Use of a Category-Based Survey To Evaluate Landscape Plants Along Urban Freeways

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There is a lack of information available concerning responses of landscape plants to urban freeway environments. The results of a category-based survey in the Phoenix metropolitan area identified landscaping installation contracts and plant location with respect to the median as two sources of variation in plant response. Differences in response did not appear to be related to age of contract. Species were evaluated as individual plants or as groups of plants. The ratio of counts in the healthy category to the summation of counts in problem categories was used as an indicator of suitability for species evaluated as individual plants. The category definitions were not well-suited for evaluation of plants as groups. The survey provided an information base useful for making decisions concerning future landscaping activities and in targeting species for detailed monitoring.

Evaluation of roadside landscaping in the past has centered on the visual aspects associated with aesthetic quality (1–3). In recent years rising costs of labor and materials have resulted in reductions in maintenance activities and an increased interest in the performance of roadside plants. Species prone to deterioration represent a loss of visual quality and inefficient use of maintenance funds. Research concerning the responses of various plant species to the roadside environment has generally concentrated on vegetation used in road cuts and highways in nonurban areas (4, 5).

The lack of information on landscape plants along urban freeways resulted in a survey of the Phoenix metropolitan area to acquire information that could be used for decision making and to provide a basis for further analysis. The decisions dealt with species selection for landscaping contracts in the near future and reductions in maintenance activities. Further long-term analysis included detailed monitoring of target species identified by the survey and evaluation of possible cause and effect relationships operating on the freeway vegetation.

The types of surveys generally used in vegetation evaluations did not meet the objectives of the present study. Rating schemes frequently used in environmental perception studies require procedures for evaluating rater reliability and unequally spaced rating scales (6). Surveys used in landscape ecology studies are generally concerned with spatial dispersion of vegetation and require detailed measurements of environmental parameters (7).

The survey used in the evaluation of the landscape plants

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along the Phoenix Metropolitan Freeway System was designed to rapidly inventory species problems and identify sources of variability in plant response. Plants were assigned to categories that were defined as recognizable problems (e.g., chlorosis). Assignment to a category depended on visual identification of the problem and did not require either a measurement or a rating.

The results of a category-based survey of the landscape plants along the freeway system are provided in this paper and the strengths and weaknesses of this type of survey are evaluated.

MATERIALS AND METHODS

The survey area was located along SR 360 from Dobson Road to Val Vista Drive and along I-10 from Dysart Road to Bullard Avenue in the Phoenix metropolitan area (Table 1). The survey area represents approximately 18 mi of landscaping that was evaluated by one person in about 80 manhours. The area was segmented by various landscape installation contracts. Contract numbers and ages are given in Table 1. The age of the contract was defined as the number of months that had elapsed since the initiation of the one-year establishment period and the time of the survey.

Categories of the survey were developed from initial field evaluations and the landscaping experience of the surveyor. Plants could be placed in one or more in the following categories: healthy (HL), sunburned (SB), chlorotic (CH), trauma (TR), noncoalesced (NC), dead (DD), out-competed (OC), and other (OR). Healthy was used to describe plants that exhibited growth patterns normal for the species as determined by comparison with arboretum and nursery specimens.

TABLE 1   IDENTIFICATION OF LANDSCAPE CONTRACTS EVALUATED BY THE VEGETATION SURVEY

CONTRACT NUMBER	CONTRACT AGE months	CONTRACT LOCATION route	mileposts
26	1	SR 360	10.4-12.5
18	17	SR 360	9.4-10.4
69	25	I-10	128.1-129.7
17	44	SR 360	7.5-9.4
16	69	SR 360	5.2-7.5

Sunburned plants exhibited cracked or peeling bark. Chlorotic plants exhibited a pale green color or appeared more yellow than expected for a normal plant. Trauma referred to any discernible physical damage such as splitting, gnawing from rodents, or destruction from vehicles. Noncoalesced was a category reserved for evaluation of groundcover plants whose canopies had not grown together. Dead was assigned only when the actual base of the missing plant remained and could be identified. Out-competed referred to species that were dominated by a noncompatible species in the landscape, thus distorting the design and placing the plant under additional stress from competition. When a plant appeared to be a poor specimen but did not exhibit any of the above symptoms, it was assigned to other as a category. Initially, water-stressed was suggested as a category but was eliminated because it proved to be too difficult to identify with certainty.

Plants were evaluated in one of two modes. Plants that generally appeared isolated from others of the same species were evaluated as individuals whereas plants that normally appeared as clusters of the same species were evaluated as groups. The landscape contract as-built plans were used as base maps. Counts for contract-species combinations do not always represent the total number of plants evaluated because each plant could be assigned to more than one category.

Statistical analysis using contingency tables and the chi square test statistic were applied to each of the species that met the following criteria: evaluation in the survey as individual plants, appearance on at least three different contracts, and presence of sufficient problems to warrant further evaluation. The species used in the analysis were *Acacia saligna* (ASL), *Acacia smallii* (ASM), *Acacia stenophylla* (AST), *Cercidium floridum* (CFL), and *Prosopis chilensis* (PCH).

RESULTS AND DISCUSSION

The statistical analysis identified the landscaping contracts and the side of the freeway on which the plants were grown as two major factors that influenced the response of the plants to the freeway environment. The effect of the landscaping contracts for each species was evaluated by comparing the status of the plants to the contract in which they were located. Status was established by comparing numbers of healthy plants to the summation of those plants that exhibited any of the symptoms identified in the survey. The probability of the chi square test of association between status and contract is given in Table 2. In four of the five species, the relationship was significant at the 0.05 acceptance level.

The cause of the difference in status with contract is unknown. The concept of the contracts as representative of length of time that the plants were exposed to the overall freeway environment was evaluated by plotting age of contract versus percent of healthy plants in each species (Figure 1). No pattern is discernible. If age were a controlling factor, the percent of healthy plants should have decreased with time of exposure. The contracts appear to represent specific environments to which the species have responded differently. The cause of the differences may be related to the alterations in the landscape design, differences in maintenance, or to initial differences in sources of plants.

The location of plants with respect to the median also appears to influence the response of plants in the freeway environment. In both areas surveyed, the freeway has an east-west alignment. The landscaping pattern tends to be a mirror image about the median with the arrangement of plants on the north side reflecting that of the south side. When plant status was

TABLE 2 PROBABILITIES OF THE CHI SQUARE TEST STATISTIC COMPUTED FOR VARIOUS COMBINATIONS OF STATUS, CONTRACT, AND SIDE FOR EACH PLANT SPECIES

PLANT SPECIES	POPU-LATION	ROW VARIABLE	COLUMN VARIABLE	CHI SQUARE PROBABILITY
ASL (a)	all	status	contract	0.000
ASL	all	status	side	0.537
ASL	problem	side	contract	0.001
ASM (b)	all	status	contract	0.223
ASM	all	status	side	0.000
ASM	problem	side	contract	--
AST (c)	all	status	contract	0.000
AST	all	status	side	0.117
AST	problem	side	contract	--
CFL (d)	all	status	contract	0.000
CFL	all	status	side	0.726
CFL	problem	side	contract	0.038
PCH (e)	all	status	contract	0.000
PCH	all	status	side	0.012
PCH	problem	side	contract	0.037

(a) Acacia saligna
(b) Acacia smallii
(c) Acacia stenophylla
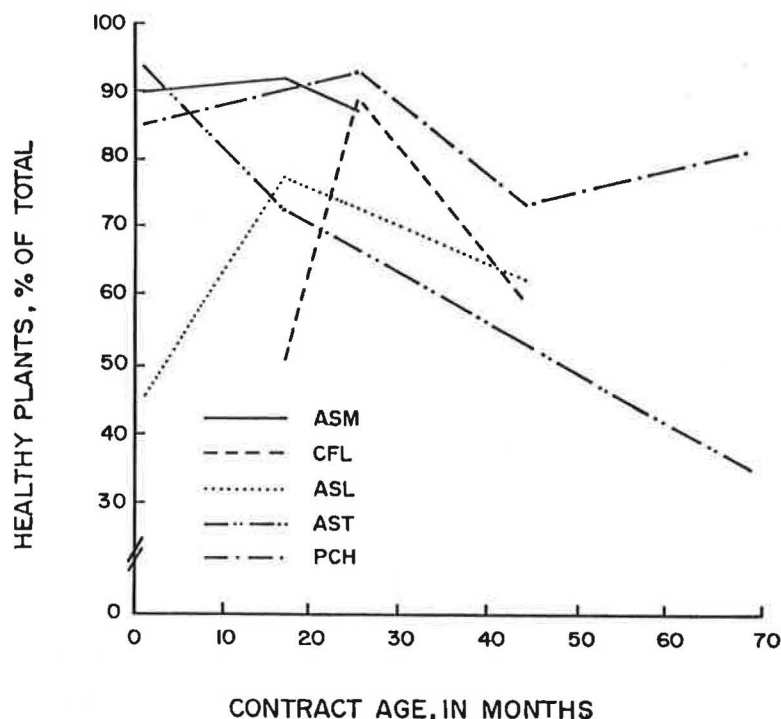(d) Cercidium floridum
(e) Prosopis chilensis

FIGURE 1   Relationship between age of contract and percent of healthy plants for each species.

compared to side without regard to contract, two species exhibited a significant relationship (Table 2). When the population was limited to plants that exhibited problems, the relationship between contract number and side is significant for three of the five species. In the other two species, low counts in contract-side combinations have invalidated the chi square test (*8*).

The cause of the effect of location (side) on the response of the plants is not known. The style of construction in this area is one of cut-and-fill, which has created slopes whose aspects are north-facing and south-facing. The influence of slope aspect on plant growth was recognized in the early literature on range plants (*9*). The same parameters may be operative in this situation, although the use of drip irrigation may mitigate the results.

The survey counts for plants evaluated as individuals are given in Table 3. The ratio of the sum of counts in problem categories versus counts in the healthy category appeared to be a useful indicator of success. Plants with a ratio of less than 0.10 were considered successful whereas those with ratios greater than 0.10 were considered unsuccessful in adjusting to the environment of the contract. Plants with a large ratio for a particular contract environment would be less likely to succeed if placed in a similar environment on a new contract.

Further evaluation of Table 3 provided information about specific species and contracts. *Acacia stenophylla* was the only species exhibiting sunburn. *Prosopis alba* appeared to be susceptible to physical trauma. *Yucca aloifolia* did not exhibit any of the symptoms cataloged in the survey but it did have a tendency to die. Characteristics specific to certain contracts can also be found. All of the out-competed counts appear on Contracts 16 and 17, and are spread throughout species. Plant competition can be controlled by trimming, which requires

skilled labor. The two contracts are the oldest and next oldest to be evaluated (Table 1). The lack of out-competed plants on younger contracts may reflect successful design adjustments made by Arizona Department of Transportation roadside personnel in order to reduce maintenance costs.

In general, the survey was successful in identifying the range of problems exhibited by the species evaluated as individuals. This is indicated by the moderate counts in the category designated as other (Table 3). The large count for *Cercidium floridum* on Contract 18 is related to a white fly infestation that was classified as OR. The OR counts in *Acacia faresiana, Acacia smallii, Prosopis chilensis,* and *Washingtonia californica* indicate that further observation of these species is needed to identify additional criteria for specific problems.

The results of the survey for some of the species evaluated as groups are provided in Table 4. The data illustrate a problem inherent in this type of survey. With the exception of noncoalesced (NC), the categories do not accurately describe all of the individuals within a group but the large numbers of plants in each group preclude their rapid evaluation as individuals. For example, the five contracts specified a combined total of 53,137 plants of *Acacia redolens* and 5,033 plants of *Nerium oleander.* The time required to evaluate each of these plants as individuals conflicts with the objective of a rapid inventory.

A modification of the category concept developed for individual plants provided limited information about groups. Assignment of a group to a category such as dead was based on the concept that not all of the plants in the group were dead but rather dead plants could be found in the group. For example, in the evaluation of *Dalea greggii,* five groups contained dead plants on Contract 26 whereas 18 groups contained healthy plants with no noticeable problems. This spe-

TABLE 3   COUNTS FOR EACH CATEGORY FOR PLANT SPECIES
EVALUATED AS INDIVIDUALS

PLANT SPECIES	CONTRACT ID	CATEGORY (a)							RATIO
		HL	SB	CH	TR	DD	OC	OR	
Acacia farnesiana	16	92	0	2	0	3	0	0	0.05
Acacia salicina	17	118	0	0	1	17	0	32	0.42
Acacia saligna	17	93	0	3	0	8	5	13	0.31
	18	55	0	16	0	0	0	0	0.29
	26	47	0	48	0	9	0	0	1.02
Acacia smallii	18	219	0	8	11	0	0	0	0.09
	26	53	0	5	0	0	0	0	0.09
	69	269	0	22	0	0	0	35	0.21
Acacia stenophylla	16	37	31	0	0	15	5	19	1.89
	18	20	6	6	0	0	0	0	0.60
	26	33	0	1	0	0	0	0	0.03
Cercidium floridum	17	261	0	1	0	47	45	33	0.48
	18	118	0	0	1	1	0	111	0.96
	69	159	0	0	1	4	0	10	0.09
Cercidium praecox	26	571	0	5	7	2	0	0	0.03
Chilopsis linearis	26	145	0	3	3	0	0	0	0.04
Eucalyptus microtheca	17	346	0	2	2	2	12	4	0.06
	26	101	0	11	0	1	0	0	0.12
	69	222	0	0	0	0	0	0	0.00
Melaleuca nesophylla	26	1	0	0	5	0	2	0	7.00
Pinus halepensis	16	2	0	285	0	6	225	1	255.0
Prosopis alba	18	341	0	0	69	3	0	0	0.21
	26	101	0	0	10	0	0	0	0.10
Prosopis chilensis	16	317	0	15	1	13	24	20	0.23
	17	293	0	39	1	23	23	22	0.37
	26	325	2	7	33	1	0	12	0.17
	69	344	0	2	3	10	0	3	0.05
Rhus lancea	16	33	0	0	0	9	0	11	0.61
Washingtonia californica	69	24	0	9	0	1	0	7	0.71
Yucca aloifolia	16	29	0	0	0	8	0	0	0.28

(a)   The abbreviations for categories are defined in the
      Materials and Methods.

TABLE 4   COUNTS FOR EACH CATEGORY FOR SOME PLANT
SPECIES EVALUATED AS GROUPS

PLANT SPECIES	CONTRACT ID	CATEGORY (a)							
		HL	SB	CH	TR	NC	DD	OC	OR
Acacia redolens	16	45	0	0	0	27	1	0	0
	17	30	0	0	0	6	0	0	0
	18	15	0	0	0	15	3	0	0
	26	9	0	17	1	20	5	0	0
	69	5	0	10	0	9	3	0	0
Caesalpinia pulcherrima	16	17	0	0	0	0	0	8	2
	17	8	0	0	0	0	2	2	1
	18	3	0	0	0	0	0	0	0
	26	3	0	0	0	0	1	0	0
	69	4	0	0	0	0	0	0	0
Dalea greggii	16	1	0	0	0	1	1	0	0
	18	9	0	0	0	10	1	0	0
	26	18	0	0	0	13	5	0	0
Justicia californica	26	4	0	3	0	0	1	0	0
	69	1	0	0	0	0	1	1	0
Myoporum parvifolium	26	11	0	0	0	11	2	0	0
	69	1	0	0	0	0	1	0	0
Nerium oleander	16	4	0	0	0	0	0	0	0
	17	9	0	0	0	0	0	0	0
	18	3	0	0	0	0	0	0	0
	26	3	0	0	0	0	0	0	0
	69	3	0	0	0	0	0	0	0

(a)   The abbreviations for categories are defined in the
Materials and Methods

cies does not appear to be well adapted to the environment of Contract 26. On the other hand, *Nerium oleander* appears to be one of the most successful plants used along the freeway regardless of the contract environments.

The most useful category applied to group plants was NC (noncoalesced). Groundcover plants that coalesce are both a landscaping design element and a potential contributor to slope erosion resistance. The intergrown canopies provide soil protection from raindrop impact. Three of the species in Table 4 are considered groundcover, *Acacia redolens*, *Dalea greggii*, and *Myoporum parvifolium* (*10*). The counts in the NC category suggest that *Acacia redolens* and *Dalea greggii* are not successfully coalescing in the different contract environments. If coalescing is desired, then a closer plant spacing may be needed for these species. Insufficient information is available to discern the success of the *Myoporum parvifolium*.

CONCLUSIONS

The category-based survey provided a useful means of rapidly establishing initial information concerning the landscape plants along the Phoenix Metropolitan Freeway System. It was used to identify two major sources of difference in the plant response to the environment of the freeway. The differences in landscaping contracts need to be considered if detailed measurements and subsequent monitoring of the plants are to be undertaken. The side of the freeway on which the plants are located should be considered in future landscaping designs for the freeway system. The use of a mirror image design may not provide the best results when a cut-and-fill style construction is used.

The success of this type of survey in providing information about the responses of individual species to the freeway environment will be defined by three conditions. First, the species must be repetitive either among the contracts or along diverse sections of the freeway. The differences in response to contract environments suggest that if the response of a plant species is known for only one contract or for only a very limited area, insufficient information is available to predict the response of that species if used in a future contract. Second, the categories must be selected with care. Categories should reflect the conditions and specific species in the area to be evaluated. High counts in collective categories such as "other" indicate a lack of knowledge about the area. Third, the plants should be evaluated as individuals rather than as groups. If excessively large numbers of plants are to be evaluated, grouping may become necessary but detailed information will be lost.

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