

Teaching Methods

College Student Knowledge and Perceptions of Invasive Species

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SUMMARY. The purpose of this study was to determine college students' understanding of invasive species and their support for plant and animal pest control and eradication methods. Surveys were administered at a university and community college in Texas in biology and agriculture departments. A total of 533 respondents participated in the study. Most students said they were not part of any type of environmental organization and felt they were not very informed about invasive species issues. More students reported learning about invasive species in high school than in college courses. The average score on knowledge questions related to invasive and native plants and animals was 32%. Most students underestimated the negative impact of invasive species but many were aware of costs to manage those species. Reliable reported sources of information included environmental organizations, college courses, and the Internet. Pearson product-moment correlations showed positive relationships between students who had college class instruction regarding invasive species and positive attitudes toward management of invasive species. Positive relationships were also found between instruction and an awareness of invasive plants or animals. Respondents who were knowledgeable of invasive species in the community had more positive attitudes toward the management of invasive species. In demographic comparisons, differences were found with males, upperclassmen, and those identifying as Caucasian or other having more knowledge of invasive species and more positive attitudes toward their management.

Elton's (1958) seminal work advanced the field of invasive species ecology and our understanding of the negative impacts

of invasive species. For decades, the scientific community has been aware of the serious threat invasive species pose to biological diversity, yet this awareness has not necessarily been grasped by the mainstream public. Public perceptions of what constitutes an invasive species and attitudes toward methods to control or eradicate invasive species have been identified as obstacles to solving the invasive species problem (Andreu et al., 2009; Bardsley and Edwards-Jones, 2006; Marshall et al., 2011; Shine and Doody, 2011). In addition, public perceptions and attitudes

regarding invasive species may even impede or halt efforts to control or manage invasive species (Bertolino and Genovesi, 2003). Numerous authors have addressed the public's influence as a component in the battle against invasive species (Fischer and van der Wal, 2007; García-Llorente et al., 2008, 2011; Gozlan et al., 2013; Marshall et al., 2011; Oxley et al., 2016; 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). The critical role played by the public in invasive species management has led to a call for studies that focus on the social relevance and public perceptions of invasive species (Schüttler et al., 2011).

Oxley et al. (2016) conducted a survey to determine the public's general knowledge, perceptions, and attitudes regarding non-native species and invasive species management in the San Marcos River, Hays County, TX. The river is a highly invaded ecosystem with at least 48 non-native species (Oxley et al., 2016). Oxley et al. (2016) demonstrated that younger and less educated individuals are less knowledgeable of invasive species issues. They also found that younger participants (18–34 years old) and less educated individuals were less likely to belong to environmental organizations. Members of environmental organizations showed greater support for invasive species control when compared with nonmembers in their study. Results of the Oxley et al. (2016) study point to a need to understand attitudes of college-age youth about impacts of invasive species and their control.

Vanderhoeven et al. (2011) pointed out that well-designed information programs targeting particular sectors or a general audience could be effective tools to educate the public about invasive species. To develop a well-designed education program, it is important to understand existing attitudes and identify where gaps in knowledge exist (Goldstein, 1993). Therefore, the purpose of this study is to survey college students in Texas to assess attitudes and gaps in knowledge related to invasive species detection and mitigation. Results of this survey allow conclusions to be drawn that will facilitate improving environmental curricula delivered to college

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students. Such a curriculum is especially relevant since a better-educated public can aid in preventing the introduction and spread of invasive species that threaten the environment, thereby contributing to the solution (Oxley et al., 2016).

Materials and methods

STUDY SITES. A sample of college students was drawn from students enrolled in biology or agriculture courses at Austin Community College in Austin, TX (Travis County) and Texas State University in San Marcos, TX (Hays County).

SAMPLE. Students volunteered to participate in the study and were recruited in the biology and agriculture classes where instructors allowed the survey to be administered. Students were offered incentives such as horticulture t-shirts, small flashlights, or ink pens to encourage participation. Because the sample and study sites were those that were available to researchers rather than those randomly assigned, results are exploratory and not necessarily generalizable beyond this research situation.

SURVEY INSTRUMENT. The survey included 26 questions and was modified from previously used instruments known to be reliable and valid (Oxley et al., 2016). The survey contained each of four sections including knowledge questions, attitudes toward invasive species management statements, questions concerning how and where students learn about invasive species, and questions directed toward gathering demographic information. The survey was reviewed for validity by a panel of experts with biology and agriculture backgrounds before pilot testing the instrument.

SURVEY PILOT TESTING. The survey was pilot-tested with college students enrolled at Austin Community College. In Aug. 2015, the pilot survey was administered to four classes with a total of 72 surveys completed. Based on the pilot survey, questions were refined to create a survey instrument designed to gauge existing knowledge/attitudes of college students regarding exotic pests and their control. A Cronbach's alpha reliability test indicated that the instrument had a suitable level of reliability at $P = 0.674$.

KNOWLEDGE OF INVASIVE SPECIES QUESTIONS. Six questions on the instrument gathered information regarding knowledge of invasive species. Depending on the specific question, answers were yes/no or multiple-choice responses. Examples of questions include a multiple choice question asking, "how many invasive species do you think are in the U.S.?", and a yes/no response option for, "do you think that invasive plants and animals have a negative economic impact on agriculture in Texas?"

ATTITUDES TOWARD MANAGEMENT OF INVASIVE SPECIES INSTRUMENT. Eight statements on the instrument related to student attitudes toward invasive species and their management. In the first section, respondents were given a series of seven questions that gauged their attitudes toward management of invasive species, and where they answered on a 1 to 5 Likert-scale that ranged from "strongly agree" to "strongly disagree." More points were allocated for more positive answers and answers were reverse coded when necessary. Possible scores ranged from 7 to 35. Examples of statements included, "all invasive species should be completely removed from the environment," and "protecting the environment from invasive species is important." One question asked respondents to mark all types of management procedures they would be against using. Answer options included a listing of varied management methods including shooting, poisoning, dredging, and egg destruction among others.

AWARENESS AND SOURCES OF INVASIVE SPECIES INFORMATION QUESTIONS. Five questions collected information regarding whether respondents felt they knew about invasive and native species and where they learned that information. Examples of questions included, "did you learn about invasive species in high school?," "have you received instruction about invasive species in your college courses," and, "how informed do you think you are about invasive species?" Answer options varied depending on the question. Some questions had "yes/no" answers, whereas others provided multiple-choice options.

DEMOGRAPHIC QUESTIONS. Seven questions were designed to gather demographic information

including gender, age, ethnicity, current academic classification, academic major, and zip code of hometown or name of home country if it is an international student.

SURVEY ADMINISTRATION. The survey instrument was administered to college students enrolled in agriculture and biology courses at Texas State University and Austin Community College in Sept. 2015. Surveys were only administered by researchers involved in the study to maintain consistency in administration. The survey length was such that, on average, participants spent 7–15 min completing the survey. The survey was prefaced with the following definition of an invasive species: "An invasive species is a species that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health." Not all participants answered every question of the survey.

DATA ANALYSIS. Data were analyzed using SPSS statistical package (version 20; IBM, Armonk, NY). Data were analyzed using frequency and descriptive statistics (measures of central tendency such as means, measures of dispersion, standard deviations, and percentile values). Relationships and differences were determined using Pearson's correlations and analysis of variance comparisons. Missing answers were treated as missing data.

Results and discussion

A total of 533 respondents participated in the study with 71.9% (383) of students participating from Texas State University and 28.1% (150) participating from Austin Community College. The sample was reasonably representative of the target population with 67.6% (357) of the sample identifying as female and 32.4% (171) male. The sample was of primarily a traditional college student age with 94.4% (504) being in the 18–34-year-old range. Fifty-one percent (270) were Caucasian, 35% (186) Hispanic, 7.7% (41) African American, 2.8% (15) Asian, and 3.6% (19) of Other descent. The sample was about evenly distributed amongst grade classifications with 21.1% (111) freshman, 32.9% (173) sophomores, 23% (121) juniors,

19.6% (103) seniors, and 3.5% (18) graduate students responding. Seven (1.3%) international students responded. Most students [88.4% (467)] said they were not part of any school, community, or national environmental organization, whereas 11.6% (61) did claim an association with a group of this kind.

AWARENESS OF INVASIVE SPECIES RESULTS. When asked the question, “how informed do you think you are about invasive species?,” most students said they felt they were “not very well informed” [45.9% (244)] or “not informed at all” [19.9% (106)]. However, 30.5% (162) felt they were “somewhat well informed” and 3.8% (20) felt they were “very well informed.”

Seventy-three percent (390) of students reported they did not learn about invasive species in high school, whereas over a quarter of the sample [26.8% (143)] said they did learn something. Less of the sample reported learning about invasive species in college classes [17.9% (95)] and 82.1% (436) reported not learning anything about invasive species in college classes. High school classes where students most often reported learning about invasive species were biology and environmental science. In college, students most often reported learning about invasive species in biology, ecology, and agriculture courses.

KNOWLEDGE OF INVASIVE SPECIES RESULTS. One question asked students to mark from a list of 12 native and invasive plants all of the invasive plants represented. A score of 6 was the best possible where one point was allocated for each invasive species identified from the presented list of species. The mean score of all respondents was 1.93 (32%) with 16.3% (87) of students scoring a zero while 0.8% (4) scored a 100%. Another question asked respondents to mark from a list of twelve native and invasive animals all of the invasive animals represented. Again, a score of 6 was the best possible score. The mean score of all respondents was 1.89 (32%) with 16.6% (88) students scoring a zero while 0.6% (3) scored a 100%.

When students were asked how many total invasive species there are in the United States, 29.4% (155) responded correctly with 50,000 species, whereas 70.6% (372) responded

incorrectly. The most common answer was 10,000 species [35.9% (189)]. A little over 12% (64) of students answered 1000 species. Therefore, most of the sample of students grossly underestimated the number of invasive species occurring in the country.

When students were asked what they perceived the annual cost to control invasive plants and animals and the damages they cause to property and natural resources in the United States, 12% (63) responded correctly with the value of \$137 billion. Overall, 88% (464) responded incorrectly with the most common answer being \$50 million [44.5% (232)], followed by \$236 million [32.3% (170)]. Therefore, respondents underestimated the amount of damage and cost to control invasive species in the United States.

When asked the question, “do you think that invasive plants and animals have a negative economic impact?,” 68.7% (366) responded “yes,” whereas nearly a third [29.8% (159)] responded “no.” When asked if they felt invasive plants and animals have a negative economic impact on agriculture in Texas, 77.5% (409) responded “yes” compared with 23.3% (118) responding “no.” It appears that while respondents underestimated the numbers and costs of invasive species, most have observed economic impacts in some way.

ATTITUDES TOWARD MANAGEMENT OF INVASIVE SPECIES RESULTS. On questions regarding students’ attitudes toward management of invasive species, scores ranged from 7 to 35 with higher scores being more positive and a median score of 17 overall. The mean score of all respondents was 26. Only 0.8% (4) respondents had scores below the median, whereas 0.6% (3) respondents had scores of 35. These results indicate most of the respondents approved of managing invasive plants and animals. When asked “would the chosen methods of control have any influence on your decision to support projects that would control invasive species,” 97 (18.2%) respondents answered “no.” Respondents answering “yes” [81.8% (436)] were further asked to indicate which of the listed methods of control they would be against. Of listed methods of invasive animal control,

86.7% (378) of respondents were against trapping and relocating, 82.1% (358) were against egg destruction and 76.6% (334) were against sterilization/contraceptives. There was less objection to poisoning [22%, (96 against)], shooting [40.8% (178 against)], and pesticides [43.8% (191 against)]. Of listed methods of invasive plant control, 82.1% (358) of respondents were against digging up plants, 72.7% (317) were against dredging, 58% (253) were against cutting, and 49.8% (217) were against herbicides.

SOURCES OF INFORMATION ON INVASIVE SPECIES. Respondents were given a list of nine sources of information from which to choose and asked to mark those options which they consider to be “the most reliable source of information about invasive plants and animals.” Most respondents rated environmental or conservation organizations as the most reliable sources [54.2% (287)], followed by college classes [28.7% (152)] and the internet [25.9% (138)]. The internet was seen as more reliable when compared with television [8.7% (46)], high school education [4% (21)], newspapers [3.6% (19)], magazines or journals [14.3% (76)], radio [1.3% (7)], social media [5.3% (28)], and other sources [3% (16)]. Although environmental or conservation organizations were rated as the most reliable source, few respondents [11.6% (61)] indicated that they belonged to any kind of environmental organization. Given that respondents considered college classes the second most reliable source of information, it would be interesting to test the effectiveness of invasive species curricula on knowledge gain in college students.

CORRELATIONAL COMPARISONS. A Pearson’s correlation was run to observe relationships between awareness of invasive species in the community and attitudes toward management of invasive species. Respondents who answered “yes” to the question, “do you know of any invasive species in your community?,” also had more positive attitudes toward management of invasive species ($r = 0.298$, $P = 0.000$, $N = 527$). This result reinforces the link other researchers have found between awareness of invasive species and support for their control. Bremner and Park

(2007) conducted a survey of public attitudes to management of invasive species in Scotland and found that respondents with prior knowledge of control and eradication programs showed higher levels of support for control of invasive species. In their survey of San Marcos River stakeholders, Oxley et al. (2016) also found that respondents indicating they knew of non-native invasive species in the river were more likely to support control measures when compared with those that indicated they did not know of any invasive species in the river. And, Oxley et al. (2016) found that respondents with college

degrees were more likely to know of invasive species in the river when compared with respondents with only a high school education.

A correlational analysis was used to determine if those students who had learned about invasive species in either high school or in college had greater awareness of invasive plants or animals. Results showed a significant positive relationship between both (high school: $r = 0.094$, $P = 0.031$, $N = 527$; college: $r = 0.387$, $P = 0.000$, $N = 526$).

A Pearson's correlation was run to observe relationships between past instruction and attitudes toward

management of invasive species. No significant relationship occurred between those who learned about invasive species in high school and positive attitudes toward management of invasive species ($P = 0.274$). However, those students who reported having some college class instruction regarding invasive species also had more positive attitudes toward management of invasive species ($r = 0.126$, $P = 0.004$, $N = 531$). These results are encouraging since often we feel that student's attitudes are fully formed by the time they reach college. However, these results show that ideas are still developing. Previous studies have

Table 1. Analysis of variance and descriptive statistics results comparing different genders on invasive species management attitude scores, knowledge of invasive plant scores and knowledge of invasive animal scores in the study of college students' knowledge, and attitudes of invasive species.

Gender	<i>n</i> ^z	Invasive species attitude score ^y	SD	df	<i>F</i>	<i>P</i>
Male	171	26.853	3.940	1	9.441	0.002*
Female	357	25.751	3.821			
Gender	<i>n</i> ^z	Knowledge of invasive plant score ^z	SD	df	<i>F</i>	<i>P</i>
Male	171	2.368	1.315	1	28.176	0.000*
Female	357	1.728	1.288			
Gender	<i>n</i> ^z	Knowledge of invasive animal score ^x	SD	df	<i>F</i>	<i>P</i>
Male	171	2.459	1.480	1	43.605	0.000*
Female	355	1.631	1.274			

^zScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive plant species in Texas.

^yScores ranged from 7 to 35 with higher scores indicating more positive attitudes toward management of invasive species.

^xScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive animal species in Texas.

*Statistically significant at the 0.05 level.

Table 2. Analysis of variance and descriptive statistic results comparing students of different ethnic backgrounds on invasive species management attitude scores, knowledge of invasive plant scores and knowledge of invasive animal scores in the study of college students' knowledge, and attitudes of invasive species.

Ethnicity	<i>n</i> ^z	Invasive species attitude score ^y	SD	df	<i>F</i>	<i>P</i>
Caucasian	270	26.748	4.037	4	4.157	0.003*
Asian	15	24.933	3.348			
African American	41	25.049	2.974			
Hispanic	186	25.522	3.727			
Other	19	25.684	3.902			
Ethnicity	<i>n</i> ^z	Knowledge of invasive plant score ^z	SD	df	<i>F</i>	<i>P</i>
Caucasian	270	2.137	1.33	4	3.858	0.004*
Asian	15	1.867	0.834			
African American	41	1.488	1.286			
Hispanic	186	1.737	1.303			
Other	19	2.000	1.563			
Ethnicity	<i>n</i> ^z	Knowledge of invasive animal score ^x	SD	df	<i>F</i>	<i>P</i>
Caucasian	269	2.245	1.411	4	10.186	0.000*
Asian	15	1.133	1.060			
African American	41	1.342	1.131			
Hispanic	186	1.567	1.318			
Other	18	2.111	1.568			

^zScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive plant species in Texas.

^yScores ranged from 7 to 35 with higher scores indicating more positive attitudes toward management of invasive species.

^xScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive animal species in Texas.

*Statistically significant at the 0.05 level.

indicated younger students, such as elementary to middle school-aged children, should be targeted to make the greatest impact in sparking new interests and making subject matter relevant (Maltese and Tai, 2010). However, this study shows promise in positively influencing young adults. This supports past research indicating education at the college level can impact university students' attitudes toward environmental issues (Waliczek et al., 2016).

A correlational analysis was used to determine if those students who were involved in a school, community

or national environmental or conservation organization had higher awareness of invasive plants or animals. Results of a Pearson's correlation indicated a significant positive relationship. Respondents who answered "yes" to the question, "do you belong to any school, community or national environmental or conservation organization?," also responded that they knew of invasive species in the community ($r = 0.223, P = 0.000, N = 523$). Studies conducted by Bremner and Park (2007) and Oxley et al. (2016) found that members of environmental organizations were

more likely to support control of invasive species. Both studies linked conservation organization membership with increased awareness of invasive species. Fischer and van der Wal (2007) concluded that the high level of public support for nature protection in the Netherlands is attributed to the public's frequent membership in conservation organizations.

DEMOGRAPHIC COMPARISONS. Demographic and campus comparisons were conducted using analysis of variance with some statistically significant differences emerging in all comparisons. Significant differences

Table 3. Analysis of variance comparisons and descriptive statistics of attitude scores, knowledge of invasive plant scores and knowledge of invasive animal scores of students from two campuses in the study of college students' knowledge, and attitudes of invasive species.

School	<i>n</i> ^z	Invasive species attitude score ^y	SD	df	<i>F</i>	<i>P</i>
Community college	150	24.953	4.259	1	15.959	0.000*
University	383	26.486	3.869			
School	<i>n</i> ^z	Knowledge of invasive plant score ^z	SD	df	<i>F</i>	<i>P</i>
Community college	150	1.527	1.309	1	19.952	0.000*
University	383	2.089	1.305			
School	<i>n</i> ^z	Knowledge of invasive animal score ^x	SD	df	<i>F</i>	<i>P</i>
Community college	149	1.416	1.285	1	25.392	0.000*
University	381	2.084	1.404			

^zScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive plant species in Texas.

^yScores ranged from 7 to 35 with higher scores indicating more positive attitudes toward management of invasive species.

^xScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive animal species in Texas.

*Statistically significant at the 0.05 level.

Table 4. Analysis of variance and descriptive statistics results comparing students of different classification on invasive species management attitude scores, knowledge of invasive plant scores and knowledge of invasive animal scores in the study of college students' knowledge, and attitudes of invasive species.

Classification	<i>n</i> ^z	Invasive species attitude score ^y	SD	df	<i>F</i>	<i>P</i>
Freshman	111	25.973	3.163	4	1.863	0.099
Sophomore	173	25.867	3.988			
Junior	121	25.777	4.371			
Senior	103	27.087	3.573			
Graduate student	14	25.143	4.721			
Classification	<i>n</i> ^z	Knowledge of invasive plant score ^z	SD	df	<i>F</i>	<i>P</i>
Freshman	111	1.888	1.299	4	6.087	0.000*
Sophomore	173	1.624	1.282			
Junior	121	1.940	1.296			
Senior	103	2.359	1.131			
Graduate student	14	2.357	1.336			
Classification	<i>n</i> ^z	Knowledge of invasive animal score ^x	SD	df	<i>F</i>	<i>P</i>
Freshman	111	1.532	1.347	4	4.217	0.001*
Sophomore	170	1.835	1.322			
Junior	121	1.893	1.482			
Senior	103	2.350	1.412			
Graduate student	14	2.143	1.231			

^zScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive plant species in Texas.

^yScores ranged from 7 to 35 with higher scores indicating more positive attitudes toward management of invasive species.

^xScores ranged from 1 to 6 with higher scores indicating more knowledge of invasive animal species in Texas.

*Statistically significant at the 0.05 level.

were found in comparisons of gender in students' attitudes toward management of invasive species and in existing knowledge of invasive plants and animals. In general and in the overall sample, males felt more positively toward management of invasive species and also had more knowledge of invasive plants and invasive animals (Table 1). Nearly 20% (71) of females scored a zero on the invasive plants quiz, while only 8.2% (14) of males scored a zero. Over 20% (72) of women in the study scored a zero on the knowledge of invasive animals quiz compared with just 8.2% (14) of males. These results are similar to those of Bremner and Park (2007) in that their study also found support for control and eradication of invasive species was higher in men as compared with women and was higher in people who had prior knowledge of control projects.

The analysis of variance comparisons based on ethnic background showed there were differences in all comparisons of attitudes toward management of invasive species, knowledge of invasive plant species and knowledge of invasive animal species (Table 2). Post hoc Fisher's least significant difference (LSD) comparisons indicated that those identifying themselves as Caucasian and Other were similar in all scores, but different from the other demographic groups. Those identifying themselves as Caucasian and Other had higher scores in all categories, which indicated a more positive attitude toward management of invasive species and more knowledge of invasive animal and plant species. However, again, all student scores were low on knowledge inventories.

When comparisons were made between the two campuses included in the study (Austin Community College and Texas State University), significant differences were found in students' attitudes toward management of invasive species and in existing knowledge of invasive plants and animals (Table 3). While scores were low for all students, students at the university had slightly higher scores and more positive attitudes toward management of invasive species and also a greater awareness of invasive plant and animal species (Table 3).

When comparisons were made between student classification groups

using an analysis of variance test, no differences were found in students' attitudes toward management of invasive species (Table 4). However, differences were found in levels of knowledge of both invasive plants and animals. Post hoc LSD comparisons showed that students classified as freshman and sophomores were significantly different when compared with upperclassmen or graduate students with upperclassmen having more knowledge. These findings support the comparisons between the two campuses (i.e., community college and university comparisons), with more lowerclassmen at the community college and a greater incidence of lower knowledge scores.

This study found that most students did not consider themselves informed about invasive species. Most students indicated they did not learn about invasive species in high school or college. Most were not able to distinguish between examples of invasive species and native species. Most students also underestimated the number of invasive species in the United States and the monetary damage they cause. Results of this study point out a serious gap in educating youth about invasive species.

Previous authors have pointed out the important role awareness and education play in increasing public support for invasive species management (Bremner and Park, 2007; García-Llorente et al., 2008; Oxley et al., 2016). Although most students in our study indicated they did not learn about invasive species in either high school or college, of those that did learn something, more indicated they learned about invasive species in high school [26.8% (143)] than in college classes [17.9% (95)]. Yet this study showed education at the college level appears to be more important in development of positive attitudes toward management of invasive species. Furthermore, students in this study ranked college classes as a highly reliable source of invasive species information, second only to environmental organizations. Therefore, it seems prudent to incorporate invasive species biology into the college curricula to gain support for invasive species control and management.

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