COMPARISON OF FOUR METHODS OF STREET TREE ASSESSMENT

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Abstract. Householders and professionals were surveyed regarding the suitability of eight street tree species planted in their area. The same species were rated in slide presentations, and physical inspections were undertaken of sidewalk damage associated with tree roots. There was more agreement among householder, expert and slide simulation procedures in rating specific attributes than in judging overall suitability of a street tree. Sidewalk inspections did not correlate with other information sources on root damage. The benefits and limitations of each assessment procedure are described.

The past decades have seen the development of several independent lines of research on street tree suitability. For the most part, these approaches have remained separate, thereby providing inconsistent and ambiguous recommendations for street tree selection, planting, and maintenance. One familiar line of research has examined public response to street trees using interviews and questionnaires. This research has found that city residents hold positive attitudes toward street trees and, in general, the more trees the better. Resident satisfaction, real estate values, and community relationships are all positively related to the amount of greenery (4,5,7,8).

A second line of research has assessed the opinions of professionals. Rather than asking about street trees in general, as is the typical approach in public surveys, professionals are questioned about individual species. Using both rating and ranking techniques, the information is used to compile lists of suitable species for different regions. Among the major conclusions of this research has been the importance of tree maintenance for the continued health and vitality of the urban forest.

A third line of research used visual simulation, such as slides or still photographs, to assess public response. Typically this research is done in a group session, using images which respondents rate for visual attractiveness. This approach resembles the public attitude surveys in focusing upon the amount of greenery. Rarely does it reach the level of individual species, as is typically the case in practitioner surveys. The major finding of this research is that the amount of greenery has a positive impact on the visual attractiveness of urban scenes.

A fourth line of research involves the physical inspection of growing trees, either in experimental plots (14) or in real-world situations (6,15). Physical inspection can focus on the tree itself, or its effect on the surrounding area, in terms of shade, erosion control, wind loss, or sidewalk damage.

Few attempts have been made to bring together and compare the information obtained from these different sources. The separation of approaches has both practical and heuristic consequences for street tree research. On a practical level, differences between public response and lists compiled by experts can lead to end-user dissatisfaction with the types of trees planted. Professionals remain in the dark as to what attributes are valued by the public, and the public feels left out of the selection process. This is not true of the small number of city residents serving on street tree commissions, but it does apply to the vast majority who have no voice in street tree selection, planting, or maintenance policies. On a heuristic level, when different researchers ask different questions among different groups of respondents, there is almost no way to pull together the findings into a coherent set of recommendations to guide policy or practice.

The present study attempts to integrate ratings of street trees obtained using four different methods: householder surveys, expert judgment, visual simulation, and physical inspection of sidewalk damage. This is done at the level of individual species in a particular geographic context.

The present research took place in the south San Francisco Bay area and involved eight species currently planted as street trees. Not all attributes could be rated in all the procedures. From the outset, we avoided asking people about issues on which they lacked information. The goal of the research was to identify areas of overlap and divergence in ratings of street trees given by lay residents with first-hand experience of a single street tree, professionals practicing in the same geographic area, groups of university students shown slides of the eight species, and inspections of sidewalk for signs of root damage.

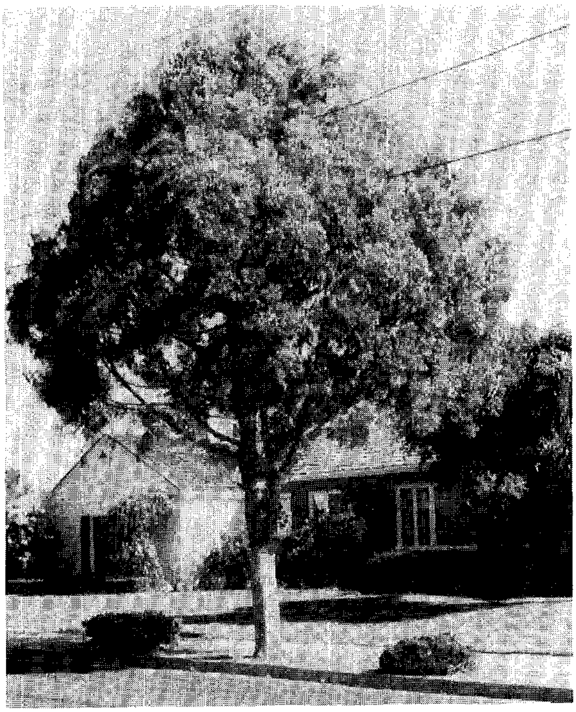
Procedure

Householder Survey. Discussions with city officials in Sunnyvale and Redwood City (CA) identified eight currently planted species about which they desired further information. A list of houses associated with each species was obtained, and visits made to the neighborhoods to verify the presence of the trees. From this list, approximately 80 houses associated with each species were sent questionnaires addressed to "Resident," a cover letter jointly signed by a city official and member of the research team and a stamped return envelope. The overall return rate was 52.9% of delivered questionnaires, which ranged from 37% to 74% for individual species. Questions covered the benefits and annoyances of the particular street tree, satisfaction with city maintenance, and various demographic items.

Professional Survey. Questionnaires, accompanied by a cover letter and a stamped return envelope, were mailed to 57 arborists, 48 landscape architects, and 107 garden supply firms in the South San Francisco Bay Area. A larger sample of gardeners was used, since their questionnaires were sent only to a company name, which was expected to yield a lower return rate. Usable replies were received from 51% of the arborists, 47% of the landscape architects, and 25% of the gardeners. Arborists averaged 16.5 years of experience (range 3-35 years) gardeners 20.9 years (range 10-40 years), landscape architects 20.8 years (range 10-50 years). The four-page questionnaire requested ratings of the eight species used in the householder surveys on 5-point scales, from very good to very poor, with an additional column for attributes that were unrateable. Scales used were visual aesthetics, shade, drought tolerance, droppings/debris, disease and insect resistance, pruning requirements, problems caused by roots, growth rate of mature trees, and overall suitability as a street tree. Subsequent analysis established that the ratings from the three types of professionals were sufficiently similar to allow consolidation into a single category of expert judgment (10).

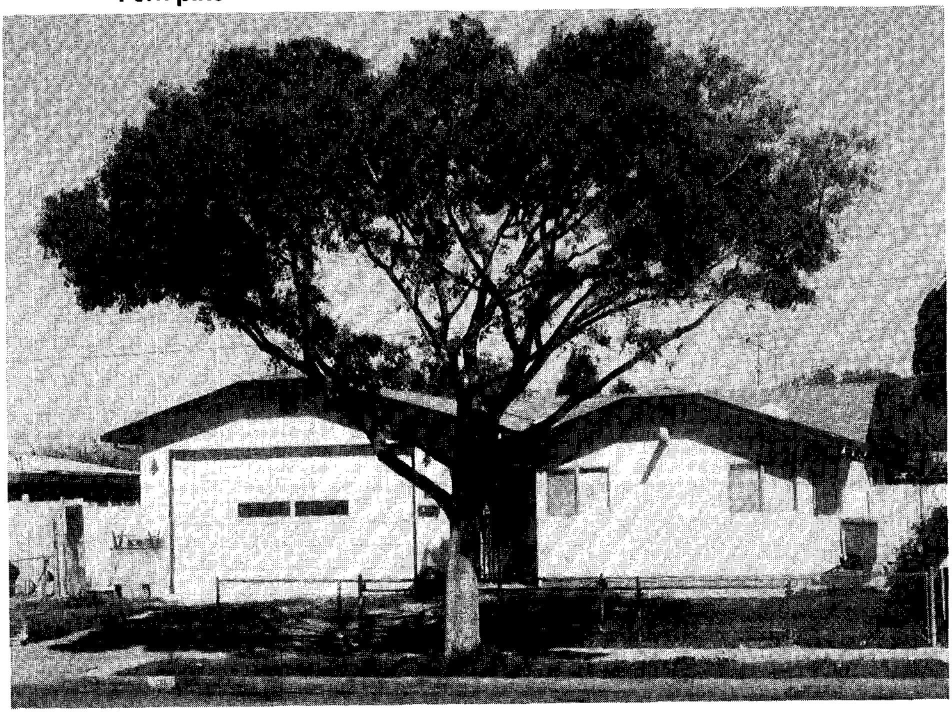
Slide Presentation. From the list of addresses associated with the eight species, a random sample of five primary addresses and three alternates was selected in case the tree at the primary addresses could not be photographed. A photographer was dispatched to these locations to photograph each tree, taking both entire tree and base area views. This produced a set of 80 slides consisting of five entire tree and five base area views of the eight species. The slide series was rated by two classes of liberal arts students and one senior landscape architecture studio (13). The ratings were made of each species separately after the respondents were shown the the slides of the species, using 5-point scales from very good to very poor, with an additional column for trees that could not be rated. For the two groups shown entire tree and base area views, the attributes rated were visual aesthetics, shade, absence of root problems, and overall suitability. For the liberal arts class shown only the entire tree images (without the base area views) ratings were made on visual aesthetics, shade, and overall suitability. Figure 1 shows two entire trees and one base area view rated by the respondents.

Sidewalk Inspection. Following the procedures recommended by Wagar & Barker (16), a trained rater was given the list of addresses of houses associated with the eight species used in the earlier studies, and he examined both sidewalk and curb areas associated with all the houses for cracks and displacement. For purposes of analysis, data on sidewalk breakage were deleted in cases where the original tree had been replaced, where



Fern pine

Australian willow, base view only



Chinese hackberry

Figure 1. Examples of trees shown to students via slides to obtain species ratings.

there were two trees planted in front of a house, or where the concrete appeared new, indicating recent repair. Curb displacement data were not counted when the tree was planted in the lawn area rather than between the sidewalk and curb.

Not all attributes were covered in each procedure. There seemed little point, for example, in asking students viewing slides to rate drought tolerance or insect resistance, or to ask householders about pruning requirements that were a municipal responsibility. Problems associated with roots were rated in all four procedures. Visual aesthetics, shade, and overall suitability were rated in three procedures. For the remaining five attributes, there were data from two procedures.

A mean rating for each species on each attribute was computed for each group of respondents. Pearson coefficients were then used to compare the ratings of the eight species by each group. The use of average ratings from each group was a conservative procedure, in that the degrees of freedom were based, not on the several hundred respondents participating in the research, but the average ranking of eight species by different groups of judges, requiring a Pearson coefficient of .707 for significance at the .05 level. For attributes where ratings from three or four groups were available, Kendall's coefficient of concordance (W) was used to assess overall agreement. This is a measure of the agreement between several different rankings of a number of items.

Results

Table 1 contains the average rating of each species on overall suitability, which householders, practitioners, and simulation respondents had rated using 5-point scales. Analysis of variance tests were used to compare the ratings, followed by Scheffé tests to identify significant differences among the three groups of respondents. It appears noteworthy that the Chinese pistache, which was rated highest in overall suitability of all three groups, was also the most highly praised species in Barker's (1) interviews with tree crew supervisors in 48 California cities. The Southern magnolia and Modesto ash were rated highest in the visual simulation procedure, probably because their surface and root problems were less apparent in the slides. The Australian willow was rated lowest in the slide simulation procedure, probably because pictures were taken following the 1990 severe freeze, and the damage was evident in the pictures. The American sycamore was rated significantly lower by professionals than by householders or people viewing slides. This may reflect the public preference for large, leafy trees, whereas professionals are more aware of some of the associated maintenance and repair costs.

Table 2 summarizes the correlations among the three groups of respondents on all rated dimensions. The dashes indicate instance of missing data where no correlation could be computed. This table shows substantial agreement among householders, professionals, and simulation respondents in rating visual aesthetics and shade. For both dimensions, the coefficients of concordance (W) were positive and significant. However, there was no significant agreement among the three groups in rating overall suitability as a street tree. Table 2 also shows substantial agreement between professionals and householders on disease and droppings/debris, along with substantial agreement among householders and visual simulation respondents in rating a tree's effect on property values and sense of community.

Table 1. Overall suitability of species rated by professionals, householders and visual simulation respondents.

Species	Average rating of professionals	householders	visual simulation	F	p
Southern magnolia	2.8	2.9	3.5[a]	9.9	.001
American sweetgum	2.6	2.7	3.5[a]	14.7	.001
Chinese pistache	4.1[b]	3.7	3.9	4.0	.02
Australian willow	3.3	3.0	2.2[a]	18.3	.001
Fern pine	3.0	3.4	3.1	2.4	NS
Chinese hackberry	3.8[a]	3.0	3.0	12.0	.001
American sycamore	3.1	3.7[b]	3.5	4.7	.01
Modesto ash	2.7[a]	3.4	3.8	22.2	.001

a Mean significantly different from both other groups.
b Mean significantly different from lowest group only.

Table 2. Correlations between ratings of householders, professionals, and visual simulation respondents.

Attributes	Pearson correlation between: House holders & professionals	Professionals & simulation	House holders & simulation	W[1]
Visual aesthetics	.42	.88*	.63	.74*
Shade	.84*	.78*	.54	.85*
Sense of community	—	—	.53	—
Privacy	—	—	.03	—
Increased property value	—	—	.76*	—
Overall suitability	.39	-.01	.44	.53
Disease & insect resistance	.90**	—	—	—
Droppings/debris	.59	—	—	—

1 Kendall's Coefficient of Concordance.
* P < .05; **P < .01.

Table 3 presents the correlation between overall suitability and the three attributes rated in all three procedures (visual attractiveness, shade, and absence of root problems). Since the professionals and the visual simulation respondents rated all eight species, their coefficients in this table represent averages using a z score transformation. This table shows that overall suitability correlated significantly with visual attractiveness in all three procedures, and was correlated with shade and absence of root problems in the professional and householder surveys, but not in the slide simulation procedure.

Sidewalk damage was assessed in all four procedures. Treatment of the data was straightforward for the professional and householder surveys, and in the visual simulation where respondents rated an individual tree or species as to the degree to which the roots caused problems. However, the sidewalk inspections were complicated by the differential frequency of sidewalk repair in the two cities, as well as the locations of trees relative to the sidewalk and curb. One of the cities quickly repaired sidewalk damage while the other city did not. This produced a systematic bias in the amount of measured damage, which was confounded with species. It also drastically reduced the number of valid cases where comparisons between species could be made. Planting location was an additional source of bias, e.g., over 90% of the curb measurement for the American sweetgum had to be deleted because the trees had been planted near the house rather than adjacent to the curb. The implications of systematic bias in sidewalk repair and tree location upon the validity of sidewalk inspection will be discussed in the next section.

Analysis of variance found significant variation among the eight species on the amount of sidewalk damage, $F(7/337) = 19.42$, $p<.001$. Scheffé tests showed that the Modesto ash and the American sycamore were associated with more sidewalk damage than were the lowest rated species. There was less curb damage overall than sidewalk damage, but there was still significant variation between species, $F(7/388) = 4.6$, $p<.001$. Scheffé tests showed that the Modesto ash was associated with more curb damage than the Chinese pistache. Consistent with these results, Barker's (1) interviews with tree crew supervisors in 48 California cities also found significant sidewalk damage associated with the American sweetgum, the Modesto ash, and the Southern magnolia.

Because the scales used to measure root damage varied according to the procedure, Table 4 shows the rank of reported damage among the eight species in each procedure. A low rank in this table indicates a lesser amount of root damage. Kendall's coefficient of concordance (W) showed a significant amount of agreement among the four methods for assessing root damage, $W = .601$, $p<.02$. However, the coefficient would have been .80 without the inclusion of the inspection data.

Table 3. Correlation between attributes rated in all three procedures and overall suitability.

Attribute	Correlation with overall suitability: Professionals	House holders	Visual simulation
Visual attractiveness	.42**	.62**	.46**
Shade	.30*	.38**	.19
Absence of root problems	.42**	.43**	.02

*P< .05; ** P< .01

The results from the sidewalk inspections did not correlate significantly with those of the other three procedures. The combination of differential sidewalk repair and different tree locations in the two cities seems responsible for the lack of validity of the inspection procedure. While it was possible to avoid counting cracks on obviously new concrete, those sidewalks that had not been repaired were those that had not been damaged originally, leading to a systematic bias in the remaining data.

Discussion

There was considerable overlap among householders, professionals, and slide presentation respondents in rating specific attributes of street trees. This is an encouraging sign for integrating these lines of research. The present results suggest, within limits of generalizability, that visual simulation ratings of aesthetics are similar to those obtained in householder surveys and expert ratings. A similar conclusion can be reached in regard to root problems. There was a reasonably high correlation between root problems as rated in a slide procedure, and in surveys among householders and experts.

While there was agreement among these procedures in ratings of specific attributes, there was less agreement among the three information sources in ratings of overall suitability. Apparently judgments of overall suitability represent more than a summation of individual characteristics, in terms of a new subjective synthesis that places differential weight on different characteristics. Although householders, practitioners, and slide viewers can agree whether or not a species has root problems, this does not ensure that the groups will attach equal importance to this information in forming judgments of overall suitability. Professionals appear to take a more broad view of city tree policies, while householders form their opinions based on a single experience. Also, the different groups had different information on which to base their ratings.

Table 4. Damage caused by roots assessed in each procedure.

Species	Rank of species (1 = least damage) as judged by:			
	Professionals	House holders	Simulation	Inspection
Chinese pistache	1	3	2	2
Australian willow	2	1	1	5
Fern pine	3	2	3	6
Chinese hackberry	4	4	6	3
American sycamore	5	6	5	7
Modesto ash	6	7	7	8
Southern magnolia	7	8	8	4
American sweetgum	8	5	4	1

This research should provide encouragement for other attempts to integrate different lines of street tree research. The advancement of knowledge is ill-served by the present separation between different approaches, in which visual simulation studies cite other visual simulation studies, while surveys of experts cite previous evaluations in experimental plots or the physical inspection of trees planted along city streets. There need to be more multi-method, multi-stage investigations of street tree suitability. Paralleling the belief that there is no such entity as a perfect street tree for all locations, we believe that there is no single assessment procedure that is suitable for all purposes. Each procedure can add useful information to the assessment process, but also has certain limitations. Our use of four different assessment procedures with the same species provides a view of both the overlap and the new information provided by each procedure:

Professional Survey. This is a very efficient way of obtaining expert ratings of species appropriate for a geographic area. Relative to other procedures, the method is very economical. Our research indicates that ratings from different groups of tree professionals, such as landscape architects and arborists, can be combined (13). The chief disadvantage of this method is that it may overlook tree characteristic important to the public.

Householder Survey. This is an excellent means for assessing public response to species planted in an area. The ratings can be very detailed and include characteristics not included in professional surveys. Attitudes toward city maintenance practices can be assessed. The chief disadvantages are the time, expertise, and cost of conducting householder surveys, which may place them beyond the means of many public agencies.

Slide Presentation. This is the easiest and quickest method for rating street tree characteristics. The challenge is using this approach is to collect slides in an unbiased manner, i.e., avoiding systematic bias in taking photographs. Overall, this is a very efficient procedure within multimethod assessment; but should probably not be used by itself to rate individual species

Sidewalk Inspection. This procedure can be carried out quickly and reliably by a trained observer (16). However, the measurements are subject to the vagaries of city sidewalk repair policies and differences in the distances trees are planted from the sidewalk and curb. Unless these factors are held constant or controlled, the use of sidewalk inspection as a means of measuring root damage seems problematic.

On a practical level, our results raise questions regarding current procedures for compiling lists of suitable species. Householder surveys reveal considerable dissatisfaction with the species of tree planted by cities (12). A majority of our respondents would have preferred the city to have planted a different species originally. This indicates that professionals who compile regional lists are not taking into account characteristics valued by householders. Brush & Moore (2) consider the development of a classification of tree attributes important to city residents to be the chief research task for behavioral scientists in regard to the urban forest. If there are to be massive urban tree planting programs (3), it is highly desirable that the species selected should maximize resident satisfaction and minimize public maintenance costs.

Restricting the study to particular species in a specific region seems necessary in order to avoid stereotyped responses to tree in general, but it limits generalizability of the findings. Such particularism is inherent in street tree research, where no single species is suitable for all locations. Ratings of visual attractiveness, for example, may differ in the desert communities in the American Southwest, small villages in the French countryside, and major cities of Southeast Asia. This is not an argument against visual assessment, so much as it is a plea for replication of studies in different regions.

The present research reveals considerable overlap among householders and experts is rating specific attributes, but divergence in how these attributes are valued. A two-pronged solution should include increased public education undertaken by experts, and increased awareness by professionals of how attributes are valued by the public. As an example, Schroeder & Cannon (9), found a strong preference among the public for large trees planted curbside, even though this combination could result in considerable sidewalk and curb damage. Conversely, some professionals may have an unduly high regard for tree flowers. Through detailed physical inspections of approximately 5,000 street trees in Hong King, Jim (6) found showy flowers to be the most frequent desirable trait, yet Sommer & Sommer (11), using householder response rather than expert opinion, found that tree flowers were considered more of a liability than an asset because of their debris. Professionals need to be educated on how tree attributes are valued by city residents. Knowledge of public attributes may also enable professionals to reduce objectionable characteristics through selective breeding and genetic engineering.

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