Extension Education Methods

Stakeholder Opinions on Invasive Species and Their Management in the San Marcos River

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SUMMARY. The San Marcos River in Texas supports a wide diversity of aquatic organisms and provides critical habitat for eight endangered species. It is also a highly invaded ecosystem, with 48 documented introduced species. Several of these are invasive and known to negatively impact native species. Increasing pressure to control or eradicate invasive species exists to mitigate their impacts. Management programs can be controversial and, in some cases, have been delayed or stopped because of public opposition. People who have a vested interest in an invaded ecosystem, stakeholders, may be the most likely to express opposition or offer support for invasive species control. Understanding opinions can help guide educational outreach to gain public support for management programs. To assess stakeholder's opinions of invasive species (defined as species that cause harm to the environment or human health), a survey instrument was distributed, and 335 completed surveys were analyzed. The majority of survey participants believed nonnative, invasive species should be controlled to conserve the environment (84.4%), where they damage native Texas species (75.9%), and in particular when they threaten rare Texas native species (89%). Proposed management methods influenced levels of support for invasive species control. Significant differences among demographic groups were found in membership in environmental organizations, knowledge of invasive species in the river, and sources of information on invasive species.

More than 50 years ago, Elton (1958) warned of an impending global environmental crisis resulting from the spread of nonnative, invasive species. Today, nonnative, invasive species are recognized as one of the largest and most serious threats to biological diversity (Mack et al., 2000). As Elton predicted, the world now faces what has been described as a global environmental emergency. Despite the recognition of threats posed by invasive species, universal agreement on how to recognize and define an invasive species is lacking.

Colautti and MacIsaac (2004) pointed out that trying to find common ground for terminology when talking about invasive species is difficult because different authors are often biased toward particular definitions. The inability to settle on a single definition or a common set of terms to define or describe invasive species is just one of the obstacles hampering discussions about invasive species issues and undermining efforts to control and manage invasive species (Colautti and MacIsaac, 2004). Other obstacles to discussions include designing reliable

and accurate methodologies to identify potential invaders (Reichard and Hamilton, 1998), developing and implementing regulations to control potentially invasive introductions (Burgiel et al., 2006), determining cost-effective and efficient control methods (Buhle et al., 2005), and determining public perceptions of what constitutes an invasive species and the role the public, itself, plays in the invasive species problem (Bardsley and Edwards-Jones, 2006; Bertolino and Genovesi, 2003; Bremner and Park, 2007; Shine and Doody, 2011).

For example, Bertolino and Genovesi (2003) documented the impact public opinion can have on the implementation of invasive species management plans. In 1997, a plan to eradicate the american grey squirrel (*Sciurus carolinensis*), an introduced nonnative species rapidly replacing Italy's native red squirrel (*Sciurus vulgaris*) and damaging trees throughout the region, was proposed by the National Wildlife Institute and the University of Turin. The first part of the plan was to eradicate a small population of the american grey squirrel to determine if the proposed methodology was effective. Preliminary results indicated the eradication program was feasible, but was strongly opposed by animal rights groups which took the National Wildlife Institute to court. During the 3 years it took to resolve the case, the eradication program was placed on hold and the american grey squirrel expanded its range to the point where eradication was no longer feasible nor practical (Bertolino and Genovesi, 2003). As a result, american grey squirrels are expected to continue to expand their range throughout continental Eurasia, presenting a major threat to the native red squirrel with major impacts on the forests and timber crops in the region (Bertolino and Genovesi, 2003). Clearly, public perceptions and attitudes regarding invasive species may impede or stop efforts to control or manage invasive species.

Public opposition to or support for control of invasive species arises from differing human values and perspectives (National Invasive Species Council, 2008). The public's perception of invasive species and their understanding of the types of impacts invasive species might have on the environment and them personally are

influenced by each individual's social and cultural values (Bremner and Park, 2007; National Invasive Species Council, 2008; Schüttler et al., 2011). Schüttler et al. (2011) point out the need for studies that focus on the social relevance of invasive species, in particular, the public's perceptions of invasive species and their management. The attitude of many people toward the control of invasive species depends on their perception of whether they believe a particular invasive species is harmful or beneficial. This perception may dictate how an invaded ecosystem is managed.

The San Marcos River in Hays County, TX, is one example of a highly invaded aquatic ecosystem. The San Marcos River is one of the most popular for recreational uses in Texas (Texas Parks and Wildlife Department, 1974). People swim and float in inner tubes in its spring-fed waters and picnic and relax along its banks (San Marcos Texas Convention and Visitor Bureau, 2015). It is also home to eight federally listed threatened and endangered aquatic species including fountain darter (*Etheostoma fonticola*), texas blind salamander (*Eurycea rathbuni*), and texas wild rice (*Zizania texana*) (Bowles and Bowles, 2001; U.S. Fish and Wildlife Service, 1995).

The San Marcos River has been impacted for more than 100 years by nonnative species (Bowles and Bowles, 2001). Bowles and Bowles (2001) found 48 species, including 16 plant species, and 18 fish species have been introduced into the San Marcos River. Thirty-two of the species have established populations in the river. Many of the plant species were introduced into the river as part of commercial production of plants for the aquarium

trade (Bowles and Bowles, 2001). A number of the fish species were introduced for the purpose of sport fishing (Bowles and Bowles, 2001). The economic, ecological, and human health impact for many of these species is unknown (Bowles and Bowles, 2001). However, several of these introduced species are known to negatively impact native species. Attempts to control some of these invasive species have been made.

Elephant ear (*Colocasia esculenta*) forms dense stands along the banks of the San Marcos River crowding out native vegetation (Arsuffi et al., 2000). Atkins and Williamson (2008) studied techniques to remove elephant ear. They tested hand removal, herbicide treatment using wicking, cutting, and a combination of cutting followed by herbicide treatment and found that both hand removal and herbicide wicking were effective in controlling the species.

Water hyacinth (*Eichhornia crassipes*) forms floating mats in the San Marcos River shading out native vegetation and can preclude waterfowl access to the river ecosystem (Arsuffi et al., 2000; Gopal, 1987). Volunteer-based efforts to control water hyacinth through hand removal have been ongoing since the 1990s (Arsuffi et al., 2000; Kimmel, 2006). Montoya et al. (2013) examined the feasibility of hand removal of water hyacinth for use in composting and found the quality of compost created from water hyacinth was in the acceptable to ideal ranges of given industry quality standards.

Beckett's water trumpet (*Cryptocoryne beckettii*), thought to have been introduced into the San Marcos River through the dumping of aquaria, was found to be encroaching into critical habitat of the endangered texas wild rice. The decision was made by the U.S. Fish and Wildlife Service to completely eradicate the invasive plant from the upper San Marcos River by dredging (Echo-Hawk et al., 2014).

Each of these invasive species control projects met with some level of success, yet each was also met with some level of public opposition (P.S. Williamson and F.M. Oxley, personal communication). Bertolino and Genovesi (2003) provided a classic example with the american grey squirrel of how public opposition can present a huge impediment to the

implementation of nonnative species management programs. Opposition to invasive species management has led researchers to recognize the importance of studying the social dimension in conservation policy (Fischer and van der Wal, 2007; García-Llorente et al., 2008, 2011; Gozlan et al., 2013; Marshall et al., 2011; Schüttler et al., 2011; Selge et al., 2011; Sharp et al., 2011; Shine and Doody, 2011; Somaweera et al., 2010; Vanderhoeven et al., 2011; Verbrugge et al., 2013). Since human opinions and attitudes can potentially affect continued introductions and management of invasive species, it is imperative to understand the level of knowledge and attitudes of people living in the area (stakeholders) toward invasive species in the San Marcos River. This information will allow managers to design and implement appropriate educational programs to inform the public of the issues and challenges of invasive species management. In addition, information on the stakeholders' knowledge and attitudes toward invasive species will help stewards/managers of other river systems to develop management strategies to effectively deal with invasive species while avoiding opposition.

To gain perspective on the stakeholders' awareness of and attitudes toward nonnative, invasive species in the San Marcos River ecosystem, a paper-pencil regional survey was administered. The objectives of this survey were to determine stakeholders' general knowledge, perceptions, and attitudes regarding nonnative species and invasive species management in the San Marcos River.

Materials and methods

A survey was developed with questions designed to establish a baseline of the participants' familiarity with and attitudes toward different aspects of nonnative, invasive species issues (Fig. 1). The survey was modeled after the survey instrument developed by Bremner and Park (2007) to measure the public's awareness of invasive species in Scotland. Survey questions in this study were used to measure the participants' awareness of invasive species issues in general, and specifically in the San Marcos River. In this study, demographic information of survey participants were

We would like to thank the Lady Bird Johnson Wildflower Center volunteers and guides for helping us pilot the survey, Texas Parks and Wildlife Department personnel, and U.S. Fish and Wildlife Service personnel for reviewing the survey, and members of the Texas Master Naturalists-San Marcos chapter for their help in administering the survey.

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Yes/no response questions Are you a member of any environmental or conservation organizations? Have you spent anytime at the San Marcos River in the past year? Are you familiar with any of the non-native species in the San Marcos River? Have you heard about any projects to control non-native invasive species in the San Marcos River? Do you know of any invasive species in the San Marcos River? If yes, would you object to it being eradicated from the river?	Five-point Likert scale questions Protecting the San Marcos River from non-native invasive species is important. All invasive non-native species should be completely removed from the San Marcos River. Non-native species should be controlled or completely removed when they cause economic damage to the San Marcos River. Non-native species should be controlled or completely removed when they threaten rare or endangered species in the San Marcos River. Controlling some non-native species is necessary to help conserve the environment. Non-native species should be controlled or eradicated where they do damage to any native Texas species. Non-native species should be controlled or eradicated where they do damage to rare native Texas species. Native Texas species should be protected at all costs. Non-native species should be controlled or eradicated only where they threaten human health.
Check all answers that apply response questions Where do you hear about invasive species issues? Please check all that apply. ☐ Television ☐ Newspapers ☐ Magazines/journals ☐ Internet ☐ Radio ☐ ☐ I don't hear about invasive species issues ☐ Other (please specify) The most effective control strategies are different for different species. Would the chosen methods of control have any influence on your decision to support projects that would control or completely remove non-native invasive species in the San Marcos River? If yes, which of the following would you be against using? Check all that apply. <div style="display: flex; justify-content: space-between;"> <div> Animals ☐ Shooting ☐ Poisoning ☐ Pesticides ☐ Egg destruction ☐ Trapping and relocating ☐ Sterilization/use of contraceptives </div> <div> Plants ☐ Cutting down ☐ Digging up ☐ Herbicides ☐ Dredging </div> </div>	Demographic questions What is your gender? What is your age? What is your ethnic group? What is the highest level of education you have achieved? What is your employment status?

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Fig. 1. Questions used in survey of stakeholder opinions of invasive species and their management in the San Marcos River, San Marcos, TX.

collected and used to look at associations with awareness and attitudes. To establish content and construct validity, the survey was reviewed and evaluated by a team of academics and U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department personnel involved in invasive species management and research. The survey protocol and instrumentation were also reviewed and an exemption granted by the Humans in Research/Institutional Review Board at Texas State University before being administered (IRB EXP2008I6719/CON2010S2231) following the typical custom of a review by peers. Only one review was necessary. On the basis of Sheatsley's (1983) recommendation to pilot-test surveys, all survey questions were pilot-tested on 88 individuals before final administration of the survey to refine the survey questions.

The survey included a total of 21 questions (Fig. 1). Some questions were designed to gather demographic information including gender, age, ethnicity, highest level of education achieved, and employment status. Other questions/statements were designed to determine participants' familiarity and attitudes toward nonnative, invasive species issues in general, in Texas, and in the San Marcos River.

Depending on the specific question, answers were yes/no responses, control all answers that apply responses, or ranked responses using a five-point Likert scale with answers ranging from 1 indicating the participant strongly disagreed with the statement to 5 indicating the participant strongly agreed with the statement. The survey length was such that on average, participants spent 8–10 min completing the survey.

The survey was prefaced with definitions of native species, non-native species, and invasive species. Native species were defined as those occurring naturally in a particular area. Nonnative species were defined as those having been introduced into areas outside their natural range. Further clarification was provided to point out that many nonnative species do not cause harm or damage, but others become invasive and can threaten native species especially native species that are rare, threatened, or endangered. Invasive species were defined as those that cause harm to the environment or human health.

Surveys were administered at multiple locations in an effort to have a diverse sample population from the region. The survey was administered to volunteers and guides at the Lady Bird Johnson Wildflower Center,

Austin, TX. Visitors to Sewell Park, City Park, and Rio Vista Park, San Marcos, TX, were surveyed. The questionnaire was also administered to Texas State University students and San Marcos Library patrons. To ensure no one responded to the instrument more than once, participants were screened before administration. On completion of the survey, all participants were given a packet of wildflower seeds for their participation. The population sample used for this study cannot be considered random, as it was chosen based on the incidence of respondents in locations, which would indicate their interest in the San Marcos River, plants, and ecosystem. Therefore, conclusions based on this research may not necessarily be generalizable to the overall population.

A total of 335 surveys were collected. Not all participants answered every question of the survey. Missing answers were treated as missing data. Data were analyzed by using frequency and descriptive statistics (measures of central tendency such as means, measures of dispersion, standard deviations, and percentile values) and chi-square analysis with the SPSS statistical package (version 20; IBM, Armonk, NY).

Results and discussion

The majority [76% (247)] of participants were residents of Hays County and 24% (88) were residents of Travis County indicating that the participants lived within ≈ 30 miles of the San Marcos River. More females [57.1% (180)] than males [42.9% (135)] completed the survey. Demographic data indicated the majority of participants were Caucasian [76.4% (240)]. Hispanics comprised 15.1% (47) of the participants, 2.2% (7) of participants designated themselves as African-American, 2.2% (7) as Asian-American, and 4.1% (13) identified as "other." The small sample size of African-Americans, Asian-American, and those identified as "other" makes it difficult to draw conclusions about these groups. In terms of age of participants, 43.5% (137) were 18–34 years of age, 20.9% (66) were 35–54 years, 15.9% (50) were 55–64 years, 14.6% (46) were 65–74 years, and ages 75 years and older represented 5.1% (16) of respondents. Overall, survey participants were educated with 37.1% (115) having earned a bachelor's

degree, 22.6% (70) a master's degree, 3.9% (12) a PhD degree, and 28.7% (89) a high school diploma. Among participants, 7.7% (24) responded "other" to level of education. The majority of participants [52.4% (162)] were employed either full time or part time. Retirees accounted for 22% (68) of participants and students accounted for 18.4% (57). Only 4.9% (15) were unemployed. The remainder [2.3% (7)] selected the category of "other" for employment status.

Most participants had some prior knowledge of invasive species. Only 48 (14.3%) of respondents indicated they had not heard of invasive species issues. Participants who did receive information about invasive species were asked to indicate where they obtained information and to select all methods that applied. The most frequently selected sources were magazines or journals [43.3% (145)] and the Internet [37.9% (127)]. Other sources of information included newspapers [32.8% (110)], television [31.9% (107)], and radio [13.4% (45)]. Participants [37.9% (127)] also received information by word of mouth, college courses, and workshops provided by organizations such as the Texas Master Naturalists and the Native Plant Society of Texas. Membership in environmental organizations is another likely source of information as 43.5% (143) of participants indicated they belonged to one or more environmental or conservation organizations. Survey responses were thus collected from a somewhat informed group.

The vast majority [84.4% (276)] of respondents agreed or strongly agreed that controlling some nonnative species is necessary to help conserve the environment. Support for control measures was not strongly linked to impact on human health. Just 32% (105) of respondents believed nonnative species should be controlled or eradicated only when they perceived an impact threatening human health. Respondents did believe that nonnative species should be controlled or eradicated when they do damage to any native Texas species, with 75.9% (252) agreeing or strongly agreeing with this statement. An even greater percentage [89% (292)] of respondents felt nonnative species should be controlled or eradicated when they do damage to rare, native Texas species,

and 63.4% (208) of respondents felt native Texas species should be protected at all costs.

Focusing on the San Marcos River specifically, the vast majority [87.2% (285)] of respondents believed protecting the river from nonnative, invasive species is important and 60.5% (196) believed all nonnative, invasive species should be completely removed from the San Marcos River. Economic impact played a role in support for measures to control nonnative species, with 81.6% (266) of respondents agreeing or strongly agreeing nonnatives should be controlled or completely removed from the river when they cause damage to the economy. Despite the support for control or eradication measures of nonnative species, most respondents [53.8% (178)] indicated they did not know any of the invasive species in the San Marcos River, and most [72.2% (236)] were not familiar with any projects to control nonnative, invasive species in the river. Of respondents indicating familiarity with control projects, the projects listed most frequently were elephant ear, hydrilla (*Hydrilla verticillata*), and water hyacinth removal programs. Support for removing nonnative, invasive species depended on the method of control.

When asked if the chosen methods of control would have any influence on their decision to support projects to control or completely remove nonnative, invasive species in the San Marcos River, 78.3% (242) responded that chosen methods of control would influence their support of projects. If the participants answered "yes" to the question, they were then asked to indicate which of several methodologies they would be against using and to control all that applied. Methods of control of invasive animal species included shooting, poisoning, trapping and relocating, pesticides/herbicides, sterilization or use of contraceptives, and egg destruction. Methods of control of invasive plant species included cutting down, digging up, herbicides, and dredging.

Methods of invasive animal control resulting in the death of the animal were favored the least. These included shooting [117 against (48.4%)] and poisoning [190 against (78.5%)]. One hundred and eighty participants (74.4%) indicated that the use of pesticides as a means to control invasive animal species was unacceptable.

Although 17.4% (42) were against sterilization or use of contraceptives and 16.5% (40) were against egg destruction, only 14.5% (35) were against trapping and relocating the animal.

In a study to determine public support for control methods, Barr et al. (2002) found that while respondents generally supported control of the american grey squirrel to help conserve red squirrel populations and prevent damage to timber crops, they did not support the poisoning of the squirrels as an acceptable control method. This attitude toward the death of animals is also supported by the findings of Bremner and Park (2007). Similarly, in this study, methods resulting in animal death, including poisoning and shooting, were least supported. Respondents were most supportive of methods that included trapping and relocation. On the basis of these results, nonnative management projects in the San Marcos River would likely gain greater public support by employing nonlethal methodology.

Of the possible methods for control of invasive plant species, the use of herbicides [59.1% against (143)] and dredging [27% against (65)] were the least acceptable. Cutting down plants [17% against (41)] and digging up plants [12.8% against (31)] were favored over the use of herbicides and dredging. Fischer and van der Wal (2007) also found that use of herbicides was viewed less favorably by the public than cutting as a management option to control the invasive tree mallow. Norgaard (2007) documented that the U.S. Forest Service's proposed use of herbicides to control invasive weeds in northern California was met with controversy and public opposition, especially by the Native American Indian Karuk Tribe, due to perceived risk from a chemical control method; the opposition resulted in suspension of the control project.

Despite public opposition to chemical control, Beck (2015) points out that herbicides are the most researched and the best understood of all methods used to decrease invasive weed populations. Beck (2015) also points out that labor is the most expensive portion of an invasive plant management project and herbicide use requires less labor than mechanical control methods. Cost estimates to control hydrilla in Claytor Lake, VA (Claytor Lake Technical Advisory Committee, 2015),

found that mechanical control would cost \$2000/acre, whereas chemical control with herbicides would cost \$1000/acre. Considering that mechanical control can be twice as expensive as chemical control, public opinion might shift in favor of herbicide use if cost is factored into the decision-making process.

The public can present an impediment to the implementation of nonnative species management programs (Bertolino and Genovesi, 2003; Marshall et al., 2011; Norgaard, 2007). On the other hand, public support for nonnative species management can help bolster control projects. Surveys of public opinions provide meaningful information to policy-makers and conservation managers (Fischer and van der Wal, 2007). Because the San Marcos River has such a large number of nonnative, invasive species and projects to control some of these species are under development, this study is timely in that it provides a broad overview of stakeholders' perceptions and attitudes toward those species and their management.

Although this study surveyed a limited sample, the results may be representative of public opinions in the region. Participants in our study closely resemble the overall demographics of the region. Female participants numbered 180 (57.1%), and 50.2% of Hays County and 49.5% of Travis County residents are female (U.S. Census Bureau, 2013). Participants in our study were educated, with 92.3% earning a high school diploma or higher, which is similar to the general public of Hays County and Travis County with 88.5% and 86.9%, respectively, having earned a high school diploma or higher. Given that Hays and Travis Counties are home to a number of universities, including Texas State University and the University of Texas at Austin, it is also not surprising that survey participants were well educated. Both Hays and Travis Counties have low unemployment rates, lower than the state or national averages (City-data.com, 2012a, 2012b), and most survey participants were employed.

In demographic comparisons, significant differences were found in the ethnic groups who were members of environmental organizations (Table 1). Caucasians were the most likely of any ethnic group to be a member

Table 1. Chi-square (χ^2) comparisons of membership in environmental organizations by ethnicity, age, and education in the survey of stakeholder opinions on invasive species and their management in the San Marcos River, San Marcos, TX.

Group	Yes [no. (%)]	No [no. (%)]	df	χ^2	P value
Ethnicity					
Total responses	134 (44.4)	168 (55.6)	6	27.764	0.001*
Caucasian	122 (51.7)	114 (48.3)			
African, American, and Hispanic ^c	8 (15.1)	45 (84.9)			
Asian and other	4 (30.8)	9 (69.2)			
Age (years)					
Total responses	139 (45.0)	170 (55.0)	5	69.935	0.001*
18–34	28 (21.1)	105 (78.9)			
35–44	14 (42.4)	19 (57.6)			
45–54	15 (46.9)	17 (53.1)			
55–64	36 (72.0)	14 (28.0)			
65–75	36 (80.0)	9 (20.0)			
>75	10 (62.5)	6 (37.5)			
Education					
Total responses	127 (44.9)	156 (55.1)	4	50.825	0.001*
High school	13 (14.6)	76 (85.4)			
Bachelor's	61 (54.5)	51 (45.5)			
Master's	45 (64.3)	25 (35.7)			
PhD	8 (66.7)	4 (33.3)			
Other	8 (36.4)	14 (63.6)			

^cCombined data to increase individual cell totals.

*Statistically significant at the 0.01 level.

[51.7% (122)]. Significant differences were also found among age groups in membership in environmental organizations (Table 1). Participants 18–34 years old appeared to be different from all other age groups, with only 21.1% (28) belonging to organizations. All other age groups were more likely to belong to environmental organizations. Age groups 35–44 years, 45–54 years, and 75 years and older were similar with 42.4% (14), 46.9% (15), and 62.5% (10), respectively, belonging to an organization. Age groups 55–64 years and 64–75 years were similar with 72% (36) and 80% (36), respectively, holding membership.

Significant differences were again found among respondents of various education levels and membership in environmental organizations (Table 1). Those with a high school diploma were different from all levels of college education. Only 14.6% (13) of participants holding a high school diploma belonged to an organization. Those with a college education were more likely to be members of environmental organizations, with 54.5% (61) holding a bachelor's degree, 64.3% (45) holding a master's degree, and 66.7% (8) holding a PhD degree belonging to an organization.

In their study of public perceptions of nonnative species, Fischer and van der Wal (2007) found that higher educated people tend to be more supportive of nature protection organizations. They also point out that in The Netherlands, public support for nature protection is generally high and attributed this attitude to frequent membership of citizens in nature protection organizations. We found similar results in that members of environmental organizations were more likely to support control of invasive species than nonmembers. Among members, 73.8% (104) indicated that all invasives should be removed from the San Marcos River, whereas only 50.5% (90) of nonmembers supported removal of all invasives from the river. Our study also found that membership in environmental organizations is lower in minority groups, 18–34 year olds, and less-educated individuals. If Fischer and van der Wal's (2007) assumption is correct, these demographic groups are candidates to recruit to increase membership in environmental organizations and perhaps gain increased public support for protection of native species.

A significant difference was also found in education levels of participants

and where they received information about invasive species (Table 2). Those with only a high school education appeared different from participants with a college education. Fewer participants with a high school diploma [28.1% (25)] indicated they receive information about invasive species issues through magazines compared with participants with a bachelor's degree [51.3% (59)], master's degree [55.7% (39)], and PhD degree [66.7% (8)].

Significant differences were also found among ethnic groups when asked if they knew of any invasive species in the San Marcos River (Table 3). Caucasians [48.9% (116)] were the most likely to report knowing invasive species in the river when compared with those of other ethnic backgrounds.

Participants indicating they knew of invasive species in the San Marcos River differed significantly among the

different education levels (Table 3). Differences were found between participants with a high school education and those with college degrees. Only 29.2% (26) of those with high school diplomas knew of invasive species in the river. Of participants with advanced degrees, 47.4% (54) with a bachelor's degree, 50.7% (35) with a master's degree, and 66.7% (8) with a PhD degree indicated they knew of invasive species in the river.

Studies including Fischer and Young (2007), Schüttler et al. (2011), and Stokes et al. (2006) illustrate the importance of public involvement in management decisions. Where an educated public has been involved in the decision-making process, success was achieved with little or no local resistance (Sheail, 2003). García-Llorente et al. (2008) noted the positive impact of public awareness campaigns for making the general public more aware of invasive species issues and gaining

the public's support. However, Bremner and Park (2007) point out public education about nonnative, invasive species issues is severely lacking and, Vanderhoeven et al. (2011) noted that well-designed information programs targeting particular sectors or a general audience could be effective tools to educate the public about invasive species. Most respondents in our study had some prior awareness of invasive species. Only 14.3% of participants indicated that they do not hear about invasive species issues. Although there was awareness of invasive species issues among our respondents, most were not familiar with any of the nonnative species in the San Marcos River or any projects to control nonnative, invasive species in the river. Interestingly, when asked to name a nonnative species or an invasive species project in the San Marcos River, the majority of participants who said they were familiar with nonnative, invasive species in the river were unable to do so. Equally interesting was the fact that a few participants named Texas wild rice, a federally listed endemic species, as an invasive, and were quite adamant about the need for its removal. These results are similar to those of Andreu et al. (2009) who found respondents to their survey were unable to accurately differentiate between invasive species and noninvasive species. Those respondents who did indicate they knew of nonnative, invasive species in the San Marcos River were more likely to support control measures when compared with those who indicated they did not know of any invasive species in the river. Of respondents who knew of invasive species in the river, 70.1% agreed or strongly agreed that all nonnative, invasive species should be completely removed from the San Marcos River compared with 52.3% of respondents who were not familiar with invasive species in the river. Clearly, a coordinated education program to inform the public about nonnative, invasive species in the San Marcos River is needed.

Because the San Marcos River has such a large number of nonnative animal and plant species, many of which are invasive, this study is significant in providing a broad overview of stakeholders' perceptions and attitudes toward those species and their management in the river. Since

Table 2. Chi-square (χ^2) comparisons of source of information about invasive species by education in the survey of stakeholder opinions on invasive species and their management in the San Marcos River, San Marcos, TX.

	Response options		Mean	df	χ^2	P value
	Yes [no. (%)]	No [no. (%)]				
Magazines						
Total responses	131 (45.8)	155 (54.2)	1.46	4	18.183	0.001*
High school	25 (28.1)	64 (71.9)	1.28			
Bachelor's	59 (51.3)	56 (48.7)	1.56			
Master's	39 (55.7)	31 (44.3)	1.56			
PhD	8 (66.7)	4 (33.3)	1.67			
Other	9 (37.5)	15 (62.5)	1.38			

*Statistically significant at the 0.01 level.

Table 3. Chi-square (χ^2) comparisons of knowledge of invasive species in the San Marcos River by ethnicity and education in the survey of stakeholder opinions on invasive species and their management in the San Marcos River, San Marcos, TX.

Group	Response options		df	χ^2	P value
	Yes [no. (%)]	No [no. (%)]			
Ethnicity					
Total responses	129 (42.6)	174 (57.4)	6	169.482	0.001*
Caucasian	116 (48.9)	121 (51.1)			
African, American, and Hispanic ^c	11 (20.8)	42 (79.2)			
Asian and other	3 (21.4)	11 (78.6)			
Education					
Total responses	135	172	4	112.750	0.009*
High school	26 (19.2)	63 (36.6)			
Bachelor's	54 (40)	59 (34.3)			
Master's	35 (25.9)	34 (19.8)			
PhD	8 (5.9)	4 (2.3)			
Other	12 (8.8)	12 (6.9)			

^cCombined data to increase individual cell totals.

*Statistically significant at the 0.01 level.

community attitudes can potentially affect continued horticultural and agricultural introductions and management of invasive species, this information will allow managers to design and implement appropriate educational programs to inform San Marcos River stakeholders of the issues and challenges of invasive species management. In addition, this knowledge will help river stewards and managers of other ecosystems develop management strategies to effectively deal with invasive species with support from the stakeholders.

Herbicide use was poorly supported as an invasive plant control method suggesting management projects should avoid chemical control methods when possible and use methods such as manual removal instead. This study also found that methods to control invasive animal species resulting in animal death, including poisoning and shooting, were least supported. Respondents were most supportive of methods that included trapping and relocation. On the basis of these results, invasive management projects in the San Marcos River would likely gain greater public support by employing nonlethal methodology.

Respondents considered themselves aware of invasive species issues, yet most were not familiar with any nonnative species in the San Marcos River or any projects to control invasive species in the river. It is essential to inform the public to gain support for management projects. On the basis of where respondents indicated they obtain information about invasive species, we recommend a comprehensive media campaign to educate all demographic groups about impacts of non-native, invasive species, and actions the public can take to contribute to the solution.

Educational outreach to improve the public's knowledge of invasive species could vary depending on the target audience. Significant differences were found in demographic groups in source of information about invasive species issues. In this study, fewer participants with a high school diploma received information about invasive species issues through magazines compared with participants with advanced degrees. Multimedia sources should be designed and employed to reach diverse demographic groups audience to provide information about

impacts of invasive species and actions that can be taken to contribute to a solution.

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