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A Survey of Public Perceptions and Attitudes about Water Availability Following Exceptional Drought in Texas

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Abstract: This study examines the results of a random sample survey of Texans evaluating citizen awareness, attitudes, and willingness to adopt water conservation practices. The study investigates changes in public attitudes following the most intense one-year drought on record in Texas by evaluating public perception of water availability, assessing Texans' attitudes and perceptions regarding drought conditions, and comparing the number of Texans adopting practices to conserve water before and after the drought of 2011. Almost 70% indicated that the likelihood of their area suffering from a prolonged drought was increasing. More than 61% of respondents have changed the way their yard is landscaped and 62% have also adopted new technologies in an effort to conserve water. Overall, responses indicated that Texans are concerned with water availability after experiencing, in 2011, the worst one-year drought on record, and that the majority of respondents are taking personal action in an effort to conserve water for the future.

Keywords: *survey, perception, water conservation, drought, attitudes*

Texas experienced its worst single-year drought on record in 2011 (Nielsen-Gammon 2012), affecting people in many ways. While farmers may have been more directly affected by drought, city dwellers also were impacted by expectations for compliance with municipal drought contingency plans and water restrictions. For some citizens, public supplies came within days of running out of water and a few systems were supplied by neighboring utilities. Reservoir levels dropped and reached record lows for storage, while aquifer levels also dropped and some wells went dry. The 2011 drought caused a record loss of $7.62 billion to Texas agriculture (Fannin 2012). Most water supply systems implemented mandatory water restrictions. The severity of the drought captured the attention of Texans from all regions of the state.

In addition to the pressures of periodic, extreme drought, the Texas Water Development Board (2017) estimates that the Texas population will increase more than 70% from 2020 to 2070, and water demand will increase by 17%. Texas' rapidly growing urban areas will lead water consumption for the state. By 2070, 30% of the total water volume included in management strategies proposed in the State Water Plan will involve demand management to reduce needs for additional water through water conservation and drought management (Texas Water Development Board 2017).

Public perceptions and attitudes toward water issues will play an important role in whether Texans choose to adopt water conservation practices. Water conservation by Texas residents will play a pivotal role in meeting water supply demands the state will face in the future. Previous research links attitudes and perceptions to water use behaviors (Campbell et al. 2004; Clarke and Brown 2006; Jorgensen et al. 2009; Willis et al. 2011). The public's attitudes regarding water supply also can

be linked to experiences in longer-term drought conditions (Delorme et al. 2003; Casagrande et al. 2007; Adams et al. 2013; Evans et al. 2015).

Texas A&M AgriLife Extension Service, in conjunction with a national needs assessment project initiated through the Pacific Northwest Regional Water Program, facilitated two mailed random sample surveys of Texans to evaluate citizen awareness, attitudes, and willingness to act on water issues (Mahler et al. 2013). The first survey was conducted in 2008 at the beginning of a relatively mild drought. The drought intensified through 2009-2012 when much of the state was categorized as enduring exceptional drought. The original survey was re-issued to another random sample of Texans in 2014, resulting in an opportunity to investigate changes in public attitudes following exposure to one of the most intense one-year droughts in Texas. The objectives of this study are to: 1) evaluate the public's perception of water availability, 2) evaluate Texans' attitudes and perceptions regarding drought conditions, and 3) compare the frequency of Texans adopting practices to conserve water before and after the drought of 2011.

Materials and Methods

A state-wide survey was developed to assess Texans' perceptions and attitudes about water resources within the state. The questionnaire is one of the survey components comprising the National Integrated Water Quality Program Needs Assessment Survey project initiated in 2002. The present survey is based on the 2002 template developed by water quality coordinators in the Pacific Northwest region, with input from other participating Land Grant Institution (LGI) water quality coordinators for the Southern, Mid-Atlantic, Northwest, Northeast, and Caribbean Island Regional Water Programs (Mahler 2010). The survey was mailed to 1,275 randomly selected Texas residents in August 2008 following methods described in Boellstorff et al. (2010); 419 surveys (33%) were completed and returned. Minor modifications were made to the template survey to adapt it to Texas' water management agencies and organizations, and to modernize particular questions before the survey was re-issued in 2014. The survey questionnaire included 59 questions addressing water resources, water quality, and other environmental issues. The study population consisted of the adult residents of Texas.

In April 2014, the questionnaire was sent via direct mail survey to 1,800 randomly selected residences in Texas following the tailored survey design method of Dillman (2000), and as the Texas population had increased, recalculating the number of mail outs necessary as described in Boellstorff et al. (2010). As in the 2008 survey, randomly selected addresses were purchased from Survey Sampling International, Fairfield, CT and, individuals were mailed a paper copy of the survey instrument, a cover letter, and a self-addressed, stamped envelope. Twenty days later, individuals were sent a reminder postcard. Twenty days after the reminder postcard was sent, another survey instrument, cover letter, and self-addressed, stamped envelope were mailed. Twenty days later, a final reminder postcard was mailed to participants.

Individuals returning the survey or indicating that they did not want to participate in the study were removed from the mailing list so that they were not re-contacted. Taking into account the number of 1) surveys "returned to sender for incorrect address," 2) recipients requesting to not participate, and 3) recipient death, the effective number of mailed questionnaires in 2014 was 1,655 and the return rate for the completed survey questionnaires was 29%. Survey responses were coded and entered into a spreadsheet. Missing data were excluded from analyses.

This study investigates the relationship of water quantity perceptions to water conservation actions. Responses to the following five questions in Table 1 for both 2008 and 2014 along with socio-demographic information requested by the survey are the focus of this article.

Additionally, this study assesses the change in public attitudes and perceptions regarding water resources and actions taken to conserve water, using data from surveys administered in 2008 and 2014, and examines the change in rate of adoption of water saving practices regarding survey year and associated socio-demographics.

The Statistical Package for Social Sciences (SPSS) Version 23 was used for data analyses.

Table 1. Question wording and response set.

Question	Response Set
1) Do you regard water quantity (having enough water) as a problem in the area where you live? (Mark one answer)	a. Definitely not b. Probably not c. I don't know d. Probably e. Definitely yes
2) The likelihood of your area suffering from a prolonged drought is:	a. Increasing b. Decreasing c. Staying the same d. No opinion
3) The likelihood of your area having enough water resources to meet all of its needs 10 years from now is:	a. High (likely enough) b. Medium c. Low (likely not enough water) d. No opinion
4) Have you or someone in your household done any of the following as part of an individual or community effort to conserve water or preserve water quality? (Mark all that apply)	a. Changed the way your yard was landscaped b. Changed how often you water your yard c. Changed use of pesticides, fertilizers, other chemicals d. Pumped your septic system (if you have one) e. Adopted new technologies (low flow showerheads, high-efficiency washing machines and dishwashers, etc.)
5) Do you think that the amount of rainfall in your area will change as a result of global warming?	a. Yes, a significant increase in rainfall b. Yes, a slight increase in rainfall c. No, no change in rainfall d. Yes, a slight decrease in rainfall e. Yes, a significant decrease in rainfall d. I don't know

Descriptive summary statistics were calculated for socio-demographic variables (Table 2). The null hypothesis that the response frequencies are the same for the various answer options and socio-demographic variables was tested using Pearson's chi-squared and logistic regression analyses. A multinomial logistic regression analysis was used to predict the likelihood of adopting water conserving actions such as: changing yard landscaping, changing lawn watering, and adopting water conserving technologies, based on socio-demographics and responses from 2008 and 2014 surveys.

Further, the potential differences in the influence of water availability perception on water management behaviors before the exceptional drought (2008 survey) and responses after the exceptional drought (2014 survey) were evaluated. Pearson's chi-squared test ($p<0.05$) was applied to determine significant differences in responses before or after the 2011 Texas drought and for demographic variables.

Table 2. Demographics of respondents for surveys conducted in 2008 and 2014.

Category		Year	
		2008 % (n)	**2014** % (n)
Gender	Male	63.9 (262)	48.7 (185)
	Female	36.1 (148)	51.3 (195)
Years lived in Texas	All my life	47.9 (197)	46.6 (180)
	More than 10 years	40.6 (167)	45.6 (176)
	5 to 9 years	7.1 (29)	4.4 (17)
	Less than 5 years	4.4 (18)	3.4 (13)
Size of residence community	> 100,000	48.1 (190)	53.5 (238)
	25,000 to 100,000	21.3 (84)	19.6 (87)
	7,000 to 25,000	12.2 (48)	11.2 (50)
	3,500 to 7,000	8.6 (34)	5.8 (26)
	<3,500	9.9 (39)	9.9 (44)
Education	Less than or some high school	5.4 (22)	3.5 (16)
	High school graduate	16.4 (67)	12.6 (58)
	Some college	31.5 (129)	27.9 (129)
	College graduate	25.4 (104)	33.5 (155)
	Advanced college degree	21.3 (87)	22.5 (104)
Age	18 - 24	1.2 (5)	0.5 (2)
	25 - 34	6.9 (29)	4.2 (16)
	35 - 49	25.3 (106)	18.9 (72)
	50 - 64	28.4 (119)	40.8 (155)
	65 years old or older	38.2 (160)	35.5 (135)
Residence location	Inside city limits	73.5 (302)	72.8 (337)
	Outside city limits, not farming	22.6 (93)	22.7 (105)
	Outside city limits, farming	3.9 (16)	4.5 (21)

Results

The 2014 water issues survey achieved a response rate of 29.4% (491 out of 1,671 surveys) with 327 respondents coming from the first mailing, and 164 from the second mailing. Demographic characteristics regarding residence for 2008 and 2014 were not significantly different. As shown in Table 2, 48.1 and 53.5% of survey respondents lived in communities of more than 100,000 in 2008 and 2014, respectively. In addition, 73.5% of survey respondents in 2008 and 72.8% in 2014 lived inside city limits. A total of 71% of respondents from both surveys resided in communities of 25,000 or more people. Twenty-nine percent lived in small communities of 7,000 people or fewer. These demographic results are similar to those reported by the 2010 U.S. Census effort, which indicated that 84.7% of Texans reside in urban areas (U.S. Census Bureau 2010). A large majority, more than

90%, of respondents for both surveys had lived in Texas for more than 10 years or for all their lives.

Respondent gender distribution differed between the 2008 and 2014 surveys; with 2014 more closely reflecting the actual demographics of the state: 48.7% male and 51.3% female ($p<0.0001$). Respondents of both surveys were somewhat better educated and older than the general Texas population (U.S. Census Bureau 2013, 2015).

Water Quantity

Respondents were asked, "Do you regard water quantity (having enough water) as a problem in the area where you live? (Mark one answer)." From the response set, respondents could choose: definitely not, probably not, I don't know, probably, or definitely yes. In 2008, 22.5% of respondents believed water quantity to be a problem where they lived (Figure 1) and 47.9% believed that water quantity definitely or probably was a problem in their area. In comparison, 37.2% from the 2014 survey responded that water quantity is a problem where they live (likelihood ratio test, $p<0.0001$), and a sum of 61.6% believed water quantity definitely or probably was a problem in their area. Furthermore in 2008, 15.1% of the respondents agreed that water quantity was definitely not a problem where they lived, while only 6.8% agreed water quantity was definitely not a problem in the 2014 survey ($p<0.0001$). A combined 44.2% of respondents indicated that there was definitely not or probably not a water quantity problem in their area, and that fell to 28.2% in 2014. Multinomial logistic regression analysis of responses from the 2014 survey indicated no statistical significance with socio-demographic variables of gender, community size, age, residence location, years in Texas, and education.

Likelihood of Prolonged Drought

Similar responses to the water quantity question were given when survey respondents were asked to evaluate the likelihood of their area suffering from a prolonged drought. In 2008, 51.6% of respondents believed that the chance of a prolonged drought in their area was increasing, while in 2014, 69.2% responded that the chances of a prolonged drought in their area was increasing ($p<0.0001$). The number of Texans responding that the likelihood of a prolonged drought in their area staying the same decreased from 37.9% in 2008 to 22.1% in 2014 ($p<0.05$; Table 3). Fewer responses in the "staying the same" category were likely the result of about 40% of Texas experiencing some level of drought in August 2008, while about 66% of Texas was in a drought in April 2014 when the survey was re-issued. In April of 2014, more than 16 million Texans lived in areas categorized as in moderate or more extreme categories of drought (U.S. Drought Monitor Map Archive, Fuchs 2014). Multinomial

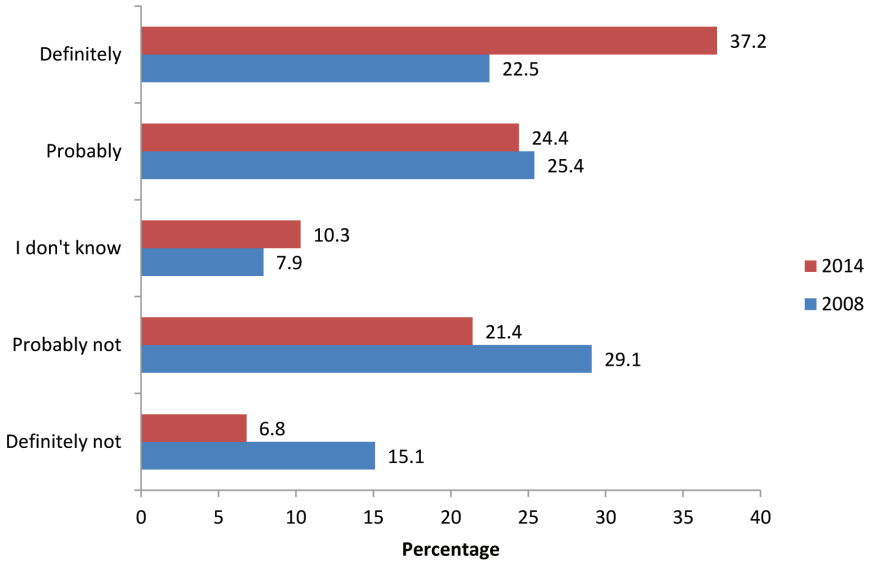

Figure 1. Is water quantity a problem where you live?

Table 3. The likelihood of your area suffering from a prolonged drought is:

		-------% Respondents-------		Percentage Point Change
		2008	2014	
Prolonged drought affecting your area	Increasing	51.6[a]	69.2[b]	17.6
	Staying the same	37.9[a]	22.1[b]	-15.8
	Decreasing	2.4[a]	2.1[a]	-0.3
	No opinion	8.1[a]	6.6[a]	-1.5

Superscript indicates significance at the 0.05 level.

logistic regression analysis of responses from the 2014 survey indicated no statistical significance of the response to the likelihood of a prolonged drought with socio-demographic variables of gender, community size, age, residence location, years in Texas, and education.

Likelihood of Enough Water to Meet Area Needs

Respondents were asked to evaluate the likelihood of their area having enough water to meet its needs 10 years from now. In 2008, 30.2% of the survey respondents believed that there would not be enough water in their area to meet all of its needs in 10 years (Figure 2). In 2014, the responses for low likelihood (likely not enough water) increased to 52.8% ($p<0.0001$). Additionally, 20.0% of survey respondents in 2008 replied that the likelihood of enough water in their area was high (likely enough water) to meet needs in 10 years, compared to only 7.1% in 2014. Multinomial regression analysis of the responses for the 2014 survey indicated respondents having more education ($p<0.001$) were more likely to believe that there would not be enough water in their area to meet needs in 10 years. Other socio-demographic variables showed no significant relationships.

Behavior Changes Protecting Water Quality or Water Quantity

Landscaping. As shown in Figure 3, respondents from the 2014 survey were more likely to have changed the way they landscaped their yards than 2008 survey respondents ($p<0.001$). Multinomial logistic regression analyses of the 2014 responses with socio-demographic variables indicated gender differences were significant ($p<0.05$). Female respondents were more likely than males to have changed the way they landscape their yard.

Watering. Surprisingly, there was no significant difference between 2008 and 2014 respondents regarding whether homeowners had changed how often they watered their yards, perhaps because municipal drought restrictions had already been commonly imposed during the drought in 2008 (chi-square). For 2014, gender ($p<0.05$) and number of years lived in Texas ($p<0.05$) were significant regarding whether respondents had changed how often they watered their yard. Females and respondents living in Texas longer were more likely to have changed the way they watered their yard.

Adopt New Technologies. Respondents in 2014 were more likely than those in 2008 to have adopted new technologies to conserve water quantity or quality (chi-square, $p=0.001$). Again, gender was the only significant predictor for adopting new technologies in an effort to conserve water (multinomial logistic regression, $p<0.006$). Females were more likely to adopt new technologies in an effort to conserve water than were males.

Rainfall Change as a Result of Global Warming

Responses to the question, "Do you think that the amount of rainfall in your area will change as a result of global warming?" differed significantly between survey years (chi-square, $p<0.001$). From the 2008 to the 2014 survey, an increased percentage of respondents (+12.4%) believed that rainfall would decrease significantly (Table 4); however, approximately one-third of respondents for both the 2008 and 2014 surveys answered that

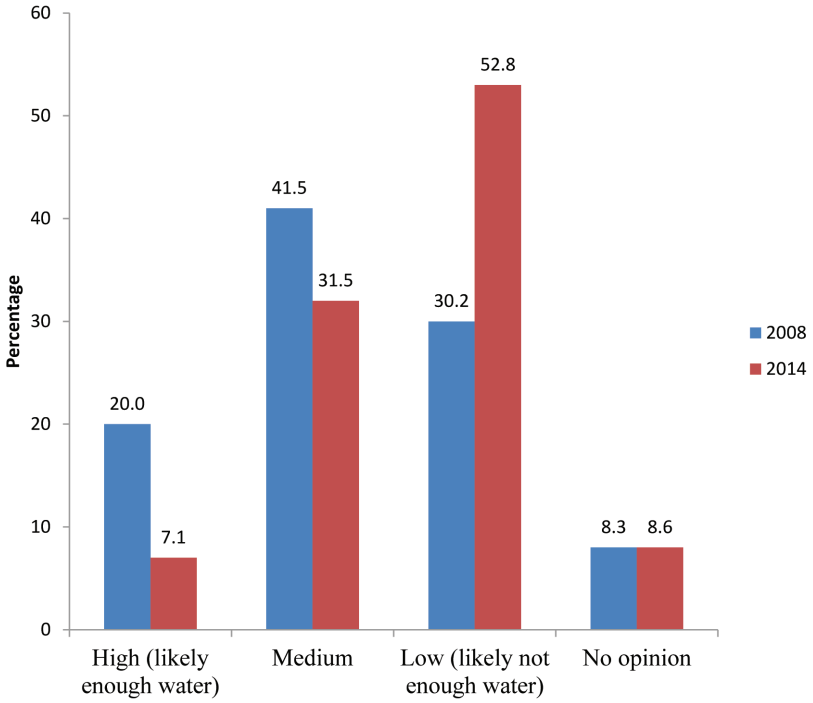

Figure 2. The likelihood of your area having enough water resources to meet all of its needs 10 years from now is:

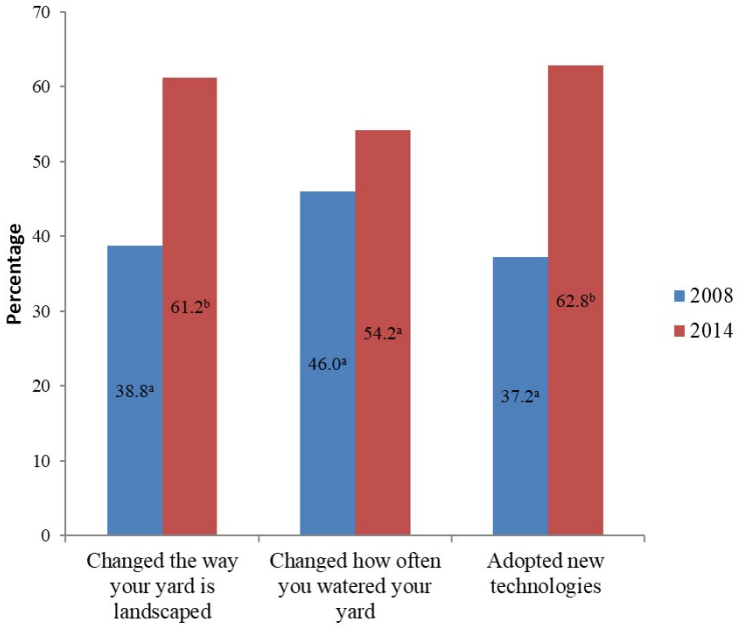

Figure 3. Have you or someone in your household done any of the following as part of an individual or community effort to conserve water or preserve water quality? Different letters indicate a significant difference at the 0.05 level.

they do not know if the amount of rainfall in their area will change.

Multinomial logistic regression of socio-demographic variables indicated that education plays a role in the perception of rainfall changes that might occur as a result of global warming (p=0.001). Those with more education were less likely to respond that rainfall will increase as a result of global warming (R2=0.06).

Discussion

Using data from surveys administered in 2008 and 2014, this study assesses the change in public attitudes and perceptions regarding water resources and actions taken to conserve water. The questionnaire is a component of the National Integrated Water Quality Program Needs Assessment Survey project initiated in 2002 (Mahler et al. 2005). The focus of this study was on the year of the survey (before or after a historical drought) and responses to questions related to current water availability issues and Texans' perceptions of future water availability. Additionally, change in rate of adoption of water saving practices was assessed regarding survey year and associated socio-demographics. The results of this study indicate that recent drought experience strongly influences public perception of current water quantity issues as well as perception of future water availability. Evans et al. (2015) similarly reported that perceptions of local drought conditions significantly affected public attitudes and awareness regarding water supply. Specifically, the public is more concerned about water resources and climate change during periods of extreme drought. Evans et al. (2015) also showed that length of residency significantly affected the perception of water availability, with respondents living in the state longer being less likely to be concerned with water supply. With the exception of how often respondents watered their yard, length of residency was not a statistically significant predictor in their adoption of water conservation practices in the present study, perhaps because the drought was exceptional in intensity and duration. Additionally, few respondents had lived in Texas for less than 10 years. News coverage of drought typically increases when drought intensifies, enhancing the awareness of extreme drought (Dow 2010).

As shown in Figure 1 and Table 3, perception of future water availability shifted significantly following the period of extended exceptional drought, at its worst in 2011, with 2014 respondents indicating more concern than did 2008 respondents. Texans have become more concerned with having enough water within 10 years to meet their needs, with 53% believing supply will not be adequate.

Table 4. Do you think that the amount of rainfall in your area will change as a result of global warming?

		---------- Year----------		Percentage Point Change
		2008 % (n)	2014 % (n)	
Do you think that the amount of rainfall in your area will change as a result of global warming?	Yes, increase significantly	6.0 (24)	2.7 (12)	-3.3
	Yes, increase slightly	7.2 (29)	2.9 (13)	-4.3
	No change	26.3 (106)	17.8 (80)	-8.5
	Yes, decrease slightly	17.1 (69)	17.3 (78)	0.2
	Yes, decrease significantly	13.2 (53)	25.6 (115)	12.4
	I don't know	30.3 (122)	33.8 (152)	3.5

Almost 70% felt that the likelihood of their area suffering from a prolonged drought was increasing. More than 61% of respondents have changed the way their yard is landscaped in efforts to conserve water. Furthermore, more than 62% have also adopted new technologies in an effort to conserve water.

Perceived importance of water resources is a significant factor that drives water conservation (Adams et al. 2013). Efforts initiated during drought periods to conserve water by changing the way a yard is landscaped or adopting new technologies (low flow showerheads, high efficiency appliances, etc.), can become long-term behavior changes. Adoptions of more permanent changes, rather than temporary or short-lived actions, represent positive behavior modification likely to continue even during normal rainfall periods. Additionally, intensifying public concern regarding water supplies during drought conditions creates unique opportunities for Extension and other water resource management organizations to deliver timely and valued water conservation information.

Perception that the amount of rainfall in their area will change as a result of global warming increased from 2008 to 2014 with a jump (+12.4%) in respondents believing rainfall will significantly decrease. However, despite frequent media reports regarding climate change, respondents indicating that they did not know what rainfall changes would occur increased slightly from 30.3 to 33.8%. Udayakumara et al. (2010) reported that environmental awareness is influenced by education. Similarly, the present study found that increased education influenced perception that rainfall would decrease as a result of global warming. Kleinberg and Colby (2014) and Leiserowitz (2005) reported that some citizens believe that climate change will not affect them as individuals or as communities, but is rather more a global or national problem. The findings of these studies may support the contention that further climate change research and/or outreach education is necessary before more of the public feel they can draw an informed conclusion.

Conclusion

Overall, responses indicate that Texans are concerned with water availability and believe that there are concerns for water resources in the future after experiencing, in 2011, the worst one-year drought on record. Results also indicate that with citizen concern, the majority of respondents are taking personal action in an effort to conserve water for the future.

This study provides useful information in support of water conservation outreach programs. Texans tend to be more concerned with water availability during and after drought, providing a timely opportunity to highlight drought conditions and teach appropriate responses and actions for citizens through outlets such as state agencies, Extension services, news outlets, and groundwater and utility districts. It may also be effective to remind the public of the extreme droughts they have experienced when conducting an outreach program. As this study indicates, Texans are more willing to make changes to their landscape during and after droughts. Outreach programs with information including best management practices for lawn irrigation, drought tolerant landscapes, and new water conservation technologies should be made available through appropriate sources. The study further supports the idea that investment in education during critical environmental events, such as drought, when audiences are seeking information is especially effective. Cohen et al. (2006) suggested that adoption during extreme events frequently results in permanent behavior changes that continue to conserve water resources when more typical weather returns.

Regional and state-wide surveys are important tools for assessing public perception and attitudes regarding water availability issues. Survey evaluations can document changes in perception and adoption of best management practices, as well as identify opportunities for expanded outreach and research efforts.

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