centers. The application of systematic sampling for the more common species in both Rochester and Syracuse has been found to provide unbiased estimates of the true stem diameter variances of the census populations. How well the variance estimates approximate the true variances for the city-wide populations of older trees in these larger cities, however, has not been determined. Additional analyses of these data are now in progress that should provide information on this point.

Another objective for studying these street tree populations was to determine the distribution of the variation in these populations. Preliminary results indicate that the amount of variation among trees of a given species along a two to three block segment of a street is considerably less than between trees on different streets. Much of these differences, however, are likely due to age differences, since the older trees along a given block were probably planted soon after the area was opened for development. Different streets were most likely developed at different times so that tree age differences of 20 or more years would be expected. Multivariate statistical analyses now in progress should permit comparisons that are independent of age.

The survey sampling procedures used for our street tree studies could be easily adapted for other purposes in the management of urban street trees. They could be used, for example, to provide an economical method of obtaining realistic estimates of the severity and extent of an urban tree problem so that reasonable plans could be formulated, or to predict an impending problem due to the buildup of insect populations. There are, no doubt, many other examples where survey procedures could be applied to urban tree management. The application of these methods should result in greater efficiency as well as decreased costs for these programs.

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Literature Cited

Mohai, P., L. Smith, F. Valentine, W. Stiteler, T. Elias, and R. Westfall. 1977. Structure of urban street tree populations and sampling designs for estimating their parameters. 1st Metropolitan Tree Improvement Alliance Conf. Proc. (Maryland): (In press).

Namkoong, G., and J.H. Roberds. 1974. *Choosing mating designs to efficiently estimate genetic variance components for trees. I. Sampling errors of standard analysis of variance estimators.* Silvae Genetica 23: 43-53.

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ABSTRACT

Hogan, Gail. 1977. **EPA: understanding enforcement.** Weeds, Trees and Turf 16(2): 12, 17.

So you think you have problems with the enforcement arm of the EPA? Amendments, signed into law by the President in October of 1972, strengthened the vague FIFRA. The new amendments prohibited any person from using any registered pesticide "in a manner inconsistent with its labeling," provided for classification of pesticides into "general" and "restricted" categories, limited those who could apply "restricted" pesticides, and gave EPA new powers of enforcement such as stop sale and removal orders, the power to initiate seizure actions, the authority to require manufacturers to register pesticide-producing establishments, and the power to initiate civil or criminal proceedings against violators. In the years that followed, EPA's enforcement arm focused its strategy on ensuring compliance of manufacturers and users through producer establishment inspections, pesticide sampling, pesticide analysis, and use surveillance.