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Short Notes

Perceived and desired outcomes of urban coyote management methods

Rebecca J. Buteau, Rachael E. Urbanek * and Christopher Dumas

Department of Environmental Sciences, University of North Carolina Wilmington, 601 S. College Ave., Wilmington, NC 28403, USA

Present address of Rebecca J. Buteau: White Oak Conservation, 581705 White Oak Rd, Yulee, FL 32097, USA
*Corresponding author. E-mail: urbanekr@uncw.edu

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Abstract

Coyote (*Canis latrans*) management becomes increasingly necessary as the species' range expands, but some methods may be controversial in urban landscapes. Understanding why the public considers certain methods acceptable may help decrease conflict between residents and wildlife managers. We surveyed 4000 registered voters in New Hanover County, North Carolina, to evaluate attitudes toward three coyote management methods: no management, public education and trap/euthanasia. We used the expectancy-value model and multinomial logistic regression models to determine which public beliefs and desires regarding outcomes of each coyote management method predicted acceptance of each method. Attitudes of respondents who accepted a method differed from those who rejected the method. Positive attitudes toward no management were influenced by outcomes involving a natural death for coyotes and family, pet and personal safety. Positive attitudes toward public education were influenced by outcomes involving family safety, public participation, fewer coyotes and for coyotes to avoid an inhumane death. Positive attitudes toward trap/euthanasia were influenced by outcomes for coyotes avoiding an unnatural and inhumane death, pet safety and public participation. Understanding the public's beliefs and desires regarding coyote management methods will help wildlife managers tailor public education programs, resolve controversies regarding alternative management methods and improve future wildlife management decisions.

Key words: beliefs, *Canis latrans*, conflict, evaluations, expectancy-value model, urban

Introduction

The recent and extensive range expansion of coyotes (*Canis latrans*) into many urban areas has led to increased human–coyote encounters that often result in conflict (Farrar 2007; Hudenko, Decker, and Siemer 2008; Timm et al. 2004). Coyote management can be controversial and difficult to implement in urban areas since a large portion of the public expects to be included in wildlife management decisions and members of the public often disagree over the acceptability of management options (Vaske and Needham 2007; Sponarski, Vaske, and Bath 2015b). Previous studies have found that public acceptance of coyote management is influenced by fear (Jackman and Rutberg 2015), wildlife value orientations (Vaske and Needham 2007), severity of human–coyote interactions (Martínez-Espiñeira 2006; Sponarski, Vaske, and Bath 2015b), demographics (Vaske and Needham 2007; Jackman and Rutberg 2015; Buteau, Urbanek, and Dumas 2022), animal rights group affiliation (Buteau, Urbanek, and Dumas 2022) and beliefs about coyotes' nativity (Buteau, Urbanek, and Dumas 2022).

Public education appears to be the most acceptable management strategy among the majority of the public when given the choice among no management, monitoring the situation, public education, hazing, relocation and lethal control (Sponarski, Vaske, and Bath 2015b; Buteau, Urbanek, and Dumas 2022). Public acceptance of either policy extreme, no management or lethal control, often is contentious (Vaske and Needham 2007; Sponarski, Vaske, and Bath 2015b; Buteau, Urbanek, and Dumas 2022). Therefore,

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understanding public acceptance of management methods also requires an examination of what individual beliefs result in acceptance of a specific method (Urbanek et al. 2015).

Public concerns about the outcomes of specific management options also help shape attitudes toward those options. Examples of factors that may influence public acceptance of wildlife management include humaneness (Arthur 1981; Reiter, Brunson, and Schmidt 1999), animal suffering (Huot and Bergman 2007), human and pet safety (Reiter, Brunson, and Schmidt 1999; Huot and Bergman 2007; Siemer, Decker, and Merchant 2010) and a desire for decreased wildlife populations (Webber 1997). While several studies have investigated the acceptance of different management techniques (Martínez-Espiñeira 2006; Vaske and Needham 2007; Jackman and Rutberg 2015; Sponarski, Vaske, and Bath 2015b), further research is needed to determine which beliefs and desires influence acceptance.

Studies have investigated beliefs and evaluations of management for other wildlife species (Kilpatrick and Walter 1997; Kilpatrick, Labonte, and Barclay 2007). For coyotes, literature exists on factors influencing public attitudes toward coyotes and coyote management. Drake et al. (2020) examined how city of residence, affectual connections to coyotes and biological knowledge predicted perceptions of the danger posed by coyotes, the support for wild coyotes living nearby, and the support for lethal coyote removal methods, but the authors did not look at how public beliefs and evaluations of management methods influenced acceptance of those methods. Nardi et al. (2020) assessed factors that influence public attitudes toward foxes and coyotes as species but not management of these species. Lu et al. (2016) explored how message framing can influence the public to participate in measures to prevent human–coyote conflict but did not look at public beliefs and evaluations toward those measures. Jackman and Rutberg (2015) considered how attitudes toward coyotes as a species shifted over time but did not analyze attitudes toward coyote management. While these papers provide valuable knowledge toward attitudes regarding coyotes in general, no studies to our knowledge have focused on public beliefs and evaluations regarding specific coyote management techniques.

Other studies have used the expectancy-value model (Fishbein and Ajzen 1975; Ajzen 1991) to understand attitudes toward wildlife management (Pate et al. 1996; Dougherty, Fulton, and Anderson 2003; Fulton et al. 2004; Urbanek et al. 2015). According to this model, a person's attitude toward a behavior is determined by the person's beliefs about certain outcomes associated with the behavior and their desire for the outcome to occur (Fishbein and Ajzen 1975; Daigle, Hrubes, and Ajzen 2002). Using this model, Pate et al. (1996) found that negative attitudes toward gray wolf (*Canis lupus*) reintroduction arose from beliefs that it would likely result in attacks on livestock, financial loss to ranchers, invasion of residential areas and ungulate population losses. Positive attitudes arose from beliefs that reintroduction would help control other wildlife populations, preserve wolves, restore natural environments and show the importance of wilderness. Similarly, Urbanek et al. (2015) used public beliefs and desires regarding outcomes of deer management methods to determine attitudes toward multiple white-tailed deer (*Odocoileus virginianus*) management methods and then used multinomial logistic regression analyses to determine which public beliefs and desires could predict public acceptance. Like its use in these studies, the expectancy-value model could be used to help identify beliefs, desires, and attitudes concerning coyote management methods.

In North Carolina, coyotes may be hunted year-round or recreationally trapped seasonally, but both management methods tend to be limited by available participants and public space in urban areas (NCWRC 2018). Alternatively, the state wildlife agency provides both public education and trap/euthanasia, with public education focusing on biology, behavior, and how to coexist with coyotes without conflict. In 2018, we conducted a household mail survey to evaluate the acceptance of three coyote management methods [no management (NM), public education (PE) and trap/euthanasia (TE)] in New Hanover County (NHC), NC, USA (Buteau, Urbanek, and Dumas 2022). PE was the most acceptable management method, regardless of how we segmented the population (e.g. by age, sex, income, education, coyote encounters and knowledge, and animal rights group affiliation). However, disparity existed between demographic groups for the acceptability of NM and TE. NM was acceptable for female respondents, younger respondents, members of animal rights groups and those who considered coyotes to be native, whereas TE was acceptable for respondents from opposite demographic segments. Residents were also least conflicted about PE, whereas NM and TE had high levels of conflict (meaning the public was split on if the method was acceptable). While the information obtained from our previous study provides useful information to wildlife managers, knowledge gaps remain regarding why respondents held contrasting attitudes toward the acceptance of coyote management techniques. Our goal for this study was to explore attitudes toward the three coyote management methods and to determine which beliefs and desires cause a respondent to determine coyote management methods as acceptable or unacceptable. We hypothesized that a resident's belief of the likelihood of eight possible outcomes from a coyote management method and their desire for a given outcome to occur would directly influence the resident's attitude toward a coyote management technique. We chose outcomes based on common major concerns regarding coyotes previously reported in the literature. We also hypothesized that individual residents would have different beliefs toward the likelihood of these outcomes depending on the coyote management method, and the interaction between their desire for a specific outcome and their belief of whether that outcome would occur if a given management method was used would directly influence their acceptance of a technique. This research will deliver additional insight regarding the causes of disparities in public opinion toward coyote management that can be addressed by wildlife managers to improve the effectiveness of programs that attempt to resolve coyote management conflicts. For example, if it is found that people think NM will decrease the coyote population, then wildlife managers can direct their education and conversation to dispel that myth.

Materials and methods

Located in southeastern North Carolina, USA, NHC is bordered by the Atlantic Ocean and the Cape Fear River. The county spans 849.5 km^2, 40% of which consists of wetlands and open water (Wickham et al. 2021). Less than 25% of the terrestrial land is forested, and the remaining undeveloped landcovers include shrubs/herbaceous cover (8%), agriculture (3%) and barren land (3%). The other 62% of the terrestrial area of the county is developed (Wickham et al. 2021), and in 2017 there were 232 274 residents and a house density of 133.29 units/km^2 (U.S. Census Bureau 2018). Between 2000 and 2010, as coyotes were first establishing a presence in the county, NHC's human population grew by 26.4% (U.S. Census Bureau 2016). Limited by space for development, the human population increased by 12.1% between 2010 and 2017.

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Survey administration

We assessed attitudes of NHC voters regarding coyote management methods through a mailed survey with the option of online completion. We pilot-tested the survey on a focus group consisting of 15–20 graduate students, wildlife state and federal employees working NC, and non-academic citizens. We then surveyed 4000 randomly selected NHC voters using a publicly available list of registered voter addresses (NCSBE 2017). Voters determine local wildlife management strategies through municipal and county elections, so we excluded nonvoting transient residents, such as university students and seasonal tourists occupying beach rentals by using this sampling frame rather than a list of all county residents. Voter names and addresses were verified using U.S. Postal Service-certified software by the University of North Carolina Wilmington mail center prior to sampling. The survey instrument was a four-page self-administered, mail-back survey that included sections on demographics; perceptions and attitudes toward coyotes; personal interactions with coyotes; economic impacts of coyotes; potential coyote management alternatives in the county; and attitudes, beliefs and expectations concerning the three management strategies. The survey methodology (a modification of Dillman's 1978 Total Design Method) was reviewed and approved by the University of North Carolina Wilmington's Internal Review Board (IRB #18-0235). Subjects were mailed a cover letter and a questionnaire that took <15 min to complete. Surveys were mailed on 25 May 2018 and were followed up with two postcard reminders to nonrespondents, mailed 3 and 9 weeks after the initial survey (18 June and 27 July). The survey ended on 25 September 2018.

We first measured the acceptability of three coyote management methods (NM, PE, TE) using a five-point Likert scale question. Respondents were asked 'In your opinion, how acceptable are each of these coyote management methods in NHC?' with response options ranging from 'very unacceptable' to 'very acceptable'. For each method, we grouped respondents who answered 'very acceptable' and 'somewhat acceptable' together and hereafter refer to them as respondents who perceived a management method as 'acceptable'. We followed the same procedure for respondents who perceived a management method as 'unacceptable'. We define neutral respondents as those who deemed a method 'neither acceptable nor unacceptable'.

We then evaluated components of the expectancy-value model, developed from the theory of planned behavior (Fishbein and Ajzen 1975; Ajzen 1991). To relate this to coyote management, the beliefs that an individual has about outcomes (e.g. coyote populations will decrease, family will be safer) of a particular management method and their desire for those outcomes to occur help form the person's attitude toward the method. Strong beliefs regarding outcomes and favorable evaluations of those outcomes contribute to a positive attitude toward a specific method. For example, a person may believe TE would likely contribute to increased family safety and may evaluate an increase in safety as desirable, forming a positive attitude toward the lethal control method. Mathematically, the expectancy-value approach models an individual's attitude toward certain actions (A_B) as directly proportional to the sum of the individual's beliefs (b_i) that certain outcomes (i) associated with the actions are likely to occur weighted by their evaluations of those outcomes (e_i): $A_B = \sum b_i e_i$. Our survey questions explored responses to eight possible outcomes (i) of each of the three coyote management methods (B). We coded outcomes as fam, my family will be safer due to fewer possible coyote interactions; self, I will be safer due to fewer possible coyote interactions; pet, my pets will be safer from possible coyote interactions; cost, a high monetary cost of management will be incurred by NHC; public, the public will be able to participate in management; inhumane, coyotes will suffer an inhumane death; unnatural, coyotes will suffer an unnatural death; and popsize, the number of coyotes will decrease in NHC. We asked survey respondents to indicate their beliefs (b_i) concerning the likelihood of each of the eight outcomes for each management method based on a five-point scale ('very unlikely' to 'very likely'). We then asked respondents to indicate the desirability (e_i) of each of the outcomes, regardless of management method, on a five-point scale ('very undesirable' to 'very desirable'). We rescaled the ratings of the outcome responses to values of −2 (very unlikely or undesirable) to +2 (very likely or desirable). This conversion allowed us to assess the mean attitudes of respondents by looking at positive (>0 mean A_B value) and negative (<0 mean A_B value) attitudes toward each management method. Positive A_B values can result from several different combinations of likelihood and desirability: (i) the sum of all respondents' beliefs and evaluations of each outcome was positive, (ii) the sum of all respondents' beliefs and evaluations of each outcome was negative and (iii) respondents held strong positive beliefs and evaluations for some outcomes that negated any slightly negative beliefs and evaluations for other outcomes when the product of the belief and evaluation values were summed. The same logic can be applied to understanding negative mean attitude values.

Data analyses

We used Microsoft Excel® with RealStats (Zaiontz 2019) and SAS (SAS 9.1, Cary, NC, USA) for all data analyses ($\alpha = 0.05$). We analyzed the survey data for three respondent groups for each management method: (i) respondents who felt the management method was acceptable, (ii) respondents who held a neutral attitude toward the management method and (iii) respondents who felt the management method was unacceptable. We compared the mean attitudes (A_B) these three groups held toward each management method using one-way analysis of variance (ANOVA; PROC GLM, SAS 9.1, SAS Institute, Cary, NC, USA; Manfredo et al. 1999; Daigle, Hrubes, and Ajzen 2002; Dougherty, Fulton, and Anderson 2003; Urbanek et al. 2015). To determine which beliefs and evaluations of outcomes influenced a person to accept a method, we then used multinomial logistic regression models (PROC LOGISTIC; SAS 9.1) and corrected Akaike's Information Criterion (AICc) model selection (Burnham and Anderson 2002) to regress the acceptance levels (acceptable, neutral, unacceptable) for each of the management methods on b_i, e_i and $b_i e_i$ variables. We used the neutral acceptance response toward the management method as the reference and determined which belief and evaluation variables were best at predicting 'unacceptable' or 'acceptable' relative to neutral opinions. For every one-unit change in the predictor variable (i.e. b_i, e_i or $b_i e_i$ variable), the multinomial log-odds for accepting (or not accepting) that method will change by the standardized parameter value (University of California, Los Angeles Statistical Consulting Group 2013).

We created a model set using respondent beliefs and evaluations and the respondents' acceptance response for each management method. We first assessed the fit of the global models using the Deviance goodness-of-fit test. Within each model set, we then created single-variable models focusing on individual beliefs and outcomes and retained any models that had an AICc

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value at least two points less than the null model. We used the variable with the lowest AICc value to start building the more complex model. We then added all other variables retained from the remaining single-variable models to the model individually and assessed if they explained more of the deviance (i.e. was ≥2 AICc points less than the previous best model). We added retained variables individually to the model using these methods until AICc was minimized. We considered any models that were ≤2 AICc points more than the best model. We then model averaged to derive the composite model using the standardized parameters and Akaike weights for each model within the subset of models. We also calculated the Akaike relative importance weights (ω) for each variable within the composite model (Burnham and Anderson 2002). Akaike relative importance weights are calculated by summing all model weights in which a particular variable is included; a higher relative importance weight signifies that a predictor variable likely contributes more to the prediction of the response variable than other predictors.

Results

We received 282 responses after the initial mailing, 109 responses after the first reminder, and 41 after the second reminder. The survey response rate was 11% ($n = 432$) and 328–331 surveys were usable for analyses (i.e. all necessary responses were provided) (Table 1). Low response rates are typical of many public surveys; however, the results of this study should be generalizable to the larger public of NHC (examining zip codes, spatially the survey respondents covered the entire county) and any other urban areas that have recently experienced coyote invasion and increased coyote conflicts. Due to financial constraints, we did not conduct a nonresponse survey.

Our survey respondents closely aligned with county data for registered voters (NCSBE 2017) in gender (survey: 41% male, 52% female; voter data: 44% male, 52% female) and race (survey: 94% white, voter data: 91% white) but individuals ≥50 years old (68%) responded more frequently to our survey compared to the number of registered voters (48%). Online and mail survey respondents were similar in age, gender, educational attainment and race ($\chi^2 = 2.66–5.90$, $P = 0.12–0.62$), so we pooled online and mail-in surveys for analysis purposes. Additionally, we investigated whether nonresponse bias existed by comparing the results of seven pertinent questions between waves of responses using chi-square and Kruskal–Wallis tests (Lambert and Harrington 1990; Urbanek, Carrozzino-Lyon, and Potts 2018; Buteau, Urbanek, and Dumas 2022). We found no nonresponse bias between waves ($\chi^2 = 0.58–5.45$, $P = 0.24–0.97$; H2 = 0.21–1.84, $P = 0.29–0.90$); hence, responses were pooled across waves.

Attitudes (A_B) of respondents who accepted each method differed significantly from attitudes of respondents who found them unacceptable ($F_{2,327–330} = 6.23–35.50$; $P = 0.0001–0.002$; Fig. 1). Respondents who rated a method acceptable tended to have significant positive attitudes toward it, whereas respondents who rated a method unacceptable tended to have significant negative attitudes toward it. The level of significance of attitudes of respondents who rated a method as neutral varied. The attitudes of respondents who were neutral toward NM were different from the attitudes of other respondents. The attitudes of respondents who were neutral toward PE were not different from the other respondents. The attitudes of respondents who were neutral toward TE were different from the attitudes of respondents who accepted the method but were not different from the attitudes of respondents who found the method unacceptable. All three global models fit the data for the multinomial logistic regression models (Table 2).

Table 1: Sample sizes of resident groups for each coyote (*Canis latrans*) management method, New Hanover County, North Carolina, 2018

Management method	Acceptable	Neutral	Unacceptable
No management	148	43	137
Public education	302	10	16
Trap/euthanasia	197	47	87

No management

We identified four models consisting of seven variables with a cumulative 62% Akaike model weight for the NM model set (Table 3). The most important variables included the evaluation of if coyote populations would decrease, the evaluation of if coyotes would suffer an unnatural death, the belief that NM would result in making a respondent's family safer, and the desire to have their family safe from coyotes (Akaike relative importance weight: $\omega = 0.62$ for each variable). Respondents who perceived NM as unacceptable desired a population decrease in coyotes more than neutral respondents, whereas respondents who accepted NM did not desire a population reduction (Fig. 2). Respondents who deemed NM acceptable rated an unnatural coyote death as less desirable than respondents who were neutral to NM. Alternatively, respondents who found this method unacceptable evaluated an unnatural coyote death positively. All respondents indicated that they did not believe they would be safer from coyotes as a result of NM and all respondents desired their families to be safer from coyotes. However, respondents who found the action of NM unacceptable held stronger beliefs and desires than neutral respondents and respondents who accepted this method held the weakest beliefs and desires for this outcome. The product of respondent beliefs and evaluations of the outcome that their families would be safer also contributed to acceptability responses ($\omega = 0.11$) and the same trends were reflected among respondents who accepted, who were neutral toward, or those who found NM of coyotes unacceptable.

Responses were also influenced by the product of respondent beliefs and evaluations of the outcome that pets would be safer ($\omega = 0.36$). For this outcome, all respondents felt pet safety was desirable but did not believe this outcome was likely with NM. Respondents who accepted NM held only a slight belief ($b_{pet} = -0.28 \pm 0.09$; mean ± SD throughout) that pet safety was an unlikely outcome, whereas those who were neutral ($b_{pet} = -0.93 \pm 0.16$) and those who found this method unacceptable ($b_{pet} = -1.00 \pm 0.11$) held stronger beliefs that pets would not be safer. Similarly, those who were neutral ($e_{pet} = 1.23 \pm 0.16$) and those who deemed NM unacceptable ($e_{pet} = 1.50 \pm 0.08$) had stronger desires for pet safety than those who accepted ($e_{pet} = 0.83 \pm 0.08$) the method. Because of the contrasting signs for beliefs and evaluations, the product of these values resulted in a negative mean attitude toward pet safety for all respondents (Fig. 2).

The belief that respondents themselves would be safer also affected a person's acceptance response ($\omega = 0.26$). All respondents believed their safety was an unlikely outcome of NM; however, respondents who were neutral and respondents who found NM unacceptable held stronger beliefs that their safety was unlikely than those who accepted the method (Fig. 2).

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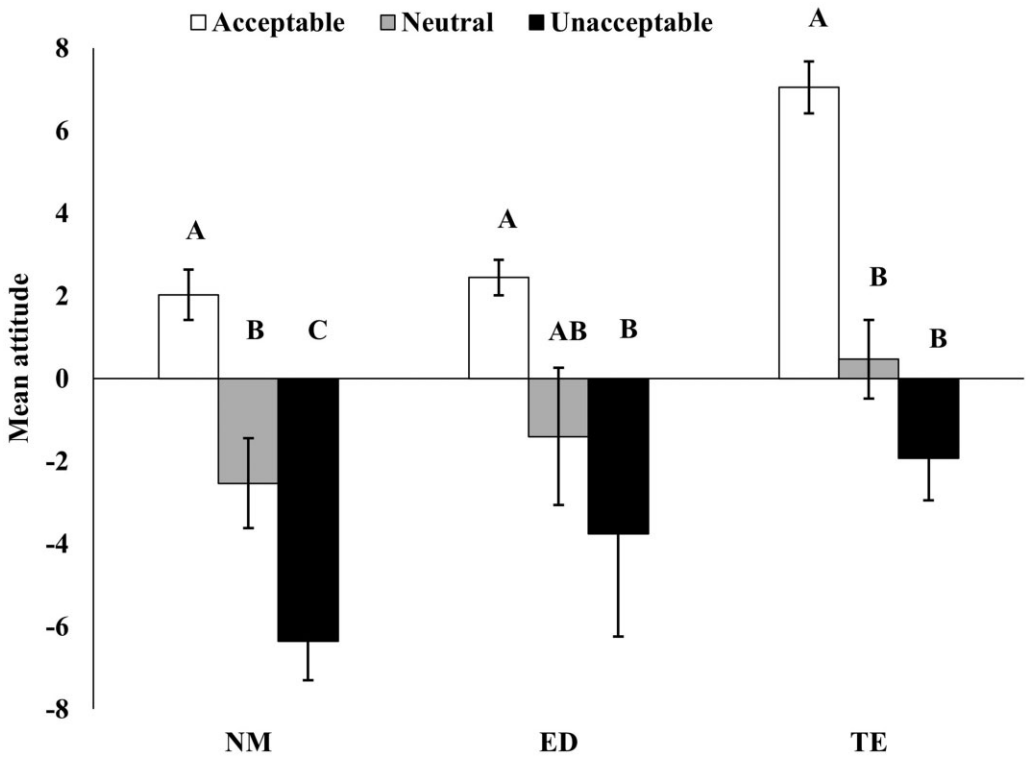

Figure 1: Mean attitudes (A_B) and standard error of respondents who deemed coyote (*Canis latrans*) management methods acceptable, neutral, and unacceptable in New Hanover County, North Carolina, 2018. Mean attitudes ($A_B = \sum b_i e_i$) are proportional to the sum of people's beliefs (b_i) that certain outcomes associated with a coyote management method will occur multiplied by their evaluations of those outcomes (e_i). Beliefs and evaluations were rated by respondents on a scale of −2 to 2 where negative numbers depicted the outcome was believed to be 'extremely unlikely' or evaluated as 'extremely undesirable' and positive numbers depicted the outcome was believed to be 'extremely likely' or evaluated as 'extremely desirable'. Different letters indicate significant difference at $P \leq 0.05$ within each management method. Error bars denote standard error of the mean

Table 2: Deviance goodness-of-fit results for three multinomial logistic regression models used to assess two acceptance levels (acceptable or unacceptable relative to a neutral option as the reference) of coyote (*Canis latrans*) management methods in New Hanover County, North Carolina, 2018

Management method	Deviance		
	D	*df*	*P*
No management	435.35	594	1.00
Public education	146.78	600	1.00
Trap/euthanasia	404.94	608	1.00

Public education

We identified four models consisting of five variables with a cumulative 91% Akaike model weight for the PE model set (Table 4). One of the most important variables was the belief that a respondent's family would be safer if PE were employed ($\omega = 0.91$). People who accepted PE were the only respondent group who held a positive belief, whereas the other two respondent groups did not believe PE would make them safer from coyotes (Fig. 3).

Participation in PE contributed to its acceptance in the form of the product of the belief and the evaluation of if the public would be able to participate in the PE process ($\omega = 0.91$); just the belief of if the public would be able to participate also influenced a respondent's acceptance ($\omega = 0.26$). All respondents evaluated public participation in coyote management as desirable ($e_{\text{public}} = 0.39–0.70 \pm 0.06–0.37$). Respondents who accepted and those who were neutral toward PE believed public participation to be a likely outcome while those who found the method unacceptable did not (Fig. 3). The product of respondent beliefs and evaluations for this outcome resulted in a negative mean attitude toward public participation for respondents who were neutral and those who found PE unacceptable but a positive mean attitude for those who accepted the method.

Respondent's evaluation of if coyotes would die an inhumane death ($\omega = 0.14$) and the product of respondent's beliefs and evaluations of if coyote populations would decrease ($\omega = 0.20$) had some influence on the respondent acceptance of PE as a coyote management technique. All respondents felt an inhumane death was undesirable but respondents who accepted PE rated an inhumane death as the least desirable compared to other respondents (Fig. 3). While all respondents desired a decrease in the coyote population, they all also believed that the coyote population would likely not decrease because of PE. Respondents who considered PE unacceptable held the strongest belief ($b_{\text{popsize}} = -1.13 \pm 0.22$) that a population decrease was unlikely when compared to those who accepted the method ($b_{\text{popsize}} = -0.43 \pm 0.06$) and those who were neutral ($b_{\text{popsize}} = -0.60 \pm 0.31$). Similarly, respondents who found PE unacceptable held the strongest desire ($e_{\text{popsize}} = 1.00 \pm 0.26$) for a population decrease compared to those who accepted the method ($e_{\text{popsize}} = 0.90 \pm 0.23$) and those who were neutral ($e_{\text{popsize}} = 0.45 \pm 0.06$). The product of respondent beliefs and evaluations resulted in a negative mean attitude toward a population decrease for all respondents (Fig. 3).

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Table 3: Top multinomial logistic models used to assess two acceptance levels (acceptable or unacceptable relative to a neutral opinion as the reference) of no management for coyotes (*Canis latrans*) in New Hanover County, North Carolina, 2018[a]

Models	β′ (A)	β′ (U)	*K*	AIC_c	ΔAIC_c	ω_i
$e_{PopSize}$	−0.12	0.38	14	498.90	0.00	0.24
$e_{Unnatural}$	−0.14	0.35				
e_{Fam}	−0.06	0.28				
b_{Fam}	0.12	0.12				
be_{Pet}	0.30	0.30				
$e_{PopSize}$	−0.14	0.38	14	499.98	1.08	0.14
$e_{Unnatural}$	−0.20	0.38				
e_{Fam}	−0.16	0.16				
b_{Fam}	0.05	−0.36				
b_{Self}	0.24	0.44				
$e_{PopSize}$	−0.12	0.40	16	500.30	1.40	0.12
$e_{Unnatural}$	−0.20	0.38				
e_{Fam}	−0.05	0.27				
b_{Fam}	0.04	−0.40				
be_{Pet}	0.26	0.30				
b_{Self}	0.14	0.33				
$e_{PopSize}$	−0.15	0.34	14	500.45	1.55	0.11
$e_{Unnatural}$	−0.20	0.38				
e_{Fam}	−0.05	0.37				
b_{Fam}	0.11	−0.31				
be_{Fam}	0.24	0.46				
$^{*}e_{PopSize}$	−0.13	0.38				
$^{*}e_{Unnatural}$	−0.20	0.37				
$^{*}e_{Fam}$	−0.08	0.27				
$^{*}b_{Fam}$	0.09	−0.30				
$^{*}be_{Pet}$	0.28	0.36				
$^{*}b_{Self}$	0.19	0.39				
$^{*}be_{Fam}$	0.24	0.46				

[a]Covariates indicate the respondent's belief (*b*) of the likelihood of an outcome, their evaluation (*e*) of how desirable the outcome is, and the product (*be*) of their belief and evaluation considering 1 of 8 possible outcomes. We present standardized parameter estimates (β') for modeling acceptable (A) and unacceptable (U) responses, number of parameters estimated in model (*K*), Akaike's Information Criterion adjusted for small samples (AIC_c), distance from lowest AIC_c (ΔAIC_c), and model weight (ω_i). Parameters for the composite model derived from model averaging are indicated by *.
PopSize, the number of coyotes will decrease in NHC; unnatural, coyotes will suffer an unnatural death; fam, family will be safer due to fewer possible coyote interactions; pet, pets will be safer from possible coyote interactions; self, respondent will be safer due to fewer possible coyote interactions.

Trap/euthanasia

We identified one model consisting of five variables with a cumulative 35% Akaike model weight for the TE model set (Table 5). The variables included the evaluation of if coyotes would suffer an unnatural death, the belief that pets would be safer, the desire to have pets safe from coyotes, the belief that coyotes would suffer an inhumane death, and the belief that the public would be able to participate in management. Respondents who were neutral toward TE and those who found TE unacceptable rated an unnatural coyote death much less desirable than respondents who accepted this method (Fig. 4). All respondents evaluated pet safety as being desirable and a likely outcome of TE. For both variables, respondents who accepted TE held stronger beliefs that their pets would be safer if this method were deployed and also desired this outcome more than other respondent groups. Alternatively, respondents who found this method unacceptable held the weakest beliefs that their pets would be safer and their desire for this outcome was also the weakest among the respondent groups. All respondents also believed coyotes would die an inhumane death if TE were employed. People who found this method unacceptable held the strongest belief that this outcome would occur. Lastly, respondents who accepted or were neutral toward TE of coyotes held slight positive beliefs that the public would be able to participate in coyote management, whereas those who found the method unacceptable held stronger beliefs that the public would not be able to participate.

Discussion

Our results supported our hypothesis that public acceptance of the three coyote management methods would be influenced by respondents' beliefs about and desires for certain outcomes, although not all of the beliefs and desires we examined influenced acceptance of all management methods. We identified the beliefs and desires which most strongly influenced public acceptance of coyote management methods.

Human safety

Human safety from coyotes highly influenced the public's acceptance of NM and PE. In a nationwide survey examining attitudes (like/dislike) toward 26 species, coyotes were rated as one of the least liked, partially because respondents associate them with human injury (Kellert 1985). A replica survey, conducted 36 years later, found more positive attitudes toward coyotes but did not discuss their association with human injury (George et al. 2016). Many surveys have reported that the public holds a general dislike and fear of coyotes and coyote interactions (Vaske and Needham 2007; Jackman and Rutberg 2015; Sponarski, Vaske, and Bath 2015a; Frank et al. 2016). Although infrequent, the number of reported coyote attacks in the US and Canada numbered 142 in the period of 1960–2006 and it is likely that others go unreported (White and Gehrt 2009). Given that coyotes are increasingly involved in conflicts with humans (Baker and Timm, 1998; Timm et al. 2004), occasionally resulting in human injury, it is not surprising that resident beliefs that PE or NM would continue to put themselves and their families at possible risk from coyotes strongly influenced their acceptance of these methods.

Neither personal nor family safety played a role in acceptance of TE indicating consensus that humans will be safer from coyotes because of their physical removal. While models that included personal and family safety were not $\leq$2 AICc points of the best model, these variables were included in models that fell within the 95% confidence interval and, as such, may play a role in attitudes toward TE to a lesser extent ($\omega = 0.11$–0.13 of a 95% confidence interval). In Reiter, Brunson, and Schmidt (1999), human safety was rated as the most important factor to consider when choosing a wildlife management strategy and most of our respondents rated personal and family safety as desirable. Sponarski, Miller, and Vaske (2018) found that those with higher perceived risk due to coyotes (including risk to human safety) were more likely to prefer nonlethal and lethal management over doing nothing. Since human safety seems to be a major concern among the public, wildlife managers can address these concerns by providing information on the success of situation-specific management, which uses PE as a primary management technique and TE as a last resort, at decreasing human–coyote conflict (Baker and Timm 1998; Baker 2007; Farrar 2007).

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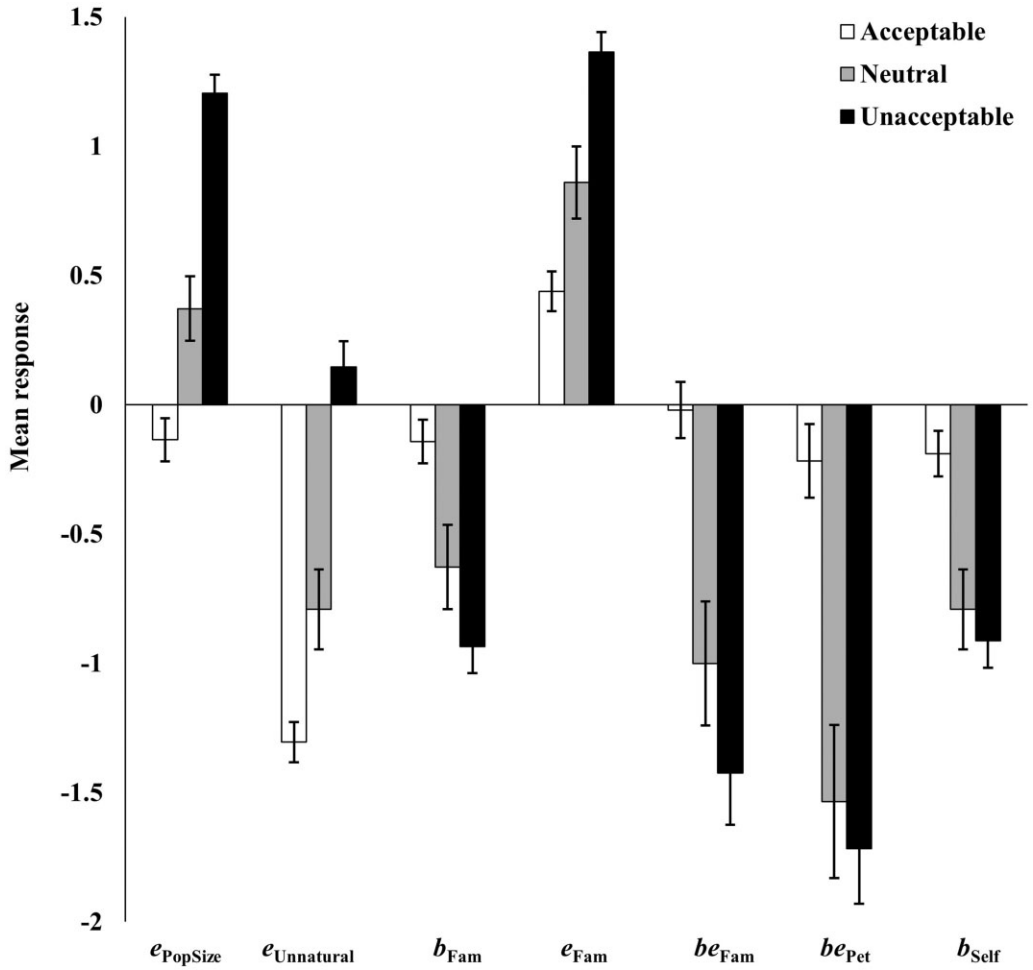

Figure 2: Mean response of beliefs (b), evaluations (e), and product of a respondent's belief and evaluation responses (be) toward outcomes of not managing coyotes (*Canis latrans*), New Hanover County, North Carolina, 2018. Beliefs and evaluations were rated by respondents on a scale of −2 to 2 where negative numbers depicted the outcome was believed to be 'extremely unlikely' or evaluated as 'extremely undesirable' and positive numbers depicted the outcome was believed to be 'extremely likely' or evaluated as 'extremely desirable'. Error bars denote one standard error of the mean

Pet safety

Pet safety was a major concern among respondents influencing acceptance of NM and TE. These results are also not surprising given that interactions involving pets (i.e. coyotes approaching adults and/or taking pets at night, chasing or taking pets not on leashes during daylight hours, attacking or taking pets on leashes or in close proximity to pet owners during daylight hours) were reported by 16% of respondents to our survey (Buteau, Urbanek, and Dumas 2022). Hudenko, Decker, and Siemer (2008) also found that both respondents who had a neutral experience and respondents who had a negative experience with coyotes were concerned about pet safety in Westchester County, NY. Similarly, pet safety was a main concern when considering management for other predator species (Riley and Decker 2000; Teel, Krannich, and Schmidt 2002; Siemer, Decker, and Merchant 2010).

Beliefs and evaluations of pet safety did not contribute to the acceptance of PE. While all respondents held positive desires for pet safety, beliefs that pet safety was a likely outcome of PE were lacking. A description of what PE involves was not provided in the survey because we were testing individual respondents' base knowledge and beliefs of outcomes, but it is possible that a large portion of the public is unaware of the format and type of information provided by PE programs. However, these programs often involve education on steps to promote pet safety, such as not feeding pets outside, supervising or keeping pets on leashes and appropriate fence height (Baker and Timm 1998; NCWRC 2018). Therefore, providing this information may have led to different results. Like human safety concerns, pet safety concerns can also be addressed by informing the public on the successes of situation-specific management at decreasing coyote attacks on pets (Farrar 2007). Using this strategy, Travis County, CA, saw a 3.5% decrease in coyotes acting aggressively toward people and pets per month. Similarly, after implementing strategies learned through PE, many other California counties saw decreases in pet attacks (Baker 2007).

Inhumane and unnatural coyote death

We did not provide definitions of 'inhumane' or 'unnatural' since even the definitions of these terms can be interpreted differently by people and wildlife value orientations are established early in life and tend to be resistant to change (Fulton, Manfredo, and Lipscomb 1996; Vaske and Needham 2007; Urbanek et al. 2015). Concerns about animal rights and welfare have been rising in the USA, and recent research indicates that

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Table 4: Top multinomial logistic models used to assess two acceptance levels (acceptable or unacceptable relative to a neutral opinion as the reference) of public education as a coyote (*Canis latrans*) management method in New Hanover County, North Carolina, 2018[a]

Models	β′ (A)	β′ (U)	K	AIC_c	ΔAIC_c	ω_i
b_{Fam}	0.54	0.16	8	198.34	0.00	0.31
be_{Public}	0.18	−0.30				
b_{Fam}	0.54	0.23	10	198.70	0.36	0.26
be_{Public}	0.18	−0.20				
b_{Public}	−0.02	−0.31				
b_{Fam}	0.57	0.26	10	199.24	0.90	0.20
be_{Public}	0.20	−0.24				
$be_{PopSize}$	−0.19	−0.36				
b_{Fam}	0.51	0.20	10	199.85	1.51	0.14
be_{Public}	0.17	−0.28				
$e_{Inhumane}$	−0.12	0.07				
$^{*}b_{Fam}$	0.54	0.21				
$^{*}be_{Public}$	0.18	−0.26				
$^{*}b_{Public}$	−0.02	−0.31				
$^{*}be_{PopSize}$	−0.19	−0.36				
$^{*}e_{Inhumane}$	0.07	0.07				

[a]Covariates indicate the respondent's belief (*b*) of the likelihood of an outcome, their evaluation (*e*) of how desirable the outcome is, and the product (*be*) of their belief and evaluation considering 1 of 8 possible outcomes. We present standardized parameter estimates (β') for modeling acceptable (A) and unacceptable (U) responses, number of parameters estimated in model (*K*), Akaike's Information Criterion adjusted for small samples (AIC_c), distance from lowest AIC_c (ΔAIC_c), and model weight (ω_i). Parameters for the composite model derived from model averaging are indicated by *.
Fam, family will be safer due to fewer possible coyote interactions; public, the public will be able to participate in coyote management; popsize, the number of coyotes will decrease in NHC; inhumane, coyotes will suffer an inhumane death.

most conservationists believe humans have an obligation to care for animals' welfare (Bruskotter et al. 2019). Evaluations about coyotes suffering an unnatural death were a strong contributor influencing acceptance of NM and TE. For most management options and respondent groups, both unnatural and inhumane deaths of coyotes were considered undesirable and were often important variables driving acceptance of management options. TE was the only management option that resulted in positive beliefs that coyotes would suffer an inhumane and unnatural death likely because it is the only lethal control method. As previously stated, lethal control devices often face opposition due to concerns about animal suffering (Huot and Bergman 2007), especially by members of animal rights groups (Hooper 1994; Warburton and Norton 2009). Like our study, previous public surveys have found that concerns about unnatural death and humanness were factors influencing public opinion on the management of coyotes (Arthur 1981; Reiter, Brunson, and Schmidt 1999) and other wildlife (Kilpatrick and Walter 1997; Reiter, Brunson, and Schmidt 1999; Dandy et al. 2012; Urbanek et al. 2015). To address these concerns, wildlife managers could provide information to the public about Association of Fish and Wildlife Agency's Best Management Practices for Trapping Program (AFWA 2002; Fall 2002; Buteau, Urbanek, and Dumas 2022). This program has evaluated over 600 types of traps, and the criteria for traps include that more than 70% of captures must have zero to only minimal injuries obtained (AFWA 2002). Advancements in trap technology are also resulting in more humane traps, such as laminated traps, which have been shown to reduce injury to coyotes (Huot and Bergman 2007). Again, no additional information about TE was provided in our survey because we were testing individual respondents' beliefs of outcomes; however, this information could have altered responses. Since wildlife value orientations are resistant to change (Vaske and Needham 2007), it is unlikely that wildlife managers will be able to change the attitudes of all citizens but increased knowledge about the humaneness of lethal control options may still aid in decreasing conflict.

Coyote population size

Whether or not respondents had a desire for coyote populations to decrease was a major factor in a respondent's acceptance of NM. Only respondents who accepted NM considered a population decrease to be undesirable, a likely result of their wildlife rights value orientations, beliefs that wildlife populations should be left alone to fluctuate naturally (Kilpatrick, Spohr, and Chasko 1997; Stout, Knuth, and Curtis 1997; Urbanek et al. 2015), or knowledge that coyotes are beneficial to the environment (Gompper 2002). Almost all respondents had a desire for populations to decrease, which may be the result of negative interactions with coyotes, knowledge that coyotes are not native to North Carolina, or a general fear of predators. Informing the public about the benefits of coyote presence and how to avoid interactions could address these desires. For those who do not desire a population decrease, managers should espouse that lethal control is used primarily in cases of human safety concerns. While respondents were in agreement that TE would result in decreased coyote population sizes, research may indicate otherwise. Previous studies have found that nonselective lethal strategies often fail while selective strategies, such as those that sterilize breeding pairs, have shown more success (Conner, Ebinger, and Knowlton 2008).

Public participation in coyote management

Another factor in determining acceptance of coyote management options was the desire for public participation and the belief of if the public would be able to participate. Public participation in management could come in many forms, such as trapping, personal behavior changes and participation in public meetings with wildlife managers; however, our survey did not define what public participation in management would involve and interpretation was left up to the respondent. All respondents had desires for public participation but only those who found PE unacceptable for a method felt that public participation in management was unlikely. However, public participation is essential with this method and managers could inform the public that education stresses personal behavior changes that would help manage and decrease negative coyote interactions (Baker and Timm 1998; Timm et al. 2004; Baker 2007; White and Gehrt 2009). For example, the public can help prevent coyote conflicts by not feeding wildlife, removing food attractants from yards, securing trash, making landscape changes and practicing hazing techniques.

Beliefs regarding if the public would be able to participate in management influenced acceptance of TE. Only respondents who found this method unacceptable believed the public would not be able to participate, whereas other respondents held neutral beliefs about the ability for public participation. Public participation in lethal control varies as some municipalities allow public trapping of coyotes and others prefer trapping instituted by wildlife management professionals to ensure compliance with laws and correct removal of the offending coyote. North

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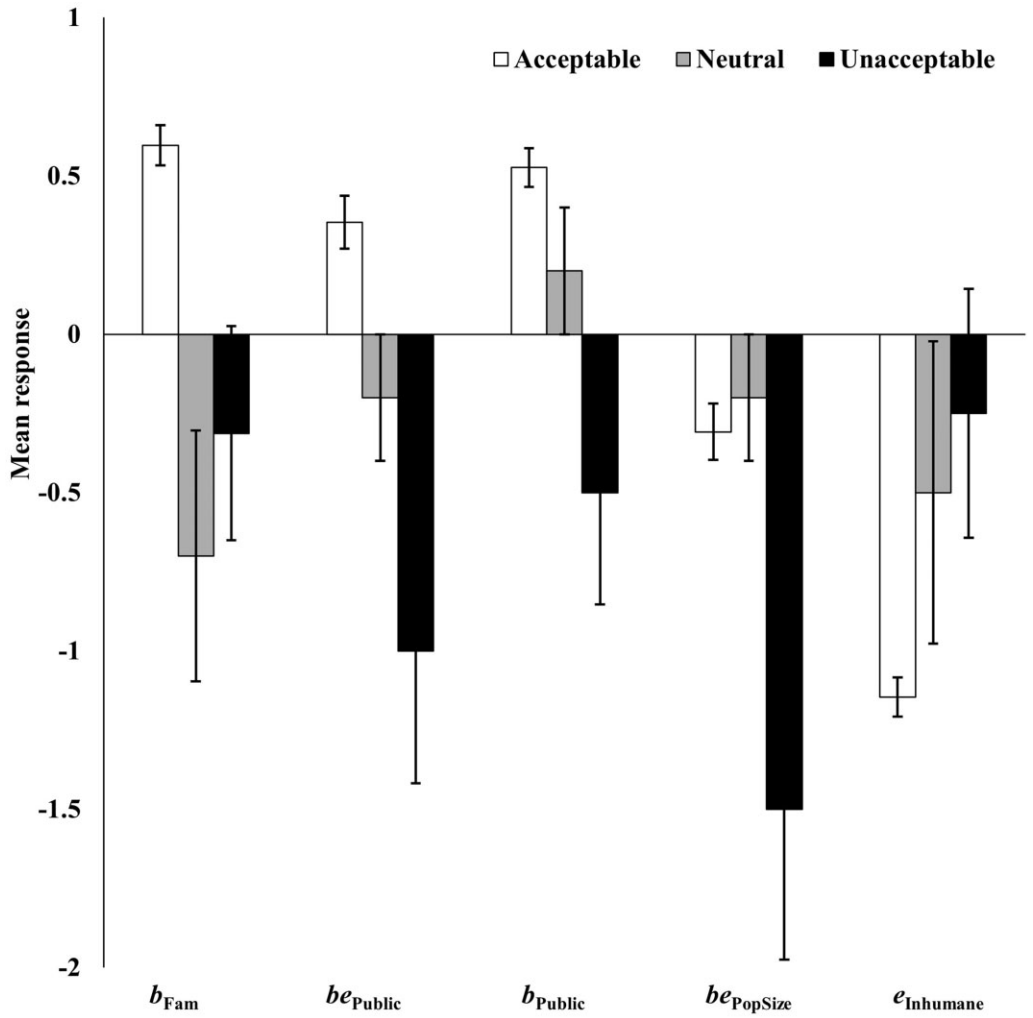

Figure 3: Mean response of beliefs (b), evaluations (e), and product of a respondent's belief and evaluation responses (be) toward outcomes of public education for coyotes (*Canis latrans*), New Hanover County, North Carolina, 2018. Beliefs and evaluations were rated by respondents on a scale of −2 to 2 where negative numbers depicted the outcome was believed to be 'extremely unlikely' or evaluated as 'extremely undesirable' and positive numbers depicted the outcome was believed to be 'extremely likely' or evaluated as 'extremely desirable'. Error bars denote one standard error of the mean

Table 5: Top multinomial logistic model used to assess two acceptance levels (acceptable or unacceptable relative to a neutral opinion as the reference) of trap/euthanasia as a coyote (*Canis latrans*) management method in New Hanover County, North Carolina, 2018[a]

Models	β′ (A)	β′ (U)	K	AIC_c	ΔAIC_c	ω_i
$e_{Unnatural}$	0.66	−0.01	14	474.11	0.00	0.35
e_{Pet}	0.16	−0.24				
$b_{Inhumane}$	−0.05	0.32				
b_{Public}	−0.09	−0.38				
b_{Pet}	0.19	−0.11				

[a]The next supported model was 2.07 ΔAIC_c points away. Covariates indicate the respondent's belief (*b*) of the likelihood of an outcome, their evaluation (*e*) of how desirable the outcome is, and the product (*be*) of their belief and evaluation considering 1 of 8 possible outcomes. We present standardized parameter estimates (β') for modeling acceptable (A) and unacceptable (U) responses, number of parameters estimated in model (K), Akaike's Information Criterion adjusted for small samples (AIC_c), distance from lowest AIC_c (ΔAIC_c), and model weight (ω_i).
Unnatural, coyotes will suffer an unnatural death; pet, pets will be safer from possible coyote interactions; inhumane, coyotes will suffer an inhumane death; public, the public will be able to participate in coyote management.

Carolina currently allows public participation by instituting coyote trapping seasons (NCWRC 2018) and wildlife managers can work to educate the public on trapping regulations and permitting procedures to promote more public participation. However, public participation can be limited because trapping must occur on lands with landowner permission, which is often lacking in urban areas. Therefore, PE is likely the best option if public participation is a concern.

Monetary cost of management

In contrast with previous studies considering coyote management (Arthur 1981; Reiter, Brunson, and Schmidt 1999), and other wildlife species (Kilpatrick, Labonte, and Barclay 2007; Urbanek et al. 2015), cost of management was the only variable that was not an important driver of respondent acceptance of any management strategy. However, both Arthur (1981) and Reiter, Brunson, and Schmidt (1999) found that cost was a lesser concern compared to other variables and may not play a major role in wildlife management acceptability. Out of all management options, only TE resulted in strong positive beliefs that a high cost of management would occur. All respondent groups were in

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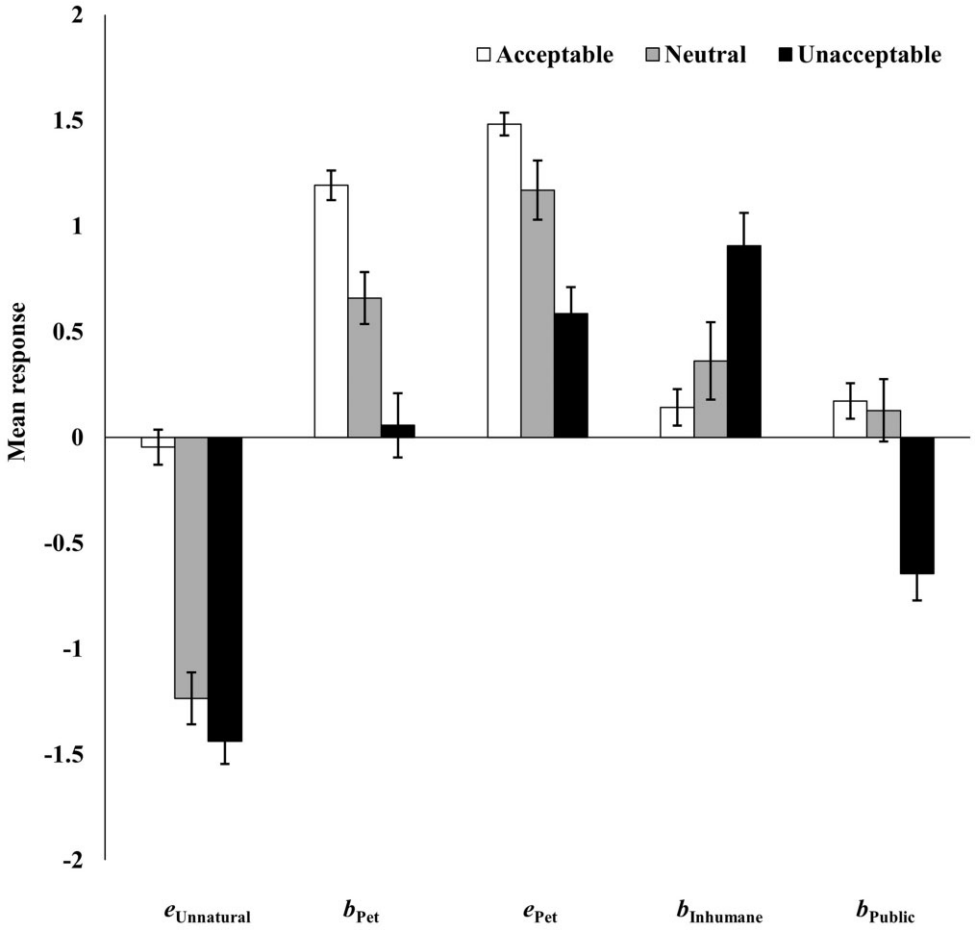

Figure 4: Mean response of beliefs (b), evaluations (e), and product of a respondent's belief and evaluation responses (be) toward outcomes of trap/euthanasia of coyotes (*Canis latrans*), New Hanover County, North Carolina, 2018. Beliefs and evaluations were rated by respondents on a scale of −2 to 2 where negative numbers depicted the outcome was believed to be 'extremely unlikely' or evaluated as 'extremely undesirable' and positive numbers depicted the outcome was believed to be 'extremely likely' or evaluated as 'extremely desirable'. Error bars denote one standard error of the mean

agreement about the likelihood of a high cost of management and the desire for that outcome. In a later question of our survey, cost examples per household per year were provided for each management option which may have resulted in this consensus. We also asked for information on annual median household incomes and most (64%) respondents to our survey reported high incomes ($70k or higher), which may have influenced our results.

Conclusions

Using the expectancy-value model to identify public beliefs and desires about wildlife management will provide valuable information to wildlife managers. Respondent beliefs and desires found to attribute to differences in acceptability can likely be addressed by wildlife managers to increase support of coyote management methods. Education can be used to target those with disparate attitudes to decrease conflict among the public and wildlife managers. For example, for those who found PE unacceptable, managers can provide information on its success at increasing safety, its dependency on public participation, and its ability to preserve important predator species. Changing beliefs and promoting the outcomes that were considered desirable by the public can help increase public acceptance of a specific management strategy. Although public attitudes and perceptions can be resistant to change, other PE programs (Sponarski et al. 2016) have had success in changing attitudes toward coyotes themselves and it is likely that the same could be done for attitudes toward coyote management techniques. However, there have been no studies that tested the effectiveness of PE at changing attitudes toward management and this research would be helpful in the future. In some cases, the public may accept certain management techniques and reject others due to a lack of knowledge of their success and limitations. In a public survey about the acceptability of coyote management techniques, Sponarski, Vaske, and Bath (2015a,b) found that the techniques that are unlikely to be successful, such as relocation, were found to be acceptable by the public. Similarly, Urbanek, Allen, and Nielsen (2011) found deer biologists preferred techniques that the public finds less acceptable but that are more likely to be successful in management goals. In these cases, educating the public on the effectiveness of different management techniques could help promote specific techniques that are more likely to solve human-wildlife conflicts. Shanahan, Siemer, and Pleasant (2001) found that providing the public with more information regarding management techniques resulted in shifting public responses toward acceptance of more effective techniques. Therefore, we recommend managers use the expectancy-value model to help determine public beliefs and desires, which can be addressed through education to aid in the resolution of management disputes.

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Author contributions

Rebecca J. Buteau (Formal analysis [lead], Visualization [lead], Writing—original draft [lead], Writing—review & editing [equal]), Rachael Elizabeth Urbanek (Conceptualization [lead], Data curation [equal], Formal analysis [supporting], Funding acquisition [equal], Investigation [equal], Methodology [lead], Project administration [lead], Supervision [lead], Validation [lead], Writing—original draft [supporting], Writing—review & editing [equal]), and Christopher Dumas (Conceptualization [lead], Data curation [equal], Funding acquisition [lead], Investigation [lead], Supervision [supporting], Writing—review & editing [supporting])

Conflict of interest statement. None declared.

Data availability

Data can be made available upon request to the corresponding author.

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