Assessing Public Opinion on Water Conservation and Water Conserving Landscapes in the Semiarid Southwestern United States

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SUMMARY. **A survey instrument was designed to determine public opinion on water conservation, water conserving landscapes, the use of native plants in landscapes, home irrigation systems, and the performance of five Texas native plant species [pink evening primrose (*Oenothera speciosa*); prairie verbena (*Verbena bipinnatifida*); red yucca (*Hesperaloe parviflora*); ceniza (*Leucophyllum frutescens*); and ruellia (*Ruellia nudiflora*)] grown in low water use landscapes in the semiarid Southwestern United States. On six occasions during the 1999 growing season, participants viewed landscapes and participated in a survey. Survey data indicate that over 90% of respondents thought water conservation was important to the state of Texas. A majority of participants however, believed water conserving landscapes to be expensive to maintain and not aesthetically pleasing. The survey revealed 79% of participants would use native plants if native plants conserved water, and 86% of participants would use native plants if native plants were attractive. Chi-square approximations revealed participant's opinions regarding water conservation and home irrigation systems were influenced by education level and amount of time they participated in weekly horticulture activities. In an open-ended question, participants indicated flowers and healthy leaves were characteristics indicating a plant was performing well. Throughout the year, species in flower received higher ratings than nonflowering species.**

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In many communities, urban landscape irrigation is a large fraction of total water use. In fact, urban landscape irrigation is estimated to consume between 40% and 70% of all water used in urban communities (Ferguson, 1987). Depletion of water tables (Jensen et al., 1997), poor water quality (McDaniels et al., 1998), and drought (Urbano, 1990) has emphasized the need for many communities to implement water conservation programs (Stabler and Martin, 2000). Because of the need to reduce water use, water conservation is often considered to be a goal of landscape design (Zajicek, 1993). One of the primary components of a water conserving landscape is the use of drought tolerant, native and adapted plants species (Paine et al., 1992). Plant species native to xeric locations are more adapted to arid environments than nonxeric plants, and therefore more likely to survive drought conditions (Wolfe and Zajicek, 1998). However, if homeowners are not satisfied with plant performance, drought tolerant plants will likely be eliminated from landscapes.

Surveys and visual evaluations have been used to assess public perception of low water use landscapes, and to assess the appeal and performance of landscape plant species. Thayer (1982) used surveys to assess the desirability of water conserving landscapes. He concluded that before the public implements low water use landscapes in their homes and communities, they must first see correctly planned and installed low water use landscapes. To measure audience perception, attitude, and knowledge of low water use landscapes, pre- and postworkshop surveys were utilized by Lohr and Bummer (1992) and McKenney and Terry (1995). In general, audience acceptance of low water use landscapes increased after workshops gave correct information regarding low water landscape principles. Wolfe and Zajicek (1998) surveyed 50 participants to determine public perception of selected ornamental grass species, use of ornamental grasses in landscapes, and the importance of research on landscape water use. Participants responded positively (highly agreed or agreed) that research on water saving ornamental grasses was important and that ornamental grasses should be used in landscapes if ornamental grasses conserve water.

Efforts to promote low water use landscapes have met with varied success. In most cases, those who participate in surveys are of the opinion that conserving water in the landscape is important, but that low water use landscapes are inherently unattractive (McKenney and Terry, 1995; Wolfe and Zajicek, 1998). However, in communities with attractively designed low water use landscapes, surveys indicate many people have positive attitudes toward water conserving landscapes (Lohr and Bummer, 1992). If landscape water conservation is to become a reality, public acceptance of low water use landscapes, and drought tolerant plants, must increase. This study utilized a survey tool to determine public opinion on water conservation, water conserving landscapes, the use of native plants in landscapes, home irrigation systems, and assess the performance of five plant species native to Texas grown in low water use landscapes.

Materials and methods

Research was conducted at the Texas Tech University Greenhouse Complex in Lubbock, Texas. During April 1998, three miniature landscape plots were installed. Each plot was kidney shaped and consisted of a stone-lined raised bed 10 cm (4.0 inches) deep. Each plot was about 6.0 m^2 (65 ft^2). Soil in each plot consisted of an Amarillo fine sandy loam (Fine-loamy, mixed, superactive thermic Aridic Paleustalfs) amended to 6% organic matter in the top 15 cm (6 inches) of the soil surface with composted cotton seed. Drip irrigation was installed on a 30 cm (1 ft) grid inside each plot (model R17-35B030; Netafim Inc., Fresno, Calif.).

Irrigation tubing was equipped with one 3.5 $L \cdot h^{-1}$ (1.0 gal/h) pressure compensating emitter every 30 cm. Soil in each plot was covered with 5 cm (2 inches) of cypress bark mulch, which was maintained at this height throughout the experiment. Each plot was fitted with a flowmeter (model Bermadon MTA; Bermad Inc., Anaheim, Calif.) and a 138-kPa (20-lb/$inch^2$) pressure regulator (model PMR 20 MF; Senninger Irrigation, Inc., Orlando, Fla.).

In April 1998, eight plants of five plant species native to xeric areas in Texas were planted in each test plot (Correll and Johnston, 1996; Kirkpatrick, 1992). Species used were pink evening primrose, prairie verbena, red yucca, ceniza, and ruellia. Pink evening primrose, prairie verbena, and ruellia were asexually propagated from plants collected near Texas Tech University. Red yucca plants were asexually propagated from commercial nursery stock. Ceniza were purchased from a local nursery in 3.8-L (1-gal) containers. During the 1998 growing season, all plots were irrigated as needed. Each year plots were weeded by hand.

An automated weather station (model Metdata1; Campbell Scientific, Inc. Logan, Utah) located about 1.6 km (1 mile) from the test site was used to monitor local weather conditions. Data received from this weather station was used to calculate weekly grass reference evapotranspiration (ETo). Grass reference evapotranspiration was calculated using ETo calculation software (Allen, 1994). Irrigation was applied once each week at a 60% replacement rate based upon total weekly ETo (mm) and test plot area (m^2).

A descriptive survey tool (Oppenheim, 1966) was used to determine public opinion on water conservation, water conserving landscapes, use of native plants in home landscapes, and home irrigation systems. In addition, participants provided a visual ranking of the five native plant species. A stratified sampling design was applied to ensure adequate representation and reduce sampling error (Alreck and Settle, 1995; Wimmer and Dominick, 1997). A population of homeowners, university students, and greenhouse visitors was used. Participants were invited to contribute by an invitation mailed to local homeowners, an announcement in university classes, and solicitation of garden tour attendees. A pilot study of the survey instrument was administered to 20 university students. Based on this survey, changes were incorporated into the questionnaire. To increase the number of respondents and enhance the confidence level of the results, the survey was administered six times during the growing season. Each collection date, a minimum of 50 people participated, and no person completed the questionnaire more than once.

Survey data was recorded as number responses. Demographic information gathered from each participant included age, level of education, gender, and amount of time each week they participated in a horticulture activity (planting, weeding, mowing, pruning, etc.). Opinions on water conservation, water conserving landscapes, use of native plants in home landscapes, and home irrigation systems were gathered through nine, five-point, bipolar questions (Wimmer and Dominick, 1997). Respondents were asked to place an "X" along a graphic scale at the location that most closely approximated their view of each question (Lohr and Bummer, 1992). A typical question scale was in the following format:

Not important : ____ : ____ : ____ : ____ : ____ : Important

Visual plant rankings were rated by participants on a five-point Likert scale (Oppenheim, 1966, Wolfe and Zajicek, 1998). Participants were asked to look at each plant in each plot and provide a numerical answer for the following statement: "This species is performing well." A 1 indicated "strongly disagree," 2 "disagree," 3 "no opinion (neutral)," 4 "agree," and 5 "strongly agree." Participants were also asked to list characteristics they believed a plant that is "performing well" should have. Before data collection, participants were not given information relating to water issues, drought, landscape irrigation, native plant species, or low water use landscape issues. To assure anonymity, finished surveys were collected and given a number.

Data from the nine, five-point, bipolar questions on the survey instrument were analyzed using the Statistical Package for the Social Sciences (SPSS Inc., 1999). Before conducting data analysis, the major assumptions of normality and homogeneity were addressed (Sokal and Rohlf, 1981). Data normality was tested using a Kolmogorov-Smirnov test. Results were significant for each variable indicating a violation of the assumption of normality ($P \leq 0.05$). Because of the violation of normality, a Levene's test was used to test the assumption of equal variances. Five of the nine variables were determined to have heteroscedastic variances. Therefore, because of violations of normality and homogeneity, nonparametric techniques were used to analyze the nine bipolar questions. A Kruskal-Wallis (Chi-square approximation) test was conducted to evaluate the hypothesis that there were no differences between respondents education level or amount of time each week respondents participated in horticulture activity and seven of the bipolar questions.

Mean scores were determined for visual plant rankings. Means from each survey and overall rating means were subjected to analysis of variance and means were separated using Fisher's Least Significant Difference (LSD) test at the 0.05 level of probability (SAS Institute Inc., 1999). To eliminate error and assure reliability, a random sample of 45 surveys (3,915 data entries) were selected by an independent observer and compared directly to the data set keyed into a computer. This resulted in a 99% reliability rating for these data.

Results and discussion

Analysis of participant demographics indicated that of the 410 participants, 41% were male and 59% were female. Of total respondents, 48% were 30 years old or less, 31% were between 31 and 60 years old, and 21% were over 60 years old. Over 90% of respondents had some college training (minimum of a BS degree or currently enrolled). In addition, 15% had at least one advanced degree. Participants also had varied horticulture experience. When asked to specify the amount of time each week they participated in a horticulture activity, 51% of respondents participated less than 1 h, 36% participated 1 to 6 h, and 13% participated over 6 h each week. The survey in May, on 2 Sept., and on 30 Sept. had more participants under the age of 20, while participants in June, July, and August participated more in weekly horticulture activities and had more participants with a college degree. These differences were likely due to an increased number of college students during the spring and fall semesters, and the lack of college students during summer.

When questioned concerning water conservation, participants indicated

that water conservation in Texas was very important, and overwhelmingly considered water conserving landscapes important (Table 1). Participants also indicated they regarded water conserving landscapes as expensive to maintain and not aesthetically pleasing, but that they would use native plants if they conserved water and were attractive (Table 1). Survey participants also indicated that home landscape irrigation systems were unnecessary and difficult to operate, but that home irrigation systems conserved water (Table 1). These results indicate that participants were interested in water conservation and that they wanted attractive plant material in their landscapes. Results agree with Wolfe and Zajicek (1998) who reported water conserving plants were important to the public, and that homeowners would be willing to incorporate plants into their landscapes if the plants conserved water.

Results also indicate public displeasure with home irrigations systems. It is interesting to note that although respondents thought irrigation systems were unnecessary and difficult to operate, a majority of participants thought home irrigation systems conserved water (61% of participants gave ratings of 4.0 or 5.0 to survey question 9). Although participants believed installed home irrigation systems conserved water, Osmond and Platt (2000) reported homes in North Carolina with installed irrigation systems used two times more landscape irrigation water when compared to homes that used moveable, hose-end sprinklers.

Chi-square approximation tests indicate differences between respondents education level or amount of time each week spent in horticulture activity for several of the bipolar survey questions (Tables 2 and 3). Participants with a Ph.D. participated more each week in

Table 1. Survey questions, response level, percent for each response level, and response level means for participants (n = 410) who answered questions regarding their attitudes toward water conservation, water-conserving landscapes, the use of native plants in landscapes, and home irrigation systems in the semiarid southwestern United States.

	Response level[z]					Response
	1	2	3	4	5	level
Survey question	Response level (%)					mean (SE)
Water conservation is not important or very important in Texas[y]	0.0	0.5	4.1	13.5	81.9	4.8 (0.03)
Water-conserving landscapes are not important or important[x]	1.3	2.9	14.2	29.9	51.7	4.3 (0.04)
Water-conserving landscapes are economical or expensive to maintain[w]	2.7	6.2	22.4	27.8	40.9	3.9 (0.06)
Water conserving landscapes are aesthetically or not aesthetically pleasing[v]	1.2	7.9	30.0	22.7	38.2	3.8 (0.05)
I would use native plants if they conserved water (highly disagree or highly agree)[u]	2.2	3.2	15.7	30.6	48.3	(4.2) (0.05)
I would use native plants if they were attractive (highly disagree or highly agree)[t]	1.0	2.5	10.8	21.2	64.5	4.6 (0.04)
Home landscape irrigation systems are necessary or unnecessary[s]	4.9	10.6	24.5	25.7	34.3	3.7 (0.06)
Home landscape irrigation systems are easy or difficult to operate[r]	4.0	7.2	27.2	24.8	36.8	3.8 (0.04)
Home landscape irrigation systems waste or conserve water[q]	4.2	8.9	25.9	26.1	34.9	3.7 (0.06)

[z]Response levels for each question are based on a 1 to 5 point bipolar question.
[y]1 = not important, 3 = neutral, 5 = very important.
[x]1 = not important, 3 = neutral, 5 = very important.
[w]1 = economical to maintain, 3 = neutral, 5 = expensive to maintain.
[v]1 = aesthetically pleasing, 3 = neutral, 5 = not aesthetically pleasing.
[u]1 = highly disagree, 3 = neutral, 5 = highly agree.
[t]1 = highly disagree, 3 = neutral, 5 = highly agree.
[s]1 = highly necessary, 3 = neutral, 5 = highly unnecessary.
[r]1 = very easy, 3 = neutral, 5 = very difficult.
[q]1 = waste water, 3 = neutral, 5 = conserve water.

Table 2. Chi-square value[z] and response level mean comparisons of survey participants (n = 410) education level and questions regarding participants weekly horticulture activity, attitudes toward water conserving landscapes, the use of native plants in landscapes, and home irrigation systems in the semiarid southwestern United States.

		Education level				
Survey question	χ^2	High school	Some college	College	Masters degree	PhD
Amount of time each week spent in horticulture activity[y]	0.001	3.05	2.25	2.94	3.00	3.88
Water conserving landscapes are economical or expensive to maintain[x,w]	0.0001	4.08	3.78	4.29	4.31	3.77
Water conserving landscapes are aesthetically or not aesthetically pleasing[v]	0.283	4.05	3.86	3.76	4.07	3.88
I would use native plants if they were attractive (highly disagree or highly agree)[u]	0.013	4.42	4.31	4.65	4.71	4.66
Home landscape irrigation systems are necessary or unnecessary[t]	0.046	3.75	3.61	3.81	4.13	3.55
Home landscape irrigation systems are easy or difficult to operate[s]	0.085	4.00	3.71	3.95	4.03	4.33
Home landscape irrigation systems waste or conserve water[r]	0.962	3.68	3.83	3.71	3.82	3.67

[z]Applied Kruskal-Wallis test (chi-square approximation) pooled across survey dates.
[y]1 = <15 min, 2 = 15 min to 1 h, 3 = 1 to 3 h, 4 = 3 to 6 h, 5 = 6 h.
[x]Response levels for each question are based upon a 1 to 5 point bipolar question.
[w]1 = economical to maintain, 3 = neutral, 5 = expensive to maintain.
[v]1 = aesthetically pleasing, 3 = neutral, 5 = not aesthetically pleasing.
[u]1 = highly disagree, 3 = neutral, 5 = highly agree.
[t]1 = necessary, 3 = neutral, 5 = unnecessary.
[s]1 = easy, 3 = neutral, 5 = difficult.
[r]1 = waste water, 3 = neutral, 5 = conserve water.

Table 3. Chi-square value[z] and response level mean comparisons of survey participants (n = 410) weekly horticulture activity and questions regarding participants education level, attitudes toward water conserving landscapes, the use of native plants in landscapes, and home irrigation systems in the semiarid southwestern United States.

		Weekly horticulture activity				
Survey question	χ^2	<15 min.	15 min 1 h	1 to 3 h	3 to 6 h	>6 h
Level of education[y]	0.001	2.28	2.14	2.71	2.62	2.61
Water conserving landscapes are economical or expensive to maintain[x,w]	0.001	3.87	3.77	4.02	3.97	4.49
Water conserving landscapes are aesthetically or not aesthetically pleasing[v]	0.177	4.25	4.22	4.21	4.45	4.43
I would use native plants if they were attractive (highly agree or highly disagree)[u]:	0.003	4.31	4.27	4.60	4.65	4.67
Home landscape irrigation systems are necessary or unnecessary[t]	0.022	3.48	3.68	3.80	3.94	4.05
Home landscape irrigation systems are easy or difficult to operate[s]	0.009	3.58	3.73	3.99	3.88	4.15
Home landscape irrigation systems waste or conserve water[r]	0.557	3.71	3.99	3.89	3.58	3.85

[z]Applied Kruskal-Wallis test (Chi-square approximation) pooled across survey dates.
[y]1 = high school, 2 = some college, 3 = college, 4 = masters degree, 5 = Ph.D.
[x]Response levels for each question are based upon a 1 to 5 point bipolar question.
[w]1 = economical to maintain, 3 = neutral, 5 = expensive to maintain.
[v]1 = aesthetically pleasing, 3 = neutral, 5 = not aesthetically pleasing.
[u]1 = highly disagree, 3 = neutral, 5 = highly agree.
[t]1 = necessary, 3 = neutral, 5 = unnecessary.
[s]1 = easy, 3 = neutral, 5 = difficult.
[r]1 = waste water, 3 = neutral, 5 = conserve water.

horticulture activities than other education levels, and respondents currently enrolled in college (those who answered "some college" on the questionnaire) participated the least each week in horticulture activities (Table 2). All respondents believed water conserving landscapes to be expensive to maintain and unattractive (mean of each education group above 3.0 which is neutral) (Table 2). Participants with a Masters degree or some college experience however, believed water conserving landscapes to be more expensive to maintain than other education groups. Use of native plants in home landscapes was also influenced by education level. Although all participants agreed they would use native plants in their home landscapes if native plants were attractive, respondents without a college education indicated they were less agreeable to use native plants than participants with a college degree (Table 2). When asked about the need for home landscape irrigation systems, all educational groups thought home landscape irrigation systems were unnecessary. Those with a master's degree however, indicated that a home landscape irrigation system was less necessary than other educational groups. Although all participants thought home landscape irrigation systems were difficult to operate and conserved water (Table 2), education level did not influence participant response.

Participants with greater weekly horticulture activity were more educated, thought water conserving landscapes were more expensive to maintain, and would more likely use native landscape plants if they were attractive (Table 3). Survey results also indicate people with greater weekly horticulture activity considered home landscape irrigation systems as unnecessary and difficult to operate (Table 3). Although all levels of weekly horticulture activity believed installed home landscape irrigation systems conserved water (all means greater than 3.0), weekly horticulture activity did not influence participant response.

Results from this research gave insight into public opinions on water conservation, water conserving landscapes, the use of native plants in landscapes, and home irrigation systems. A vast majority of participants believed water conservation and water conserving landscapes were very important. Most participants however, believed water conserving landscapes to be expensive to maintain and not aesthetically pleasing. Similar results were reported by McKenney and Terry (1995), and Wolfe and Zajicek (1998). Robbins et al. (1994) however, advises properly installed water conserving landscapes reduce landscape water use, protect water quality, decrease the need for pest control, and increase landscape health and beauty. Participants also supported the

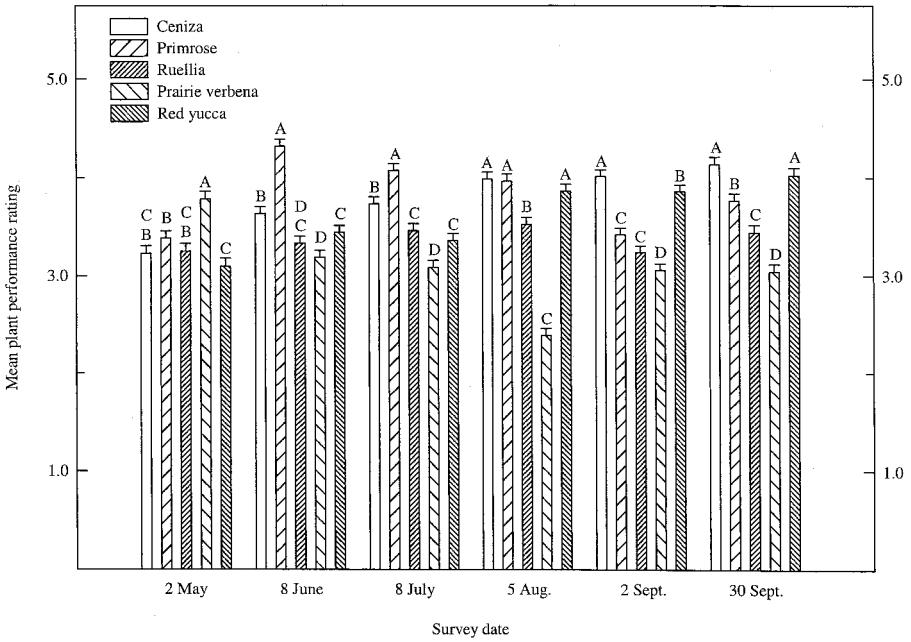

Fig. 1. Mean plant performance ratings (±SE) given by survey participants (n = 410) based on a 1 to 5 Likert scale (1 = plant is not performing well, 3 = neutral, 5 = plant is performing well). Survey participants were asked to rate five ornamental plant species native to Texas [ceniza (*Leucophyllum frutescens*), pink evening primrose (*Oenothera speciosa*), ruellia (*Ruellia nudiflora*), prairie verbena (*Verbena bipinnatifida*), and red yucca (*Hesperaloe parviflora*)] on six survey dates in the semiarid southwestern United States. Different letters over bars indicate differences among species rating within each survey date (LSD, $P \leq 0.05$).

use of native plants in landscapes if native plant species were attractive and conserved water. Wolfe and Zajicek (1998) reported similar results for landscapes planted with native grasses.

Participants education level and amount of time spent each week in horticulture activity appeared to be closely related, and these two factors influenced opinions. Participants with more education spent more time in horticulture activities, were more likely to use native plants in their home landscapes, and believed installed home irrigation systems were unnecessary. It is interesting to note that education level did not influence participants difficulty in using home irrigation systems, but the ease of using home irrigation systems was influenced by participants horticulture activity (Tables 2 and 3).

At each survey date, participants were asked to visually rate the performance of each species. In an open-ended question, survey participants were allowed to share what qualities they looked for in a plant that was "performing well". Flowering (30%) and healthy leaves (30%) each received the greatest response. Proper plant growth (proportional shape and size) was listed as a characteristic by 20% of participants. Responses for the remaining 20% were in the categories of excessive growth, turgid leaves and stems, very little leaf browning, and lack of disease or insects. Overall, survey participants considered plants in flower and with abundant foliage as performing best.

Weather during the survey period was typical for late spring, summer, and early fall days in western Texas. Air temperature ranged from 3.5 °C (38.3 °F) in the morning to 38.6 °C (101.4 °F) in the afternoon. Relative humidity dropped below 10% on many afternoons after beginning some days near 100%. Days were mostly sunny and precipitation totaled 41.5 cm (16.4 inches) which was 32% greater than normal for this time period. For the survey period, total ETo was 106 cm (42 inches). Mean daily ETo during June, July, and August was 0.8 $cm \cdot d^{-1}$ (0.3 inch/d) and mean daily ETo for May and September was 0.6 $cm \cdot d^{-1}$ (0.24 inch/d).

Participant species preferences are revealed by survey ratings. A significant species × survey date interaction was found, therefore survey results are presented by survey date (Fig. 1). Trends were to rate species in flower as performing better than nonflowering species. For example, prairie verbena (which blooms in late spring) was the highest rated species in May (Fig. 1). By early summer (when prairie verbena is no longer in flower), and for the remaining growing season, prairie verbena was given the lowest rating of all species. Red yucca and ceniza follow a similar, but opposite trend. Each of these species received low ratings during the May, June, and July surveys (Fig. 1). However, for the remaining growing season, red yucca and ceniza were in flower and were the highest rated species.

Survey data from this research revealed people in Lubbock, Texas believed landscape water conservation and the use of water conserving landscape plants are important. However, a majority of participants believed landscape irrigation systems are difficult to operate, and that water conserving landscapes are not aesthetically pleasing and expensive to maintain. In addition, this research indicated public preference for flowering plants and that the use of water conserving plants with a prolonged flowering period would appeal to home gardeners. Surveys also indicated that species used in this research have potential to maintain healthy growth and appearance in a water conserving landscape in a semiarid, region of western Texas.

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