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Review

Meta-Analysis of Attitudes toward Damage-Causing Mammalian Wildlife

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Abstract: *Many populations of threatened mammals persist outside formally protected areas, and their survival depends on the willingness of communities to coexist with them. An understanding of the attitudes, and specifically the tolerance, of individuals and communities and the factors that determine these is therefore fundamental to designing strategies to alleviate human-wildlife conflict. We conducted a meta-analysis to identify factors that affected attitudes toward 4 groups of terrestrial mammals. Elephants (65%) elicited the most positive attitudes, followed by primates (55%), ungulates (53%), and carnivores (44%). Urban residents presented the most positive attitudes (80%), followed by commercial farmers (51%) and communal farmers (26%). A tolerance to damage index showed that human tolerance of ungulates and primates was proportional to the probability of experiencing damage while elephants elicited tolerance levels higher than anticipated and carnivores elicited tolerance levels lower than anticipated. Contrary to conventional wisdom, experiencing damage was not always the dominant factor determining attitudes. Communal farmers had a lower probability of being positive toward carnivores irrespective of probability of experiencing damage, while commercial farmers and urban residents were more likely to be positive toward carnivores irrespective of damage. Urban residents were more likely to be positive toward ungulates, elephants, and primates when probability of damage was low, but not when it was high. Commercial and communal farmers had a higher probability of being positive toward ungulates, primates, and elephants irrespective of probability of experiencing damage. Taxonomic bias may therefore be important. Identifying the distinct factors explaining these attitudes and the specific contexts in which they operate, inclusive of the species causing damage, will be essential for prioritizing conservation investments.*

Keywords: carnivores, conservation psychology, elephant, human-wildlife conflict, primates, tolerance, ungulates

Meta-Análisis de las Posturas hacia la Mamíferos Silvestres Causantes de Daños

Resumen: *Muchas poblaciones de mamíferos amenazados persisten fuera de áreas protegidas formales y su supervivencia depende de la buena voluntad de las comunidades que coexisten con ellos. Un entendimiento de las posturas, y específicamente de la tolerancia, de los individuos y las comunidades y los factores que los determinan es fundamental para diseñar estrategias que alivien el conflicto humano – vida silvestre. Llevamos a cabo un meta-análisis para identificar los factores que afectaron las posturas hacia cuatro grupos de mamíferos terrestres. Los elefantes (65%) provocaron las posturas más positivas. Los siguieron los primates (55%), los ungulados (53%) y los carnívoros (44%). Los residentes urbanos presentaron las posturas más positivas (80%), seguidos por los granjeros comerciales (51%) y los granjeros comunales (26%). Un índice de tolerancia a los daños mostró que la tolerancia humana a los ungulados y primates fue proporcional*

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a la probabilidad de experimentar daños mientras que los elefantes provocaron niveles de tolerancia más altos de lo esperado y los carnívoros provocaron niveles de tolerancia más bajos de lo esperado. Contrario a la sabiduría convencional, experimentar daños no fue siempre el factor dominante para determinar las posturas. Los granjeros comunales tuvieron una baja probabilidad de ser positivos hacia los carnívoros independientemente de la probabilidad de experimentar daños, mientras que los granjeros comerciales y los residentes urbanos tuvieron mayor probabilidad de ser positivos hacia los carnívoros independientemente de los daños. Los residentes urbanos tuvieron mayor probabilidad de ser positivos hacia los ungulados, los elefantes y los primates cuando la probabilidad de daños fue baja, pero no cuando fue alta. Los granjeros comerciales y comunales tuvieron una mayor probabilidad de ser positivos hacia los ungulados, los primates y los elefantes independientemente de la probabilidad de experimentar daños. El prejuicio taxonómico por eso puede ser importante. El identificar los distintos factores que explican estas posturas y los contextos específicos en los cuales operan, inclusivo de especies que causan daños, será esencial para priorizar las inversiones en la conservación.

Palabras Clave: Carnívoros, conflicto humano–vida silvestre, elefante, primates, psicología de la conservación, tolerancia, ungulado

Introduction

Human Dimensions of Conservation and Human-Wildlife Conflict

Understanding and empowering people through conservation initiatives is widely regarded as essential for implementing effective conservation initiatives (Smith et al. 2009; Minteer & Miller 2011). However, integration of the natural and social sciences has been slow (Mascia et al. 2003; Saunders et al. 2006; Decker et al. 2009) and remains a major challenge (Jentsch et al. 2003; Gilbert & Hulst 2006). Effective wildlife management in the 21st century should therefore aim to manage interactions between wildlife and people to achieve goals valued by stakeholders (Riley et al. 2002). This requires conservation managers and policy makers to consider the values of stakeholders whose cooperation and support is required to achieve conservation goals (Decker et al. 2011). Human-wildlife conflict (HWC) is more than simply competition for space, food, and life—it pits different values for nature against one another, demanding attention from economic, legal, social, and environmental policy makers (Knight 2000; Nie 2002).

Human Attitudes in HWC

Attitudes can be defined as a disposition or tendency to respond with some degree of favorableness, or not, to a psychological object, the psychological object being any discernible aspect of an individual's world including an object, a person, an issue, or a behavior (Fishbein & Ajzen 2010). The attitude construct has occupied a central position in social psychology (Allport 1935; Fiske & Taylor 2013), and specifically environmental psychology (Clayton 2012), for decades because of how pervasive evaluation is in everyday life. Without the ability to evaluate our environment in terms of good and bad, desirable and undesirable, or approach and avoid an individual's existence would be truly chaotic and probably quite short (Fazio & Olson 2012). For this reason, the attitude concept has been at the center of attempts to predict and explain human behavior (Fishbein & Ajzen 2010). The attitude concept has been extensively applied in research into the human dimensions of wildlife management (Manfredo et al. 2009*a*, 2009*b*; Decker et al. 2012).

The concept of tolerance in the HWC literature has generally been used interchangeably with the attitude concept (Naughton-Treves et al. 2003; Karlsson & Sjöström 2011). *Tolerance* can be defined as "the action of bearing hardship, or the ability to bear pain and hardship" (*Oxford English Dictionary*, x ed. [online], s.v. "tolerance") and more specifically in the context of HWC as an ability to accept damage from wildlife (Marker et al. 2003; Zimmermann et al. 2005).

We conducted a meta-analysis (Glass 1976) of studies investigating the attitudes of people experiencing direct conflict with large and medium-sized mammals, specifically carnivores, elephants, primates, and ungulates. Larger mammalian species are generally more at risk of extinction (Purvis et al. 2000; Schipper et al. 2008; Inskip & Zimmermann 2009), often fulfill critical roles in ecosystem functioning (Estes et al. 2011), and occur mostly outside protected areas (Grunblatt et al. 1996; Crooks et al. 2011; Cantu´-Salazar et al 2013). This is particularly the case for carnivores. For example, more than 80% of remaining habitat occupied by tigers (*Panthera tigris*) is outside reserves (Miquelle et al. 1999), and more than 90% of jaguar (*Panthera onca*) and snow leopard (*Panthera uncia)* habitat is outside reserves (Nowell & Jackson 1996).

Accordingly, the attitudes, perceptions, and tolerance of people living with wildlife are relevant to conservation managers and policy makers (Decker et al. 2011). Despite the large number of global studies examining attitudes toward HWC, including qualitative reviews (Naughton & Treves 1999; Sillero-Zubiri & Laurenson 2001; Treves 2009; Dickman 2010), we are aware of only one quantitative review, which was limited specifically to wolves (Williams et al. 2002). Our aims were to quantify

potential differences in attitudes toward species groups across countries and stakeholder groups; determine if experiencing damage contributes to attitudes toward species groups; and, develop a measure of human tolerance toward HWC that allows comparisons between different stakeholder groups in different locations for different species and species groups.

Methods

We conducted a meta-analysis of peer-reviewed journal articles published from 1 January 1990 through March 2011 in English that quantified the attitudes of stakeholders who had experienced direct conflict with carnivores, elephants, primates, or ungulates. We defined an attitude as "a disposition or tendency to respond with some degree of favor, or not, to a psychological object" (Fishbein & Ajzen 2010). To qualify, attitude measures had to be evaluative and quantified on a scale. Studies detailing attitudes of individuals not having direct experience with HWC were excluded because the general public can have more positive attitudes toward wildlife when not directly affected (Williams et al. 2002; Martín-López et al. 2008), although, in some cases, negative attitudes are displayed by people not having contact with a species (Treves et al. 2013). We restricted our references to those published in scientific journals (Calver & King 1999). Although inclusion of gray literature in meta-analyses is sometimes recommended to prevent publication bias for significant results (Rosenthal 1979), this was not an issue in our review because attitudes were recorded as percentage of respondents having positive, neutral, or negative attitudes.

We searched Web of science for terms listed in Supporting Information. We then located additional publications by examining the reference list of each publication. Finally, we refined the publications to include only those published after 1990 because studies conducted before 1990 were few and commonly applied outdated methods. We then examined the selected publications in detail and extracted and compiled 8 variables in an Excel spreadsheet. The variables extracted were defined by their availability across all publications and their relevance to our research questions. The variables are defined in Table 1.

Data Analyses

The attitudes reported in percentages in each publication were extracted and converted to a binary variable as either positive or nonpositive. A binary variable was necessary because some publications reported 2 category responses (e.g., yes or no) to attitude questions. Where a middle value of an attitude scale was used, we categorized it as either a positive or nonpositive value depending on the context of the question. For example, for questions, such as would you like the population of species x to increase, stay the same, or decrease? We combined "stay the same" and "increase" because we considered "stay the same" to be more aligned with a positive rather than nonpositive attitude. For cases where the middle value was not obviously aligned with a positive attitude, responses were categorized as nonpositive. We think it is more robust to have a false negative than a false positive because assuming people are more positive than they are would be more detrimental to a species.

We assigned responses for each individual participating in a survey to a positive or nonpositive attitude category using the following computation: if 20% of a survey sample of 300 individuals reported positive attitudes, 60 individuals were coded as positive and 240 nonpositive. To derive a similar individual record for the damage variable, we converted the percentage of respondents experiencing damage into a probability of experiencing damage per individual. For example, if 40% of a sample experienced damage, then the probability of each individual experiencing damage was 0.4. We assigned a probability to each individual rather than a definitive yes or no because information on individual respondents was typically unavailable.

Not all publications reported what proportion of the sample experienced damage from individual species. We therefore compiled 2 types of data sets, a smaller one which did not report a damage proportion and a larger one that did. For most analyses, we used the 2 data sets combined to create one large data set without a damage variable (whole data set [WD]). However, since we were also interested in the effect of experiencing damage on attitudes, we used the smaller data set (damage data set [DD]) to examine this.

We conducted 2 types of multivariate analyses. First, we used classification and regression trees (CART) (Breiman et al. 1993) to produce importance plots and cost sequence plots (Supporting Information). Second, we used logistic regressions to calculate Wald statistic and odds ratios. For both analyses, we used Statistica 11 (StatSoft 2012). Due to the exploratory approach of the CART procedure and subsequent risk of overfitting the data, we randomly split the data set into a test sample of 30% of all records and a train sample of the remaining 70% of the data. We compared the results of these 2 subsets to check the validity of our tests. Analysis of the damage extent variable was conducted using one-way ANOVA with Fisher least signficant difference (LSD) post hoc tests. As described above and in Table 1, we used 2 data sets WD and DD and thus conducted 2 analyses (CART and logistic regression) on each. We also conducted 2 scales of analysis, the first on primary variables (column 1 in Table 1) and the second on secondary variables (column 3 in Table 1). Secondary variables formed subcategories of primary variables. For example, the primary variable stakeholder comprised

Table 1. The primary and secondary variables extracted from publications and examined for their affect on attitudes toward 4 groups of mammalian wildlife.

Primary variable	*Definition*	*Secondary variables*
Question type	items (i.e., questions) used in individual studies to measure respondents attitudes, perceptions, and tolerance	Questions were coded into 7 themes that emerged from the data and were not based on any prior theoretical concepts. These were questions seeking responses: support for an increase, decrease, or stable future population of a species; whether a person had or would kill or remove a species from her or his property; desirability of a species on a persons' property or desirability of living near a species; support for removal or lethal control of a species as a management option, in the context of under-abundant species; support for reduction of over-abundant species with nonlethal control; describes an affect or cognition of a species, such as the extent to which a species is liked or should be conserved (questions consisted of single or multiple questions summarized into a single index); degree to which an individual will tolerate damage from a species.
Attitude	proportion of all individuals surveyed in the publications included in this meta-analysis who presented positive or nonpositive attitudes	A binary variable was computed by collapsing scales with multiple categories into 2 categories of responses. When the scale consisted of an even number of items, the binary variable was created by splitting the number of items equally and summing each half. When the scale consisted of an uneven number of items, the middle category was added to either the positive or nonpositive categories, depending on the context.
Species	animals widely recognized as a biologically distinct group for which attitudes were reported	Each species was afforded a separate entry. Some publications reported on several species while others focused on a single species. The full species list is reported in Supporting Information.
Species group	order or grand order to which a species belonged	Species were categorized into 4 groups as carnivores, ungulates, primates, or elephants by order or grand order according to Kingdon (2003).
Country development status	status of a country as categorized by criteria of wealth and human well-being	Countries were categorized as either developed or developing according to the United Nations criteria of developed or developing regions. Developing countries were those from Africa, the Caribbean, Central America, South America, Asia, excluding Japan, and the Americas, excluding North America. Developed regions were North America, Europe, and Japan (http://unstats.un.org/unsd/methods/m49/m49regin.htm#least)
Experience direct conflict	respondents who lived within the range of the species under consideration	Publications were initially excluded if respondents' attitudes were not recorded separately for respondents who lived within the range of the species under consideration and those who did not live within the range of the species under consideration. However, the small number of publications identified with this criterion necessitated that we include those publications that consisted of both types of respondents. Ultimately, 2 categories of publications were identified: live in conflict zone (LCZ) and live in mixed conflict and nonconflict zone (MZ).

Continued

Table 1. continued

Primary variable	*Definition*	*Secondary variables*
Stakeholder group	categories of respondents surveyed in the publications included in this meta-analysis	Five categories emerged from the publications surveyed: commercial farmers (broad-scale producers of crop and animal products primarily for commercial sale), communal farmers (small-scale crop and animal producers who primarily produce for subsistence or possibly for sale), urban residents, other (applied when a publication did not explicitly identify a stakeholder type or to any other type of stakeholder that experienced direct conflict but was not categorized as commercial or communal farmer, urban resident, or "no damage" by the researcher, for example rural residents, hunters, berry pickers). The second type of "other" in the other category was necessary because there was an insufficient number of publications with these stakeholder categories to analyze statistically. No damage stakeholders were those who, although living in an area where a species occurred, did not have costs imposed by wildlife, for example tourists visiting a nature reserve.
Damage	proportion of respondents who experienced a cost from a species	Not all publications reported what proportion of the sample experienced damage from a particular species. Two types of data sets were therefore compiled, a smaller one which did not report a damage proportion and a larger one that did. Most analyses used the 2 data sets combined to create one large data set without a damage variable (whole data set [WD]). Because the effect of experiencing damage on attitudes was also of interest, we used the smaller data set (damage data set [DD]) to examine this.

[a]*The primary variables are defined in the second column. The secondary variables were subcategories of the primary variables and are listed and defined in the third column.*

4 secondary variables: commercial farmers, communal farmers, urban residents, and others. For most analyses we report on the WD only, while analyses of the DD are reported when examining the effect of experiencing damage on an individual's attitudes. We defined tolerance as "the proportion of individuals who have a positive attitude toward a species group despite suffering damage by that species group" and computed a tolerance to damage index (TDI) as follows: TDI = proportion of individuals suffering damage – (1 – proportion of individuals with positive attitudes), where the proportion of individuals suffering damage is the proportion of the respondents in a study who experienced some damage from a species and 1 – proportion positive is the proportion of individuals in a study whose responses were nonpositive.

A tolerance value of 0 indicates neutrality (i.e., proportion of respondents with a positive attitude is proportional to the proportion of respondents experiencing damage). A negative value indicates low tolerance, and a positive value indicates high tolerance. Because we could not match damage data to individual attitudes, we calculated this index with publication level data and thus could not incorporate sample sizes of each study into this index.

We identified 508 publications related to the topic of HWC, which was refined down to 54 publications that met the criteria for inclusion in the meta-analysis (Supporting Information). When coded, this produced a data set of 83,820 individual responses for the WD and 28,436 individual responses for the DD. The 54 publications covered 22 countries and 43 different species (Supporting Information). Twenty-two (41%) of the studies were conducted in developed nations and 32 (59%) in developing nations. One publication was conducted in both developed and developing countries (Supporting Information).

The number of publications which surveyed people's attitudes toward different carnivore species (64) was more than twice the number of publications which surveyed people's attitudes toward different ungulate species (30), 9 times more than the number of publications which surveyed people's attitudes toward elephants (7), and 16 times more than the number of publications which surveyed people's attitudes toward primates (4) (Supporting Information). Considering the total number of respondents surveyed, 81% were surveyed on their attitudes toward carnivores, 14% were surveyed on their attitudes toward ungulates, 3% were surveyed on their attitudes toward elephants, and 2% were surveyed

Table 2. Attitudes of respondents toward damage-causing mammalian wildlife by stakeholder and species group.

Group	*Positive attitude (%)*	*Nonpositive attitudes (%)*
Stakeholder type[a]		
all stakeholders	46	54
urban residents	80	20
commercial farmers	51	49
communal farmers	26	74
other	43	57
no damage	61	39
Species		
elephants	65	35
primates	55	45
ungulates	53	47
carnivores	44	56

[a]*The stakeholder categories are defined in Table 1.*

on their attitudes toward primates. Attitudes of respondents were solicited for 22% of carnivore species (International Union for Conservation of Nature [IUCN] total = 285 spp.), 9% of ungulate species (IUCN total = 329 spp.), and 1% of primate species (IUCN total = 414 spp.) listed on the IUCN Red List (2008). The percentage for elephants was 3500% because there are only 2 species.

Results

Describing Attitudes

Forty-six percent of respondents presented positive attitudes, and 54% had nonpositive attitudes. Eighty percent of urban residents had positive attitudes, whereas 51% of commercial farmers and 26% of communal farmers had positive attitudes. Forty-three percent of others and 61% of those who experienced no damage had positive attitudes (Table 2).

Elephants elicited the greatest proportion of positive responses from stakeholders (65%), while carnivores elicited the smallest proportion of positive attitudes (44%). Primates (55%) and ungulates (53%) elicited similar proportions of positive attitudes and respondents had equal probability of presenting positive and non positive attitudes towards primates and ungulates (Table 2).

Experience of Damage

On average, 40% of individuals surveyed from developed countries and 39% from developing countries experienced damage from wildlife. These differences were not significantly different ($F_{(1, 103)} = 0.13523$, $p = 0.71$). Sixty-two percent of all stakeholders experienced damage from elephants, 55% from ungulates, 49% from primates, and 31% from carnivores. Significant differences were found between species groups ($F = 6.7$, $p < 0.01$), and post hoc tests showed a significant difference between carnivores and elephants ($p = 0.01$) and carnivores and ungulates ($p = 0.01$), but not between carnivores and primates or elephants and primates (Fig. 1a).

Communal farmers (43%), urban residents (43%), and commercial farmers (39%) had similar probabilities of experiencing damage from wildlife (one-way ANOVA $F = 1.42$, $p = 0.24$). Other stakeholders experienced the lowest probability of damage (21%) (Fig. 1b).

Tolerance to Damage Index

The TDI (Table 1) was 0.15 for both developed and developing countries ($F(1,103) = 0.00396$, $p = 0.95$). Respondents were most tolerant of elephants (0.16) and least tolerant of carnivores (−0.26). Tolerance of ungulates (0.03) and primates (0.04) was close to zero, indicating that attitudes were proportional to damage experienced. The TDI between species groups differed significantly ($F(3,101) = 5.889$, $p < 0.01$). In post hoc tests, respondent tolerance of carnivores was significantly lower than their tolerance of ungulates ($p < 0.01$), primates ($p < 0.05$), and elephants ($p = 0.014$), but there were no significant differences between respondent tolerance of ungulates, primates, or elephants (Fig. 2a).

The TDI was negative for all stakeholders: lowest for other stakeholders (−0.32) and highest for commercial farmers (−0.05). Urban residents (−0.19) and communal farmers (−0.20) presented similar TDIs. There were no significant differences in TDI among stakeholders ($F(1,101) = 1.906$, $p = 0.13$), although differences between communal and commercial farmers ($p = 0.075$) and between other and commercial farmers ($p = 0.055$) were nearly significant (Fig. 2b).

Explaining Attitudes

Analysis of primary variables was conducted on the WD with attitude as the response variable and 5 predictor variables: stakeholder group, question type, species group, experience of direct conflict and development status (Table 1). Logistic regressions identified all 5 variables as contributing significantly to explaining positive attitudes toward species ($p < 0.001$). The stakeholder group had the highest Wald statistic (1674), followed by question type (1287), species group (753), and development status of the country (295) (Fig. 3a). Results of the CART analysis showed similar rankings for question type code (2nd) and development status of country (4th) but ranked species group as the most important (1st), while stakeholder group ranked third (Fig. 3b).

Using the DD with attitude as the dependent variable and the 5 independent variables above, in addition to the damage variable as the 6th variable, damage contributed significantly to explaining positive attitudes ($p < 0.0001$). In addition, damage ranked 4th (Wald = 64) in the

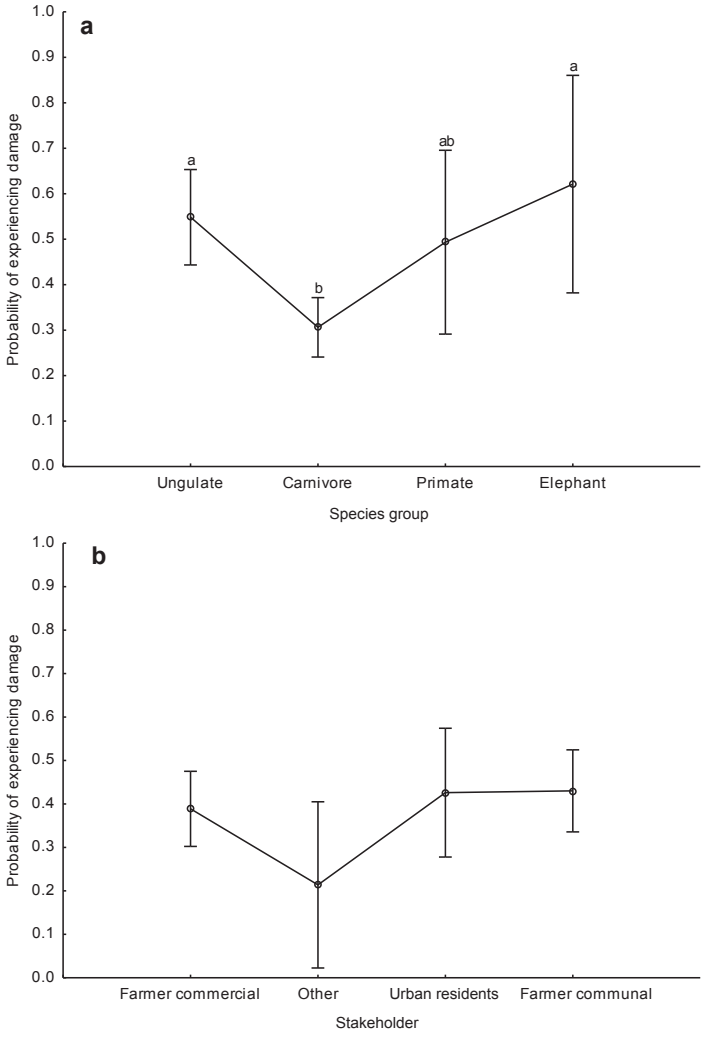

Figure 1. The probability of a survey respondent experiencing damage due to the presence of wildlife by (a) species group and (b) stakeholder group. Letters above bars indicate significant post hoc differences between groups. Comparing 2 groups, if at least one letter occurs in each group, the groups do not differ significantly ($p > 0.05$). No overlapping letters indicate significant differences ($p < 0.05$).

logistic regression (Fig. 3a) and third in the CART analysis (Fig. 3b).

Logistic regressions of the secondary variables Table 1 with the WD data set presented significant p values for all 5 stakeholder groups ($p < 0.001$). Commercial farmers (odds ratio = 1.35) and urban residents (odds ratio = 1.9) were more likely to exhibit positive attitudes, while communal farmers (odds ratio = 0.48) and other stakeholders (odds ratio = 0.74) were between 2 and 1.4 times more likely to have nonpositive attitudes, respectively.

Significant p values were obtained for all 4 species groups ($p < 0.001$). Elephants (odds ratio = 2.3) were more likely to elicit positive attitudes, while primates (odds ratio = 0.9), ungulates (odds ratio = 0.8), and carnivores (odds ratio = 0.6) were more likely to elicit nonpositive attitudes. The CART analysis suggested that communal farmers were particularly likely to present nonpositive attitudes toward carnivores, irrespective of the question type (72% compared to 54% of all stakeholders).

Logistic regression on the DD indicated that the probability of experiencing damage was a significant variable in explaining attitudes toward different species groups ($p < 0.001$). The effect of damage was corroborated by the CART analysis, where 5 trends emerged (Fig. 4). Similar to the WD, communal farmers were also more likely to elicit a nonpositive response toward carnivores irrespective of question type and the probability of experiencing damage (77% vs. 56%). For commercial farmers, urban residents and other stakeholders, the probability of a positive or nonpositive response was similar, but it tended toward positive (47% vs. 44%). Communal farmers, commercial farmers, and no damage stakeholders were more likely to present positive attitudes toward ungulates, primates, and elephants (66% vs. 44%) irrespective of question type and probability of damage. Urban residents and other stakeholders were more likely to be nonpositive when probabilities of damage from ungulates, elephants, and primates were high (62% vs. 44%) and more likely to be positive with low

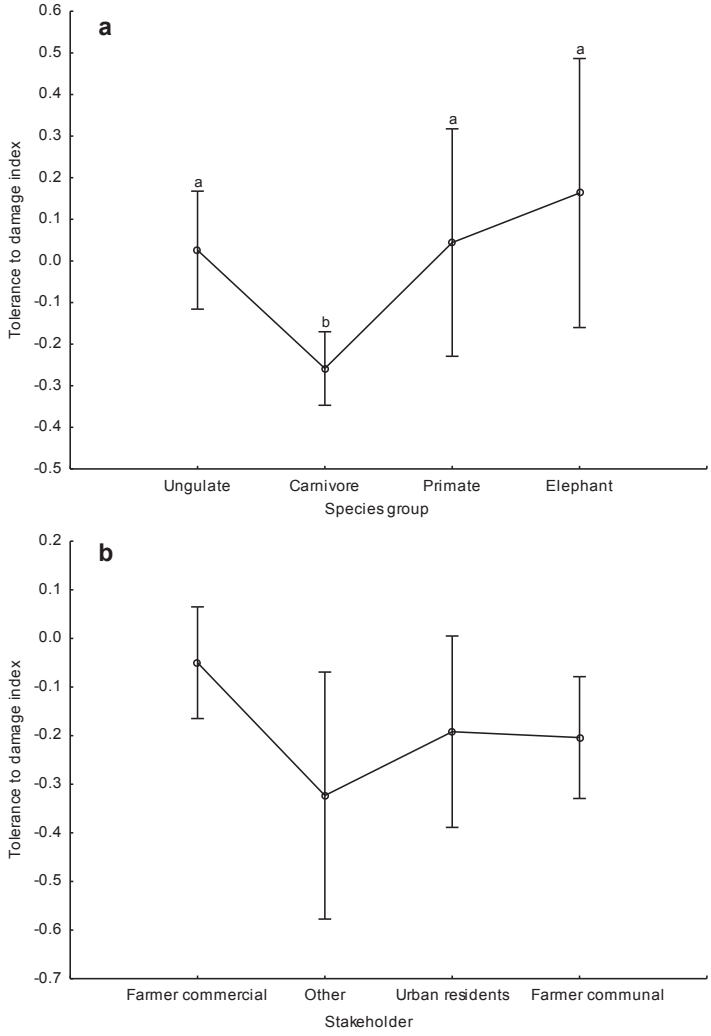

Figure 2. Mean values of the tolerance to wildlife damage index (TDI) by (a) species group and (b) stakeholder group. A tolerance value of zero indicates neutrality (i.e., proportion of respondents with a positive attitude is proportional to the proportion of respondents experiencing damage). A negative value indicates low tolerance, and a positive value indicates high tolerance. Letters above bars indicate significant post hoc differences between groups. Comparing 2 groups, if at least one letter occurs in each group, the groups do not differ significantly ($p > 0.05$). No overlapping letters indicate significant differences ($p < 0.05$).

probabilities of damage from these groups (74% vs. 56%) (Fig. 4).

Carnivores

Carnivores were the only group within the WD for which there was a sufficiently large number of individual species studied to allow exploration of attitudes toward different carnivore species. Logistic regression indicated that mountain lion (*Puma concolor*) (odds ratio = 1.12) and lynx (*Lynx* spp.) (odds ratios = 1) were equally likely to elicit positive or nonpositive attitudes (Fig. 5). The remaining species all had significant p values ($p < 0.001$). Species with high probabilities of eliciting positive attitudes were tiger (odds ratio = 2.4), wild dog (*Lycaon pictus*) (odds ratio = 1.86), lion (*Panthera leo leo)* (odds ratio = 1.64), leopard (*Panthera pardus*) (odds ratio = 1.63), cheetah (*Acinonyx jubatus*) (odds ratio = 1.2), and jackal (*Canis mesomelas*) (odds ratio = 1.2). The species that were significantly more likely to elicit a nonpositive attitude were wolverine (*Gulo gulo*) (odds ratio = 0.8), wolf (*Canis lupus*) (odds ratio = 0.66), bear (*Ursus* spp.) (odds ratio = 0.65), hyena (*Crocuta crocuta*, *Hyaena* sp.) (odds ratio = 0.57), and coyote (*Canis latrans*) (odds ratio = 0.3) (Fig. 5).

Finally, we explored the effect of damage by individual carnivore species on different stakeholder groups using the DD. Four trends emerged from the CART analysis (Fig. 6). Commercial farmers, urban, and other stakeholders were more likely to exhibit nonpositive attitudes toward coyotes (77% vs. 65%) and positive attitudes toward wolf, bear, mountain lion, cheetah, hyena, leopard, jackal, wild dog, and tiger, irrespective of probability of damage or question type. For the majority of cases, communal farmers were more likely to exhibit nonpositive attitudes toward all carnivore species when the probability of damage was low (81% vs. 65%), but for a small subset of cases (300), counter-intuitively, they were more

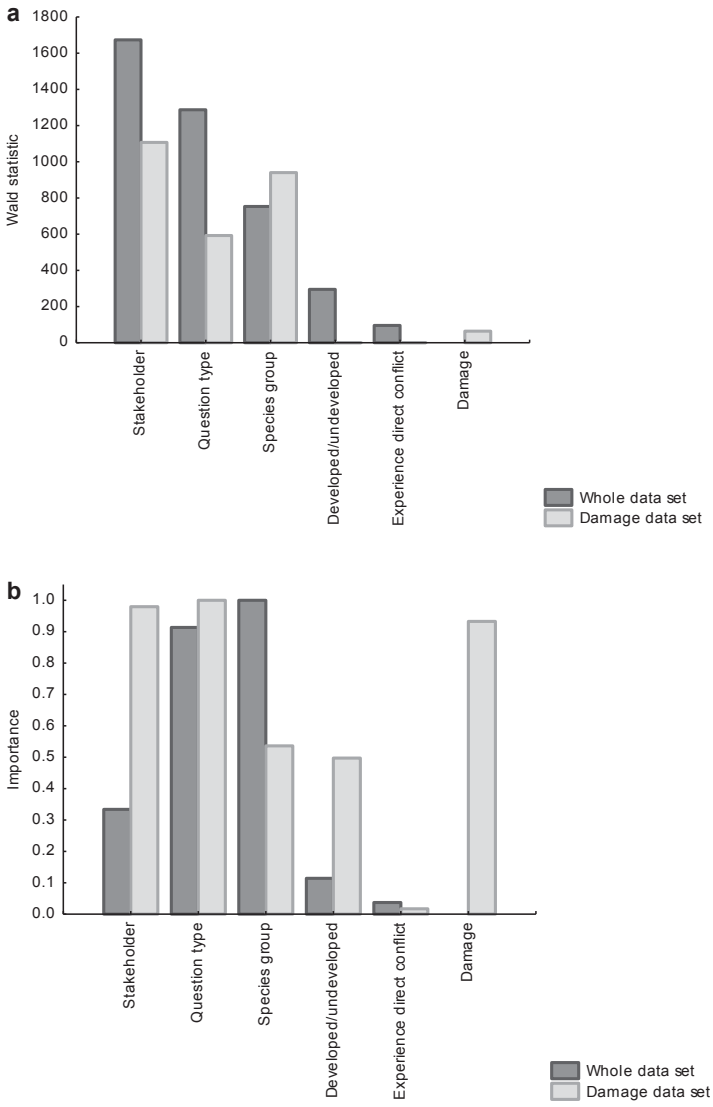

Figure 3. (a) Results of (a) logistic regression (Wald statistic) and (b) CART analysis for both the whole data set and the damage data set, showing contribution and relative importance, respectively, of 6 variables to explaining positive attitudes toward different wildlife species. Variable definitions are defined in Table 1. For logistic regression (a) whole data set, all five variables significantly contributed to explaining positive attitudes ($p < 0.0001$). For logistic regression, damage data set, all variables contributed to explaining positive attitudes ($p < 0.0001$) except developed/undeveloped and experience direct conflict.

likely to be positive when the probability of experiencing damage was high (65% vs. 35%), irrespective of question type (Fig. 6).

Discussion

Development Status of Country

The development status of a country was statistically significant, but of relatively low importance in determining positive attitudes toward damage causing wildlife (Fig. 3). This suggests that while stakeholder group, question type, and species group mostly explained positive attitudes, the development status of a country did explain some positive attitudes. Since differences between developed and developing countries are often related to wealth, health services, education, and institutional infrastructure, research explaining the factors determining these differences will assist in designing more effective species management policies and strategies.

Tolerance of Damage

Respondents' tolerance to damage from ungulates and primates was proportional to the probability of experiencing damage (Fig. 2), but they presented lower tolerance toward carnivores and higher tolerance toward elephants. Our damage variable measured whether a respondent experienced damage or not and did not account for the severity or financial costs accruing to stakeholders, meaning stakeholders may have experienced more severe damage from carnivores than from elephants, ungulates, or primates. Alternatively, livestock may have intangible values that were not documented,

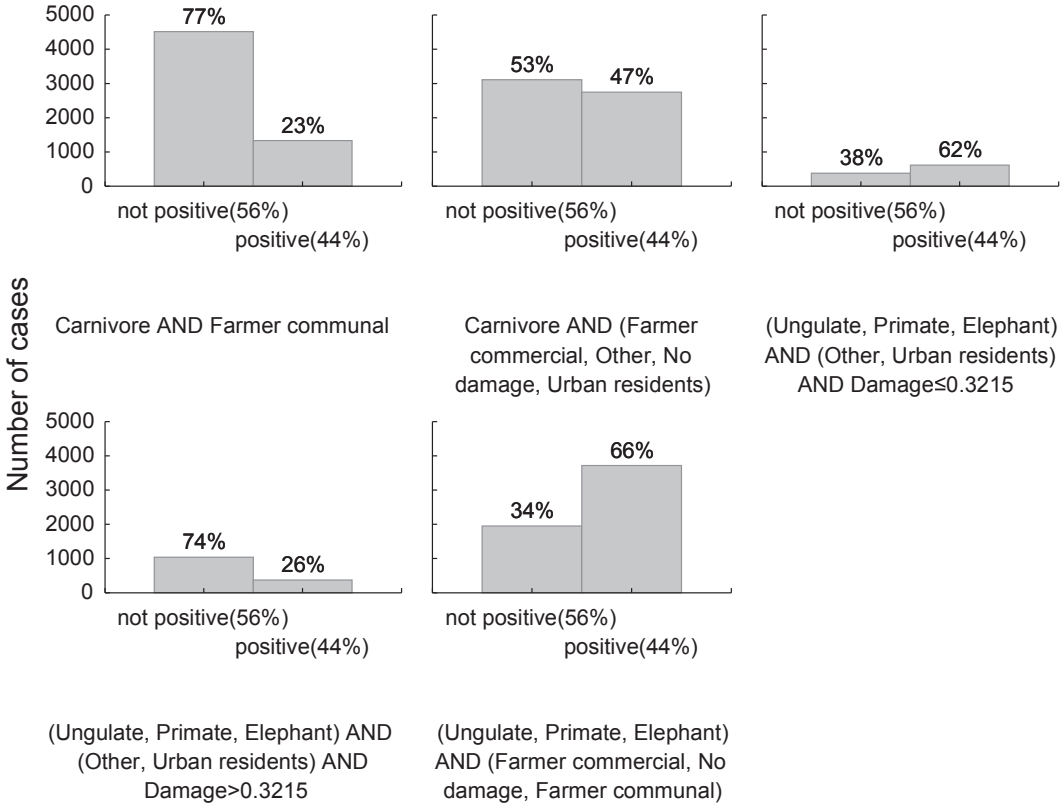

Figure 4. Attitudes (positive and not positive) of respondents toward different wildlife species determined by CART cost sequence analysis of the damage data set and secondary variables. Primary and secondary variables are described in Table 1. CART partitions the data into subgroups (each characterized by a rule which identifies the subgroup) which are as distinct as possible. Here 5 subgroups were generated. The percentages in parentheses on the x-axis indicate the percentage of that class in the whole data set. The percentage above the bar gives the percentage of the class in the subgroup. For example, for the first subgroup (carnivores and farmer communal), 77% of the cases were "not positive," whereas for the whole data set 56% of cases were not positive. The damage probability value is the cut-off point generated by CART rules.

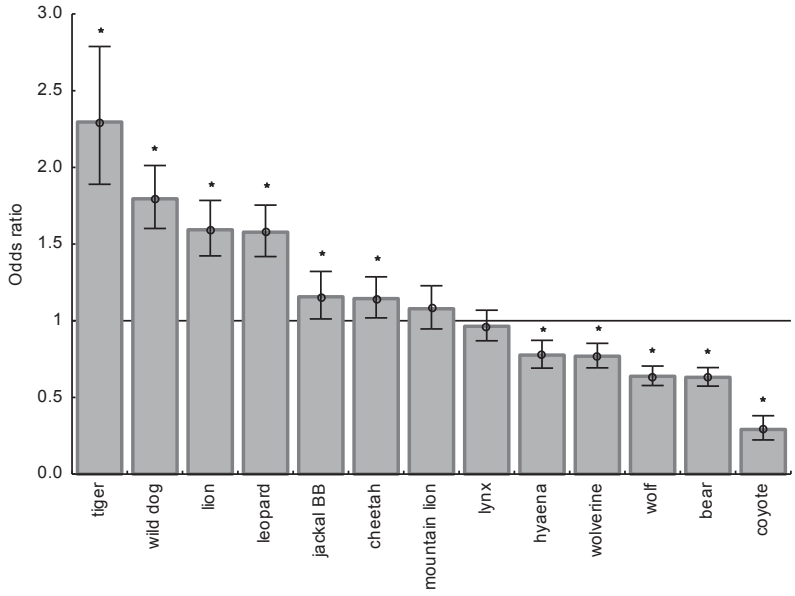

*Figure 5. Attitudes (positive and not positive) toward carnivore species as determined by logistical regression analysis (described in methods) with the whole data set (described in methods) (BB, black backed jackal; bars, 95% confidence limits; * $p<0.001$).*

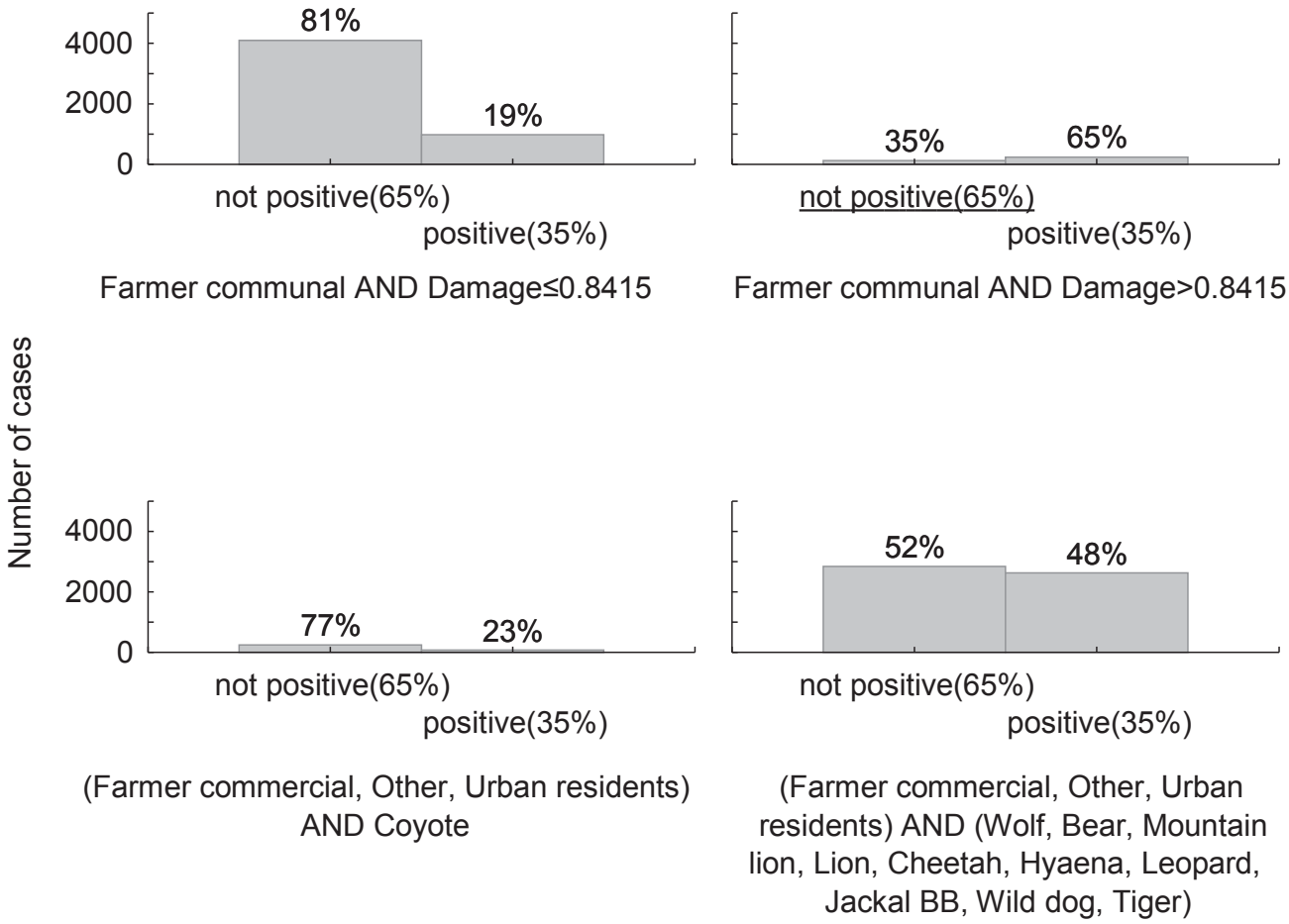

Figure 6. Attitudes (positive and not positive) of respondents toward carnivore species determined by CART cost sequence analysis of the damage data set for carnivores. All primary and secondary variables are described in Table 1. CART partitions the data into subgroups (each characterized by a rule which identifies the subgroup) which are as distinct as possible. Here, 4 subgroups were generated. The percentages in brackets on the x-axis indicate the percentage of that class in the whole data set. The percentage above the bar gives the percentage of the class in the subgroup. For example, for the first subgroup (farmer communal and damage ≤ 0.8415), 81% of the cases were "not positive," whereas in the whole data set 65% of the cases were not positive. The damage probability value is the cut-off point generated by CART rules. (BB, clack backed jackal; damage probability value, cut-off point generated by CART rules).

meaning any loss due to carnivores would be substantial. It is possible that the small number of elephant studies may not be representative of the full range of attitudes and that alternatively, similar trends to those of the carnivores. If, however, these differences are accurate, the reason may be due to a more positive cultural symbolism of elephants (Kuriyan 2002) relative to carnivores (West 2001; Dickman 2008; Lewis-Williams & Challis 2011), perhaps given the long history of carnivores preying on humans (Kruuk 2002).

Our TDI presented no significant differences between stakeholder types or between developed and developing countries. However, because our TDI did not take into account the severity of damage or its frequency or rate over time, differences may be masked by these factors. A damage measure that accounts for these additional dimensions would be valuable for constructing tolerance indexes in the future.

Until comparative data is available that uses comparable measures of attitudes as well as tangible and intangible costs and benefits, explaining differences between species groups and the lack of differences between stakeholder groups and between developed and developing countries is problematic. Differences between species groups is likely given the human propensity to value animal species unequally (Bonnet et al. 2002; Serpell 2004; Stokes 2007) and the wide range of reasons potentially explaining this heterogeneity (organismal complexity: Proenca et al. 2008; morphological and behavioral similarity to humans: Batt 2009; size, rarity, charisma: Johnson

et al. 2010; attractiveness: Frynta et al. 2010). These differences could have important implications for managing species in general and HWC in particular, meaning knowledge of differences in human behavior should inform the design of interventions, strategies, and policies (Knight et al. 2010). It is likely that context-specific species management approaches will be required.

Importance of Damage

Damage was an important factor explaining positive attitudes toward wildlife; however, stakeholder group, question type, and species group were either equally or more important (Figs. 3a & b). Nonpositive attitudes were presented by 39% of stakeholders who experienced no damage. These findings support the results of similar research where damage was not significant in explaining attitudes toward a species in 61% of publications (R.K. unpublished data). They are also consistent with results of other research highlighting the importance of nondamage factors (Naughton-Treves et al. 2003; Skogen & Krange 2003; Dickman 2010; Shelly et al. 2011).

Damage interacted with different stakeholders (i.e., commercial farmer, communal farmers, and urban residents) and species groups (i.e., carnivores, ungulates, primates, and elephants) in complex and unexpected ways, as revealed by the CART analyses (Figs. 4 & 6). For example, damage did not explain attitudes of all stakeholder groups toward carnivores (Fig. 4) or attitudes of commercial farmers or communal farmers toward ungulates, primates, or elephants (Fig. 4). Damage was however important for urban residents and a subset of communal farmers. Urban residents displayed intuitively meaningful responses toward ungulates, primates, and elephants (i.e., positive attitudes in cases exhibiting a low probability of damage and nonpositive attitudes where the probability of damage was high) (Fig. 4). However, for a subset of communal farmers the relationship with some carnivore species was unanticipated. Those who experienced a high probability of damage displayed more positive attitudes, while those with a low probability of experiencing damage were more nonpositive (Fig. 6). Because of this complexity, identifying the contexts in which damage drives attitudes and human tolerance is essential because HWC mitigation strategies typically assume damage to be the causal factor (Hulme & Murphee 1999; Distefano 2003; Dickman 2010). If damage is not a driver of specific stakeholders' attitudes toward species, then mitigating damage may offer a low return on investment of typically scarce conservation funds. Identifying the costs and benefits of species important to stakeholder groups is an important future research direction because damage may also fail to predict attitudes in cases where the additional costs and effort of implementing mitigation measures causes increased resentment toward species. A more holistic approach that considers both tangible and intangible costs and benefits of living with wildlife may be more effective at determining the role of damage in explaining an individual's attitude toward individual animals and groups of species. Such an approach could promote the development and implementation of spatially extensive policies and strategies, which could prove more effective than the site and species-specific approaches currently employed.

Stakeholders' Attitudes toward Species Groups

Although communal farmers were twice as likely as other stakeholders to have nonpositive attitudes, this was not uniform for all species and damage probabilities (Figs. 4 & 6). Communal farmers were more positive toward elephants, ungulates, and primates and less positive toward carnivores, irrespective of probability of experiencing damage and of question type (Fig. 4). However, a subset of communal farmers living in proximity to a subset of carnivore species were counter intuitively more positive when there was a large probability of undergoing damage than when there was a low probability of damage (Fig. 6). This suggests that at least some communal farmers are able to adapt to living with damage causing wildlife. Because adaptation is a general human propensity (Arieli 2010), we wondered why urban residents do not adapt as well; urban residents were less likely to be positive when probabilities of damage from ungulates, elephants, and primates were high (Fig. 4). Fifty-seven percent of communal farmers in the high damage probability category were from developing Asian countries, while 24% in the low damage probability category were from Africa. Eastern religions may predispose people to be more sympathetic toward wildlife, in general (Waldau & Patton 2006; Manfredo 2008), and to damage causing wildlife in particular. For example, people in Nepal view damage by the snow leopard (*Panthera uncia*) as punishment from a mountain god, which shifts blame from the species (Ale 1998).

Urban residents and commercial farmers tend to be neutral or slightly more positive toward most carnivores, except coyote (Fig. 6), while communal farmers are typically less positive (Fig. 4) (except in the cases of Asian stakeholders outlined above [Fig. 6]). For urban residents, these differences could be explained by urban residents being exposed to carnivore species that have a lower impact on their livelihood and lives or by their general tolerance of wildlife (i.e., mutualistic wildlife value orientations [Manfredo 2008]). Mutualistic wildlife value orientations are associated with urbanization and modernization, where a reduction in the association of wildlife as a food source and an increase in wildlife as deserving of equal rights to humans are thought to result in higher tolerance (Manfredo 2008). For example, Williams et al. (2002) reported that urban residents (61%) had more positive attitudes toward wolves than rural residents (45%)

and farmers (35%). However, because these studies did not differentiate between stakeholders within each group who experienced direct conflict and those that did not, it was not possible to determine if urban residents would retain their mutualistic value orientations when experiencing more extensive damage. Our finding that the positive attitudes displayed by urban residents did not extend to ungulates in communities where the probability of damage was high, in addition to the TDI not indicating a higher overall tolerance of damage by urban residents (Fig. 2), suggests that urban residents' mutualistic value orientations may diminish above a certain threshold of damage.

Communal farmers were the least positive toward carnivores (Figs. 4 & 6), possibly because livestock contribute substantially more to their well-being or have high cultural value. In developing countries, rural communities may have little access to credit, so livestock represent an investment or safety net that provides a diverse range of functions and benefits to owners and to the community at large (Andrew et al. 2003). Where stock numbers are small, or where privatization of communal lands has resulted in smaller, less viable parcels of land for livestock farming (Galvin et al. 2008; Western et al. 2009), any loss may impose substantial costs. Those dependent on a single livelihood strategy may be less resilient and hence less tolerant of stock and crop losses (Shackleton & Shackleton 2004; Dickman 2010). Rural communities are also more exposed to carnivores during their daily activities because they depend primarily on locally available resources for their well-being (Koziell & Saunders 2001; Maikhuri et al. 2001; Clarke 2012). Carnivore species, such as lions and tigers, can be dangerous, meaning people may suffer disproportionately from fear, injuries, and mortality (Kaltenborn et al. 2006 Clarke 2012). In contrast, commercial farmers tend to be wealthier and so less dependent on livestock losses. They may also have greater resources for protecting livestock, such as proactive culling of carnivores, and thereby reducing the magnitude of damage (Saberwal et al. 1994). They may also benefit more from tourism opportunities on their land as well as from trophy hunting. This interpretation supports the finding that the probability of damage did not affect attitudes of commercial farmers toward carnivores.

Many populations of threatened mammals occur outside formally protected areas, and their survival depends on the willingness of communities to tolerate them. As the term suggests, HWC involves 2 parties—people and wildlife. It is therefore essential that research into the human psychological dimension of HWC increase in quantity and scope and be designed to complement the technical interventions, such as chili fences (i.e., chili crops planted around food crops) or guard dogs, that separate wildlife from the resources people value. Given the uncertainty surrounding the degree to which damage determines attitudes and the inconsistency with which damage is quantified among studies (Naughton & Treves 1999; Schwerdtner & Gruber 2007; Inskip & Zimmermann 2009), widely agreed upon standardized methods to measure the type and extent of damage incurred to different stakeholders by different species are urgently required. In addition, determining and quantifying the relative importance of factors other than damage that define a person's attitudes will be important for prioritizing conservation actions and developing effective policies that can be applied at a scale broader than the site and species-specific strategies currently employed.

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Supporting Information

A list of the search terms used (Appendix S1), a summary of classification tree method (Appendix S2), and a list of the publications used in the meta-analysis, including a species list, species red-list category, and the study sites (Appendix S3) are avialable online. The authors are soley 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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