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Contributed Paper

Understanding public perceptions of risk regarding outdoor pet cats to inform conservation action

Ashley Gramza,* ¶ Tara Teel,* Susan VandeWoude,† and Kevin Crooks‡

*Department of Human Dimensions of Natural Resources, Colorado State University, Campus Delivery 1480, Fort Collins, CO 80523, U.S.A.

†Department of Microbiology, Immunology, and Pathology, Colorado State University, 228 Pathology, Fort Collins, CO 80523, U.S.A.

‡Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Campus Delivery 1474, Fort Collins, CO 80523, U.S.A.

Abstract: *Free-ranging domestic cats (*Felis catus*) incur and impose risks on ecosystems and represent a complex issue of critical importance to biodiversity conservation and cat and human health globally. Prior social science research on this topic is limited and has emphasized feral cats even though owned cats often comprise a large proportion of the outdoor cat population, particularly in urban areas. To address this gap, we examined public risk perceptions and attitudes toward outdoor pet cats across varying levels of urbanization, including along the wildland–urban interface, in Colorado (U.S.A.), through a mail survey of 1397 residents. Residents did not view all types of risks uniformly. They viewed risks of cat predation on wildlife and carnivore predation on cats as more likely than disease-related risks. Additionally, risk perceptions were related to attitudes, prior experiences with cats and cat–wildlife interactions, and cat-owner behavior. Our findings suggest that changes in risk perceptions may result in behavior change. Therefore, knowledge of cat-related risk perceptions and attitudes could be used to develop communication programs aimed at promoting risk-aversive behaviors among cat owners and cat-management strategies that are acceptable to the public and that directly advance the conservation of native species.*

Keywords: attitudes, carnivores, communication, domestic cats, exotic species, risk perceptions, social science, urbanization

Entender las Percepciones Públicas del Riesgo respecto a los Gatos Domésticos al Aire Libre para Informar la Acción de Conservación

Resumen: *Los gatos domésticos sueltos (*Felis catus*) provocan y presentan riesgos sobre los ecosistemas y representan un tema complejo de importancia crítica para la conservación de la biodiversidad y la salud humana y felina a nivel global. Las investigaciones sociales previas sobre este tema son limitadas y han enfatizado a los gatos ferales, aunque los gatos domésticos representan una gran proporción de la población felina al aire libre, particularmente en áreas urbanas. Para enfocarnos en este vacío, examinamos las percepciones públicas de riesgo y las actitudes hacia los gatos domésticos al aire libre en varios niveles de urbanización, incluyendo a lo largo de la interconexión urbana-silvestre en Colorado (EUA). Esto se realizó mediante una encuesta por correo aplicada a 1397 residentes, los cuales no vieron todos los tipos de riesgo uniformemente. Ellos vieron los riesgos de la depredación de la vida silvestre por gatos y la depredación de los gatos por carnívoros como más probables que los riesgos relacionados con enfermedades. Adicionalmente, las percepciones de riesgo estuvieron relacionadas con actitudes, experiencias previas con gatos e interacciones gato-vida silvestre, y con el comportamiento de los dueños de los gatos. Nuestros resultados sugieren que los cambios en las percepciones de riesgo pueden derivar en cambios en el comportamiento. Por esto, el conocimiento sobre las actitudes y las percepciones de riesgo relacionados con gatos podría usarse para desarrollar programas de comunicación enfocados en promover comportamientos que eviten riesgos entre los dueños de los gatos y estrategias que son aceptables para el público y que avancen directamente la conservación de las especies nativas.*

Palabras Clave: actitudes, carnívoros, ciencias sociales, comunicación, especies exóticas, gatos domésticos, percepciones de riesgo, urbanización, vida silvestre

¶*email agramza@rams.colostate.edu*
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Introduction

Free-ranging domestic cats (*Felis catus*), including feral, stray, and outdoor pet cats, represent a complex issue of critical importance to biodiversity conservation and cat and human health (Kays & DeWan 2004; van Heezik et al. 2010; Bevins et al. 2012). Globally, there is growing evidence of the ecological impacts of cats via direct predation on native prey (Crooks & Soulé 1999; Baker et al. 2005; van Heezik et al. 2010; Loss et al. 2013), making them one of the 100 worst invasive species in the world (Lowe et al. 2000). In the United States alone, it is estimated that cats kill between 1.4 and 3.7 billion birds annually, the majority of which are native species (Loss et al. 2013). Cats may also indirectly alter prey foraging habits and survival by their mere presence in ecosystems (Bonnington et al. 2013). In addition, cats can transmit diseases to native carnivores, particularly wild felids, and can transmit zoonotic diseases to humans (Brown et al. 2008; Gerhold & Jessup 2013). Conversely, free-ranging cats face a variety of risks, such as threats from vehicles, domestic dogs, and other cats; predation by native carnivores; and contraction of diseases (Crooks & Soulé 1999; Grubbs & Krausman 2009; Bevins et al. 2012). The risks that cats both incur and impose (hereafter bidirectional risks) are likely compounded when cats roam along the wildland–urban interface (WUI), where urban and suburban development abut wildland vegetation (Radeloff et al. 2005) and the potential for cat–wildlife interactions may be greater (van Heezik et al. 2010; Bevins et al. 2012). The WUI therefore becomes a critical context in which to explore solutions to minimize these risks.

As with many of today's conservation challenges, there is an inherent social dimension to the issue of free-ranging domestic cats, partly because these animals are often owned or cared for by humans. Consequently, human behavior can contribute to the cause as well as the solution to this problem. For example, humans can perpetuate the occurrence of cats on the landscape by allowing their pets to spend time outdoors unrestrained and by feeding unowned free-ranging cats (Lord 2008). Alternatively, humans can minimize bidirectional risks by restricting their cats' outdoor activity, vaccinating and sterilizing cats, and using anti-predatory devices such as bibs or belled collars (Calver et al. 2007; Gordon et al. 2010).

Management of free-ranging cats has become a highly controversial topic that often pits wildlife advocates against animal-rights organizations due to cats' roles as both charismatic pets and predators of wildlife (Peterson et al. 2012). Despite ubiquitous media attention, there is a paucity of literature regarding public perceptions of free-ranging cats and their interactions with wildlife. In particular, research is needed to determine how people perceive the risks associated with cat–wildlife interactions and management actions that may reduce those risks (Loyd & Miller 2010). Further, to maximize the practical utility of findings, there is a need to better understand how these perceptions of risk may influence human behaviors that are often at the root of conservation problems such as the free-ranging cat situation (Schultz 2011; Inskip et al. 2014). Prior social science research has focused primarily on identifying public attitudes toward feral cats and their management (Lepczyk et al. 2003; Lord 2008; Loyd & Miller 2010; Lohr & Lepczyk 2013; Wald et al. 2013); little attention has been devoted to perceptions regarding owned cats that often comprise a large proportion of the outdoor cat population, particularly in urban areas (Thomas et al. 2012). Public attitudes toward outdoor pet cats and their management are likely different than attitudes toward feral cats and therefore should be examined to inform management interventions and communication efforts (Farnworth et al. 2011).

To address these gaps, we examined perceptions of outdoor pet cats among residents of two areas in Colorado (U.S.A.) that encompass varying levels of urbanization and a rapidly expanding WUI. We sought to examine perceptions about the bidirectional risks associated with pet cats (objective 1); identify unique segments (i.e., risk clusters) of the population based on variation in those perceptions (objective 2); and explore differences among the resulting segments relative to other factors, including attitudes, prior experiences with cats and cat interactions with wildlife, sociodemographics (e.g., urban or rural residence), and cat-owner behaviors (objective 3). Our intent was to facilitate segmentation of the target audience for development of future risk-communication programs and provide a foundation for exploring relationships with other factors theorized to influence risk perceptions. Such data could be used to inform communication and other strategies aimed at minimizing risks associated with outdoor pet cats in urbanizing landscapes.

Our study was grounded in theory from social psychology adapted for use in understanding wildlife and other conservation-related issues (Manfredo 2008), with a particular focus on attitude and risk-perception concepts. According to a predominant theoretical tradition in this area, now known as the reasoned-action approach (Fishbein & Ajzen 2010), attitudes refer to one's overall evaluation (e.g., good or bad) of a particular object (e.g., an issue, entity, or behavior, such as cats being allowed outside) and are often rooted in more specific beliefs about that object. Attitudes are a highly studied topic in social psychology and applied fields given their role in directing human behavior and their utility in describing how people feel about a given issue. For risk perceptions, we relied primarily on Slovic's (1987) psychometric paradigm that has been applied in various wildlife-related contexts (Gore et al. 2009). These perceptions, which can influence wildlife-related attitudes,

including support for wildlife management programs (Riley & Decker 2000*a*; Wieczorek-Hudenko 2012), are defined as an intuitive and often value-based risk judgment by an individual. Risk perceptions often do not coincide with actual risk potential, and they can be a function of personality traits or group membership as well as prior experiences (Riley & Decker 2000*a*; Gore et al. 2009).

Based on this prior work, we expected residents with higher risk perceptions to have more negative attitudes toward outdoor pet cats and more positive attitudes toward cat management strategies. We also predicted that higher risk perceptions would relate to prior negative experiences, such as cats damaging property, capturing wildlife prey, or being injured or killed by wild carnivores. Further, we expected rural residents to have lower risk perceptions than urban residents given prior research showing that rural residents have more positive attitudes toward feral cats, which may in turn be linked to lower risk perceptions (Coleman & Temple 1993; Riley & Decker 2000*b*; Lord 2008). Finally, we predicted that cat owners who allow their cats outside without restrictions would have lower risk perceptions than owners who restrict cat outdoor activity and residents who do not own cats.

Methods

Data Collection

Our two study areas included an area of low-density exurban and rural development surrounded by natural habitat on protected and private land on the western slope of the continental divide between the cities of Montrose and Telluride (hereafter western slope) and an area of high-density urban and suburban development and low-density exurban development bordering natural areas along the WUI on the eastern slope of the continental divide, west of the city of Boulder (hereafter front range). Although our primary interest was in broad comparisons across study areas, we targeted residents in rural, exurban, urban, and suburban locations within each to ensure adequate representation of population subgroups and maximize our ability to capture the potential range of resident perceptions. We assumed residents within 175 m of the WUI were particularly likely to have had experience with cats and potential cat interactions with wildlife and thus were suitable subjects to examine perceptions about outdoor pet cats (Supporting Information).

We collected data via a mail survey administered to 4872 households in both study areas from November 2011 through January 2012. We chose this approach in part because it facilitated a lengthier and more complex survey design relative to other modes of data collection such as phone or onsite surveys. The sampling frame was identified using geographic information system-based county tax parcel data that allowed for mailing addresses to be linked to geographic locations. We used a modified Dillman approach to survey administration: two survey mailings and a reminder postcard (Dillman et al. 2009). Survey development was informed by an elicitation phone survey ($n = 42$) designed to identify salient beliefs of the target population regarding outdoor pet cats and factors that would encourage or discourage owners from allowing cats outside. The survey was also pre-tested with a small sample of residents ($n = 36$) similar in demographics to the target population to confirm the effectiveness and comprehension of question wording. The final survey (Supporting Information) and administration procedures were approved for use with human subjects prior to implementation (CSU IRB protocol 10-2330H). To test for nonresponse bias, we conducted a phone survey of nonrespondents ($n = 193$) in each study area following data collection. The phone survey contained a sample of key questions from the mail survey, including items to assess interest, attitudes, and risk perceptions regarding outdoor pet-cat issues, sociodemographics, and cat-owner behaviors.

Measurement

We measured risk perceptions based on statements representing possible bidirectional risks of cats spending time outdoors. Respondents rated the likelihood of these risks on a 7-point scale from extremely unlikely to extremely likely (Table 1). We measured attitudes by asking respondents to indicate on a 7-point scale whether "having outdoor pet cats in your neighborhood" is good, bad, or neither and their overall level of approval of "people allowing their cats to spend time outdoors." Attitudes toward cat management strategies were measured on a 7-point scale from highly unacceptable to highly acceptable. Management strategies included the legal mandate of certain outdoor cat restrictions (e.g., leash laws or prohibition of cats being allowed outdoors), sterilization, vaccination, and licensing.

We measured prior experiences by asking if respondents had experienced problems with neighborhood cats in the last 12 months (yes or no and an open-ended area for type of problem). We also asked current cat owners about their experience with cat predation on wildlife (frequency of cats bringing home different categories of wild prey, collapsed to yes or no) and whether respondents had ever owned a cat that was injured or killed by wildlife or contracted a disease from wildlife (yes or no). We used fixed-response options to measure sociodemographics, including sex, age, income, education, and type of community where respondents were raised (urban or rural). As per our sampling strategy, respondents were also grouped by study area (front range or western slope) to facilitate urban–rural comparisons.

Cat-owner behaviors included current cat ownership (yes or no), vaccination (percentage of respondents who vaccinate at least one of their cats), veterinary care

Table 1. Reliability and principle components analysis (PCA) results from a 2011–2012 survey of Colorado front-range and western-slope residents about their perceptions of risks that outdoor pet cats incur and impose.

	Risk-dimension factor loading[b]			
Risk-perception items (pet cats spending time outdoors in my neighborhood would result in . . .)[a]	*disease*	*predation from wildlife*	*anthropogenic*	*predation on wildlife*
Cats giving diseases to other pets	0.85			
Cats getting diseases from other pets	0.79			
Cats giving diseases to wildlife	0.78			
Cats giving diseases to humans	0.73			
Cats getting diseases from wildlife	0.72			
Cats being injured or killed by mountain lions		0.88		
Cats being injured or killed by bobcats		0.85		
Cats being injured or killed by foxes		0.81		
Cats being injured or killed by coyotes		0.76		
Cats being hit by cars			0.84	
Cats being injured or killed by other pets			0.71	
Cats being lost or stolen			0.65	
Cats damaging people's property	0.43		0.53	
Cats injuring or killing small farm animals[c]	0.41		0.41	
A decrease in populations of small mammals				0.90
A decrease in populations of birds				0.85
Eigenvalues	5.86	2.32	1.35	1.24
Variance explained (%)	36.60	14.51	8.41	7.74
Cronbach's alpha	0.87	0.87	0.77	0.80

[a] *Item responses coded on a 7-point scale from 1, extremely unlikely, to 7, extremely likely.*
[b] *Only factor loadings >0.40, denoting practical significance (Vaske 2008), are shown.*
[c] *Because "cats injuring or killing small farm animals" had equivalent factor loadings for disease and anthropogenic risk factors, we placed it in the latter category (anthropogenic) for scale creation given the greater likelihood of this event in urban landscapes.*

(percentage of respondents who regularly seek veterinary care for at least one of their cats), and outdoor restrictions (fixed choices such as keeping cats indoors at night, allowing cats outdoors only under human supervision, and an open-ended choice of "other"). Outdoor-restriction behavior was further operationalized by combining cat ownership and restriction behavior to classify respondents along a continuum from 0 to 3 (0, respondent does not currently own a cat; 1, respondent keeps all cats indoors; 2, respondent allows at least one cat outdoors with restrictions; 3, respondent allows all cats outdoors without restrictions).

Data Analyses

We analyzed data in SPSS (Chicago, Illinois). To address objective 1, we performed principal components analysis (PCA) to examine patterns of thought, or dimensions, represented in responses to the risk-perception items. We used dimensions identified in the PCA to conduct a reliability analysis that examined the internal consistency of risk-perception scales. For scales yielding a Cronbach's alpha >0.75, indicating sufficient reliability (Vaske 2008), we computed composite scores by averaging responses for items comprising each scale.

To address objective 2, we then performed *K*-means cluster analysis to identify unique groups of respondents based on their responses to risk-perception items. We used the full suite of items ($n = 16$; Table 1) instead of dimensions from the PCA to maximize variability and preserve the diversity of responses and to avoid constraining the structure of the clusters. We used chi-square tests of successive cluster numbers to help determine the best cluster solution that yielded both conceptually meaningful groupings and group sizes large enough to encompass a substantial number of respondents. We validated the final cluster solution and further explored the distinctiveness of resulting groups by performing an analysis of variance (ANOVA) on dimensions from the PCA.

To address objective 3, we used ANOVA and chi-square tests to explore differences among risk clusters in attitudes, prior experiences, sociodemographics, and cat-owner behaviors. We used an alpha level of $p < 0.05$ to designate statistical significance and computed effect size measures, as indicators of practical significance, to account for a higher likelihood of finding statistical significance with large sample sizes. We used accepted criteria (Vaske 2008) to determine small, medium, and large effects (eta $\geq$ 0.10, 0.24, 0.37; Cramer's $V \geq$ 0.1, 0.3, 0.5).

Results

We received 1397 completed surveys (over 400 per study area, allowing for population estimates within 5% at the 95% confidence level; 599 were undeliverable) for a

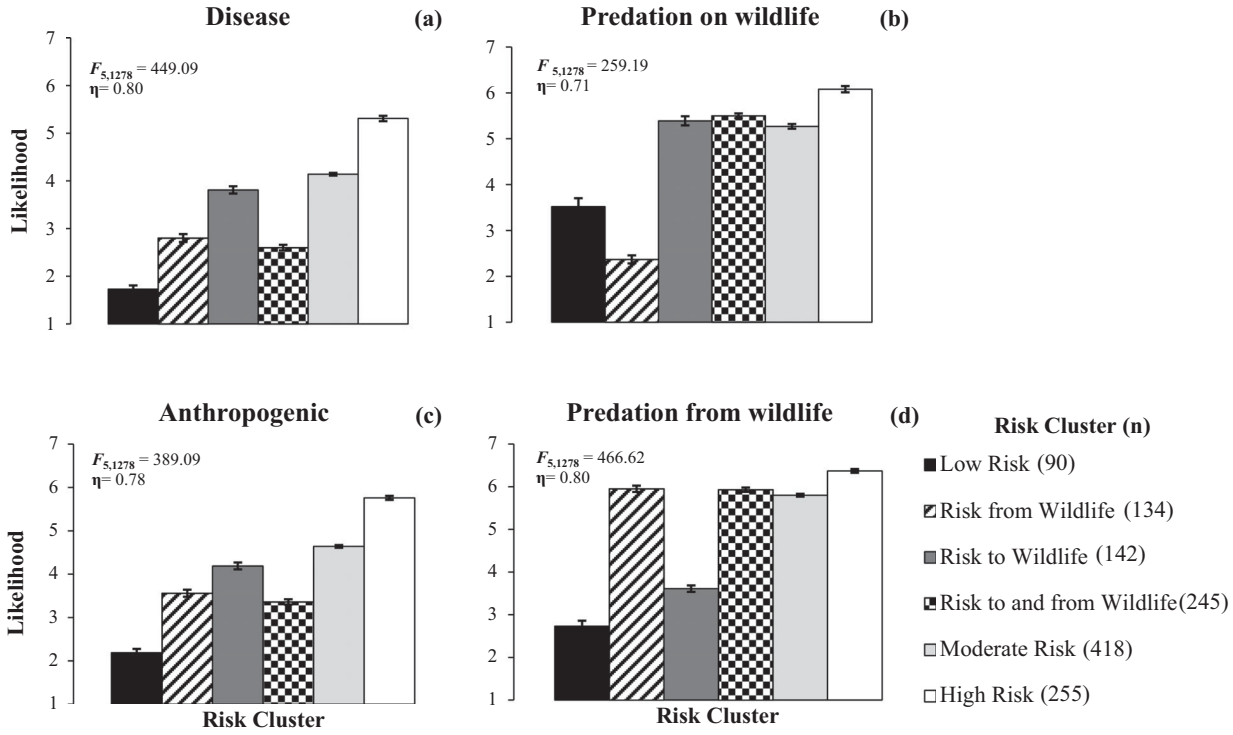

Figure 1. Comparison of risk clusters relative to the perceived likelihood of occurrence of (a) disease, (b) predation on wildlife, (c) anthropogenic events (i.e., events related to human development such as cats being injured by other pets or cars), and (d) predation from wildlife. Risk clusters represent unique groups of respondents identified through K-means cluster analysis based on their perceptions of risks that outdoor pet cats incur and impose (bars, mean score for each risk cluster on composite scales derived from individual items measured on a 7-point scale from 1, extremely unlikely, to 7, extremely likely; error bars, SE). All differences were statistically significant at $p < 0.001$ and η = eta, a measure of effect size to denote practical significance (Vaske 2008).

response rate of 33%. The follow-up phone survey revealed only minimal variation between respondents and nonrespondents on most items, with the exception of interest in outdoor pet-cat issues (eta = 0.31, indicating a moderate effect size); mail survey respondents (mean [SE] = 4.15 [0.05]) expressed greater interest than nonrespondents (mean [SE] = 2.39 [0.13]). This salience difference is consistent with prior conservation social science research (Connelly et al. 2003), and we decided not to weight the data because interest was not significantly correlated with other predictor variables.

The PCA revealed four distinct dimensions of risk perception that explained 67% of the variance in responses (Table 1). Dimensions were defined by factors representing disease risk, risk of predation by wildlife on cats (predation from wildlife), risk of predation by cats on wildlife (predation on wildlife), and anthropogenic risk, which included items related to human development such as cats being injured by other pets or cars. Reliability analyses indicated high internal consistency for risk-perception scales (Cronbach's alpha range: 0.77–0.87; Table 1).

Cluster analysis showed strong evidence for a conceptually meaningful 6-cluster solution (Fig. 1). Clusters differed across risk-perception dimensions (effect sizes were large, eta ≥ 0.71), and ranged from a group who believed all risks were unlikely (low risk cluster) to a group who believed that all risks were likely (high risk cluster; Fig. 1). Seventy-three percent of our sample was classified in groups between these two extremes. One of the defining characteristics distinguishing these intermediate groups was their perception of predation-related risks, which were also viewed as the most likely of all risks by respondents as a whole. Three of the six respondent clusters indicated that only those risks involving cat predation on wildlife (risk to wildlife cluster), wildlife injuring or killing cats (risk from wildlife cluster), or both (risk to and from wildlife cluster) were likely to occur. Finally, a moderate risk cluster included respondents who thought all risks were somewhat likely. In contrast, perceptions of disease and anthropogenic-related risks, generally perceived as less likely, varied less across respondents, and clusters therefore did not emerge based solely on these dimensions. Overall means for risk-perception scales indicated respondents perceived the risk of cats contracting or transmitting diseases to be the most unlikely of all risks (mean [SE] = 3.71 [0.04]), and the risk of carnivores injuring or killing cats to be the most likely (mean = 5.50 [0.04]).

Table 2. Comparison of risk clusters relative to respondents' attitudes toward outdoor pet cats, cat-owner behaviors, and prior experiences with outdoor pet cats and cat interactions with wildlife (2011–2012 survey of Colorado front-range and western-slope residents).[a]

	Risk cluster[b]								
Comparison factors	*Low risk*	*Risk from wildlife*	*Risk to wildlife*	*Risk to and from wildlife*	*Moderate risk*	*High risk*	χ^2 *or F (df)*[c]	*Overall mean (SE) or %*	*ES*[d]
Attitudes toward . . .[e]									
Outdoor pet cats	5.39 (0.14)	4.05 (0.15)	4.00 (0.15)	4.26 (0.17)	3.67 (0.80)	2.48 (0.10)	54.72 (5, 1270)**	3.74 (0.05)	0.42
People allowing their cats to spend time outdoors	6.06 (0.14)	4.70 (0.19)	4.38 (0.16)	4.89 (0.13)	4.15 (0.09)	2.82 (0.12)	51.55 (5, 1271)**	4.24 (0.06)	0.41
Cat-owner behaviors									
Current cat owner (%)	58.89	51.49	45.00	46.72	40.00	31.50	30.06 (5)**	42.68	0.15
People that vaccinate at least one cat (%)	77.55	84.85	85.00	84.40	92.86	89.87	10.38 (5)	87.23	–
People that take at least one cat to the vet regularly (%)	49.98	72.06	49.18	59.26	67.92	62.03	13.39 (5)*	61.83	0.16
Prior experiences[f]									
Problems with outdoor pet cats in last 12 months (%)	11.24	7.46	31.91	11.89	20.96	43.82	111.53 (5)**	22.84	0.30
Cat injured by predator ever %	36.84	39.60	26.21	49.48	31.89	32.91	22.68 (5)**	36.44	0.16
Cat getting a disease from wildlife ever (%)	2.44	2.86	3.09	2.02	3.72	9.93	16.56 (5)*	4.10	0.14
Cats preying on . . . .[g]									
Small mammals (%)	81.25	58.18	75.86	74.51	54.81	55.88	22.41 (5)**	65.02	0.22
Birds (%)	60.42	41.82	64.81	60.61	47.37	43.75	13.00 (5)*	52.54	0.17
Other (%)	19.15	20.00	21.15	16.33	4.62	15.63	14.86 (5)*	14.13	0.18

[a]*With the exception of the variables "current cat owner" and "problems with cats in the last 12 months," all cat-owner behavior and prior experience variables represent only cat-owner responses.*

[b]*Risk clusters represent unique groups of respondents identified through K-means cluster analysis based on their perceptions of risks that outdoor pet cats incur and impose. Cell values for each variable indicate either cluster means compared using ANOVA (F statistic) or percentages (% per cluster) compared using chi-square tests. Standard errors are listed parenthetically after each mean.*

[c]*Significance:* $^{*}p < 0.05$; $^{**}p < 0.001$.

[d]*Effect size measures to denote practical significance (Vaske 2008). Cramer's V was used for chi-square analysis and eta was used for ANOVA.*

[e]*Attitudes were measured on a 7-point scale. Higher values indicate higher levels of favor or approval.*

[f]*Respondents (per cluster) who answered yes to each event.*

[g]*Respondents (per cluster) who answered yes to their cat bringing home each type of prey.*

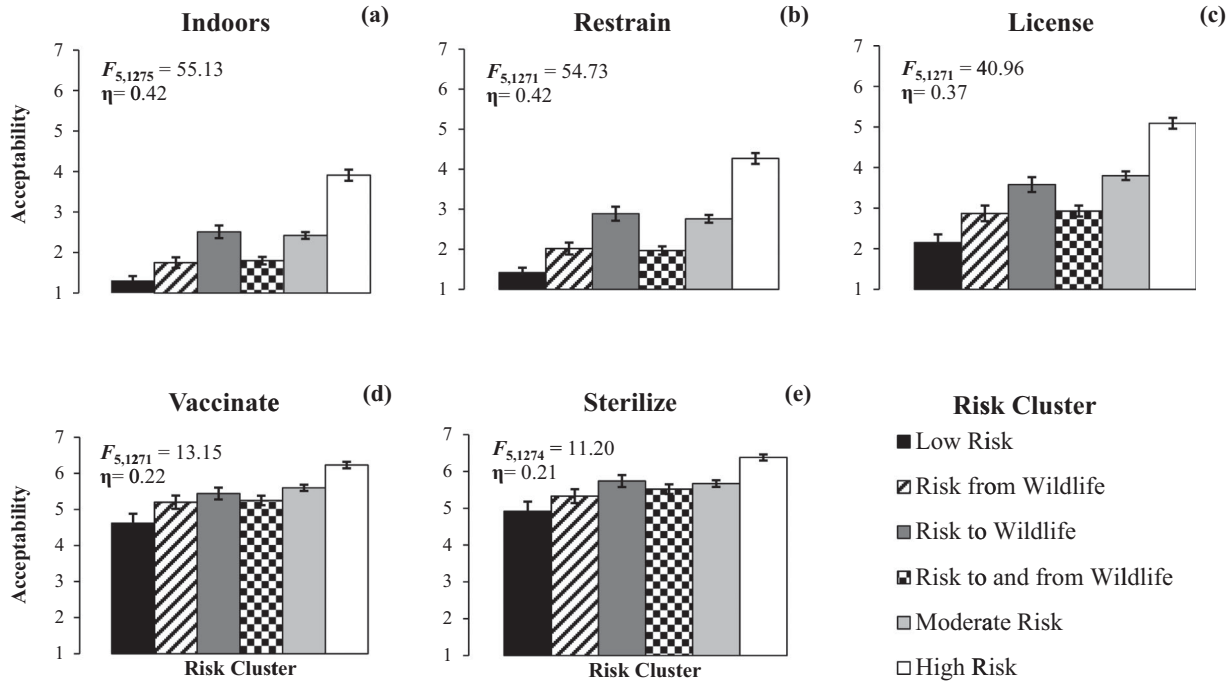

Figure 2. Comparison of risk clusters relative to respondent attitudes toward cat management strategies, including the legal mandate of (a) keeping cats indoors, (b) keeping cats restrained while outside, (c) licensing, (d) vaccination, and (e) sterilization. Risk clusters represent unique groups of respondents identified through K-means cluster analysis based on their perceptions of risks that outdoor pet cats incur and impose (bars, mean score for each risk cluster on a 7-point scale from 1, highly unacceptable, to 7 highly acceptable; error bars, SE). All differences were statistically significant at $p < 0.001$, and η = eta, a measure of effect size to denote practical significance (Vaske 2008).

As predicted, respondents in the low-risk cluster generally had more positive attitudes than respondents in the moderate and high-risk clusters (Table 2). Also as predicted, acceptability of cat management strategies increased with perceived risk; those in the high-risk cluster found these strategies more acceptable than those in the lower-risk groups (Fig. 2). The most invasive strategies, such as legally requiring cats to be kept indoors (overall mean [SE] = 2.47 [0.05]) or restrained while outside (mean = 2.74 [0.06]), had the lowest overall approval ratings (slightly to moderately unacceptable). In contrast, legally requiring cats to be vaccinated (mean = 5.55 [0.05]) and sterilized (mean = 5.71 [0.05]) had the highest mean ratings (slightly to moderately acceptable). With the exception of attitudes toward sterilization and vaccination requirements, which had close to medium effect sizes (eta = 0.21-0.22), all attitude variables included in our comparisons yielded large practical differences (eta ≥ 0.37) between risk clusters.

Cat-owner behaviors and prior experiences also differed among clusters (Table 2; Fig. 3), although effect sizes indicated these factors did not explain as much variation as the attitude variables. With the exception of vaccination, all differences among clusters were statistically significant (Table 2). The largest effect sizes (0.21–0.30, near or at the moderate level) were noted for outdoor restriction behavior and experiences in the form of recent problems with neighborhood cats and cats preying on small mammals. Consistent with our predictions, the high-risk cluster contained the highest percentage of non-owners and owners with indoor-only cats, and the low-risk group had the highest percentage of owners who allow all their pet cats outdoors without restrictions (Fig. 3). The high-risk cluster also contained the highest percentage of people reporting problems with outdoor pet cats in the prior year (44%), followed by the risk to wildlife cluster (32%) (Table 2). The most commonly reported problems gleaned from open-ended survey responses included cats urinating and defecating on property, cats killing wildlife, and other outdoor cats fighting with respondents' cats. Contrary to our prediction, the low-risk cluster contained a high percentage of respondents with cats bringing home small mammals (81%). However, the risk to wildlife (76%) and risk to and from wildlife (75%) clusters also contained a high percentage of respondents reporting this event.

All sociodemographics, except age, significantly differed among clusters (Table 3). However, with the exception of study area, which had close to a moderate

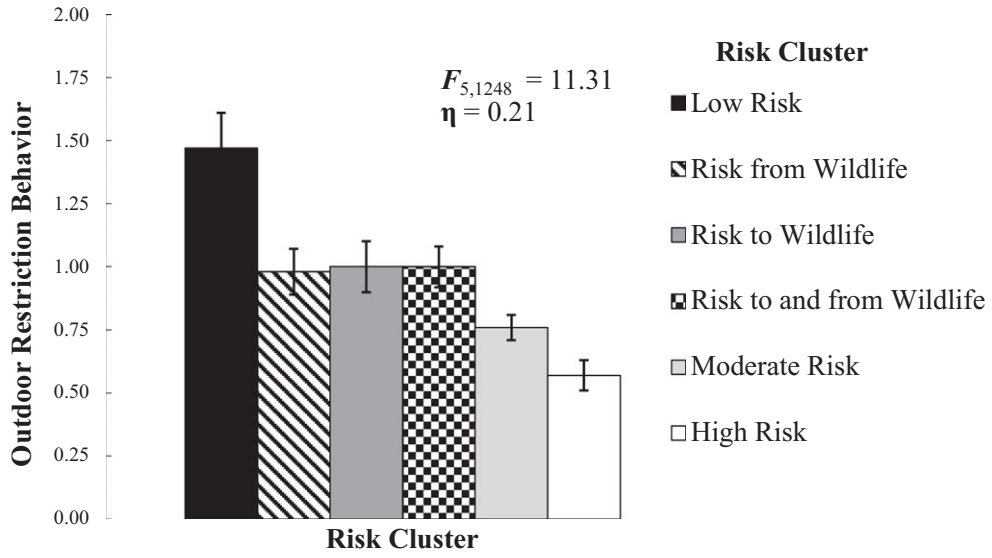

Figure 3. Comparison of risk clusters relative to outdoor restriction behaviors reported by cat owners. Risk clusters represent unique groups of respondents identified through K-means cluster analysis based on their perceptions of risks that outdoor pet cats incur and impose (bars, mean score for each risk cluster on a 4-point scale [0, respondent does not currently own a cat; 1, respondent keeps all cats indoors; 2, respondent allows at least one cat outdoors with restrictions; 3, respondent allows all cats outdoors without restrictions]; error bars, SE). All differences were statistically significant at $p < 0.001$, and η = eta, a measure of effect size to denote practical significance (Vaske 2008).

Table 3. Comparison of risk clusters relative to respondents' sociodemographic characteristics (2011–2012 survey of Colorado front range and western slope residents about outdoor pet cats).

	Risk cluster[a]								
Comparison factors	*Low risk*	*Risk from wildlife*	*Risk to wildlife*	*Risk to and from wildlife*	*Moderate risk*	*High risk*	χ^2 *or F (df)*[b]	*Overall mean (SE) or %*	*ES*[c]
Study area[d]	42.22	79.10	38.03	71.78	73.98	65.08	98.02 (5)**	66.09	0.28
Percent male respondents	68.18	66.41	46.38	63.37	57.46	56.35	18.16 (5)*	58.84	0.12
Community where raised[e]	5.21 (0.28)	4.16 (0.21)	4.49 (0.23)	4.12 (0.17)	3.97 (0.12)	4.09 (0.17)	3.75 (5, 1218)*	4.19 (0.07)	0.12
Household income[f]	5.24 (0.23)	6.15 (0.20)	5.28 (0.20)	6.12 (0.14)	6.07 (0.11)	6.12 (0.13)	5.66 (5, 1072)**	5.95 (0.06)	0.16
Education[g]	3.65 (0.12)	4.16 (0.07)	3.64 (0.11)	4.07 (0.06)	4.14 (0.53)	4.03 (0.07)	7.28 (5, 1232)**	4.02 (0.03)	0.17
Age	60.57 (1.47)	56.40 (1.07)	58.52 (1.38)	58.67 (0.76)	56.81 (0.68)	57.97 (0.79)	1.82 (5, 1239)	57.80 (0.37)	–

[a] *Risk clusters represent unique groups of respondents identified through K-means cluster analysis based on their perceptions of risks that outdoor pet cats incur and impose. Values for each variable indicate either cluster means compared using ANOVA (F statistic) or percentages (% per cluster) compared using chi-square tests. Standard errors are listed parenthetically after each mean.*
[b] *Significance: * $p < 0.05$; ** $p < 0.001$.*
[c] *Effect size measures to denote practical significance (Vaske 2008). Cramer's V was used for chi-square analysis and eta was used for ANOVA.*
[d] *Values represent the percentage of respondents living in the Front Range study area. Higher percentages indicate the cluster is composed of more urban or suburban as opposed to rural (i.e., western slope) residents.*
[e] *Mean scores on an 8-point scale from 1, large city with ≥250,000 people, to 8, farm or rural area.*
[f] *Mean scores on a 9-point scale from 1, <$10,000, to 9, ≥$200,000.*
[g] *Mean scores on a 5-point scale from 1, less than high school diploma, to 5, advanced degree beyond 4-year college degree.*

effect size (Cramer's $V = 0.28$), differences among clusters were not substantial. Sex, income, education, and community where respondents were raised all had small effect sizes, and risk perceptions generally increased as the percentage of women, income, education, and urban upbringing increased in the clusters. Consistent with our predictions, the low-risk cluster was composed of a lower percentage of respondents from the more urban front range (42%) compared with the high-risk cluster that had a higher percentage of front-range residents and

a lower percentage of rural residents from the western slope (35%). The cluster with the lowest percentage of front-range residents was risk to wildlife (38%), and clusters with the highest percentages of front-range residents were risk from wildlife (79%) and moderate risk (74%).

Discussion

As is the case for many contemporary conservation problems (Schultz 2011), long-term solutions to the issue of free-ranging domestic cats will necessitate human behavior change. Although communication is often a preferred behavior-change strategy, developing effective communication programs is difficult and should begin with a clear understanding of target audiences, including their attitudes and beliefs (Jacobson 2009; Fishbein & Ajzen 2010). Toward this end, we addressed important gaps in the scientific literature by characterizing public perceptions of risk regarding outdoor pet cats and their interactions with wildlife and considered how findings could inform future communication and other conservation strategies. Specifically, we sought to make a unique contribution by emphasizing owned outdoor cats, as opposed to feral cats that have largely been the focus of the limited social science research on the topic; applying the concept of risk perceptions (Slovic 1987; Gore et al. 2009) to an understudied area; and examining the link between risk perceptions and other factors, including attitudes, sociodemographics, and actual behaviors, to better understand the concept's utility in the conservation context. By including residents along the WUI, where risk potential is heightened by a greater likelihood of cat–wildlife interactions, our findings may have more immediate impact for efforts aimed at minimizing the risks associated with outdoor pet cats in urbanizing environments.

Our results suggest that individuals do not perceive the risks associated with outdoor pet cats equally. Whereas some people assigned a low probability to bidirectional risks and others believed all risks were likely, most of our study participants (73%) were classified in groups between these two extremes. The risks of wildlife predation on cats and cats preying on wildlife have been confirmed by numerous studies worldwide (Grubbs & Krausman 2009; Loss et al. 2013). Similarly, cats can both contract diseases from and transmit diseases to wildlife (Brown et al. 2008; Gerhold & Jessup 2013) and harbor zoonotic pathogens such as *Toxoplasma gondii* (Patronek 1998). Although the real likelihood of predation risks seems to align with public perceptions characterized by our study, there appears to be a disconnect regarding disease-related risks. This finding is consistent with other studies showing that risk perceptions do not often coincide with actual risk potential (Gore et al. 2009), and it suggests a need to target misperceptions regarding disease transmission in communication programs about outdoor pet cats. Further, such programs could be strengthened by incorporating information from biological assessments of actual risks in localized settings, bringing greater attention and relevance to the disease potential among residents.

We identified several underlying factors related to differences in risk perceptions. Consistent with our hypothesis, respondents with higher risk perceptions had more negative attitudes toward cats being allowed outside. Similarly, individuals with higher risk perceptions showed greater support for cat-management strategies. The most acceptable strategies were those requiring sterilization and vaccination, a finding consistent with that of other domestic cat-related studies (Grayson & Calver 2004; Lilith et al. 2006), suggesting it may behoove local municipalities to focus management efforts on these measures as well as funding them if cost has a large bearing on compliance. Although a variety of factors need to be considered in policy decisions, adopting management strategies that are more acceptable to the public can minimize conflict (Teel & Manfredo 2009) and simultaneously reduce the risk of negative cat-wildlife interactions. Additionally, promoting these measures and raising awareness about risks through communication may increase the acceptability of and compliance with cat-management strategies as a whole (Cho 2003).

As expected, certain prior experiences, including recent problems with neighborhood cats, were related to heightened risk perceptions. We also found evidence for our predicted relationship between risk perceptions and cat-owner behaviors. Owners who do not restrict their cats' outdoor activity had lower risk perceptions than owners with indoor-only cats and owners who use restrictions, such as using outdoor cat enclosures or letting cats outside only during daylight hours. These findings provide additional support for the notion that changes in risk perceptions could result in behavior change (Cho 2003). More specifically, they suggest that local, targeted information that can increase risk perceptions regarding outdoor pet cats may prove useful in conservation efforts aimed at promoting adoption of risk-mitigation actions.

Previous conservation social science studies show that individuals' sociodemographic characteristics tend not to be strong predictors of cognitive variables such as attitudes (Teel & Manfredo 2009). Similarly, we did not find practically meaningful differences between risk clusters based on sociodemographics, with the exception of urban versus rural residence. Urban residents in the front range near the WUI had higher overall risk perceptions than more rural residents on the western slope. This finding is consistent with prior research identifying heightened risk perceptions among urban residents (Coleman & Temple 1993; Riley & Decker 2000*b*; Lord 2008) and suggests that communication and management efforts should not be developed with a one-size-fits-all

approach; instead, such efforts should be tailored to each community. Further, this finding emphasizes the importance of understanding risk perceptions of residents near the WUI, a rapidly expanding interface of human–wildlife interaction worldwide (Radeloff et al. 2005).

Overall, our results indicate that information about risk perceptions, given their connection to cat-owner behaviors and attitudes toward management actions, could play a valuable role in the development of effective communication programs utilized by organizations such as those concerned with animal welfare, wildlife conservation, and human health. Although communication is unlikely to change the perceptions and behaviors of individuals with extreme positions, most respondents in our study belonged to intermediate risk clusters, groups that would likely achieve the greatest results if targeted (Teel et al. 2006). Also, whereas it is important to acknowledge that communication is not the only strategy to mitigate outdoor-cat-related risks, it can, by promoting self-efficacy and maintaining one's freedom of choice, lead to more long-lasting behavior change and less public controversy relative to other alternatives such as legal mandates (Schweizer et al. 2009).

Further insight would be gained from studies aimed at identifying additional factors at the root of human behavior as they relate to free-ranging cats. For example, affective components of risk perceptions, such as feelings of dread or happiness associated with risks (Riley & Decker 2000*a*; Wieczorek-Hudenko 2012), could be explored relative to outdoor pet-cat issues. Identification of possible normative influences, shown to have a powerful effect on certain behaviors (Schultz 2011), would also be informative. Normative factors would include beliefs about how one ought to behave based on what others around you (e.g., neighbors, important peer groups) think and do. It would also be useful to determine what barriers and benefits may exist to adoption of certain risk-mitigation behaviors because these variables are a critical consideration in the success of behavior-change campaigns (McKenzie-Mohr et al. 2012). Another consideration is the impact of thresholds (e.g., particular events such as a sighting of a large predator or pet attack) that might cause owners to restrict their cats' activity. Given that our study was based on self-reported behaviors and experiences, future research should also attempt to incorporate observational methods to validate our conclusions. Finally, to strengthen the applied outcomes of this type of research, experimental social-ecological investigations could be designed to examine possible changes in cat-owner behavior and subsequent conservation impacts as a function of risk communication and other strategies informed by our findings (Miller et al. 2012).

Restricting the outdoor activity of free-ranging cats on the landscape is paramount to addressing their negative impacts on wildlife and the natural environment, and changing people's behaviors will be necessary to accomplish this goal. Thus, the conservation implications of communication aimed at behavior change that can be informed by this type of social science inquiry are clear, and they extend beyond the realm of outdoor pet-cat issues. By relying on a theory-driven approach, which builds on demonstrated relationships among concepts known to influence human behavior, lessons learned from social-science investigations will have greater cross-contextual relevance across multiple issues and geographic settings for the conservation of biodiversity in human-dominated landscapes.

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Supporting Information

Our sampling method (Appendix S1) and the survey instrument (Appendix S2) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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