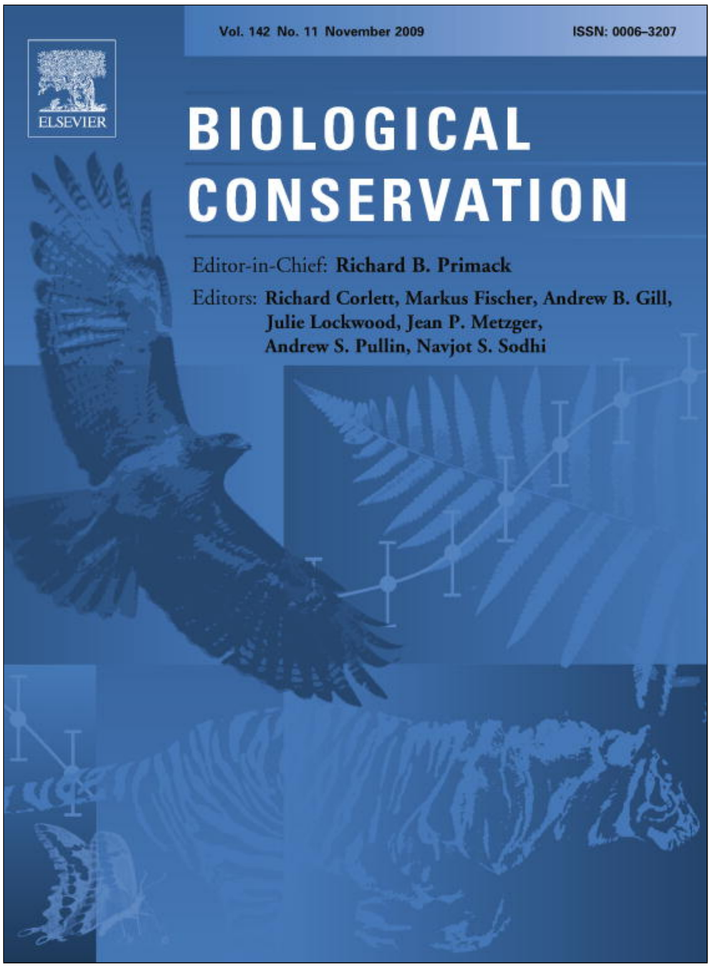
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Lions and Warriors: Social factors underlying declining African lion populations and the effect of incentive-based management in Kenya

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ABSTRACT

African lion (*Panthera leo*) populations are in decline throughout most of Africa, but the problem is particularly acute in southern Kenya, where Maasai people are spearing and poisoning lions at a rate that will ensure near term local extinction. Lion killing is shaped by Maasai perception of livestock depredation, socio-economic factors, and the complex relationship between Maasai and conservation. These all affect tolerance for lions and consequently Maasai behavior towards conservation initiatives and carnivores in general. We used an in-depth quantitative questionnaire and participatory rural appraisals (PRAs) to identify the social and ecological predictors of lion killing and to investigate the effect of a compensation scheme on individual tolerance. Individuals who lose a greater proportion of their livestock to predators relative to their overall livestock loss, those affiliated with an evangelical church, and those who mainly sell rather than accumulate livestock all reported a higher propensity to kill carnivores. The future of carnivore conservation in this region depends on a better understanding of the nuances of human–carnivore conflict and a concerted effort to address appropriate cultural and community-level institutions, chiefly by providing economic benefits to local people who engage in positive conservation activities.

1. Introduction

Africa's large carnivore populations have decreased substantially over the past 30 years (Ginsberg and Macdonald, 1990; Nowell and Jackson, 1996; Mills and Hofer, 1998). There are no reliable data from earlier periods, but scientists estimate that Africa's lion population prior to colonization have been falling steadily to perhaps 500,000 by 1950, about 200,000 by 1975 (Myers, 1975), and less than 100,000 by the early 1990s (Nowell and Jackson, 1996). Point estimates of continent-wide numbers range from 23,000 (Bauer and Van Der Merwe, 2004) to 39,000 (Chardonnet, 2002). The most recent, and likely most accurate estimate, is 29,665 (IUCN, 2006). Historically lions occupied a range in Africa of over 22,211,900 km^2. Their range is now less than 3,802,873 km^2 – a reduction of 83% (Ray et al., 2005).

Human–carnivore conflict over livestock depredation is the most important reason for lion population decline (Nowell and Jackson, 1996; Woodroffe and Ginsberg, 1998; Linnell et al., 1999), followed by habitat loss and interspecific conflict over resources (Ray et al., 2005). Studies in East Africa provide similar evidence that lion populations are declining in areas where pastoralism persists (Frank, 1998; Ogada et al., 2003; Ikanda and Packer, 2008; Kissui, 2008; Maclennan et al., 2009). Historically, lions and other wildlife have been first eliminated in heavily agricultural areas, persisting in areas suited only for pastoralism. However, the ubiquity of modern weapons has largely eliminated wildlife from Kenya's northern rangelands (Frank, 1998), and an apparent loss of tolerance for predators in Maasailand of southern Kenya has resulted in a precipitous drop in lion numbers there (Hazzah, 2006; Maclennan et al., 2009). The current resentment of lions in pastoral areas suggest that conflict is rooted not only in actual losses, but in actual and perceived vulnerability linked to land use changes, lost territory, and imposition of conservation measures, as suggested by others working in these ecosystems (Lindsay, 1987; Berger, 1993; Adams and McShane, 1996).

Meanwhile, livestock losses to predators have a significant effect on pastoralists' livelihoods that can undermine their tolerance for predators (Mishra, 1997; Marker et al., 2003; Groom, 2007; Holmern et al., 2007). Many conservationists hope that compensation payments for livestock lost to predators, will better balance

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the distribution of costs and benefits of large carnivores (Naughton-Treves et al., 2003), and deter local retaliatory killing of carnivores (Wagner et al., 1997; Nyhus et al., 2005). But seldom has the effectiveness of compensation programs been assessed, particularly in an African context, as a means to increase pastoralist tolerance of carnivores.

Maasai and other traditional pastoralists have coexisted with large carnivores for centuries (Guggisberg, 1975); but tolerance has declined in recent years (Mishra, 1997; Marker et al., 2003). Historically, Maasai speared lions for cultural reasons and to protect themselves and their livestock, but recent availability of cheap, effective poison has improved their ability to eliminate predators (Treves and Naughton-Treves, 1999; Ogada et al., 2003; Woodroffe and Frank, 2005; Gavshon and Magratten, 2009). Despite this impact, fundamental explanations for tolerance versus extirpation are elusive. Some argue that *perceived* rather than actual levels of conflict drive retributive killings and that modern conservation rules and individualization of risk have heightened pastoralists' sense of vulnerability (Mishra, 1997; Marker et al., 2003; Naughton-Treves and Treves, 2005). Individual perceptions of human–wildlife conflict and tolerance towards carnivores are shaped not only by severity and frequency of losses, but also by the economic, social, and environmental context within which pastoralism is practiced (Treves et al., 2006). For instance, although African pastoralists traditionally accumulate rather than sell cattle, increasing market access has allowed many to engage in a growing livestock trade, which might alter perceptions toward livestock and ultimately tolerance of carnivores (Bagchi and Mishra, 2006). In addition, participation in lengthy Christian ceremonies sometimes results in neglect of herding, leaving livestock more vulnerable to depredation (Hazzah, 2006). Thus, carnivore conservation depends on the sociopolitical landscape as much as, if not more than, the biological landscape (Treves and Karanth, 2003; Naughton-Treves and Treves, 2005).

Although there have been numerous studies of rural attitudes toward carnivores, there have been few studies of the individual, household, and community variables that underlie retaliation against carnivores in response to depredation, or on the effect of compensation schemes on retributive killings of predators. Here we provide a systematic review of the within-community factors associated with one specific measure of wildlife tolerance – the propensity to kill lions in Maasailand, an area that until recently supported the highest density of lions in Kenya (Chardonnet, 2002). Reported propensity to kill predators is used as a proxy index for tolerance of carnivores. We examined key variables drawn from the literature on attitudes toward large carnivores (Oli et al., 1994; Ogada et al., 2003; Bagchi and Mishra, 2006) including: wealth, age, dependence on livestock and depredation rates. We also included variables emerging from pilot interviews and participatory rural appraisal (PRA) exercises: namely, religious affiliation, and individual experience with compensation and conservation programs (Hazzah, 2006). We examined the relative importance of these variables against individual's reported propensity to kill lions in a multivariate model using Akaike's Information Criterion (AIC) model selection criteria. Lastly, subsidiary preliminary analyses were done to investigate the role of perception on the effects discovered. Our analysis may help inform those considering compensation payments as a strategy to enhance local tolerance for large carnivores, particularly in developing countries.

1.1. Lion killing in the Amboseli-Tsavo ecosystem

There has been little published on lion killing in Kenya, and even less information on specific killing around the Amboseli-Tsavo ecosystem, in southern Kenya. Between 1990 and 1993 Maasai communities surrounding Amboseli National Park (ANP) eradicated the park's entire population of lions, in response to livestock predation and in protest against loss of grazing land and access to swamp lands. In 1994, two lions re-colonized ANP from surrounding areas (Chardonnet, 2002). However, local Maasai have since continued to kill lions in the Amboseli-Tsavo ecosystem; at least 140 lions in this ecosystem were speared or poisoned between 2001 and 2006 (unpublished data). Currently, over 40% of Kenya's remaining lions occur in Maasailand, the country's most important tourist destination.

Traditionally, Maasai recognize two types of lion hunting: *Olamayio* and *Olkiyioi*. *Olamayio* is a warrior's manhood ritual which brings prestige to the warrior (*murran*) who first spears the lion (Ikanda and Packer, 2008). By contrast, *Olkiyioi* killings are carried out by anyone in the community in response to a lion attack on livestock, particularly cattle (Hazzah, 2006; Ikanda and Packer, 2008; Kissui, 2008). Today the distinction between these types of killing is blurred and access to markets, increased educational opportunities, and religious movements appear to influence local motivation to kill lions (Hazzah, 2006). Recently, widespread availability of the agricultural insecticide carbofuran has become a cheap and efficient way to eliminate lions and other carnivores from the ecosystem (Frank, 1998; Maina, 2007; Gavshon and Magratten, 2009). Unlike spearing, which is considered a heroic public display of bravery, poisoning is often carried out in secret (Hazzah, 2006).

1.2. Background to the Mbirikani Predator Compensation Fund (MPCF)

In an attempt to halt lion killings on Mbirikani Group Ranch, the Mbirikani Predator Compensation Fund (MPCF) was initiated in early 2003 to reimburse people for livestock lost to predators so to increase local tolerance of carnivores. This program uses proactive incentives and reactive disincentives, attempting to promote better livestock husbandry, and imposes penalties for killing predator (for details see Maclennan et al., 2009).

MPCF's policy of verifying losses as a pre-condition for payments provides accurate data on livestock loss rates. Trained verification officers visit kill sites to corroborate reports, but some wildlife damages may not have been recorded. From MPCF records, Maclennan et al. (2009), concluded that, in descending order of importance, spotted hyena (*Crocuta crocuta*), lion, and cheetah (*Acinonyx jubatus*)/leopard (*Panthera pardus*) caused the greatest number of cattle losses; while, spotted hyena, cheetah/leopard, and lion killed 'shoats' (goats and sheep).

2. Methods

2.1. Study area

Mbirikani Group Ranch (MGR) is 1229 km^2 of communally-owned Maasai land lying 7 km west of the 392 km^2 Amboseli National Park (ANP) and bordering the 471 km^2 Chyulu Hills National Park (CHNP) to the east (see Fig. 1). The ranch connects wildlife from the two parks (Muthiani and Wandera, 2000), as well as from Tsavo National Park, 16 km to the southwest. MGR lies in the heart of the 9000 km^2 greater Amboseli-Tsavo ecosystem and supports subsistence pastoralism and a diverse assemblage of African savanna mammals (Western et al., 1994). Currently about 10,000 Maasai and 90,000 livestock live on MGR (Groom, 2007).

The study area ranges from dry semi-arid savanna and swamps to montane forest near the CHNP (Hurt, 1999). MGR experiences low and highly variable rainfall, sporadic droughts, and spatially heterogeneous pasture resources (Berger, 1993). The short rains typically fall in October–December and the long rains from

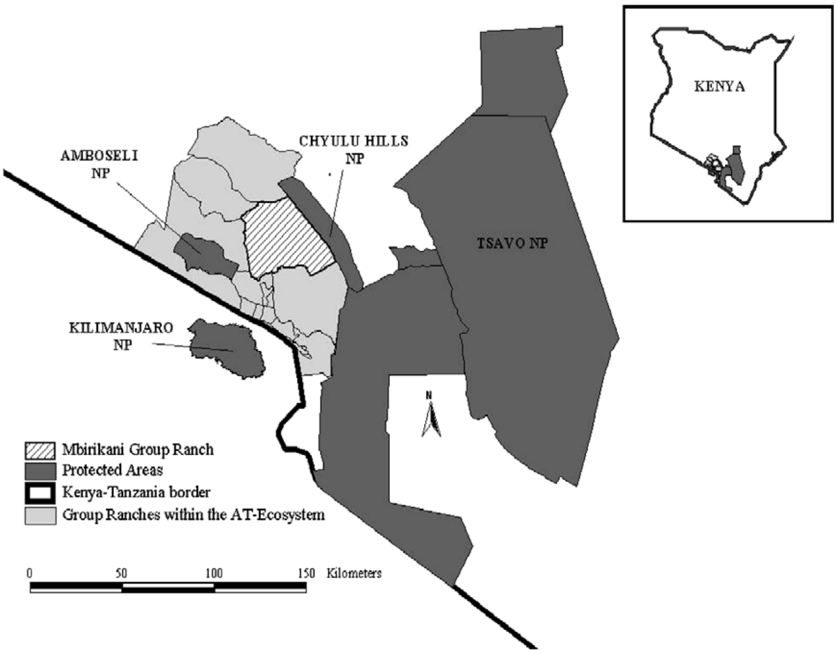

Fig. 1. Mbirikani group ranch within the Amboseli-Tsavo ecosystem.

April–June. Annual rainfall of the Amboseli basin varies between 132 mm and 553 mm (Altmann et al., 2002).

2.2. Sampling and survey instruments

To evaluate the relative importance of social and ecological factors in shaping attitudes and conservation outcomes, we chose seven focal communities in the eastern region of MGR, which had the highest reported livestock depredation by lions and other carnivores and were also responsible for the highest number of lion killings on the ranch. Thus, these study sites are not necessarily representative of all Maasai communities' interactions with wildlife, but they allow us to evaluate the relative importance of social and ecological factors shaping attitudes and conservation outcomes within a high-conflict region.

Data collection took place between May 2005 and April 2006. A semi-structured, household-level questionnaire was used to evaluate a person's propensity to kill carnivores, effect of compensation on tolerance, and the effect of conflict perception on carnivores and conservation attitudes. After pilot testing the questionnaire for 2 months ($n = 25$), LH and a field assistant conducted 100 household interviews (approximately 11% of the households in MGR) in the Maa language. We used a criterion sampling framework: only Maasai men living within the study area were interviewed because these individuals are primarily responsible for livestock herding and only men kill lions. We did not interview individuals who shared a herd with a previous respondent. These interviews allowed us to compare techniques and investments in methods of protecting livestock from predators, and to assess variation in tolerance and attitudes towards carnivores. Each respondent personally answered the question, unless indicated otherwise, and there were no missing data.

2.3. Data analysis

We analyzed all data using Statistical Package for Social Scientist (SPSS) PC version 12.0 (SPSS Inc., Chicago, USA). Prior to analysis we tested continuous independent variables for collinearity using Spearman rank analysis and Pearson r correlations, as appropriate, and categorical variables using Pearson Chi-square to test for association between categorical variables (see Hazzah, 2006 for correlation matrix). The cut-off value for significance of the Spearman Rank and Pearson was $r > 0.70$ and p value <0.0001 for Pearson Chi-square tests. We also tested the variance inflation factor (VIF) and checked the variance decomposition proportions; both tests confirmed that there was no collinearity present among the predictors. Lastly, we ran additional diagnostic tests to check for outliers, influential observations, and heteroskedasticity; specifically, DfBetas, Cooks distance, and studentized residuals (Fox, 1997). All test results were at normal levels; allowing us to proceed with the regression and the AIC analyses. Table 1 presents the predictors included in the logistic regression and explanations of each variable.

After choosing independent variables, we ran logistic regressions (with a backward manual removal procedure) and recorded the −log-likelihoods for each resulting model. The output of the regression with the AIC values is displayed in Table 3, which examines each of the 20 models separately. We combined this conventional approach (regression) with newer information theoretic techniques (AIC), following recent statistical practice (Burnham and Anderson, 2002). As argued by Towner and Luttbeg (2007) classical, likelihood, and Bayesian statistical approaches did not develop *nor should be applied* in isolation from each other. Following Shtatland et al. (2001), we use the stepwise technique "to decrease drastically the total number of models under consideration" (2 2 2), and AIC to implement the selection of the "best" models (Burnham and Anderson, 2004). The problems associated with classical stepwise regression, which is based on tests of null hypotheses and p-values, is the inflation of Type 1 error rates (Mundry and Nunn, 2009), precisely why Burnham and Anderson (2004) and others (Anderson et al., 1994; Mazerolle, 2006) advise utilizing AIC for model selection.

There are two measures associated with AIC for comparing models. First, the delta AIC_i (Delta $AIC_i < 2$; Mazerolle, 2006) looks at the difference in AIC value between the ith contending model and the "best model", the latter being the one with the lowest

Table 1
Variables included in logistic regression.

Predictors	Explanations and variable type	
Age	Respondents' age-groups	Three categories: young, middle, and old
Cattle herd	Number of cows owned	Continuous: (0–2000)
Share herd	Does the respondent share his herd with another individual	Two categories: yes = 0, no = l
StockSale	Primary purpose in rearing livestock	Three categories: sale = 2, subsistence = 1, tradition = 0
# of children	# of children currently enrolled in school	Continuous: (0–20)
KAG	Respondents religious affiliation	Three categories: Kenyan Assemblies of God (KAG) = 2, other = l, none = 0
Clan	Clan to which respondent belongs	Three categories: Ilmolelian, Ilaiser, and Illaitayiok
Lion problem	Perceived magnitude of lion problem	Three categories: serious, moderate, low
PA important	Attitude towards protected areas and conservation	Two categories: yes = 0, no = 1
Lion like [a]	Positive attitude towards lions (1st time)	Two categories: like = 0, dislike = l
Lion dislike[a]	Negative attitude towards lions (2nd time)	Two categories: like = 0, dislike = 1
Freq loss	How often livestock are reportedly attacked (provided by key informants)	Three categories: low = 0 (few times a year), medium = 1 (1–2 times a month), high = 2 (once a week)
Predation loss 5 years	Reported proportion of cows killed in 5 years relative to the overall number lost to other factors (including: drought, disease, sales, and theft)	Ordinal: (0–44%)
Predationlosslyr	Reported proportion of cows killed in last 1 year relative to the overall number lost to other factors (including: drought, disease, sales, and theft)	Ordinal: (0–50%)
Comp times	Number of times compensated by MPCT	Continuous: (0–10)
Olamayio Freq	Persistence of ritual lion hunts on MGR	Two categories: no = 0, yes = l
NARC dislike	Attitudes towards the national govt. in Kenya	Two categories: like = 0, dislike = 1
Comp attitude	Attitudes towards the compensation program	Two categories: like = 0, dislike = 1
Lion here	Perceptions of lion presence in the area	Four categories: never = 0 ,not common = 1, common = 2, very common = 3
GR dislike	Attitudes towards the group ranch committee	Two categories: like = 0, dislike = 1
KWS dislike	Attitudes towards the Kenyan Wildlife Service	Two categories: like = 0, dislike = 1

[a] Lion like/dislike were two different questions asked to cross-check the respondents' answers (they are not inverse responses).

AIC value among all models considered. The second, the AIC weight (w_i), is given by the ratio of the delta AIC of the *i*th model relative to the delta AIC values of the whole set of candidate models and represents the strength of the model relative to the entire set of contender models. In essence, we used all the information available from the set of all possible best models to make inferences (multimodel inference) about the relationships among predictors and the relative strengths of predictors. The average regression estimates among the best subset of models that were calculated in the last step we then inserted into a logistic regression (i.e. constraining the beta values). The model produced is the "consensus" model, which contains the best estimate of each predictor to explain the dependent variable with the greatest precision. Finally, the unconditional standard error (SE) and the 95% confidence intervals of each coefficient were calculated to evaluate the range of variation in predictive power for each variable retained in the model; narrow intervals indicate precise estimates (Mazerolle, 2006). Any variable whose standard error excluded 0 was deemed significant. To further investigate the results of the AIC we ran univariate tests, including the Mann Whitney *U* test, Kruskal Wallis, and Chi-square, as appropriate. All tests were two-tailed unless indicated otherwise.

The preliminary analysis on Maasai perception of conflict and attitudes toward carnivores is bivariate, not fully controlled for statistical interactions among predictors. A larger sample would be needed to examine the precise links between Maasai perceptions and carnivore conflict whereby the propensity to kill analysis is mediated and controlled through extensive regression and model building techniques (AIC). However, the subsidiary results enrich the interpretation of pastoralist-carnivore tolerance and likelihood of retaliation against lions.

2.4. Participatory rural appraisals and participant observation

To reduce possible reporting biases, LH lived in the communities for 2 months prior to initiating the questionnaire and a total of 10 months throughout the study. During the initial three months, LH did not ask about carnivore conflict or other sensitive topics. Instead, she participated in community life, attended community workshops and church services, helped women carry water, and herded livestock. Because familiarity and aid builds trust, this pilot phase subsequently helped us gather data with greater confidence in its accuracy. Lastly, LH cross-checked the responses by key informants during the initial months of the study (e.g., counted cows, compared information with other informants and/or assistants) to ensure accuracy.

Initial research focused on ethnographic inquiry and Participatory Rural Appraisals (PRA's), which were crucial in questionnaire design. LH conducted a total of 31 PRA interviews (50 participants in total) and three all-male focus groups (10 participants in each group), and found PRA respondents and informants opportunistically through regular visits to *bomas* (thornbush-enclosed Maasai homesteads). Pilot interviews revealed that many Maasai were unable to express livestock losses quantitatively. LH instead used a method of sorting pebbles with respondents (Watson, 1994; Cullis, 1994). Ten pebbles were presented and the respondent was asked to remove a pebble to represent the proportion of a herd lost in the last year to drought, depredation, sale, and disease. The respondents were then presented with 10 pebbles again and asked to estimate proportions of losses over the past 5 years (variables termed "Predation loss 1 year and Predation loss 5 years"). Approximately 67% of respondents used the pebble method instead of providing numerical responses on loss. Non-parametric tests indicate that there was no significant difference between those who used pebbles and those who reported numbers. These responses were validated by follow-up questions to ensure that this method was uniformly understood among respondents and that each pebble ('value') was correctly placed under the intended loss category. The 'pebble method' lacks precision (losses can only be recorded to nearest 10%). It was also more difficult for respondents with large herds to express their losses. However, this method proved to be a culturally appropriate and efficient means of gathering data on perceived losses.

Table 2
Wealth indicators.

Wealth indicators	Range	Mean	Median
Number of children	0–50	8	5
Number of cows	3–2000	215	100
Number of shoats	0–1500	240	200

3. Results

During the PRA's we examined Maasai perceptions of wealth. The top three indicators (in order of importance) were (1) number of children (2) number of cows and shoats (goat and sheep combined; see Tables 2 and 3) farm ownership.

All respondents owned livestock and 74% of respondents also owned a farm. However, 24% of those who owned a farm were not currently cultivating their land. The average farm size was reported to be 3.5 acres.

3.1. Respondent characteristics

Respondents ($n = 100$) were divided into three age-categories: young (18–29), middle (30–42), old (43 and above). Seventy-three percent of the interviewees had never attended school, 13% had completed primary school, and 14% had completed secondary school. All respondents owned livestock. Sixty-one percent of respondents considered themselves pastoralists, 12% were employed as game scouts, 9% were livestock traders, and the remaining 18% indicated "other" (i.e. farmer, teacher, or laborer).

3.2. Variables affecting reported propensity to kill

The dependent variable was coded from the question, "What is your normal response if your cow has been killed by a predator?" into a dichotomous variable – kill or not kill. Twenty-five percent of interviewees responded "kill" and 75% responded "not kill". The kill category included respondents who indicated that they would ask someone else to carry-out the killing.

Binary logistic regression (with backward manual removal procedure) of 20 models combining the 20 predictors that were not collinear are presented in Table 3, which includes the specific predictors that were removed at each step. The model with 10 predictors has the lowest AIC and is therefore the best fit to the data. After calculating the Delta AIC$_i$ and the Delta weight, Models 9–13 (Table 4) remained contenders for the best model.

The consensus model was significant ($p \leqslant 0.0001$) and the Hosmer and Lemeshow Fit test ($p = 0.872$) suggests that this model is a very good fit (the closer the value is to 1 the better the fit). The confidence interval of the beta coefficients for each predictor in the consensus model is displayed in Table 5.

Only three variables (listed in order of predictive strength) had confidence intervals for the coefficients which did not encompass 0 (indicated by an asterisk in Table 5): reported proportion of cows lost to depredation by carnivores in the past year (Predation loss 1 year), religious affiliation (KAG), and livestock dependence (StockSale). We place heavy reliance on the variables identified as 'significant' using the AIC method, because these models, unlike the presentation of the raw data, account for covariation among predictor variables.

3.3. Effect of proportional loss to carnivores on reported propensity to kill

Individuals who perceived a greater proportion of cattle mortality attributable to predators relative to other causes of loss (i.e. disease, drought, theft, and sale) reported the greatest propensity to kill lions. Eighty-five percent of the interviewees indicated that their livestock (cow, goat, sheep, and donkey) had been attacked

Table 3
Backward regression for AIC.

Number of predictors	−2log-likelihood	K	N	AIC	Delta AIC$_i$	Variable removed at each step
20	27.384	21	100	81.23	12.223	
19	27.592	20	100	78.22	9.23	Lion here
18	36.124	19	100	83.62	14.63	Clan
17	36.124	18	100	80.57	11.57	# of children
16	36.128	17	100	77.59	8.59	GR dislike
15	36.409	16	100	74.96	5.97	Cattle herd
14	36.666	15	100	72.38	3.38	Lion dislike
13	37.082	14	100	70.02	1.03	Freq loss
12	39.131	13	100	69.36	0.37	NARC dislike
11	42.110	12	100	69.70	0.70	Share herd
10	43.998	11	100	69.00	0.00	Predation loss 5 years
9	47.131	10	100	69.60	0.60	PA important
8	55.740	9	100	75.74	6.74	Age
7	59.821	8	100	77.40	8.41	Lion problem
6	64.801	7	100	80.02	11.02	*Olamayio* Freq
5	69.665	6	100	82.57	13.57	KWS dislike
4	79.300	5	100	89.94	20.94	StockSale
3	86.793	4	100	95.21	26.22	Comp attitude
2	95.801	3	100	102.05	33.05	KAG
1	104.121	2	100	108.24	39.25	Comptimes
Constant		1	100			(Predation loss 1 year)

Table 4
AIC contender models.

Best models (# of predictors)	−2log-likelihood	N	K	AIC	Delta AIC$_i$	Exp delta AIC	AIC-weight	Evidence ratio
13	37.082	100	14	70.023	1.025	0.599	0.155	1.670
12	39.131	100	13	69.364	0.366	0.833	0.215	1.201
11	42.110	100	12	69.696	0.698	0.705	0.182	1.418
10	43.998	100	11	68.998	0.000	1.000	0.258	1.000
9	47.131	100	10	69.603	0.605	0.739	0.191	1.353

Table 5
Coefficients, SE and upper/lower confidence intervals for the predictors used in the consensus model.

Predictors	# of models present	Regression estimate of all five models	SE	Upper 95%	Lower 95%
Predation loss 1 year*	5	16.654	2.47	21.500	11.807
KAG*	5	4.635	2.046	8.646	0.728
StockSale*	5	−3.910	1.965	−0.059	−7.762
Comp attitude	5	2.608	1.901	6.334	−1.118
Comp times	5	−2.212	1.907	1.525	−5.950
Age	5	−1.331	1.920	2.431	−5.094
Lion problem	5	2.103	1.892	5.811	−1.605
Olamayio Freq	5	−2.525	3.450	4.237	−9.288
KWS dislike	5	3.323	1.887	7.022	−0.377
PA important	4	2.168	2.341	6.756	−2.421
Predation loss 5 years	3	5.880	5.726	17.103	−5.342
Share herd	2	0.744	2.230	5.114	−3.626
NARC dislike	1	0.369	2.187	4.655	−3.917
Intercept	5	−9.159	3.398	−2.499	−15.819

by a predator in the past year. Of these, 25% reported losing livestock weekly. People who reported greater losses to carnivores (as proportion of total) were more likely to indicate they would kill a lion (see Table 5). Fig. 2 shows that the minimum point of the interquartile range of the kill category is 11% (i.e. 75% of people in 'kill lion' category had proportional losses over 10%).

We next examined which wealth class experiences a higher proportional loss to carnivores. Those individuals who owned fewer cows lost a higher proportion of their cattle to carnivores in the past year compared to those who owned more cattle (Fig. 3). Reported propensity to kill is clustered among those who lose a higher proportion to carnivores, especially among the less affluent. The effect is still significant when we drop the outliers (see methods for specific outlier tests).

Interestingly, there was no correlation between reported number of cows or shoats attacked by carnivores and reported propensity to kill a lion (Mann Whitney U test: Cows $z = -0.775$, $p = 0.438$; Shoats $z = -0.334$, $p = 0.731$). To confirm this finding, we tested respondent's propensity to kill a lion against frequency of depredation (how often they lost livestock to predators) that was provided by a key informant (freq loss). There was no correlation ($\chi^2 = 0.475$, $p = 0.789$). Also, we tested how affluence effects depredation and found that richer families (larger herds) suffer a higher frequency of attacks (Fig. 4) but do not report a higher propensity to kill, while people who own small herds endure less conflict (Kruskal Wallis: $\chi^2 = 38.187$, $p \leqslant 0.0001$). Additionally, self-reported number of cows attacked by predators and the frequency of depredation on livestock provided by key informants (Kruskal Wallis: $\chi^2 = 31.00$, $p \leqslant 0.0001$) is significantly associated. In other words, those who experienced a higher frequency of livestock lost

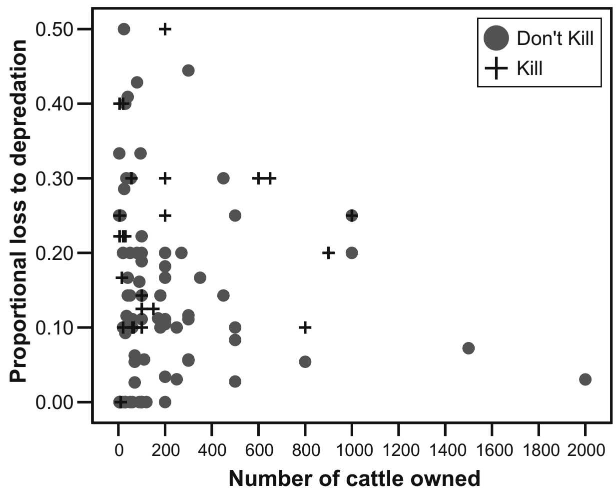

Fig. 3. Reported propensity to kill in relation to an individual's proportion of cattle mortality due to depredation versus herd size.

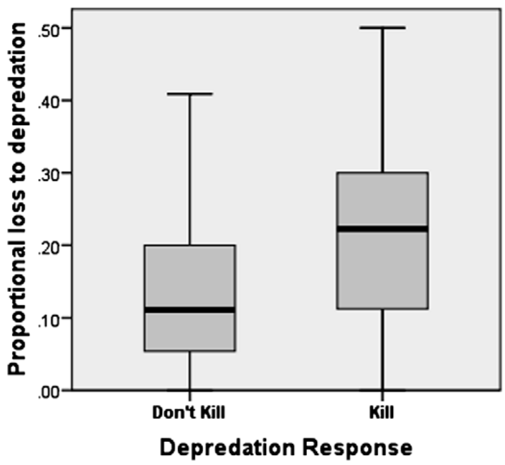

Fig. 2. Proportion of cattle mortality attributable to carnivores versus respondents reported propensity to kill lions (length of box = interquartile range, black bar = median, length of whiskers = range).

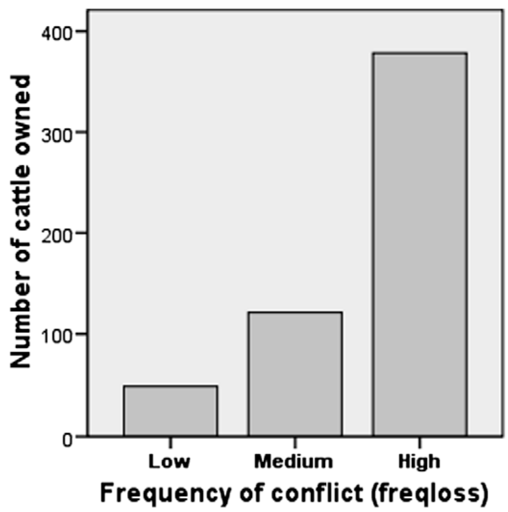

Fig. 4. Total number of cows owned and frequency of depredation provided by key informants (low = few times per year, medium = 1–2 times per month, high = once a week).

to predators did not necessarily report a higher propensity to kill a lion; rather, it is an individual's proportional loss of cows attributable to carnivores that drove lion killings (Mann Whitney *U* test: $z = -1.750$, $p = 0.008$).

3.4. Religious affiliation and reported propensity to kill lions

Approximately half (48%) of our respondents belonged to an evangelical sect, Kenyan Assemblies of God (KAG), 21% belonged to other churches (primarily Catholic and Anglican), and nearly one third (31%) were not associated with any church, either following traditional Maasai beliefs or none at all. The AIC tests showed that religious affiliation was the second strongest predictor and significantly correlated with an individual's reported propensity to kill a predator. Univariate tests showed a significant association between church affiliation and reported likelihood of killing a lion ($\chi^2 = 6.885$, $df = 2$, $p = 0.026$). Roughly one third (35%) of those affiliated with KAG responded that they would kill a lion, whereas only 14% of those affiliated with other churches or no church reported a propensity to kill a lion.

3.5. Effect of livestock sale on propensity to kill

Dependence on livestock was categorized into three groups from the following question "What is the main reason you produce your livestock?" Sixty-eight percent answered domestic consumption, 27% for sale, and only 5% for traditional (status) reasons. Respondents who kept livestock for sale had twice the propensity to kill a lion compared with the majority who produced livestock for subsistence or traditional reasons ($\chi^2 = 8.744$, $df = 2$, $p = 0.013$). A Kruskal Wallis test showed no association between livestock use and an individual's cattle loss to predators in the past year ($\chi^2 = 3.047$, $p = 0.218$) and no association between livestock use and key informant's reported frequency of conflict with carnivores ($\chi^2 = 7.076$, $p = 0.132$).

3.6. Perceptions of depredation

Additional analyses on perceptions of depredation reveal that perceptions and attitudes toward conflict could be important when considering possible conservation interventions, even though they were not selected by the AIC test. We asked people to list the three major problems their livestock confront. Thirty-five percent reported disease as one of the top three concerns, followed by drought (30%), and only 16% indicated depredation. Respondents who listed depredation as one of their top three problems also had a higher proportional loss to carnivores (Mann Whitney *U* test: $z = -2.546$, $p = 0.011$).

Lastly, there was a strong association between losing cattle and shoats to predation (and specific predator) and reported propensity to kill (cattle: $\chi^2 = 17.404$, $p = 0.008$; shoats: $\chi^2 = 9.775$, $p = 0.021$). Fig. 5 illustrates that with respect to cattle, people who perceive predators as a threat reported a propensity to kill them according to the level of perceived threat. With respect to shoats, however, kill responses seem indiscriminate, and people still seem to prefer killing lions, regardless of which carnivore was perceived to be responsible for the damage.

3.7. Role of compensation

Univariate tests indicate those who had received compensation for their livestock were less likely to report an inclination to kill a

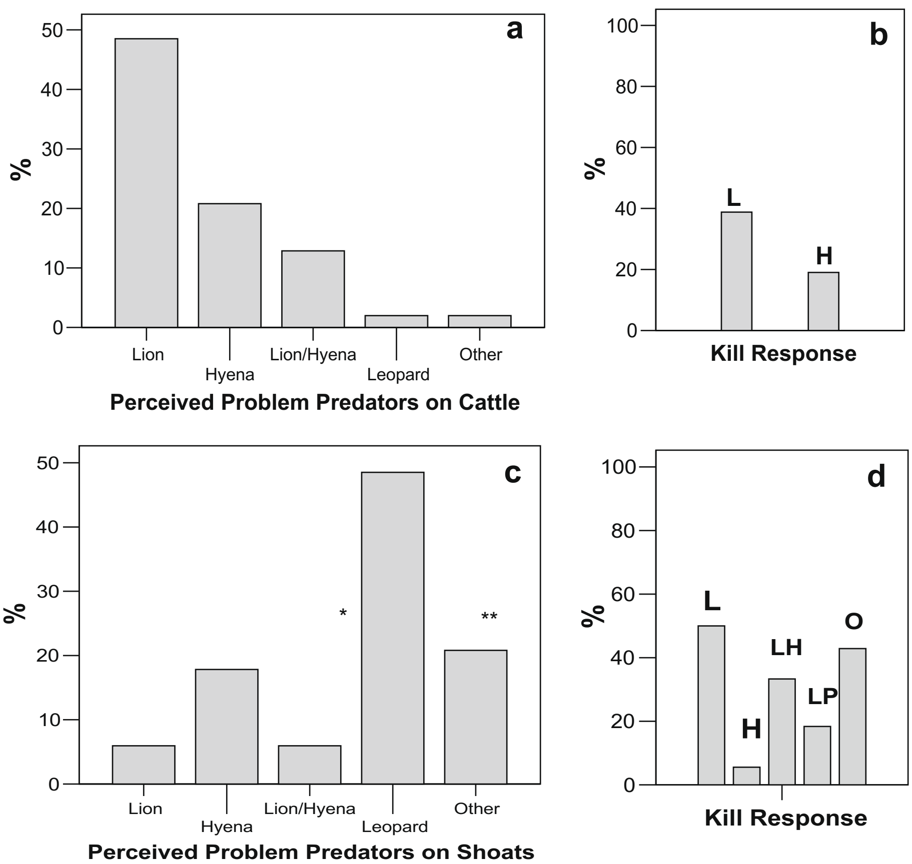

Fig. 5. Perceived livestock predators (a) predators on cattle (b) kill response for cattle predators; (c) and (d) show the same but for shoats. [*]Respondents chose both lion and hyena as the top predator. [**]Other category includes: cheetah, elephant, and buffalo. [***]Other category includes: cheetah, jackal, and python.

lion (Mann Whitney U test: $z = -2.574$, $p = 0.010$). In addition, respondents who approved of the compensation program were less likely to report a propensity to kill a predator ($\chi^2 = 8.358$, $p = 0.004$).

4. Discussion

Our results indicate that Maasai living in our survey areas perceived high levels of conflict with lions; however, actual rates (on a per head of livestock basis for all MGR) are quite low, 5% (Maclennan et al., 2009). Only 25% of the interviewees indicated that they would retaliate and kill a lion after their livestock was killed. This could be interpreted to mean that this community is generally tolerant in comparison to others: Marker et al. (2003) reported that close to 80% of farmers in Namibia indicated that they would remove a problem cheetah, while Naughton-Treves et al. (2003) found that 59% of rural residents in Wisconsin would kill a wolf if it threatened their livestock. However, comparisons across sites are hindered by marked variation in methods such as survey questions, legal and social contexts, and the technology locally available for killing carnivores. Furthermore, just one intolerant individual who sets out poison can kill many predators, even if most of the community disagrees with his actions.

The AIC statistical tests evaluated the strength of 20 possible predictors in combination and indicated that estimated proportion of cattle lost due to depredation relative to other losses, religious affiliation, and economic dependence on livestock are the key factors correlated with peoples' reported propensity to kill lions on MGR. These variables are not intercorrelated and are therefore individually significant. That these predictors were most powerful when combined rather than in univariate tests illustrates the interaction among these variables. Interestingly, univariate and qualitative analyses suggest that *Olamayio* (traditional lion hunts) is not commonly practiced on MGR today; rather retaliatory killings are much more prevalent. Respondents indicated that the ramifications of *Olamayio*, specifically arrests and fines, discourage traditional lion hunts. However, this attitude is very much site specific, as *Olamayio* persists on ranches adjacent to Mbirikani, specifically around Amboseli National Park (Maclennan et al., 2009) and Ngorongoro Crater in Tanzania (Ikanda and Packer, 2008).

4.1. Reported propensity to kill a carnivore

Though reported propensity to kill lions is only a proxy measure of tolerance and may not necessarily always reflect actual behavior in terms of lion killing, it is a relevant indicator of resentment against lions and the risk people pose to them. Our results indicate that the most important predictor motivating Maasai to kill lions is the proportion of all livestock mortality due to predators, rather than absolute frequency of livestock lost to them. Consistent with other studies (i.e. Oli et al., 1994; Mishra, 1997), our findings imply that a single depredation event is particularly devastating for someone who owns few livestock, perhaps making him more likely to retaliate. This may be due to the cost of effective herding (e.g., hiring herders is more difficult for the poor) (Naughton-Treves, 1997; Jackson and Wangchuk, 2001), inability to purchase material to improve livestock bomas and residing in high risk areas (Saberwal et al., 1994; Ogada et al., 2003).

4.2. Influence of religion on propensity to kill

Respondents who were affiliated with the evangelical Kenyan Assemblies of God church had a higher reported propensity to kill predators than those who attended other churches or none at all. Our qualitative data supports this finding as well. For example, one elder lost 20 cows to hyenas while attending a crusade (a multiple day religious event) but stated that, "there is no need to return home when I am in the house of God; he will surely protect my livestock from danger". An Anglican pastor on MGR provided a possible explanation, "KAG does not include the Old Testament in its sermons, and this part of the bible includes the critical passages regarding the importance of the environment".

The link between religion and conservation behavior is complex. For example, scholars suggests that Christianity both undermines conservation through its doctrine of man's dominion over nature (White, 1967), and promotes values of stewardship and accountability of man to conserve the environment (Barr, 1972).

Maasai in our study area who attended the Roman Catholic Church were found to be more tolerant of carnivores, perhaps because the Catholic Church in Kenya is one of the few that has included environmental issues and in sermons and is more tolerant of other cultures and traditions (Gitau, 2000). Noss and Cuellar (2001) found that the Catholic Church in South America is more tolerant than Evangelical churches of traditional cultural beliefs and their respect for nature, whereas, Evangelical churches emphasize humans' dominance over nature. D. Hodgson (pers. commun.) suggests that the evangelical Tanzanian Assemblies of God (TAG) is similarly less tolerant than the Catholic Church of traditional Maasai culture. These dynamics would seem to underlie our effect, though more research is needed in order to identify differences among Christian denominations with respect to doctrine regarding wildlife and conservation, and eventually the role of ceremony induced herd neglect.

4.3. Livestock dependence

Respondents who raise livestock for sale have a higher reported likelihood of retaliating against predators compared to those who keep stock only for domestic consumption or traditional reasons. Similarly, Bagchi and Mishra (2006) concluded that tolerance and attitudes towards carnivores in India are directly related to the economic value of livestock. In a focus group Maasai elders stated that "people who sell livestock buy very expensive breeds and so when carnivores kill their livestock it is like losing four or five ordinary cows". Breed should thus be included as a variable in future studies.

Attitudes appeared to vary according to the number of livestock owned and an individuals' dependence on their livestock. For example, an elder that owned only two cows stated, "I cannot lose anymore livestock because I need to feed my family–so the answer is to look for poison and poison the remaining carcass, so that animal that attacked my cow will feed on the carcass and die, just like my dead cow". Other more affluent individuals were not as vengeful, "we have always lost livestock to carnivores but now we are getting some benefits [from conservation] like school bursaries for our children, so I can tolerate them". These findings resemble those of Naughton-Treves (1998) who found that cash crop damage angered men more than did subsistence crop damage, which angered women more. However, poorer livestock producers are not always the most vociferous in complaints of predator damage. In Uganda, Graham (1973) noted that wealthy individuals complained more frequently and fervently about crop damage by wildlife, even though there neighbors were ultimately losing greater proportions of crops.

4.4. Perceptions of conflict

Maasai on MGR appear to eliminate the most controllable factor (carnivores) that threaten their livestock. Killing carnivores is simpler and cheaper than preventing disease, which accounts for the majority of livestock mortality, and drought, which is beyond control.

Although lions kill a smaller percentage of livestock than other predators, Maasai disproportionately remove lions in retaliation. Compensation records showed that lions were responsible for only 62 out of 1141 (5%) of all livestock attacked between May 2005 and May 2006 (Maclennan et al., 2009). Similarly, Marker et al. (2003) found that 60% of white farmers in Namibia indiscriminately removed cheetahs even though they did not consider cheetahs problematic. Mishra (1997) found that agro-pastoralists in the Himalayas persecuted wolves (*Canis lupus*), whereas snow leopards (*Uncia uncia*) were responsible for the majority of depredation events.

These results differ from those of Kissui (2008) on traditional Maasai in Tanzania, where lions were the main predator on livestock and thus retaliatory killings were consistent with the frequency of lion attacks on livestock. Ogada et al. (2003) and Woodroffe and Frank (2005) found that white ranchers in Laikipia do not indiscriminately kill lions, but rather kill only those individuals that have attacked their livestock. Thus, more precisely targeted Problem Animal Control (PAC) is quite feasible, and in fact is probably exemplified in traditional *Olkiyioi* hunts, when Maasai spear a lion after it has attacked livestock.

4.5. What are the implications for predator compensation schemes?

Even though univariate tests indicated that individuals who had been compensated reported a lower propensity to kill lions, our multivariate test reveals that this association disappeared due to a stronger association with three other variables. The strength of the compensation variables are weak overall in the AIC results; the standard errors included 0 (see Table 5 in Results), so we cannot conclude that compensation plays a powerful role in affecting people's reported propensity to kill lions in high-conflict areas on Mbirikani Ranch. However, in areas of low conflict the compensation program has successfully increased tolerance toward carnivores (Rodriguez, 2006).

To understand the influence of compensation on people's attitudes and tolerance of carnivores on MGR, we ran additional AIC and logistic regression tests (see Hazzah, 2006 for full analysis) that were identical in methodology as reported here. These illustrated that during this study period, the majority of respondents (88%) had been compensated for their livestock losses, but only about half of those compensated approved of the program (Hazzah, 2006). Those individuals who had been compensated at least once were more positive toward the compensation program and conservation initiatives than those individuals who had never received compensation ($\chi^2 = 4.833$, $p = 0.027$). However, respondents who were compensated multiple times were not any more likely to hold a positive view regarding the compensation program than those receiving compensation only once (Mann Whitney *U* test: $z = -1.481$, $p = 0.139$).

Compensating an individual repeatedly did not necessarily result in a more favorable view towards the program or conservation efforts in general. However, failing to compensate people each time their livestock are attacked could be highly detrimental, causing additional resentment towards carnivores and conservation efforts (Naughton-Treves et al., 2003). Although compensation may not "buy" an individual's tolerance of carnivores, these payments can have an important political role and earn carnivores some tolerance at a broader level (Naughton-Treves et. al., 2003).

4.6. Management implications and conclusions

Even though predators are not the primary cause of livestock loss on Mbirikani Group Ranch, they represent a vivid and immediate threat that herders themselves can control. Lions are most vulnerable because: (i) they are the easiest carnivore to kill using traditional methods (spearing), while leopards, hyenas, and cheetahs are much more difficult to track and kill; (ii) spearing a lion provides immense prestige within Maasai society (Berger, 1993), but killing other predators does not; and (iii) although lions kill fewer livestock than other predators, they predominantly attack cattle, which are of such great cultural significance to Maasai, that their loss incites greater resentment than killing shoats (Dickman 2005; Bagchi and Mishra, 2006). Thus, people kill lions in disproportion to their actual impact. Additionally, because lions return to carcasses, they are also very easy to poison.

Both economic factors (proportional loss and sale orientation) and ideological factors (evangelical church affiliation) associated with lion killing must be addressed. Sixty-five percent of depredation losses occur when livestock are left outside of bomas at night (Maclennan et al., 2009) and could be substantially reduced by better herding practices, while losses from *bomas* could be essentially eliminated through better construction practices (Ogada et al., 2003). Our data suggest that such efforts should target small herd owners. Conservationists must also engage religious leaders and church congregations about emphasizing wildlife stewardship as part of their teachings. Further, more effective law enforcement is required; killing lions is illegal, but few offenders are arrested, and even fewer are prosecuted (Maclennan et al., 2009). Although compensation does not appear to "buy" tolerance of carnivores in areas of high-conflict, we believe it is a useful investment that opens dialogue between pastoralists and conservationists, and can thus lead to the development of co-management strategies.

Compared to other large carnivores, lions are relatively insignificant as livestock predators so the intense resentment of lions expressed by 25% of respondents suggest that conflict is rooted in perceptions rather than actual losses, possibly influenced by vulnerability linked to land use changes, displacement, and the imposition of conservation measures (Lindsay, 1987; Berger, 1993; Adams and McShane, 1996). Maasai have not only lost much of their former tolerance that allowed them to coexist with lions, availability of cheap and effective poison now gives them the means to eliminate predators.

In today's Kenya, wild animals outside of protected areas have no positive economic value; they are only an expensive nuisance to the people who lose crops, livestock, and occasionally human life. This negative situation can only be reversed through reforms at the national level that would allow rural people to profit economically from ecotourism or other wildlife-based enterprises (Borgerhoff Mulder and Coppolillo, 2005). Properly managed trophy hunting, with profits transparently distributed to community members, could generate significant income and attendant good will towards wildlife, but has been unavailable as a conservation option in Kenya since 1977 (Lindsey et al., 2007). Retributive killing of wildlife is unlikely to end until the burden of wildlife property damage ceases to fall on local communities, requiring a shift toward a more decentralized conservation agenda.

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References

Adams, J., McShane, T.O., 1996. The Myth of Wild Africa: Conservation Without Illusion. University of California Press, Los Angeles.

Altmann, J., Alberts, S.C., Altmann, S.A., Roy, S.B., 2002. Dramatic change in local climate patterns in the Amboseli basin, Kenya. African Journal of Ecology 40, 248–251.

Anderson, D., Burnham, K.P., White, G.C., 1994. AIC model selection in overdispersed capture–recapture data. Ecology 75, 1780–1793.

Bagchi, S., Mishra, C., 2006. Living with large carnivores: predation on livestock by the snow leopard (*Uncia uncia*). Journal of Zoology 268, 217–224.

Barr, J., 1972. Man and nature – the ecological controversy and the old testament. Bull J Rylands Univ Libr Manchester 55, 9–32.

Bauer, H., Van Der Merwe, S., 2004. Inventory of free-ranging lion *Panthera leo* in Africa. Oryx 38, 26–31.

Berger, D., 1993. Wildlife Extension: Participatory Conservation by the Maasai of Kenya. English Press Ltd., Nairobi, Kenya.

Borgerhoff Mulder, M., Coppolillo, P., 2005. Conservation Linking Ecology, Economics, and Culture. Princeton University Press, Princeton, New Jersey.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference. A Practical Information-theoretic Approach. Springer, New York.

Burnham, K.P., Anderson, D.R., 2004. Multimodel inference: understanding AIC and BIC in model selection. Sociological Methods & Research 33, 261.

Chardonnet, P., 2002. Conservation of the African Lion: Contributions to a Status Survey. International Foundation for the Conservation of Wildlife, Paris, France.

Cullis, A., 1994. Ranking with shagaa in mongolia. RRA Notes, 87-88.

Dickman, A., 2005. An assessment of pastoralist attitudes and wildlife conflict in the Rungwa-Ruaha region, Tanzania, with particular reference to large carnivores. In: Biodiversity, Conservation and Management. University of Oxford, Oxford, p. 95.

Fox, J., 1997. Applied Regression Analysis, Linear Models, and related models. Sage Publications, Inc., California.

Frank, L., 1998. Living with Lions: Carnivore Conservation and Livestock in Laikipia District, Kenya. US Agency for International Development, Conservation of Biodiverse Resource Areas Project, Bethesda, Maryland. p. 63.

Gavshon, M., Magratten, D., 2009. CBS 60 Minutes. <http://www.cbsnews.com/stories/2009/03/26/60minutes/main4894945.shtml>.

Ginsberg, J.R., Macdonald, D.W., 1990. Foxes, Wolves, Jackals, and Dogs: An Action Plan for the Conservation of Canids. World Conservation Union. Gland, Switzerland.

Gitau, S., 2000. The Environmental Crisis: A Challenge for African Christianity. Acton Publishers, Nairobi, Kenya.

Graham, A.D., 1973. The Gardeners of Eden. Allen and Unwin, London, UK.

Groom, R., 2007. How to make Land Subdivision Work: An Analysis of the Ecological and Socio-Economic Factors Affecting Conservation Outcomes During Land Privatisation in Kenyan Maasailand. University of Bristol, Bristol.

Guggisberg, C.A.W., 1975. Wild Cats of the World. David and Charles, London.

Hazzah, L., 2006. Living among lions (*Panthera leo*): coexistence or Killing? community attitudes towards conservation initiatives and the motivations behind lion killing in Kenyan Maasailand. In: Conservation Biology and Sustainable Development. University of Wisconsin-Madison, Madison, p. 140.

Holmern, T., Nyahongo, J., Roskaft, E., 2007. Livestock loss caused by predators outside the Serengeti National Park, Tanzania. Biological Conservation 135, 518–526.

Hurt, H., 1999. The ecological, economic and social sustainability of natural resources on Mbirikani Ranch, Kajiado, Kenya. In: Centre for Environmental Technology. University of London, London, p. 98.

Ikanda, D.K., Packer, C., 2008. Ritual vs. Retaliatory Killing of African Lions in the Ngrorongoro Conservation Area, Tanzania. (endangered species update).

IUCN, 2006. Regional Conservation Strategy for the Lion *Panthera leo* in Eastern and Southern Africa, IUCN, Gland, Switzerland.

Jackson, R., Wangchuk, R., 2001. Linking snow leopard conservation and people-wildlife conflict resolution: grassroots measures to protect the endangered snow leopard from herder retribution. Endangered Species Update 18, 138–141.

Kissui, B., 2008. Livestock predation by lions, leopards, spotted hyenas, and their vulnerability to retaliatory killing in the Maasai steppe, Tanzania. Animal Conservation 11, 422–432.

Lindsay, W.K., 1987. Integrating parks and pastoralists: some lessons from Amboseli. In: Anderson, D., Grove, R. (Eds.), Conservation in Africa: People, Policies, and Practice. Cambridge University Press, Cambridge, UK, pp. 149–167.

Lindsey, P.A., Roulet, P.A., Romañach, S.S., 2007. Economic and conservation significance of the trophy hunting industry in sub-Saharan Africa. Biological Conservation 134, 455–469.

Linnell, J., Odden, J., Smith, M., Aanes, R., Swenson, J., 1999. Large carnivores that kill livestock: do "problem individuals" really exist? Wildlife Society Bulletin 27, 698–705.

Maclennan, S., Groom, R., Macdonald, D.W., Frank, L., 2009. Evaluation of a compensation scheme to bring about pastoralist tolerance of lions. Biological Conservation 142, 2419–2427.

Maina, S., 2007. Furadan: poisioning predators and vultures. Swara, 30.

Marker, L.L., Mills, M.G.L., Macdonald, D.W., 2003. Factors influencing perceptions of conflict and tolerance toward cheetahs on Namibian Farmlands. Conservation Biology 17, 1290–1298.

Mazerolle, M., 2006. Improving data analysis in herpetology: using Akaike's Information Criterion (AIC) to assess the strength of biological hypotheses. Amphibia–Reptilia 27, 169–180.

Mills, M.G.L., Hofer, H., 1998. Hyenas: Status Survey and Conservation Action Plan. World Conservation Union, Gland, Switzerland.

Mishra, C., 1997. Livestock depredation by large carnivores in the Indian trans-Himalaya: conflict perceptions and conservation prospects. Environmental Conservation 24, 338–343.

Mundry, R., Nunn, C., 2009. Stepwise model fitting and statistical inference. turning noise into signal pollution. The American Naturalist 173, 119–123.

Muthiani, E., Wandera, P., 2000. Feed Preferences, Optimal Integrated Stocking Rates of Selected Browsers and Grazers and Economic Viability of Integrating Wildlife and Livestock in Selected ASALs. Kenya Agriculture Research Institute, Makindu. pp. 1–84.

Myers, N., 1975. The silent savannahs. International Wildlife 5, 5–10.

Naughton-Treves, L., 1997. Farming the forest edge: vulnerable places and people around Kibale National Park, Uganda. The Geographical Review 87, 27–46.

Naughton-Treves, L., 1998. Predicting patterns of crop damage by wildlife around Kibale national park, Uganda. Conservation Biology 12, 156–168.

Naughton-Treves, L., Treves, A., 2005. Socio-ecological factors shaping local support for wildlife: crop raiding by elephants and other wildlife in Africa. In: Woodroffe, R., Thirgood, S., Rabinowitz, A. (Eds.), People and Wildlife: Conflict or Coexistence. Cambridge University Press, Cambridge.

Naughton-Treves, R., Grossberg, Treves, A., 2003. Paying for tolerance. rural citizens' attitudes toward wolf depredation and compensation. Conservation Biology 17, 1500–1511.

Noss, A., Cuellar, R., 2001. Community attitudes towards wildlife management in the Bolivian Chaco. Oryx 35, 292–300.

Nowell, K., Jackson, P., 1996. Wild Cats: Status Survey and Conservation Action Plan. World Conservation Union, Gland, Switzerland.

Nyhus, P., Osofsky, S., Ferraro, J.P., Madden, F., Fischer, H., 2005. Bearing the costs of human–wildlife conflict: the challenges of compensation schemes. In: Woodroffe, R., Thirgood, S., Rabinowitz, A. (Eds.), People and Wildlife: Conflict or Coexistence. Cambridge University Press, Cambridge.

Ogada, M.O., Woodroffe, R., Oguge, N.O., Frank, L.G., 2003. Limiting depredation by African carnivores: the role of livestock husbandry. Conservation Biology 17, 1521–1530.

Oli, M.K., Taylor, I.R., Rogers, M.E., 1994. Snow Leopard *Panthera uncia* predation of livestock: an assessment of local perception in the Annapurna conservation area, Nepal. Biological Conservation 68, 63–68.

Ray, J., Hunter, L., Zigouris, J., 2005. Setting Conservation and Research Priorities for Larger African Carnivores. Working Paper No. 24. Wildlife Conservation Society (WCS), New York. p. 216.

Rodriguez, S., 2006. Perceptions and attitudes of a Maasai community in southern Kenya regarding predator-damage compensation, wildlife conservation and the predators that prey on their livestock. School for International Training (SIT), Brattleboro, VT.

Saberwal, V.K., Gibbs, J.P., Chellam, R., Johnsingh, A.J.T., 1994. Lion–Human conflict in the Gir forest, India. Conservation Biology 8, 501–507.

Shtatland, E.S., Cain, E., Barton, M.B., 2001. The perils of stepwise logistic regression and how to escape them using information criteria and the output delivery system. In: Proceedings of the Twenty-Sixth Annual SAS Users Group International Conference, Paper 222-26. SAS Institute Inc., Long Beach, California.

Tower, M., Luttbeg, B., 2007. Alternative statistical approaches to the use of data as evidence for hypotheses in human behavioral ecology. Evolutionary Anthropology 16, 107–118.

Treves, A., Karanth, K.U., 2003. Human–carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17, 1491–1499.

Treves, A., Naughton-Treves, L., 1999. Risk and opportunity for humans coexisting with large carnivores. Journal of Human Evolution 36, 275–282.

Treves, A., Wallace, R., Naughton-Treves, L., Morales, A., 2006. Co-managing human–wildlife conflict. Human Dimensions of Wildlife 11, 1–14.

Wagner, K., Schmidt, R., Conover, M., 1997. Compensation programs for wildlife damage in North America. Wildlife Society Bulletin 25, 312–319.

Watson, C., 1994. Proportional piling in Turkana: a case study. RRA Notes 20, 131–132.

Western, D., Wright, M., Strum, S., 1994. Natural Connection: Perspectives in Community-Based Conservation. Island Press, Washington, DC.

White, L., 1967. The historical roots of our ecologic crisis. Science 155, 1203–1207.

Woodroffe, R., Frank, L., 2005. Lethal control of African lion (*Panthera leo*): local and regional population impacts. Animal Conservation.

Woodroffe, R., Ginsberg, J.R., 1998. Edge effects and the extinction of populations inside protected areas. Science 280, 2126–2128.