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A profile of wild pig hunters in Texas, USA

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Abstract: Wild pigs (*Sus scrofa*) are a widespread exotic, invasive species that poses ecological, agricultural, and human health risks in invaded areas. Wildlife managers often manage wild pig abundance and expansion to mitigate these risks. The diversity of stakeholders involved in the issue of wild pig management complicates efforts to manage the species, and, to be successful, wildlife professionals should consider the human dimensions associated with wild pig management. The prevalence of privately owned lands in Texas, USA necessitates cooperation to enact effective management policies. In this study, we investigate the factors that affect a hunter's likelihood to participate in wild pig hunting. Multiple factors affect participation in wild pig hunting activities. We found that participation in other types of big game hunting increased the likelihood of participation in wild pig hunting and that wild pig hunting does not deter individuals from participating in other types of hunting activities. Additionally, hunters' attitudes toward wild pigs are important in determining the likelihood of participation in wild pig hunting. Finally, our results suggest that hunters are largely uninformed about wild pigs and do not hold the same perceptions, values, or tolerance levels of the species. The diversity of preferences among wild pig hunters necessitates that wildlife managers consider the desires of the public as well as natural resource needs in creating socially acceptable management plans for the species.

Key words: big game, feral hogs, hunting, invasive species, *Sus scrofa*, Texas, wild pigs

Wild pigs (*Sus scrofa*) are a widespread exotic species, considered among the most invasive mammals in the world (Lowe et al. 2000). Adaptive to a broad array of ecological conditions, wild pigs exhibit strong invasion potential in many regions (Sales et al. 2017). In areas invaded by wild pigs, management is often necessary to mitigate ecological and agricultural damage caused by the species (Rollins et al. 2007). Wild pigs, however, pose both threats and potential benefits to various stakeholder groups in these invaded areas. In order for management of wild pigs to ultimately succeed, decision makers should consider both the costs and benefits associated with wild pigs. Thus, the issue of wild pig management provides an opportunity to investigate attitudes toward an exotic, invasive species that is both valued as a hunting resource and the subject of human–wildlife conflict.

Stakeholder diversity and widespread wild pig presence in the state of Texas, USA provide an ideal opportunity to investigate the complexity of wild pig management. Recognized as the largest wild pig population in the United States (Mayer 2014), despite continued efforts by various organizations to control wild pig population abundance and range expansion, the species is now found in all but 1 county in Texas (Timmons et al. 2012, Bevins et al. 2014, Snow et al. 2017, U.S. Department of Agriculture [USDA] 2018). Due to legal ownership of wild pigs by landowners (Texas Administrative Code 2019), this species provides a year-round resource for hunting with no harvest limits (Timmons et al. 2011).

Fee-based hunting opportunities, high reproductive potential of the species, and a lack of legal limits on hunting or harvest presents the potential for wild pigs to become viewed as a financial asset across invaded areas in the United States. Landowners may hold different attitudes toward wild pigs depending on their experience with the species on their property, hunting participation, and income threatened by wild pig damage (Watkins et al. 2019). However, stakeholders who benefit from wild pig presence may tolerate the risks associated with higher wild pig abundance, making it difficult to manage the species on private lands where they are considered a resource rather than a nuisance. As Tolleson et al. (1995) foresaw, some landowners perceive a benefit from wild pigs in the form of leased hunting rights for the animals or to trap and sell them to meat processors. Consequently, this likely incentivizes the expansion and persistence of wild pig populations for their continued use (Zivin et al. 2000). Aditionally, landowners may perceive an incentive to tolerate the species as a potential source of revenue during periods of economic hardships.

Such differences in losses and gains experienced by stakeholders as a result of wild pigs can create potential for conflict among stakeholders, given resulting levels of acceptance for wild pigs based on personal experience (Decker and Purdy 1988). Wild pigs have both positive and negative impacts on various stakeholder groups (Conover 2007, Weeks and Packard 2009, Frank and Conover 2015). For example, hunters may perceive a benefit because wild pigs provide hunting opportunities closer to their home (Tolleson et al. 1995), while a nearby rancher may suffer extensive range damage due to the same wild pigs' foraging activities that destroy crops and pastures (Mengak 2012). In a formal context, stakeholder wildlife acceptance capacity (SWAC) describes the maximum size of a species population that is acceptable to a stakeholder group (Carpenter et al. 2000, Riley and Decker 2000*a*). In a similar sense that habitat conditions dictate the biological carrying capacity of a landscape for a species, SWAC is determined by sociocultural factors such as attitudes, values, and risk perceptions (Riley and Decker 2000*b*, Zinn et al. 2000). The SWAC suggests that different stakeholder groups may tolerate different population sizes due to their perceptions of risks and benefits associated with a species (Decker and Purdy 1988, Zinn et al. 2000, Lischka et al. 2008).

In areas where wild pigs provide benefits or hold cultural importance, resident stakeholders may tolerate wild pig presence despite their undesirable impacts (Weeks and Packard 2009). In such cases, the development of a management plan necessitates cooperation and mutual understanding between wildlife managers and various stakeholder groups. Given that 95% of land in Texas is privately owned (Anderson et al. 2014), similar to other states in the southeastern United States where invasive wild pigs now occur, stakeholder involvement and support are necessary to achieve wild pig management goals. Stakeholder attitudes, risk perceptions, and values change over time, and differences in losses and benefits between groups have the potential to cause conflict when creating management plans (Estevez et al. 2014, Frank and Conover 2015, Novoa et al. 2018). An optimal management program for wild pigs must strike a balance between the damages caused by the species and the benefits generated by maintaining populations for hunting use and market sale (Zivin et al. 2000).

Although a critical need for effective management, existing research on human–wild pig interactions in Texas focuses on landowners, land managers, and pesticide applicator license holders at Texas A&M AgriLife Extension Service educational seminars (Adams et al. 2006, Kubecka 2016). Further, data are limited in geographic extent and may not be representative of diverse publics within the state that interact with wild pigs. In particular, comprehensive knowledge of hunter attitudes and motivations on the subject of wild pigs is not available (Beasley et al. 2018). Given that hunters are a highly engaged stakeholder group that can present significant barriers to wild pig management when motivated to do so, wildlife managers must better understand the motivations of wild pig hunters to create durable, effective management solutions. Effective and well recieved management plans for the species should rely on sound wild pig population or damage management methods while reasonably accommodating the values of various stakeholder groups, including wild pig hunters.

In this study, we sought to generate a greater understanding of wild pig hunter attributes and attitudes in Texas. Our research objectives were to identify factors that influence participation in wild pig hunting activities and create a model for participation in wild pig hunting activities using hunter demographics, knowledge, attitudes, and habit-based factors. We employ the SWAC concept to develop a model that incorporates the effect of differing stakeholder group membership on wild pig hunting participation. We explore various aspects that strongly inform our model and generate insights into self-identified wild pig hunters. We end with implications for those seeking to manage wild pig abundance in the context of recreational harvest.

Methods

This study was reviewed by Texas A&M University Institutional Review Board and determined to meet the criteria for exemption (IRB ID: IRB2018-1219M). We developed the online version of the Texas A&M Human Dimensions of Wild Pigs Survey questionnaire using Qualtrics Survey Software (Provo, Utah, USA). We also developed a paper version of the questionnaire to mirror the online version as closely as possible to accommodate respondents with limited internet access or technological proficiency (Appendix 1). The questionnaire contained 79 items, although instructions directed respondents to answer only the items applicable to them.

Our sample was comprised of all Texas hunting license holders above the age of 18 who provided an email address (n = 169,619), representing 15.3% of total non-youth Texas hunting license sales in 2018 (n = 1,106,625). Our sample also included a randomly selected subset of 2,615 licensed Texas hunters who did not provide an email address. We acquired mail and email contact information for all Texas hunting license holders in 2018 from the Texas Parks and Wildlife Department (TPWD). Following Dillman's tailored design method (Dillman et al. 2008), we contacted potential respondents through both email and physical mail. Members of the email sample group received an email invitation to participate in the online survey on June 4, 2019. We sent reminder email messages to email group non-respondents 3 and 5 days after the initial invitation (June 7 and June 10, 2019). We contacted physical mail group sample members through an invitation letter sent on June 5, 2019. We followed the invitation letter with a reminder postcard to 1,000 randomly selected mail group non-respondents 21 days later on June 26, 2019. The survey remained open for response submissions from both email and mail respondents until August 13, 2019.

The survey asked respondents items related to their hunting activity, landownership status, attitudes toward and knowledge about wild pigs in Texas, several demographic variables, and their area of residence. We developed a relational database to organize and manage response data using FileMaker Pro Advanced 17 (Claris International Inc., Cupertino, California, USA). We manually entered paper survey responses into the database. We downloaded electronic response data to the database on July 9, 2019 for cleaning and analyses. We conducted all data analyses in Program R (R Development Core Team 2018).

Variable measurement and data analyses

We asked respondents a series of items about their hunting habits in Texas. We used these responses to identify hunters who participated in wild pig hunting as well as hunting other types of game and their preferences for wild pig abundance and distribution in Texas. We also collected demographic information such as age, gender, annual household income, education level, and ethnicity.

We analyzed responses to 7 Likert items and developed a scale measuring respondent attitudes toward wild pig management. Respondents reported their level of agreement from completely disagree to completely agree for 7 opinion-based statements about wild pigs in Texas (Appendix 1, items 53–59; Cronbach's alpha = 0.86). We conducted a principal component analysis (PCA) on the 7 attitude items with VARIMAX rotation (Field 2013). We calculated eigenvalues for each factor in the data. We calculated respondent scores on 3 factors that emerged from the PCA for use in a regression analysis.

Respondents answered a series of 10 true-or-false items regarding their knowledge of wild pig biology, ecology, distribution, and legal status in Texas (Appendix 1, items 42–51; Cronbach's alpha = 0.66). We coded each correct response as

Table 1. Hunter response to demographic and locality items. "Unknown" indicates respondent did not answer the question.

Respondent demographics	Results
Age, years	
Mean (SD)	51.548 (13.8)
Median	53
Range	10–117
Unknown	7,833
Gender	
Female	1,164 (4.3%)
Male	25,983 (95.7%)
Unknown	7,680
Education level	
High school graduate, diploma or GED	5,418 (20.0%)
Some college, no degree	2,208 (8.2%)
Associate degree	2,058 (7.6%)
Trade/technical/vocational training	1,703 (6.3%)
Bachelor's degree	10,209 (37.7%)
Master's degree	3,805 (14.1%)
Doctoral degree	1,644 (6.1%)
Unknown	7,782
Ethnicity	
White	24,444 (90.9%)
Spanish, Hispanic, or Latino	1,460 (5.4%)
Other	976 (3.6%)
Unknown	7,947
Income	
Less than $35,000	726 (2.8%)
$35,000 to $49,999	1,106 (4.3%)
$50,000 to $74,999	3,127 (12.2%)
$75,000 to $99,999	3,926 (15.3%)
Over $100,000	16,782 (65.4%)
Unknown	9,160
Ecoregion	
Blackland Prairies	2,973 (12.4%)
Cross Timbers	3,519 (14.7%)
Edwards Plateau	4,183 (17.4%)
Gulf Prairies	3,003 (12.5%)
High Plains	857 (3.6%)
Piney Woods	4,460 (18.6%)
Post Oak Savannah	2,899 (12.1%)
Rolling Plains	696 (2.9%)
South Texas Plains	1,283 (5.3%)
Trans-Pecos	135 (0.6%)
Unknown	10,819

1 and each incorrect response as 0. We determined the number of items each respondent answered correctly and tallied this number as a knowledge score. Thus, knowledge scores could range from 0, indicating all incorrect answers, to 10, all correct answers.

To approximate the spatial distribution of hunters, we asked respondents to provide the ZIP code for their primary residence. We used U.S. Department of Housing and Urban Development U.S. Postal Service ZIP Code Crosswalk Files data (2018) to match ZIP Codes to Texas counties. We then sorted each respondent into 1 of 10 natural regions of the state by county (Gould et al. 1960).

We created a candidate model that included 13 variables and various interactions based on stakeholder group membership. We hypothesized that SWAC would influence hunter likelihood to participate in wild pig hunting. Following the SWAC concept, we selected interactions between variables, which we hypothesized would affect hunters' acceptance capacity for wild pigs for inclusion in the candidate model. We incorporated sociocultural factors important in informing individuals' SWAC for wild pigs: attitudes toward wild pigs, knowledge on wild pigs, preference for wild pig population change, big game hunter status, and landownership as a proxy for risk perception. Given that hunters may suffer from wild pig damage on private property, we hypothesized that landownership or management status would be an important covariate on hunter attitudes toward wild pigs and wild pig population preference in the models. Because wild pigs exsist at differing densities in various regions of the state, we also hypothesized that ecoregion of residence would affect landowner or land manager participation in wild pig hunting.

We used stepwise Akaike information criterion (AIC) procedures with small sample approximation as a pen-

alty for additional complexity to select the most parsimonious model for predicting wild pig hunting participation (Burnham and Anderson 2002). We calculated McFadden's pseudo-r^2 to assess the explanatory power of the selected model (McFadden 1973). We calculated odds ratios to understand the effects of model variables on wild pig hunting participation among Texas licensed hunters (Field 2013).

Results

Survey response

We contacted 159,420 licensed hunters through email and 2,494 through conventional mail methods (total n = 161,914). We received 37,225 total responses to the survey for a combined response rate of 23.0%. Participants in the email contact group responded at the rate of 23.2% to the survey while 7.1% of those in the conventional mail group responded. We intended to test for mode bias; however, low response rates within the conventional mail group prevented us from conducting meaningful comparisons between the 2 groups. Overall, non-response was high but not unexpected given declining response rates to surveys over time (Connelly et al. 2003). Although we did not conduct a formal non-response bias analysis due to logistical constraints due to large sample size, we regressed several key items (items 1, 2, 31, and 73 in Appendix 1) on the number of days to response as an indicator for potential non-response bias. While responses were different by the number of days to response ($P < 0.05$), effect sizes were small (r^2 = 0.0003). We therefore assumed no significant effect of non-response bias and that results could be generalized to the target population (Lindner et al. 2001).

Respondent demographics, preferences, and knowledge

Of all survey respondents, 93.6% indicated they hunted in Texas (n = 34,827), 77.8% of those who identified themselves as hunters also indicated they hunt wild pigs (n = 27,100), 93.3% of wild pig hunters also reported hunting other big game animals in Texas, and 50.9% of wild pig hunters reported owning or managing land in Texas. We report additional respondent demographic and locality response results (Table 1).

Hunters indicated varying preferences for changes in wild pig population numbers in Texas. The majority of hunters wished for wild pig numbers to be reduced (60.4%); 16.5% wished for wild pigs to be completely removed, 15.4% for wild pig populations to remain the same, and 2.2% for wild pig populations to increase. Of all hunters, 5.6% reported they did not know their preference for change in wild pig population numbers in Texas.

Wild pig hunters answered a mean of 4.01 wild pig knowledge questions correctly (SD = 2.2). More than half of the 10 knowledge questions were answered incorrectly by over half of respondents (Figure 1).

Principal component analysis

There were 7 factors with eigenvalues that ranged from 0.48–5.88 and we retained the 3 factors that individually explained the largest percent of variance for further analyses. Two factors had eigenvalues >1 (Kaiser 1960), and a third factor had an eigenvalue of 0.93. Combined, the 3 selected factors (PC1, PC2, and PC3) explained 75.7% of the variance in the data. We report the factor loadings after rotation (Table 2).

Factor loadings suggest that PC1 represents general attitudes toward wild pigs (Table 2). High values of PC1 indicate the respondent holds an overall positive attitude toward wild pigs. A hunter with high value in PC1 may, for example, agree that wild pigs belong in Texas and provide benefits that outweigh the harm they cause in the state. The PC2 factor represents hunter perceptions of the utilitarian value of wild pigs (Table 2). High values of PC2 indicate the respondent appreciates the utilitarian value of wild pigs. Respondents with high values of PC2 would agree that wild pigs are a valuable resource for recreation, meat, or income in Texas and provide benefits that outweigh the harm they cause in the state. Finally, PC3 represents hunter tolerance of wild pig damage (Table 2). Respondents with low values of PC3 do not believe that wild pigs have the right to exist wherever they occur and agree the harm caused by the species outweighs the benefits of having them in Texas.

Factors affecting participation in wild pig hunting

We selected all respondents who identified themselves as Texas hunters and removed all

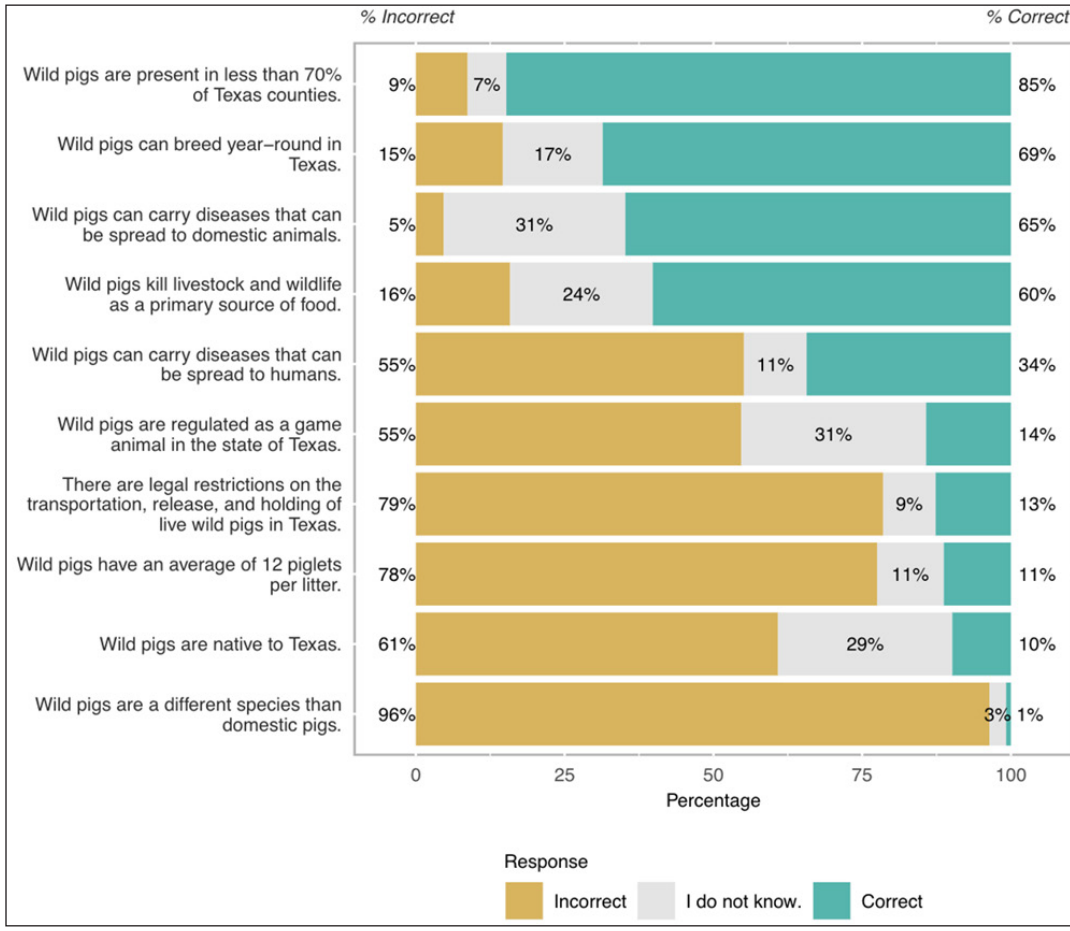

Figure 1. Responses to wild pig (*Sus scrofa*) knowledge questions.

Table 2. Factor loadings (PC1, PC2, PC3) for selected components of principal components analysis. Asterisk (*) indicates the response is reverse coded.

Items[a]	PC1	PC2	PC3
53*	-0.35	-0.53	-0.22
54	-0.40	0.49	-0.55
55*	-0.37	-0.54	0.03
56	-0.46	0.29	0.09
57*	-0.45	-0.13	0.08
58	-0.28	0.21	-0.08
59*	-0.30	0.22	0.79

[a]Items 53–59 in Appendix 1.

incomplete records, leaving 21,843 records for analysis. We considered incomplete records those in which the respondent failed to answer any of the items used in this analysis. In the regression analysis, we attempted to predict participation in wild pig hunting using knowledge score, PC1, PC2, PC3, landowner status, preference for wild pig population change, age, gender, income, education, ethnicity, big game hunter status, and ecoregion of residence. Stepwise AIC procedures indicated that model 4 was the most parsimonious predictor of licensed Texas hunter's participation in wild pig hunting activities among those models considered (Table 3). The McFadden's pseudo-r^2 value of top performing model was 0.38 (df = 44). We calculated odds ratios for each indicator variable (Table 4).

Each correct response to a knowledge item about wild pigs increased the likelihood of

Table 3. Stepwise Akaike information criterion (AIC) output conducted on all considered variables in wild pig (*Sus scrofa*) hunting. Null model represents no correlation between any variables and wild pig hunting. Full model represents the model with all considered variables correlating to wild pig huting. Models 2–4 represent steps in the stepwise AIC model selection procedure.

Model	K[a]	AICc	Delta AICc[b]	AICc weight	Log-likelihood
Model 4	44	12,411.63	0.00	0.54	-6,161.72
Model 3	45	12,412.78	1.15	0.30	-6,161.29
Model 2	46	12,414.45	2.83	0.13	-6,161.13
Full model	52	12,417.69	6.07	0.03	-6,156.72
Null model	1	19,805.35	7,393.73	0.00	-9,901.68

[a]K denotes the number of parameters within the model.
[b]AICc: Akaike information criterion with penalty for additional complexity.

Table 4. Odds ratios for factors in Model 4. Asterisk (*) indicates an interaction between 2 variables.

Factors	Odds ratio	β estimate	SE	z value	Pr(>|z|)
(Intercept)	0.18	-1.69	0.44	-3.86	<0.001
Knowledge score	1.24	0.21	0.02	13.09	<0.001
PC1: Perception	1.20	0.18	0.01	12.42	<0.001
Q31: Landowner status	1.21	0.19	0.22	0.86	0.390
PC2: Utilitarian	1.34	0.29	0.03	9.12	<0.001
PC3: Tolerance	1.04	0.04	0.03	1.62	0.105
Q38: Completely removed	1.44	0.37	0.16	2.26	0.024
Q38: Reduced	1.83	0.60	0.14	4.43	<0.001
Q38: Remain the same	3.23	1.17	0.18	6.62	<0.001
Q38: Increase	3.13	1.14	0.34	3.33	<0.001
Q73: Age, years	0.98	-0.02	0.01	-2.74	0.006
Q74: Male	1.01	0.01	0.41	0.02	0.981
Q76: Spanish, Hispanic, or Latino	0.82	-0.20	0.11	-1.90	0.057
Q76: Other	1.20	0.18	0.14	1.29	0.196
Q77: $35,000 to $49,999	1.65	0.50	0.17	3.02	0.002
Q77: $50,000 to $74,999	1.59	0.46	0.14	3.30	<0.001
Q77: $75,000 to $99,999	1.54	0.43	0.14	3.14	0.002
Q77: Over $100,000	1.81	0.59	0.13	4.63	<0.001
Big game hunter status	13.40	2.60	0.23	11.09	<0.001
Ecoregion: Blackland Prairies	1.07	0.07	0.12	0.56	0.575
Ecoregion: Cross Timbers	1.15	0.14	0.12	1.19	0.234
Ecoregion: Edwards Plateau	0.91	-0.10	0.11	-0.83	0.404
Ecoregion: Gulf Prairies	1.02	0.02	0.12	0.17	0.868
Ecoregion: High Plains	0.64	-0.45	0.18	-2.56	0.010
Ecoregion: Post Oak Savannah	1.19	0.17	0.15	1.17	0.242
Ecoregion: Rolling Plains	0.57	-0.57	0.22	-2.56	0.010
Ecoregion: South Texas Plains	1.10	0.10	0.19	0.51	0.609
Ecoregion: Trans-Pecos	0.37	-0.99	0.37	-2.71	0.007

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Q31 * PC2 Utilitarian	0.87	-0.14	0.04	-3.06	0.002
Q31 * Q38 Completely removed	1.29	0.26	0.22	1.15	0.249
Q31 * Q38 Reduced	0.93	-0.07	0.21	-0.35	0.727
Q31 * Q38 Remain the same	0.67	-0.39	0.27	-1.47	0.141
Q31 * Q38 Increase	0.39	-0.93	0.51	-1.81	0.069
Q73: Age, years * Q74 Male	0.99	-0.01	0.01	-1.72	0.085
Q74: Male * Big game hunter status	2.98	1.09	0.24	4.54	<0.001
Q31 * Ecoregion: Blackland Prairies	1.07	0.07	0.18	0.37	0.709
Q31 * Ecoregion: Cross Timbers	0.86	-0.15	0.17	-0.87	0.386
Q31 * Ecoregion: Edwards Plateau	0.81	-0.21	0.16	-1.37	0.171
Q31 * Ecoregion: Gulf Prairies	1.03	0.03	0.18	0.19	0.853
Q31 * Ecoregion: High Plains	0.81	-0.21	0.25	-0.82	0.413
Q31 * Ecoregion: Post Oak Savannah	1.10	0.09	0.19	0.48	0.629
Q31 * Ecoregion: Rolling Plains	2.81	1.03	0.30	3.44	<0.001
Q31 * Ecoregion: South Texas Plains	0.79	-0.24	0.24	-0.99	0.324
Q31 * Ecoregion: Trans-Pecos	1.94	0.66	0.56	1.19	0.235

hunting them (odds ratio = 1.2; $P < 0.05$). Hunters who held generally negative perceptions about wild pigs were less likely to hunt them (odds ratio = 0.8; $P < 0.05$). Hunters who did not ascribe utilitarian value to wild pigs were less likely to hunt them (odds ratio = 0.7; $P < 0.05$). Tolerance was not an important indicator for participation in wild pig hunting (odds ratio = 1.0; $P > 0.05$).

Compared to hunters who answered "I do not know" when asked their preference for wild pig population change in the state, having any kind of population preference for wild pigs increased the likelihood of hunting them and preferring the wild pig population to remain the same was the strongest predictor of wild pig hunting participation ($P < 0.05$). Hunters who wished to see wild pig populations remain the same were 3.2 times more likely to participate in wild pig hunting than those who did not report a preference for wild pig population change. Hunters who desired an increase in wild pig population numbers were 3.1 times more likely to hunt them. Hunters who desired a reduction in wild pig population numbers were 1.8 times more likely to hunt them, and those who wanted pigs completely removed were 1.4 times more likely to hunt them.

Age was a significant predictor of wild pig hunting participation, and the likelihood of participation decreased with age (odds ratio = 1.0; $P < 0.05$). For each additional year of age, hunters were 1.826% less likely to participate in wild pig hunting. Gender alone was not a significant indicator, and females were not different from males in likelihood to participate in wild pig hunting (odds ratio = 1.0; $P > 0.05$). However, male big game hunters were 3.0 times as likely as female big game hunters to participate in wild pig hunting (odds ratio = 3.0; $P < 0.05$). Hunters who hunted other types of big game animals were more likely to hunt wild pigs than those who did not (odds ratio = 13.4; $P < 0.05$).

Individuals who identified as Spanish, Hispanic, or Latino were 18.4% less likely to hunt wild pigs than those who identified as white (odds ratio = 0.8; $P = 0.056$). Income levels were all significant indicators of wild pig participation. Hunters who made >$100,000 per year in household income were significantly more likely to participate in wild pig hunting (odds ratio = 1.8; $P < 0.05$) and were 80.8% more likely to participate than individuals who made <$35,000 per year. Hunters whose household income was $35,000–$49,999 were 65.1% more likely to hunt wild pigs than hunters whose annual household income was <$35,000;

$50,000–$74,999 were 58.5% more likely; and $75,000–$99,999 were 53.9% more likely.

Hunters residing within the High Plains, Rolling Plains, and Trans-Pecos ecoregions were significantly less likely to hunt wild pigs than hunters in the Piney Woods ecoregion ($P < 0.05$). Hunters in the High Plains ecoregion were 36.2% less likely, Rolling Plains ecoregion were 43.2% less likely, and Trans-Pecos ecoregion were 62.8% less likely to participate in wild pig hunting than hunters in the Piney Woods ecoregion ($P < 0.05$). Hunters in the Blackland Prairies, Cross Timbers, Edwards Plateau, Gulf Prairies, Post Oak Savannah, and South Texas Plains ecoregions were equally likely to participate in wild pig hunting compared to hunters in the Piney Woods ecoregion.

Neither landownership nor management status was an important overall indicator of participation in wild pig hunting ($P > 0.05$). However, there was an important interaction effect of landownership and management status on hunters' utilitarian perceptions of wild pigs and their ecoregion of residence. Landowners and managers who held low utilitarian values toward wild pigs were more likely to hunt them than those who did not (odds ratio = 1.1; $P < 0.05$). For each 1 unit decrease in utilitarian values of wild pigs, landowners or land managers were 14.6% more likely to hunt wild pigs. While landowners or managers residing in other ecoregions were not significantly more or less likely to participate in wild pig hunting that those in the Piney Woods ecoregion, landowners and managers in the Rolling Plains ecoregion were 2.8 times more likely to hunt wild pigs ($P < 0.05$). The interaction of landownership and management status on wild pig population preference did not significantly change the odds of participation in wild pig hunting ($P > 0.05$).

Discussion

Participation in wild pig hunting versus native big game hunting

Our findings suggest that participation in other types of big game hunting is a strong indicator of participation in wild pig hunting. Overall, Texas big game hunters are more likely to participate in wild pig hunting than hunters who do not pursue native big game species. Our results suggest that wild pig hunting does not replace other types of big game hunting. Therefore, one may consider wild pig hunting as an additive, rather than compensatory, hunting activity among Texas licensed hunters. Hunters may harvest both native game and wild pigs during the same trip, and most Texas hunters appear to harvest wild pigs opportunistically while primarily pursuing other types of game animals.

In 2019, when this survey was issued, Texas law required a hunting license to hunt wild pigs. During the 2019 hunting season, however, hunters were not required to possess a Texas hunting license to hunt wild pigs. Only 3.3% of licensed hunters surveyed reported exclusively hunting wild pigs in Texas. Therefore, Texas may expect to see only marginal decreases in hunting license sales and revenue due to the recent change in license requirements.

Knowledge of wild pigs

Hunters with higher wild pig knowledge scores were more likely to hunt them than those with lower scores. Nevertheless, our findings demonstrate a clear deficiency in knowledge of wild pig biology, natural history, and regulations among licensed hunters. The knowledge statements that hunters most typically answered incorrectly illustrate educational deficiencies related to wild pigs.

Very few hunters (1%) correctly identified wild pigs as belonging to the same species as domestic pigs, and only 10% of hunters correctly identified that wild pigs are not native to Texas (Figure 1). This may be due to the long history of wild pig presence in the region, leading to generational amnesia concerning their introduction (Papworth et al. 2009). This should cause concern among wildlife managers seeking to mitigate exotic, invasive wild pig damage and range expansion. As with invasive species issues in other areas (García-Llorente et al. 2008, Papworth et al. 2009, Schüttler et al. 2011, Speziale et al. 2012, Clavero 2014), the lack of recognition of wild pigs as exotic may illustrate a shifting baseline among hunters, where hunters fail to recognize problems associated with longstanding invasive species. In areas of the state where self-sustaining wild pig populations have existed since the 1800s (Taylor 2003), hunters may view wild pigs as native components of ecosystems (Weeks and Packard 2009).

Thus, hunters may encounter difficulties identifying wild pigs as a non-native species due to the length of time since the species introduction (Warren 2007). Ultimately, hunter failure to identify wild pigs as an invasive species may prove problematic in efforts to manage them and may, in fact, lead hunters to value the species similarly to native fauna (Weeks and Packard 2009, Schüttler et al. 2011). This invariably complicates regulatory actions designed to curb the expansion of wild pigs.

Hunters were largely unaware of the legal status of wild pigs (14% correct response) and legal restrictions on live wild pig transportation, release, and holding of wild pigs (13% correct response; Figure 1). Hunter misinformation regarding these regulations is problematic because it suggests that such regulations, designed to curb the human-induced expansion of wild pigs, have not yet permeated the wild pig hunter stakeholder group. Thus, hunters who do not understand and abide by the legal restrictions on transporting live wild pigs likely assist in the introduction of the species to new areas. In Europe, hunting opportunities incentivize the introduction and spread of invasive species used as game animals (Carpio et al. 2017). Similarly, wild pig distribution expansion in the United States is largely associated with human translocations (Caudell et al. 2016). The human-aided spread of invasive wild pigs to new areas for hunting purposes poses a challenge for wildlife managers, who must disincentivize the introduction and spread of invasive and ecologically dangerous species.

Movement of wild pigs to new areas carries important implications not only for ecological damages related to the species, but also for animal and human health. Strikingly, only 34% of hunters correctly reported that wild pigs can carry diseases that can be transmitted to humans (Figure 1). Wild pigs vector several zoonotic diseases, including swine brucellosis, tularemia, anthrax, hepatitis E, and leptospirosis, among others (Meng et al. 2009). These diseases pose significant health risks to hunters who do not take proper precautions. Our findings highlight the need for more effective communication about zoonotic diseases present in wild pig populations and proper personal protective equipment that hunters should use when handling wild pigs. Despite >30 years of education by various government agencies in Texas (Rollins et al. 2007), hunter knowledge of wild pigs and associated risks remain rudimentary.

Hunter perceptions and population preference

We found that hunters tend to participate in wild pig hunting if they hold any population preference for wild pigs, positive or negative. Hunters who preferred the wild pig population remain the same or increase, however, were more likely to hunt wild pigs than those who preferred a lower population number or complete removal of wild pigs. It should be noted that few hunters wished to see increased numbers of wild pigs (2.2%).

Respondents who expressed no preference for wild pig numbers were least likely to be wild pig hunters, suggesting that hunters who experience positive or negative interactions with wild pigs hold stronger opinions about the future management of the species. Interestingly, we did not find population preferences for wild pigs significantly impacted by landowner or land manager status. We posit that hunters who own or manage the land where they hunt may tolerate wild pig damage on their land because they have access to wild pig hunting opportunites. By the same token, landowners who lease their property for wild pig hunting may tolerate wild pigs due to the lease revenue generated from this year-round hunting opportunity. For those seeking to reduce overall wild pig numbers, additional work could elucidate the bounds of what hunters and landowners consider acceptable wild pig numbers.

Results indicate that hunter perceptions of wild pigs and their utilitarian value affect the likelihood of hunting the species. Hunters who held more positive perceptions of wild pigs and attribute utilitarian value to them are more likely to hunt them. We found hunters who own or manage land and do not identify utilitarian value associated with wild pigs to be more likely to hunt them than those who do identify this value. This may be an indicator of the economic value that wild pig hunting, trapping, or lease revenue opportunities provide to some landowners. Generally, those hunters who did not own or manage land ascribe higher utilitarian value to wild pigs. We posit this is likely

because they do not have firsthand experience with costly wild pig damage. Landowners or land managers, however, may fail to identify benefits associated with wild pigs due to greater losses suffered to wild pig damage. We propose the existence of a threshold of tolerance, above which landowners no longer perceive benefits associated with wild pigs due to the damage they cause. The same may be true below a threshold where negative impacts of wild pigs appear negligible to landowners who access benefits associated with the species.

Therefore, we suggest that 2 types of wild pig hunters exist in Texas: recreational hunters and management hunters. Non-landowning hunters likely hold higher utilitarian values for wild pigs because the species benefits them and presents minimal observable risks. They do not perceive wild pig damages in the same way as landowners, given that damages pose no financial risk to them. These non-landowning hunters are therefore more likely to hunt wild pigs for recreational purposes. Conversely, landowning hunters may be more likely to hunt wild pigs as a means of controlling their population or mitigating damage. It should be noted that landowners may be recreational hunters, and non-landowners may hunt purely for management. The disconnect between perceptions and actions presents a challenge for those managing wild pigs when some stakeholders may consider them a valued resource.

Hunter locality and demographics

Although wild pigs today inhabit all but 1 county in Texas (USDA 2018), historic patterns of wild pig presence and densities would logically influence rates of participation in wild pig hunting. Hunters residing within the High Plains, Rolling Plains, and Trans-Pecos ecoregions were significantly less likely to hunt wild pigs than hunters in the Piney Woods ecoregion ($P < 0.05$), where wild pigs have existed the longest in Texas (Timmons et al. 2012). Related to a history of presence, this pattern may reflect differences in wild pig density in those ecoregions, as earlier studies found wild pigs to exist at lower densities in the High Plains and Trans-Pecos regions due to lower availability of habitat (Timmons et al. 2012). Lower densities of wild pigs may present considerably fewer opportunities to hunt them in these regions. In general, hunters living in the Rolling Plains ecoregion are significantly less likely to hunt wild pigs. Interestingly, hunters living in the Rolling Plains ecoregion who own or manage land were 2.8 times more likely to hunt wild pigs than those in the Piney Woods ecoregion (Table 4). One might speculate that landowners or managers in the Rolling Plains ecoregion may not offer lease hunting opportunities for wild pigs and, instead, hunt them on their own properties, likely as a form of landowner-driven wild pig damage management. We posit the Rolling Plains ecoregion presents an interesting case study at the nexus of a threshold of action: large enough pig densities for landowners to feel that hunting is necessary to manage damage, but not enough to incentivize economic gain from wild pigs. It should be noted, however, that we received relatively small numbers of responses from hunters in the Rolling Plains, Trans-Pecos, and High Plains ecoregions (Table 1). It is possible that fewer hunters in those ecoregions participated in this survey due to limited experience with wild pig damage or hunting opportunities involving wild pigs. Additionally, hunters may hunt in areas outside of their ecoregions of residence. Unfortunately, we were unable to capture information about where hunters hunted relative to where they live.

Just as geography affects respondents' attitudes about wild pigs, demographic factors also affect hunter participation in wild pig hunting; these factors include age, ethnicity, and income. Overall, the median age of hunters who participated in the survey was greater than the median age for Texas hunting license holders above 18 years old in 2018 (50 years and 46 years, respectively; TPWD, unpublished data). Nevertheless, wild pig hunting activities appear to attract younger hunters: the median age for wild pig hunters in the respondent group was 3 years younger than Texas licensed hunters in general (50 years and 53 years, respectively). This may be due to motivational differences among younger and older hunters, where younger hunters may hold different motivational drivers more suited to wild pig hunting than do older hunters.

We found that hunters with annual household incomes exceeding $100,000 were more likely to be wild pig hunters than those with

lower annual household income earnings. As higher income earners are generally more likely to purchase a hunting license (Floyd and Lee 2002), recreational wild pig hunting may be particularly inaccessible to lower-income individuals. However, because individuals managing wild pig damage through shooting were not legally required to purchase a hunting license at the time of this survey, we may have failed to capture response data from those involved with wild pigs in a purely management-oriented context. As wild pig hunters are no longer required to hold a hunting license to hunt wild pigs in Texas (Texas Parks and Wildlife Department Code 2019), recreational wild pig hunting may become more popular among individuals who previously did not hold a hunting license. We argue that research should investigate participation in wild pig hunting as it relates to the cost of access to other hunting opportunities, as economic drivers are often cited as a reason for declining rates of hunting recruitment. Although economics certainly affect participation of individuals in various hunting activities, other social factors, such as culture and ethnicity, may influence rates of participation as well.

Few studies to date have explicitly considered the racial or ethnic composition of the wild pig hunting public. Unfortunately, we had too few responses from African American, Asian American, or other ethnic groups to make inferences as to their participation in wild pig hunting. Hunters who identified as Spanish, Hispanic, or Latino were significantly less likely to participate in wild pig hunting than those who identified as white. This is consistent with the finding that, in general, hunters are more likely to be white than any other ethnic group (Floyd and Lee 2002). This result suggests that wild pig hunting is not sought out by or not available to Hispanic hunters. Lopez et al. (2005) notes that Hispanic households in Texas generally do not generate as much annual income as white households. Given that we found wild pig hunters to be typically wealthier hunters, Hispanic hunters may be excluded from participation in wild pig hunting activities due to costs of private land access and lack of public land accessibility. Nevertheless, it also is possible that cultural factors exist that this survey did not consider and that impact Hispanic and Latino hunter participation in wild pig hunting. Hispanic or Latino is the largest minority group in Texas (39.6%; Quick Facts 2020). We strongly encourage further research into Hispanic hunters' perceptions and use of wild pigs, as this will become important as Hispanic populations continue to grow in both Texas and throughout the United States.

While gender did not appear to significantly influence hunters' wild pig hunting participation on its own, male big game hunters were significantly more likely to hunt wild pigs than were female big game hunters. Although males are generally more likely to purchase a hunting license than females (Floyd and Lee 2002) and Texas hunters are overwhelmingly male (95.7% male; 4.3% female), the lower proportions of female big game hunters participating in wild pig hunting (Table 1) suggests this activity is not sought out by or not accessible to the female big game hunter. Given that females are often socialized into hunting participation by males (Heberlein et al. 2008), it is possible that female recruitment into wild pig hunting is not facilitated as often as it is for other types of big game hunting. However, we lack sufficient sample size to determine the causal factor of the strikingly low rate of participation among females who already hunt other big game.

Conclusions

This study represents an effort to understand the identity of the wild pig hunter for the purpose of providing reference for those seeking to manage wild pigs by direct control (i.e., trapping, shooting) or indirectly (i.e., hunter harvest). Wild pig hunters are predominantly middle-aged, white, male, and high-income earners. Importantly, wild pig hunters often hunt other big game animals as well, yet wild pig hunting appears to be a secondary pursuit to native big game hunting. Additionally, individual perceptions of the species are important factors contributing to wild pig hunting activity. Wild pig hunters tend to perceive the species positively and attribute a degree of utilitarian value to them, specifically when they do not directly experience damages associated with them as a landowner or land manager.

Our work contributes to the growing understanding of the human dimensions of wild pig management, which necessitates unravelling a

complicated dichotomy of perceptions, risks, and benefits among wild pig resource users and damage managers. Even within wild pig hunters, differences in utilitarian attitudes toward wild pigs exist between landowners and nonlandowners and in different regions. Moving forward, those tasked with managing wild pigs for ecological and human interests must decide how to balance competing stakeholder interests in the contexts of risks and opportunities associated with the species.

Our results suggest that those aiming to educate hunters about wild pigs face a largely uninformed public that does not hold the same perceptions, values, or tolerance levels of the species, even among this single stakeholder group. This study demonstrated that wild pig hunters poorly understand wild pigs and their effects on human health, agricultural production, and ecological processes. We suggest that efforts be made to more accurately convey information on ecological, agricultural, and economic risks associated with wild pigs to the public in meaningful education campaigns aiming to adjust public perceptions at a broad scale. Education efforts targeting hunters should include information regarding wild pig natural history, relevant zoonotic disease risks, and legal regulations at the state level. Future education efforts concerning wild pigs will be important in shaping public perceptions in ways that favor ecologically appropriate management activities for the species.

The issue of wild pig management is dynamic, including both realized and potential risks and benefits among multiple stakeholder groups. We sought to better understand wild pig hunters, given their status as a key stakeholder group in understanding the human dimensions of wild pig management. Although it does not appear that wild pig hunting replaces hunting of native big game, wild pigs are a popular hunting quarry among Texas hunters. Positive perceptions of the species may increase as hunters identify benefits related to wild pigs, such as increased hunting access, and may, therefore, be less willing to support control of the species. Potential changes in hunter use and perceptions of wild pigs in Texas as this new license requirement takes effect will be informative for other states and agencies considering adopting or modifying wild pig hunting regulations.

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Appendix

Appendix 1 can be viewed as a supplemental file download at https://digitalcommons.usu.edu/hwi/vol15/iss1/8.

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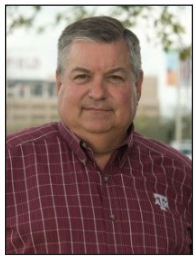

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