Estimating the Economic Value of Lethal Versus Nonlethal Deer Control in Suburban Communities

J. M. BOWKER

USDA Forest Service
Southern Research Station

DAVID H. NEWMAN
ROBERT J. WARREN

Warnell School of Forest Resources
University of Georgia
Athens, Georgia, USA

DAVID W. HENDERSON

Sea Pines Plantation
Hilton Head, South Carolina, USA

Negative people/wildlife interaction has raised public interest in wildlife population control. We present a contingent valuation study of alternative deer control measures considered for Hilton Head Island, SC. Lethal control using sharpshooters and nonlethal immuno-contraception techniques are evaluated. A mail-back survey was used to collect resident willingness-to-pay (WTP) information for reduced deer densities and consequent property damage. Residents are unwilling to spend more for the nonlethal alternative. The estimated WTP appears theoretically consistent as increasing levels of abatement for both lethal and nonlethal alternatives demonstrate diminishing marginal benefits. Over 60% of respondents bid zero regardless of control measure, suggesting a referendum would fail. However, only half of these zero bidders expressed no problem with deer, while the other half bid zero because of distaste for the control alternative, safety concerns, or doubt about effectiveness. Inclusion of these responses as legitimate zero bids depressed mean WTP estimates from 22 to 31%.

Keywords contingent valuation, deer management, immuno-contraception, mail survey, protest bids, Tobit

Conflicts between humans and wildlife are increasing throughout the United States. In the East, conflict with white-tailed deer is the most visible and economically

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Address correspondence to David H. Newman, Warnell School of Forest Resources, University of Georgia, Athens, GA 30602-2152, USA. E-mail: dnewman@arches.uga.edu

important (McShea et al. 1997; Warren 1997). Serious problems include deer–vehicle collisions, damage to residential landscaping and gardens, damage to commercial crops, and the transmission of Lyme and other diseases. While people often enjoy viewing deer, an increasing number of communities are concerned with the "deer problem" and are actively seeking management solutions (Warren 1997).

One practical solution involves reaching and maintaining reduced deer densities, thus reducing negative deer–people interactions. However, reaching this solution is often fraught with difficulties. Many wildlife professionals consider the lethal removal of animals to be the most common and cost-effective method to reduce deer densities and decrease human/deer conflicts. However, this kind of management evokes considerable emotion and debate within (and outside) communities where deer are considered a problem (Lauber and Knuth 2000).

Research by Kellert (1984) provides a basis for some of the disagreement about wildlife management. He found humanistic and moralistic attitudes toward animals and nature to be the most frequently occurring attitude types among urban residents. A humanistic attitude implies a "primary interest and strong affection for individual animals, principally pets, and highly emotional perspective of the natural world," while a moralistic attitude reflects "primary focus on the right and wrong treatment of animals and nature, with strong opposition to environmental exploitation and cruelty toward animals." However, he also found frequent occurrence of conflicting negativistic and utilitarian attitudes—the former with "primary orientation, an avoidance of animals and natural objects due to indifference, dislike or fear," and the latter expressing "primary concern for the practical and material value of animals and the natural environment."

From an economic perspective, a number of studies have shown that the public maintains a positive value or willingness to pay (WTP) for management choices that provide for the protection and augmentation of various wildlife populations including salmon, whooping cranes, and other fauna (Boyle and Bishop 1987; Halstead et al. 1992; Loomis and White 1996; Zawacki et al. 2000). In response to expressed economic values and contrasting attitudes about wildlife, managers faced with animal control problems have often pushed for more costly nonlethal alternatives such as trapping/relocating and immuno-contraception.

Nonlethal control methods have received considerable attention and discussion, even though they are considered more costly and often of questionable effectiveness (see Warren 1997). For example, immuno-contraceptive costs per treated female have recently been reported to range between \$802 and \$1100 (Rudolf et al. 2000), while herd reduction via lethal methods has been reported to cost between \$94 and \$286 per deer (Butfiloski et al. 1997). Nielsen et al. (1997) demonstrate that while cost of control (as measured with hours of effort) varies with initial and desired population density, immuno-contraception requires about from 2.5 to 4.2 times as much effort as culling to reach and maintain a given herd density.

Little empirical analysis exists to assess whether the potentially increased social acceptability of nonlethal control methods translates into sufficient economic benefits to justify these more costly procedures. In this article, we explore the differences that residents of a resort community express regarding willingness to pay for alternative deer control levels and techniques. The community on which we focus is Sea Pines Plantation on Hilton Head Island, SC, where a rapidly expanding deer population (at the time of the study it was about $50/\text{km}^2$) has caused substantial landscape damage and human safety concerns. We use a contingent valuation (CV) procedure (Mitchell and Carson 1989; Breffle et al. 1998) to estimate the willingness to pay associated with reducing deer densities and consequent property damage via lethal and nonlethal means. The problem of deer control on Hilton Head Island represents a novel and perhaps unique opportunity for the use of the CV methodology. Although there have been well over a thousand documented studies in the past 35 years using CV to provide economic value information for nonmarket goods and services, relatively few have dealt with a problem this intimate and emotional for respondents. The people on the island are very knowledgeable about the deer problem, have been directly impacted by the problem, and know that there is a strong likelihood that they will have to pay for any control measures through their island association dues if some option is used (Henderson et al. 2000). Thus, the estimates of WTP that we derive are based on a direct issue, not just an abstraction or hypothetical concern. Moreover, the people on the island harbor strong feelings about the way that control measures should be implemented.

In this article, we first present a brief background to the deer problem on Hilton Head and our survey design. We then present our data collection methods and the use of the CV instrument. Our survey and analytical results of our hypothesis tests follow, and we close with a discussion of the results and their possible interpretation. Through this analysis, we can directly test whether people in this community express different economic values for lethal and nonlethal methods of control. Additionally, given the structure of our analysis, we can test for issues of scope, that is, whether individuals can discern a difference in contingent outcomes and demonstrate so by bids that are consistent with differing levels of the contingent good or service.

Background to the Hilton Head Deer Problem

Sea Pines is a 2137-ha residential/resort community located on the southern portion of Hilton Head Island, SC. Development of Sea Pines began in the 1950s and has continued to this day. Approximately 95% of the available lots in Sea Pines have already been developed. Currently, Sea Pines contains 3300 single-family homes, 2100 multifamily units (condos), and 4 golf courses. The 242-ha Sea Pines Forest Preserve, located in the northern part of the community, is the only significant portion of land left undeveloped.

Deer have always been present on Sea Pines; however, since the early 1990s, residents have reported increased conflicts with deer. These conflicts include landscape depredation, deer defecating in yards, deer–vehicle collisions (40–50 deer killed per year), and concern over transmission of disease. The deer population has grown to about 500 deer or about 1 deer per 4 ha. This is higher than the normal barrier island carrying capacity of around 1 deer per 5–10 ha (Nelms 1999). The herd is considered healthy, but the increasing incidence of negative interactions has caused substantial concerns, most of which have received press attention. Community Services Associates, Inc. (CSA), is the homeowner organization responsible for maintenance and security within Sea Pines, which includes handling conflicts between residents and wildlife. Its attempts to control the deer population through traditional (lethal) animal control methods have been hampered by a very active animal rights group (www.hiltonheaddeer.com). Management via hunting is prohibited by local ordinance.

Data and Methods

To assess the economic impact of the deer problem in the area, we designed a self-administered, mail-back questionnaire to characterize residents and their properties for the CV analysis. The questionnaires were identical for permanent and nonpermanent residents of two Sea Pines communities, Baynard Cove and Gull Point. Permanent residents, making up 77% of the mailings, were defined as those having a Sea Pines mailing address, and nonpermanent residents as those having a mailing address outside of Sea Pines. A total of 513 questionnaires were mailed representing 100% of the households in these two communities. For couples, names were alternated by gender to ensure proportional representation. Residents were asked a variety of questions about their perceptions of present and future deer utilization of their yard, deer abundance, the amount of money they spent on landscaping, the amount spent to avoid deer damage, and the amount required to replace plants damaged by deer. We also included some demographic questions such as age, gender, duration of residence, education, profession, and the type of area where they were raised.[1]

In addition to these general questions, we included a contingent valuation component in the questionnaire. Contingent valuation is a procedure used to estimate an individual's economic value or willingness-to-pay for any good, service, or policy for which markets do not exist or might be considered unsuitable. Environmental amenities such as preserving open space and endangered species or maintaining ecosystems fall into the category of nonmarket goods or services, as does the abatement of environmental disamenities like air pollution and groundwater contamination. On Hilton Head, the deer population has reached the point where, for many, deer and consequent problems caused by deer are considered an environmental disamenity.

For this application, WTP represents the amount individuals will pay to receive a certain level of abatement from the existing level of damage caused by deer. We chose to phrase our CV question in terms of willingness-to-pay for a reduction, by a given percentage, of damage caused by deer (Appendix 1). We selected this format because, while deer numbers correlate highly with the amount of damage, exact relationships remain somewhat uncertain because of location and plant variety differences. We included separate treatments to control for a number of possible effects as described below.

Using an indirect utility framework, the economic valuation construct can be represented as

$$V_0(Y_0, D_0, P_0) = V_0(Y_0 - \text{WTP}, D_1, P_0) \tag{1}$$

where, for a given individual, V_0 is a base level of utility, P_0 is the existing level of prices, Y_0 is current income, D_0 is the current level of damage being caused by deer, and D_1 is the reduced level of damage. Hence, WTP represents the amount of income the individual will give up to obtain the proposed level of abatement while maintaining a constant level of utility.

The estimation of WTP may be complicated if an individual's WTP is influenced by the method of proceeding from D_0 to D_1. This framework may be expressed as

$$V_0(Y_0, D_0, P_0) = V_0(Y_0 - \text{WTP}, D_1, P_0) = V_0(Y_0 - [\text{WTP} + \text{NL}], D_1, P_0) \tag{2}$$

where an individual would be willing to pay an additional amount, NL, for the assurance that immuno-contraceptive rather than lethal means are employed. If this additional amount, when aggregated across the population, is sufficiently large, then the greater costs of a contraceptive program could be justified in a benefit–cost analysis.

We partitioned the sample in an attempt to control for a number of potential problems common to CV. First, to control for bias resulting from the order in which questions were asked, we systematically varied the CV questions in the survey. For example, one-third of the surveys included both lethal and nonlethal questions with the lethal question first. One-third of the surveys received both lethal and nonlethal questions with the nonlethal question first. The remaining one-third of respondents received a question with only the lethal alternative. This procedure allowed us to determine if the presence of a nonlethal alternative affected lethal bids. Second, both the lethal and nonlethal alternatives were posed with either a 25% or 50% reduction in damage as a result of the control method used. These levels were posed independently, thus allowing for a scope test. Finally, to account for potential biases associated with zero bidders, we followed common protocol and elicited reasons for zero bids. This is typically done to segregate those individuals for whom the contingent good or service has no value from those who oppose the implementation of the proposed plan for noneconomic reasons (Halstead et al. 1992; Jorgensen and Syme 2000).

We sent a presurvey letter, the questionnaire, and a maximum of two follow-up mailings following a modification of Dillman's (1978) total design method for mail surveys. All questionnaires were numbered for identification purposes and were mailed in August of 1996. The overall survey response rate was 82%, with 85% response from permanent and 71% from nonpermanent residents.

Results

Descriptive statistics summarizing the deer problem on Hilton Head are reported in Table 1. Respondents reported seeing on average just over 15 deer per week on their property. Overall, 44% of respondents wanted the number of deer using their yard in the future to decrease significantly, 23% wanted the number to decrease moderately, 26% wanted the number to remain about the same, 5% wanted the number to increase moderately, and the remaining 2% wanted the number to increase significantly. These numbers contrast sharply with desired neighborhood deer levels reported in a national sample of urban areas (Conover 1997b), where only 10% of respondents wanted to see fewer deer, 27% wanted to see more deer, and 63% wanted the number of deer to remain about constant. However, our numbers are very similar to those reported by Kilpatrick and Walter (1997) for a community in Connecticut where approximately 75% of respondents felt there were too many deer.

Approximately 74% of Sea Pines respondents reported damage caused by deer to their yards during the 3-month period preceding the survey, while about 46% reported taking some preventive measures to avert damage caused by deer. Conover (1997a) found that while 61% of urban residents experienced some wildlife-related problem in the previous year, only 4% resulted from deer. Kilpatrick and Walter (1997) reported 53% of residents experienced deer induced damage to landscape plantings.

On average, Sea Pines respondents reported general landscaping expenditures of $1487 per year. Replacement costs for damage attributed to deer ranged up to $9000 with a mean of $280. Annual costs of preventive measures like fencing and repellents ranged up to $1200 with an average of just under $50. It is apparent from these data that the residents not only spend a substantial amount of money maintaining their landscaping but they have a high degree of interaction with the deer in their yards.

TABLE 1 Summary Statistics on the Deer Problem for the Hilton Head Survey

Question	Mean	SD[a]	Minimum	Maximum	Cases
Have you received any damage from deer in your yard? (1 = yes)	0.74	0.44	0	1	372
Do you attempt to prevent deer damage? (1 = yes)	0.46	0.5	0	1	415
Annual landscaping costs ($)	$1487.21	$1255.49	0	9998	373
Deer damage replacement costs ($)	$280.65	$754.7	0	9000	351
Deer damage prevention costs ($)	$43.31	$123.43	0	1200	376
How many deer do you see in your yard in an average week? (number)	15.84	20.89	0	120	374
In the future would you like to see the number of deer using your yard:					
Decrease significantly	0.44				398
Decrease moderately	0.23				398
Remain about the same	0.26				398
Increase moderately	0.05				398
Increase significantly	0.02				398

Note. All questions other than landscape costs relate to the previous 3 months of deer activity.
[a]Estimated population standard deviation is reported.

In Table 2, we report subsample mean WTP bids for each of the four scenarios: lethal 25%, lethal 50%, nonlethal 25%, and nonlethal 50%. In addition, zero bids under the lethal and nonlethal scenarios are disaggregated according to whether the individual (a) was opposed to managing deer by the proposed method, (b) was concerned about safety under the proposed method, (c) doubted the method would achieve the stated results, or (d) had no problem with the current deer situation. For each of the control scenarios, we report mean WTP with and without the inclusion of the zero bidders who chose reasons other than having no problem with deer.

There is some debate among users of CV about dealing with individuals who report a zero bid for reasons other than the final good or service being of no value to them (Halstead et al. 1992; Lindsey 1994; Jorgensen and Syme 2000). Depending on their reasons for bidding zero, these individuals are sometimes referred to as "protestors." Among the more common reasons for protest zero bids in CV studies are:

TABLE 2 Average WTP Bid Values and Justifications Given for a Zero Bids

Question	Mean	SE[a]	Minimum	Maximum	Cases
Lethal alternatives:					
25% Lethal control (with protest bids)	$40.05	$23.76	0	$700	186
25% Lethal control (no protest bids)	$58.00	9.54	0	$700	125
50% Lethal control (with protest bids)	$49.29	7.70	0	$500	196
50% Lethal control (no protest bids)	$70.00	10.62	0	$500	136
Zero bidders	0.64		0	1	382
Zero bid justification:					
Opposed to managing this way	0.25		0	1	382
Have safety concerns	0.05		0	1	382
Doubt its effectiveness	0.07		0	1	382
Deer are not a problem	0.32		0	1	382
Nonlethal alternatives:					
25% Nonlethal control (with protest bids)	$24.31	5.06	0	$250	120
25% Nonlethal control (no protest bids)	$34.73	9.17	0	$250	84
50% Nonlethal control (with protest bids)	$41.37	8.48	0	$500	128
50% Nonlethal control (no protest bids)	$52.75	10.60	0	$500	89
Zero bidders	0.70		0	1	248
Zero bid justification:					
Opposed to managing this way	0.10		0	1	248
Have safety concerns	0.02		0	1	248
Doubt its effectiveness	0.20		0	1	248
Deer are not a problem	0.39		0	1	248

[a]Estimated standard error of the estimated mean is reported.

disagreement with the payment vehicle or some other aspect of the contingent market, ethical objections to personal payments for a public good, or the belief that the level of good should be provided with no additional payments (Jorgensen and Syme 2000; Freeman 1993, 187). Halstead et al. (1992) report a number of studies wherein protest zero bids range from 24% to over 50% of the sample.

In our study, there was little concern over the payment vehicle, the idea of a contingent market, or having to pay for additional services. However, more than 60% of respondents bid zero under each of the four CV scenarios presented (Table 2). Approximately half of the zero bidders (32% lethal and 39% nonlethal) claimed to have no problem with deer, thus indicating that further reduction of the herd held no economic value for them. We treated these responses as legitimate zero bids.

Among those responding to lethal control questions, 32% could be classified as protest zero bidders because they appeared to reject some aspect of the constructed market scenario. The majority of these, 25%, were opposed to managing deer by lethal control. Seven percent doubted the program would attain the desired result and 5% expressed safety concerns.[2] Among those receiving contraceptive control questions, 31% of respondents could be classified as protest zero bidders. Approximately 10% opposed managing deer via contraceptive control, 20% indicated that they doubted the success of the technique, and about 2% indicated safety concerns led them to bid zero.

It is interesting to note that our study differs from a number of CV studies wherein protest zero respondents reject the constructed market because they are opposed to paying for the good or service. We find that the delivery of the service can effectuate large numbers of zero bids. The majority of protest zero bidders under the lethal method reject the procedure for delivering the service, while the majority of protest zero bidders under the nonlethal method doubt that the contraceptive procedure can really deliver the stated level of control.

For the lethal alternatives, the mean annual WTP for a 25% reduction in damage is \$40.85 including protest bids and \$58.00 with protest bids excluded. For a 50% reduction in damage, the mean annual WTP with protest bids is \$49.29, while excluding protest bids yielded an estimated annual WTP of \$70.00. For the nonlethal alternatives, the pattern is similar but the magnitude of the bids is somewhat less. Estimated annual WTP for a 25% reduction in damages, including protest bids, is \$24.31. For the same level of control, the average WTP increases to \$34.73 when protestors are excluded. Under the 50% reduction alternative, the average annual WTP including protestors is \$41.37. Excluding protest bids, which accounted for about 30% of the nonlethal bids, the average rises to \$52.75.

Based on the descriptive statistics, it would appear that respondents are able to distinguish between levels of control under both alternatives. Under both lethal and nonlethal scenarios, respondents' average WTP is more for the higher level of damage reduction. It would also appear that they are willing to pay less, rather than more, under the nonlethal alternatives. These differences occur regardless of the inclusion of protest bids. However, the inclusion of roughly one-third more zero bids for protestors lowers the mean WTP in all cases by a significant amount.

We formally test for statistically significant differences between lethal and nonlethal WTPs and for scope effects through the use of regression analysis. The WTP survey data for this study are considered censored because of the large number of reported WTPs of zero. In such cases, the ordinary least-squares regression procedure is inappropriate and a Tobit regression procedure should be used. Following Greene (1997), the Tobit model can be generally formated:

$$\begin{array}{ll} \mathrm{WTP}_i = X_i\beta + u_i & X_i\beta + u_i > 0 \\ \mathrm{WTP}_i = 0 & X_i\beta + u_i \leq 0 \end{array} \quad (3)$$

where for the ith individual, X_i is a vector of explanatory variables, u_i is a random disturbance term, and β is a parameter vector common to all individuals. Assuming the random error is independent and normally distributed across respondents, the expected WTP for an observation drawn at random is

$$E(\mathrm{WTP}_i|X_i) = \Phi(X_i\beta/\sigma)X_i\beta + \sigma\phi(X_i\beta/\sigma) \quad (4)$$

where Φ represents the normal distribution function, ϕ represents the normal density function, and σ represents the standard deviation. Unlike linear models, the marginal effect or partial derivative for a given explanatory variable is represented as

$$\frac{\partial E(\mathrm{WTP}_i|X_i)}{\partial X_i} = \beta\Phi(X_i\beta/\sigma) \quad (5)$$

Hence, the regression parameter estimates are not slope coefficients as they are in linear models.

The WTP regression models for both lethal and nonlethal deer control contain three common explanatory variables. The first is a binary variable, DAMAGED, indicating whether the respondent experienced recent deer-induced damage to their property. The second, LANDCOST, is based on the respondent's estimate of annual landscaping costs. This variable serves as a proxy for both wealth and the relative importance of landscaping. We chose not to ask for respondent income on the questionnaire because this is often considered invasive and has detrimental effects on response rates, especially in such a localized population. Moreover, given the exclusive nature of the community, we simply didn't expect much response variation in income. Respondent gender, SEX, was included to account for potential differences in attitudes between males and females regarding wildlife value orientations (Bright et al. 2000). We included an additional variable, LTHONLY, in each of the lethal WTP models. This binary variable was included to test whether the presence of a nonlethal alternative in a subset of the questionnaires would have any effect on stated WTP. Other variables like age, education, years of residence, and question order were examined in preliminary models and found to be insignificant.

Tobit regression models were estimated using LIMDEP 7.0 (Greene 1995). Table 3 contains results including protest bids, while models in Table 4 exclude protest responses. Parameter estimates along with statistical significance levels, explanatory variable means, and partial derivatives ($\delta E(Y)/\delta X$) evaluated at sample means are reported. As indicated by the significance of the ancillary parameter (σ) in each estimated equation, the Tobit model appears appropriate for these data.

For the models including protest bids (Table 3), signs on the explanatory variables generally meet with expectations. Those households with higher landscaping costs (LANDCOST) place a higher premium on deer reduction regardless of the lethal or nonlethal management alternative. The results are similar for those experiencing recent deer damage (DAMAGED = 1). The binary variable identifying individuals who did not receive a nonlethal question (LTHONLY = 1) has a positive sign in both the 25% and 50% lethal equations, suggesting that not considering the nonlethal alternative may lead to higher lethal bids. However, the significance level on this parameter estimate in both equations is only between 10% and 20%.

TABLE 3 Tobit MLE Willingness-to-pay Regression Equations for Lethal and Nonlethal, 25% and 50% Deer Control Alternatives, Including Protest Zero Bids

Variable	Coefficient	b/SE	$\delta E(Y)/\delta X$	Mean X
Lethal 25% reduction ($n = 147$)				
Constant	− 266.07	− 4.48	− 81.666	1
DAMAGED	160.29	3.27	49.197	0.714
LANDCOST	0.0633	4.18	0.0194	1548
SEX	− 98.719	− 2.73	− 30.300	0.483
LTHONLY	49.474	1.33	15.185	0.327
σ	168.49	9.45		
Nonlethal 25% reduction ($n = 88$)				
Constant	− 267.13	− 3.52	− 63.57	1
DAMAGED	180.28	2.84	42.90	0.705
LANDCOST	0.0221	1.55	0.0053	1548
SEX	30.651	0.81	7.294	0.409
σ	131.04	6.17		
Lethal 50% reduction ($n = 154$)				
Constant	− 338.69	− 4.79	− 105.29	1
DAMAGED	283.24	4.44	88.055	0.721
LANDCOST	0.0317	1.74	0.0099	1278
SEX	− 40.865	− 1.06	− 12.704	0.474
LTHONLY	67.042	1.64	20.842	0.305
σ	188.32	9.79		
Nonlethal 50% reduction ($n = 93$)				
Constant	− 320.23	− 4.66	− 94.93	1
DAMAGED	162.33	2.96	48.12	0.720
LANDCOST	0.0757	3.81	0.0225	1296
SEX	56.50	1.46	16.75	0.473
σ	146.69	7.17		

The gender variable (SEX, female = 1) leads to mixed results. The estimated coefficient has negative signs in both of the lethal equations and positive signs in both of the nonlethal equations, suggesting that women bid lower for lethal alternatives and higher for nonlethal alternatives than men. However, the SEX variable is only significant at the 5% level in the lethal 25% reduction equation.

Regression results with protest bids eliminated are presented in Table 4. Like the models presented in Table 3, the estimated coefficients on both the binary variable for deer damage in the last 3 months (DAMAGED) and landscaping costs (LANDOST) are statistically significant and positive across both alternatives and levels of control. The LHTHONLY variable has a positive coefficient in each of the lethal models and is statistically significant at the 5% level in the 50% reduction model. This result, coupled with the findings for the lethal models including protest bids, suggests that bids may be influenced by the presence of a competing alternative (or lack thereof). In this case, it appears those receiving the questionnaires with only the lethal removal alternative could be prone to bid more than bidders facing both

TABLE 4 Tobit MLE Willingness-to-pay Regression Equations for Lethal and Nonlethal, 25% and 50% Deer Control Alternatives, Excluding Protest Zero Bids

Variable	Coefficient	$b/$SE	$\delta E(Y)/\delta X$	Mean X
Lethal 25% reduction ($n=97$)				
Constant	− 218.64	− 3.95	− 105.31	1
DAMAGED	159.31	3.335	76.746	0.732
LANDCOST	0.0569	3.94	0.0274	1669
SEX	− 34.808	− 0.95	− 16.766	0.360
LTHONLY	38.536	1.05	18.562	0.330
σ	151.01	9.63		
Nonlethal 25% reduction ($n=63$)				
Constant	− 216.61	− 3.45	− 72.79	1
DAMAGED	174.37	3.21	58.60	0.667
LANDCOST	0.0373	2.34	0.013	1484
SEX	0.501	0.02	0.168	0.460
σ	105.81	6.42		
Lethal 50% reduction ($n=103$)				
Constant	− 305.54	− 4.83	− 142.83	1
DAMAGED	285.04	4.96	133.25	0.718
LANDCOST	0.0481	2.70	0.0225	1226.21
SEX	10.376	0.28	4.850	0.388
LTHONLY	82.800	2.04	38.706	0.301
σ	157.05	9.91		
Nonlethal 50% reduction ($n=68$)				
Constant	− 218.21	− 4.16	− 88.28	1
DAMAGED	160.38	3.61	64.89	.662
LANDCOST	0.0495	2.95	0.020	1369
SEX	35.27	1.07	14.27	.485
σ	112.61	7.19		

control alternatives. While there is insufficient evidence to conclude one way or the other, researchers should be wary of potential biasing of bids if respondents feel strongly about one method or the other.

The gender variable, SEX, is insignificant across all of the models where protestors are removed. However, the frequencies of females remaining in the lethal subsamples after protestors are removed drops from 0.48 to 0.36 in the 25% model and from 0.47 to 0.39 in the 50% reduction model. This result, along with the results in Table 3, suggests that females appear to have lower WTPs for lethal methods of control than males and are more likely to be protest bidders under lethal alternatives. Such is not the case for nonlethal alternatives. This result is consistent with findings by Bright et al. (2000). In a study examining market segments of the Colorado public regarding value orientations to wildlife planning, they found that women made up a large majority of the segment favoring animal rights while men comprised a distinct majority of the utility-oriented segment.

TABLE 5 Mean Willingness-to-Pay and Associated *t*-Statistics for Paired Difference Tests Across Control Alternatives and Levels of Damage Reduction (With and Without Protest Bids)

	Lethal mean WTP	Nonlethal mean WTP	*t*-Statistic for H_0: LWTP − NWTP = 0
Protest bids included			
25% Damage reduction	$43.64	$27.37	8.60
50% Damage reduction	$56.34	$45.75	5.41
t-Statistic for H_0: WTP50 − WTP25 = 0	9.77	9.95	
Protest bids excluded			
25% Damage reduction	$59.98	$39.05	20.84
50% Damage reduction	$88.23	$52.02	20.08
t-Statistic for H_0: WTP50 − WTP25 = 0	17.27	16.15	

To test for differences in WTP between methods and for scope effects, we develop a series of mean difference tests based on applying the estimated Tobit regression equations across the population (Souter and Bowker 1996). Predicted WTP means for each alternative with and without protest bids (lethal 25%, nonlethal 25%, lethal 50%, and nonlethal 50%) are calculated using the 322 sample observations containing the full set of regressors. These WTP means are reported in Table 5. In addition, *t*-statistics based on mean difference tests across control methods and across levels of control (scope effects) are reported with and without protest bids.

The results reported in Table 5 indicate that with or without protest bids included, the null hypothesis that the difference between lethal WTP and nonlethal WTP is zero, at a given level of damage control, is clearly rejected (*t*-values in column 4 of Table 5). Including protest bids, the mean WTPs for lethal removal at the 25% and 50% levels, respectively, are $43.64 and $56.34. This result compares to $27.37 and $45.75 for the comparable nonlethal cases. Deleting protest zeros causes the means to increase across both control alternatives and removal levels, but the pattern is the same. Mean WTPs for the 25% and 50% lethal alternatives are $59.98 and $88.23, respectively, while means are $39.05 and $52.02 for the comparable nonlethal cases. It is apparent that not only are residents unwilling to pay more for the described nonlethal alternative method of control, but the mean WTP is noticeably less in all comparable cases. This result persists in spite of removing those bidding zero for the nonlethal control because they doubt the effectiveness of the method.

We can think of a number of potential explanations for the lethal WTPs exceeding their nonlethal counterparts. First, people may be bidding more for the same amount of removal under the lethal alternative because they get additional benefit from knowing the deer that are removed will be processed and donated to food banks. Second, although they do not report it, they may still have doubts about the effectiveness of nonlethal control and consequently reflect this doubt in their bids. Finally, time may be a consideration. Implemented alone, nonlethal programs require considerably longer time frames to significantly reduce the existing population.

Tests for scope effects within either the lethal or nonlethal alternatives suggest the null hypothesis that WTP does not vary between 50% and 25% damage reduction can also be rejected. This result holds across both alternatives and levels (*t*-values in rows 4 and 8 of Table 5). The 50% alternative exceeds the 25% alternative by a difference of from $12.70 to $28.25 across the various scenarios. Although the differences in means across the two levels of damage reduction are not proportional to the amount of reduction, people's bids nevertheless reflect an ability to differentiate between the levels of control. This is not always the case in CV applications.

Conclusions

In this article we explored the use of CV as a tool to assist communities and wildlife managers in evaluating the economic benefits associated with different alternatives for and levels of wildlife control. Accurate assessment of benefits can be compared to the costs associated with control alternatives to determine economically efficient management programs. In addition to seeking valid estimates of WTP to control damage done by deer, we were interested in determining whether individuals would be willing to pay a premium for nonlethal control and whether independently obtained individual bids would be able to capture differences between levels of control.

One readily apparent finding from this study is that while average estimated annual WTP for reducing damage caused by deer exceeds $27 regardless of the level and control option chosen, a majority of residents expressed zero bids for the four scenarios offered in the survey (64% lethal, 70% nonlethal). If put to a referendum, it would first appear that by either method, the majority of residents would favor no action over any of the scenarios offered here. However, only one-third of those receiving the lethal option and 40% of those receiving the nonlethal option indicated that deer were not enough of a problem to merit their bidding any amount for further control. So, approximately half of the lethal zero bidders and about 43% of the nonlethal zero bidders listed method-related reasons as driving their zero bids.

For the lethal zero bidders, most were opposed to the idea of lethal removal. For the nonlethal zero bidders, most doubted the effectiveness of the program. This presents an interesting situation for the use of CV because a significant number of respondents are familiar enough with the problem and feel strongly enough about the methods of mitigation to be unwilling to view the ends separately from the means. Often in CV studies the ends are sufficiently abstract that details regarding means are difficult to specify. For example, numerous studies have estimated household WTP to preserve various levels of threatened and endangered species with little or no detail regarding how this could physically be accomplished.

For this type of wildlife management application, where the method of delivery is difficult to separate from the end product, we would suggest that all zero bids, including protest zeros, be included in any models and subsequent estimates used to arrive at an aggregate measure of benefits. This approach is consistent with recommendations from Jorgensen and Syme (2000) and Halstead et al. (1992). Hence, under lethal removal, the 25% and 50% reduction WTPs are $43.64 and $56.34, respectively. For the nonlethal reduction program, the 25% and 50% reduction WTPs are $27.37 and $45.75, respectively. At a minimum, we feel these numbers could be aggregated across 522 households comprising the two sections of Sea Pines in the survey area to arrive at estimates of annual benefits from the two levels of damage abatement.

The estimated WTPs appear to be consistent with economic theory as demonstrated by the fact that the 25% and 50% abatement WTP estimates for both the lethal and nonlethal alternatives appear to be demonstrating diminishing marginal benefits. Moreover, scope test results indicate that, on average, people can and do distinguish between different levels of abatement. Because the marginal costs of abatement by either method are known to be increasing, an economically optimal level of control should exist. However, the costs of information gathering to obtain multiple points on marginal benefit and marginal cost curves would likely be excessive.

Comparing the economic benefits from the two control methods, it is clear that, given existing attitudes and technology, the economic benefits of nonlethal control are insufficient to offset the additional costs. In fact, regardless of the inclusion of protest zero bids, the hypothesis that residents will on average pay more for the nonlethal control cannot be supported with our data. The fact that all comparable scenarios in this study reveal that residents are willing to pay *more* for lethal rather than nonlethal control is interesting and is probably the result of a number of factors. Within the lethal scenario, we include a stipulation for the donation of venison to food banks. This could provide additional utility to respondents and thus result in WTPs that represent more than just damage abatement. However, to exclude donation of venison from the lethal scenario is unrealistic. Within the nonlethal scenario, we stipulate that the technique is still in experimental stages. In spite of the population's knowledge of deer problems and control, this could have resulted in a downward influence on positive bids. It is also likely to have influenced many of the zero bids from respondents who claimed to doubt the effectiveness of the procedure. Continued improvement of and information about nonlethal control could lead to a shrinking proportion of these zero bidders and thus an increase in nonlethal WTP. Conversely, we do not think the number of respondents who bid zero because they oppose lethal control will drop noticeably. Unfortunately, lack of funding necessary to debrief respondents, either individually or through focus groups, precluded us from further exploring this issue.

Residential expansion and consequent human encroachment into wildlife habitat will continue to create conflict between humans and wildlife, particularly with highly adaptive species like white-tailed deer. These interactions will inevitably produce conflicts among humans possessing conflicting attitudes toward wildlife and wildlife management alternatives. Some dimensions of and proposed solutions for these complex problems will continue to evoke emotionally charged exchanges among stakeholders. Contingent valuation and resultant economic information should prove useful to communities and wildlife professionals as one means of evaluating wildlife management alternatives.

Appendix 1: CV Questions Used for the Analysis

Instructions: Please answer the following questions concerning deer in your yard on Sea Pines. Responses should be given by the person addressed on the envelope. Completion of the survey should not take more than ten minutes. Your individual responses will be held confidential. Please use your best estimate for those answer choices you feel unsure about...

Finally, we would like your input on **potential** management programs for deer. Your individual responses **will not** result in any direct management program for deer on Sea Pines. The results from this survey will aid CSA, South Carolina Department of Natural Resources, and Sea Pines residents in their future considerations of what might be done, if anything. Two **hypothetical** management programs are described below for you to consider:

Lethal Removal

This program would involve the killing of deer by trained wildlife professionals. The program would be conducted during the winter months to maximize efficiency and safety and to minimize public conflict and inconvenience. All meat would be donated to food banks or other charitable organizations. Lethal removal is relatively cost efficient, and is an option currently available for deer on Sea Pines. Assume it might be possible to implement a lethal removal program that would remove enough deer each year to reduce by _____% your economic losses resulting from deer damage to landscape plantings in your yard. How much would you be willing to pay each year for this benefit? _____$/year

Contraception[3]

Scientists are currently developing this form of nonlethal control. If successfully developed and approved, this program would involve the treatment of deer by trained wildlife professional during late summer prior to the breeding season. Presently, contraception is experimental, relatively expensive to apply, and not currently available for management of deer on Sea Pines. However, assume that a contraceptive program could be done, and that this program would treat enough deer each year to reduce by _____% your economic losses resulting from deer damage to landscape plantings in your yard. How much would you be willing to pay each year for this benefit?

_____$/year

For both questions on a given survey, the percentage reduction rate was set at either 25% or at 50%.[4]

Notes

1. The entire questionnaire is available in Henderson (1998) or it can be obtained directly from the authors.
2. The percentages do not sum to 32 because a small portion of respondents ticked multiple reasons.
3. One reviewer noted that our contraceptive scenario appeared more hypothetical than the lethal scenario and this could have resulted in lower estimated values. We acknowledge this concern. However, given the knowledge level of locals, we wanted the scenario to be as factual as possible.
4. It was noted by one reviewer that our use of the phrase "willing to pay" rather than "would pay" could introduce further hypothetical bias than is the norm in CV studies.

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