Determinants of attitudes towards predators in central Kenya and suggestions for increasing tolerance in livestock dominated landscapes

Stephanie S. Romañach, Peter A. Lindsey and Rosie Woodroffe

Abstract Where people and livestock live with predators there is often conflict that can lead to lethal control of predators. We evaluated attitudes of local people towards large predators and developed a novel index of tolerance by quantifying the number of livestock respondents would be willing to lose before killing the predator responsible. We interviewed 416 subsistence livestock farmers (community members) and commercial livestock ranchers in central Kenya. Commercial ranchers had more positive attitudes and higher tolerance than community members. Community members said their tolerance would increase if they were to derive income from ecotourism or trophy hunting. We found that community members with land title deeds were most tolerant of predators, stressing the importance of land security for conservation efforts. Subsistence livestock farming is the primary land use throughout much of Africa and, as a result, identifying strategies to improve tolerance of predators under this land tenure system is of major conservation significance.

Keywords Commercial ranching, communal land, human-wildlife conflict, husbandry, Kenya, lethal control, trophy hunting.

This paper contains supplementary material that can only be found online at http://journals.cambridge.org

Introduction

Large carnivores are among the most difficult species to conserve because they tend to occur at low densities, range widely, and can conflict with human interests (Linnell *et al.*, 2001; Macdonald & Sillero-Zubiri, 2002). Population sizes and distributions of large predators are declining in Africa, and some species are increasingly limited to protected areas. For example, after disappearing from most of their former range the estimated *c.* 40,000 (Chardonnet, 2002) or 16,500–30,000 (Bauer & Van Der Merwe, 2004) wild African lions *Panthera leo* now occur only in sub-Saharan Africa, and African wild dogs *Lycaon pictus* have been extirpated from 25 of the 39 countries they once inhabited and now number <5,800 individuals (Woodroffe *et al.*, 2004). For some predator species, particularly those that range widely, lethal control of animals found outside protected areas has even resulted in extirpations of populations occurring inside protected areas (e.g. wild dogs; Woodroffe & Ginsberg, 1998).

Human-wildlife conflict can arise when wildlife clashes with the goals of people (Madden, 2004; Woodroffe *et al.*, 2005b). Lethal control has been a key factor causing the decline of predators in Africa (Woodroffe & Ginsberg, 1998), historically in the form of state sponsored eradication programmes (e.g. wild dogs in Zambia; Buk, 1995), and more recently because of conflict with farmers over livestock or game. For example, lions are killed in Kenya because of their impact on livestock (Woodroffe & Frank, 2005), and cheetahs *Acinonyx jubatus* (Marker *et al.*, 2003a) and African wild dogs (Lindsey *et al.*, 2005) are killed on southern African game ranches because of their perceived impact on livestock and wildlife populations.

Throughout Africa, rising human population sizes result in increased pressure on wildlife populations from the bushmeat trade and habitat destruction (Awere, 1996). In Kenya human population growth is 3.8% per year (Lang & Bolig, 2005), resulting in acute pressure on wildlife and habitats. More than 70% of Kenya's wildlife is found outside protected areas, in privately- and communally-owned land (Grunblatt *et al.*, 1995). These wildlife populations are of key importance for conservation and for the persistence of Kenya's primary industry, tourism (Ottichilo *et al.*, 2000).

Stephanie S. Romañach* (Corresponding author) Mpala Research Centre, PO Box 555, Nanyuki, Kenya. E-mail stephanie.romanach@gmail.com

Peter A. Lindsey University of Zimbabwe, PO Box 167, Mount Pleasant, Harare, Zimbabwe.

Rosie Woodroffe Department of Wildlife, Fish, and Conservation Biology, University of California, One Shields Avenue, Davis, CA 95616, USA.

*Current address: University of Zimbabwe, PO Box 167, Mount Pleasant, Harare, Zimbabwe.

Received 19 May 2006. Revision requested 11 August 2006. Accepted 6 October 2006.

Assessing attitudes of people living with wildlife and identifying the determinants of these attitudes are important for conservation planning. Several studies have assessed people's attitudes towards predators in Europe (Bjerke & Kaltenborn, 1999; Ericsson & Heberlein, 2003) and the USA (Pate *et al.*, 1996; Naughton-Treves *et al.*, 2003a), but there have been fewer such studies in Africa, most of which have focused on local citizens' attitudes towards protected areas and access to natural resources (de Boer & Baquete, 1998; Infield, 1998; Gillingham & Lee, 1999; Archabald & Naughton-Treves, 2001; Infield & Namara, 2001; Picard, 2003; Weladji & Tchamba, 2003). The few studies that have evaluated attitudes towards predators focused on only commercial ranchers (Marker *et al.*, 2003b; Lindsey *et al.*, 2005; but see Bauer, 1995), and none of these studies have quantified the tolerance for livestock losses to predators.

We assessed attitudes of subsistence pastoralists and commercial ranchers towards predators in central Kenya to investigate threats to carnivores and identify possible solutions for promotion of long-term coexistence between people and predators. We explore the viability of ecotourism and trophy hunting for achieving coexistence. Our analyses are partly based on a novel index to measure tolerance for livestock losses. We examine attitudes and tolerance relative to socioeconomic factors, livestock losses, and land uses. The results are potentially applicable to the development of conservation strategies for large predators occurring outside protected areas throughout Africa.

Study area

Our study area in central Kenya (Fig. 1) is dominated by livestock but contains significant wildlife populations (Mizutani, 1999). Wildlife in Kenya is owned by the state and not by landowners, as is the case in some southern African countries (Bond *et al.*, 2004). Conflict between people and wildlife is one of the main threats to the persistence of wildlife in this area, which is home to significant populations of cheetahs, jackals *Canis mesomelas*, lions, leopards *Panthera pardus*, spotted hyaenas *Crocuta crocuta*, striped hyaenas *Hyaena hyaena*, and African wild dogs. These predators occupy a mosaic of land uses, including subsistence pastoralism, small-scale agriculture, commercial livestock ranching, and privately-owned ranches reserved for wildlife conservation. Most of this land is unfenced, and thus wildlife can move freely.

Throughout the area livestock owners practice traditional livestock husbandry such as herding and keeping livestock in corrals at night (Frank, 1998; Ogada *et al.*, 2003; Woodroffe *et al.*, 2005a). Thirty-four of the 48 privately-owned ranches have large-scale commercial activities. Interspersed with commercial ranches are

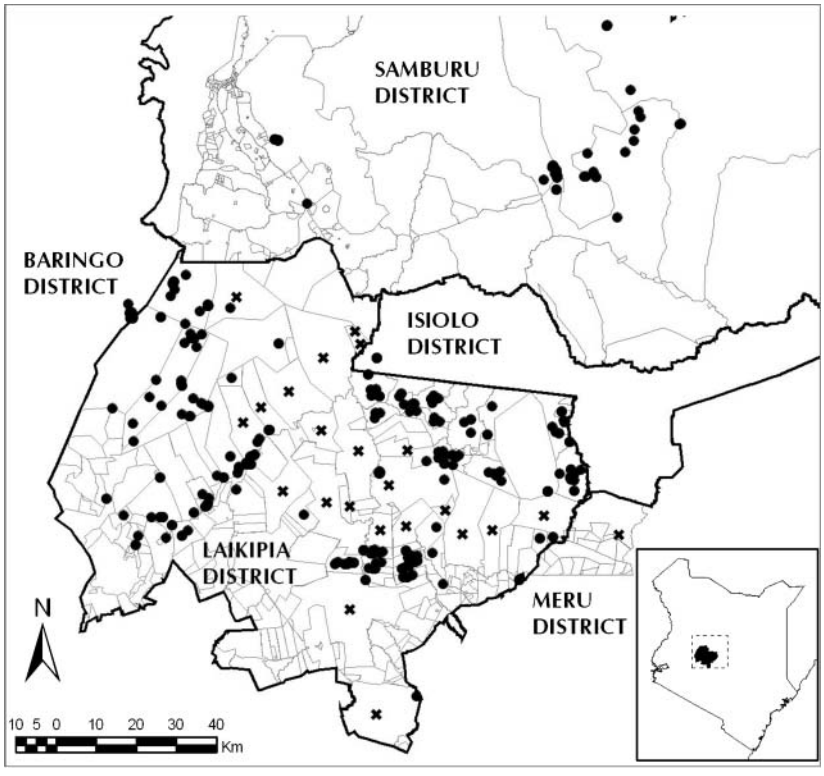

Fig. 1 Study area with crosses representing commercial rancher interview locations, and circles representing community member interview locations. The inset shows the location of the main figure in Kenya.

non-commercial producers, termed community members. Most community members are pastoralists, keeping cattle, and sheep and goats (shoats), although some are subsistence farmers with small agricultural plots and few or no livestock. Community members typically live in one of three land tenure systems: group ranches where the members hold a title deed to communal land, government land designated for settlement, or unofficial settlement on private or government land (i.e. squatters). The majority of the area is inhabited by Maasais and Samburus, although there are also people of the Borana, Kalenjin, Kikuyu, Merian, Pokot, Rendile, Somali and Turkana.

Methods

A mixture of closed- and open-ended questions, in 416 questionnaires (Appendix), were completed as one-on-one interviews between June 2004 and March 2005. Questionnaires were designed to assess respondents' attitudes towards and tolerance for livestock losses from cheetahs, jackals, leopards, lions, spotted hyenas, striped hyenas, and wild dogs. We trained six Community Liaison Officers from local non-governmental organizations and three research assistants who conducted interviews in their native languages in areas where they lived and worked. Interviewers periodically monitored one another's interviews to promote consistency. Interviewees were randomly selected in villages (e.g. every third home) and at market gatherings until the minimum sample size of 400 was reached. Multiple interviews were conducted in some locations where people from a wider area congregated (e.g. markets), and thus the map of interview locations (Fig. 1) underestimates the geographic coverage. To ensure familiarity with predators, interviewees were shown colour illustrations, before each interview, of large predators in the area, and behaviours of each were discussed (e.g. diurnal vs nocturnal, group living vs solitary). People who have experienced depredation may exaggerate losses (Rasmussen, 1999). To minimize potential exaggeration respondents were told, before each interview, that information collected would be anonymous, was part of a research study, and responses would not influence policies such as taxes or compensation.

The survey aimed to assess attitudes towards predators by asking whether people preferred to have each predator on their land (yes or no), tolerance by asking for the number of cattle and shoats respondents were willing to lose before trying to kill the predator responsible, and what tolerance was 20 years ago. We asked for suggestions to promote coexistence between people and predators, numbers of livestock killed, retribution killings of predators in the last year, and opinions on legalizing trophy hunting (banned in Kenya since 1977). We recorded socioeconomic data including age, gender, ethnic group, years of formal education, and income source, and property characteristics including land use and presence of wildlife conservation areas (Table 1).

We used multivariate logistic regressions to analyse tolerance in relation to socioeconomic and property characteristics. Model selection was by backward stepwise regression, with the software *JMPIN* (SAS Institute, Cary, USA).

Results

Desire to have predators

We analysed responses from commercial ranchers and community members separately because significantly more commercial ranchers desired predators on their properties (cheetah $\chi^2 = 26.38$, $P < 0.01$; jackal $\chi^2 = 26.65$, $P < 0.01$; leopard $\chi^2 = 25.94$, $P < 0.01$; lion $\chi^2 = 22.78$, $P < 0.01$; spotted hyena $\chi^2 = 57.88$, $P < 0.01$; striped hyena $\chi^2 = 57.73$, $P < 0.01$; wild dog $\chi^2 = 27.81$, $P < 0.01$; Fig. 2). Commercial ranchers were generally positive about having predators on their land (Fig. 2) with no influence of socioeconomic or property characteristics. Ranchers were least positive about lion on their properties, although only 3 of 23 respondents preferred not to have lions.

Most community members had negative attitudes towards predators and the most disliked predator was spotted hyena (Fig. 2). Community members had positive attitudes towards some predators if their primary household income came from tourism (Table 2). Maasai and Samburu were more positive towards all predators than other tribal groups (Table 2). Land tenure had a significant effect on community members' attitudes towards all predators apart from cheetah, with group ranch members most positive towards carnivores and squatters least so (Table 2). Respondents with tourism or plans to set aside a conservation area had positive attitudes (Table 2).

Tolerance and lethal control

Some interviewees stated they would not kill predators responsible for depredation, no matter how much livestock was lost (Fig. 3a). Commercial ranchers had higher tolerance than community members for all predators apart from lions, which both groups were equally likely to kill in response to depredation (cheetah $\chi^2 = 35.21$, $P < 0.01$; jackal $\chi^2 = 8.81$, $P < 0.01$; leopard $\chi^2 = 8.18$, $P < 0.01$; lion $\chi^2 = 0.28$, $P = 0.60$; spotted hyena $\chi^2 = 21.03$,

Table 1 Proportions of commercial ranchers, community members, and of all respondents combined, with each property and socioeconomic characteristic, and who had experienced depredation and killed predators. Average respondent age, years of education, and numbers of cattle and shoats lost also reported. χ^2 or Wilcoxon test statistics given where comparisons made between commercial ranchers and community members.

	Commercial ranchers (n = 23)	Community members (n = 393)	Overall (n = 416)	Statistics
Property characteristics				
Proportion receiving benefits from wildlife	0.65	0.31	0.33	$\chi^2 = 3.6$, P = 0.06
Proportion with wildlife conservation area	0.52	0.31	0.32	$\chi^2 = 4.6$, P = 0.03
Proportion planning conservation area, if without one	0.00	0.15	0.14	$\chi^2 = 1.9$, P = 0.16
Proportion with wildlife tourism	0.65	0.35	0.36	$\chi^2 = 8.8$, P <0.01
Proportion living on group ranches		0.34		
Proportion living on government land		0.64		
Proportion living as squatters		0.02		
Socioeconomic characteristics				
Proportion of men	1.00	0.74	0.76	
Proportion of women	0.00	0.26	0.24	
Average age (years)	44.4	41.7	41.8	Z = 1.1, P = 0.27
Average education (years)	13.5	4.8	5.3	Z = 7.3, P <0.01
Depredation & retribution killings in previous year				
Proportion having lost livestock to cheetahs	0.17	0.14	0.14	$\chi^2 = 0.2$, P = 0.62
Proportion having lost livestock to jackals	0.04	0.21	0.20	$\chi^2 = 3.9$, P = 0.05
Proportion having lost livestock to leopards	0.61	0.30	0.32	$\chi^2 = 9.3$, P <0.01
Proportion having lost livestock to lions	0.96	0.24	0.28	$\chi^2 = 54.2$, P <0.01
Proportion having lost livestock to spotted hyenas	0.48	0.36	0.37	$\chi^2 = 1.2$, P = 0.27
Proportion having lost livestock to striped hyenas	0.00	0.09	0.09	$\chi^2 = 2.4$, P = 0.12
Proportion having lost livestock to wild dogs	0.04	0.05	0.05	$\chi^2 = 0.0$, P = 0.96
Average number of cattle lost to all predators	21.9	0.78	1.9	Z = 7.1, P <0.01
Average number of shoats lost to all predators	30.4	5.03	6.4	Z = 2.0, P = 0.04
Proportion having killed predators	0.48	0.15	0.16	$\chi^2 = 16.2$, P <0.01

P <0.01; striped hyena $\chi^2 = 42.74$, P <0.01; wild dog $\chi^2 = 19.50$, P <0.01). Thirty-eight percent of interviewees owned livestock 20 years ago and, of those, 31% were more tolerant now and 6% were less tolerant now (Fig. 4).

Only one commercial rancher had a kill on sight policy, and that was for spotted hyenas (Fig. 3b). There was no influence of socioeconomic characteristics of commercial ranchers on tolerance. Ranchers on land with tourism as the primary source of income had higher tolerance for cattle (Table 3) and shoat (Table 4) losses to some predators compared to ranchers who relied on livestock for income.

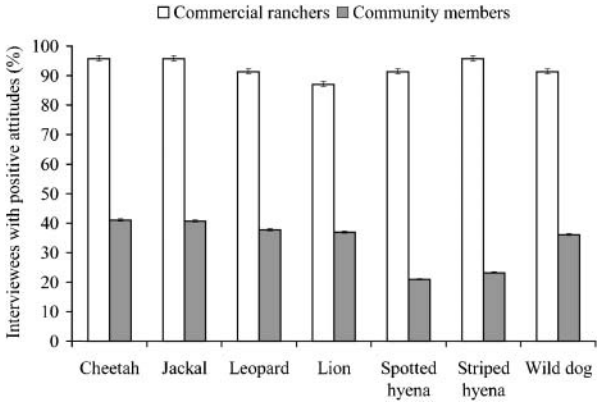

Fig. 2 Percentages (95% confidence intervals) of commercial ranchers and community members who wanted each predator on their property.

Community members' mean tolerance was less than one cow or shoat to each predator (Fig. 4b), and 79% of respondents had a kill on sight policy. Community members with income from tourism and those with more education were more tolerant of shoat losses to some predators (Table 4). Contrary to expectations, if the interviewee had lost livestock to any predator in the previous year, reported tolerance for cattle (Table 3) and shoat (Table 4) attacks was higher for some predators compared to interviewees who had not lost livestock. Community members who experienced depredation in the last year were more likely to have killed predators than people who had not lost livestock ($\chi^2 = 6.05$, P = 0.01). Lethal control was not a reflection of degree of livestock losses; people who lost fewer livestock were more likely to have killed predators than those who lost more livestock ($\chi^2 = 5.46$, P = 0.02). Community members living on group ranches were more tolerant of cattle (Table 3) and shoat (Table 4) losses compared to those living on government-owned land or squatters. Presence of tourism and wildlife conservation areas led to higher tolerance for

Table 2 Attitudes of community members as they relate to property and socioeconomic characteristics. Logistic regression results presented as χ^2 values for the whole model with only significant variables included (i.e. after backwards stepwise procedure), and Likelihood Ratio chi-square values for each significant variable. Empty cells represent non-significance.

	Cheetah	Jackal	Leopard	Lion	Spotted hyena	Striped hyena	Wild dog
Property characteristics	$\chi^2 = 72.67$ $P < 0.31$	$\chi^2 = 60.38$ $P < 0.01$	$\chi^2 = 80.02$ $P < 0.01$	$\chi^2 = 50.03$ $P < 0.01$	$\chi^2 = 56.17$ $P < 0.01$	$\chi^2 = 117.01$ $P < 0.01$	$\chi^2 = 48.73$ $P < 0.01$
Land use	$\chi^2 = 72.67$ $P < 0.31$		$\chi^2 = 27.80$ $P < 0.01$	$\chi^2 = 19.69$ $P < 0.01$	$\chi^2 = 16.22$ $P = 0.01$	$\chi^2 = 35.11$ $P < 0.01$	
Tourism		$\chi^2 = 29.88$ $P < 0.01$	$\chi^2 = 6.47$ $P = 0.04$		$\chi^2 = 7.52$ $P = 0.02$	$\chi^2 = 11.19$ $P = 0.01$	
Plan to start conservation area				$\chi^2 = 7.81$ $P = 0.02$			$\chi^2 = 8.99$ $P = 0.01$
Socio-economic characteristics	$\chi^2 = 125.52$ $P << 0.01$	$\chi^2 = 35.07$ $P < 0.01$	$\chi^2 = 101.72$ $P << 0.01$	$\chi^2 = 96.40$ $P << 0.01$	$\chi^2 = 47.60$ $P < 0.01$	$\chi^2 = 61.58$ $P < 0.01$	$\chi^2 = 111.64$ $P << 0.01$
Age	$\chi^2 = 10.12$ $P < 0.01$		$\chi^2 = 14.30$ $P < 0.01$	$\chi^2 = 10.50$ $P < 0.01$	$\chi^2 = 12.43$ $P = 0.02$	$\chi^2 = 8.00$ $P = 0.05$	$\chi^2 = 18.72$ $P < 0.01$
Gender	$\chi^2 = 7.29$ $P = 0.03$						$\chi^2 = 7.56$ $P = 0.02$
Education	$\chi^2 = 11.60$ $P < 0.01$		$\chi^2 = 7.50$ $P = 0.02$				
Ethnic group	$\chi^2 = 60.35$ $P << 0.01$	$\chi^2 = 35.06$ $P < 0.01$	$\chi^2 = 43.73$ $P < 0.01$	$\chi^2 = 53.78$ $P << 0.01$	$\chi^2 = 32.57$ $P = 0.02$	$\chi^2 = 52.79$ $P < 0.01$	$\chi^2 = 39.75$ $P < 0.01$
Primary income source			$\chi^2 = 16.07$ $P = 0.01$	$\chi^2 = 17.67$ $P < 0.01$			$\chi^2 = 13.71$ $P = 0.03$

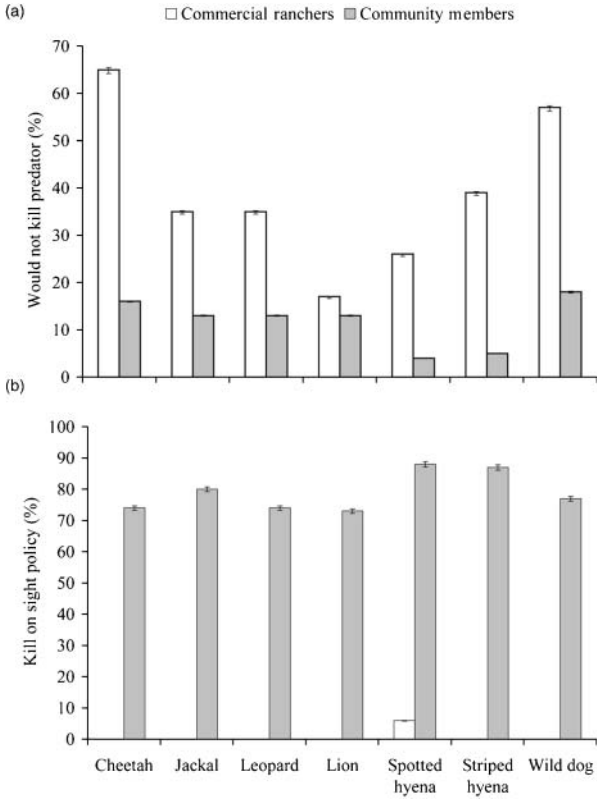

Fig. 3 Percentages (95% confidence intervals) of commercial ranchers and community members (a) who would not kill predators responsible for livestock attacks, no matter how much livestock was lost, and (b) of those who would kill, the percentage with 'kill on sight' policies.

wild dog attacks (Tables 3 & 4). Of community members, 7.7% would set wire snares to kill predators compared to 0% of commercial ranchers. Only one commercial rancher would use poison to kill predators compared to 168 community members ($\chi^2 = 13.40$, $P < 0.01$).

Coexistence with predators

All commercial ranchers felt that coexistence between people and predators was possible. The most common response given (by 22% of ranchers) about ways to promote coexistence was to begin trophy hunting. Seventeen percent of respondents said that any income from wildlife would promote coexistence, and 17% felt that improved livestock husbandry techniques would allow coexistence.

Forty-two percent of community members stated that coexistence was not possible. The second most common response (20%) was to receive income from wildlife through tourism or trophy hunting. Fourteen percent suggested financial compensation for livestock killed by predators.

When asked directly about legalization of trophy hunting, only two ranchers did not support trophy hunting. There was no influence of socioeconomic characteristics on whether ranchers supported trophy hunting (whole model $\chi^2 = 2.88$, $P = 0.24$). Half of community members supported trophy hunting. Older community members wanted hunting ($\chi^2 = 7.80$, $P < 0.01$; whole model $\chi^2 = 56.70$, $P < 0.01$), mentioning employment opportunities. Those with tourism did

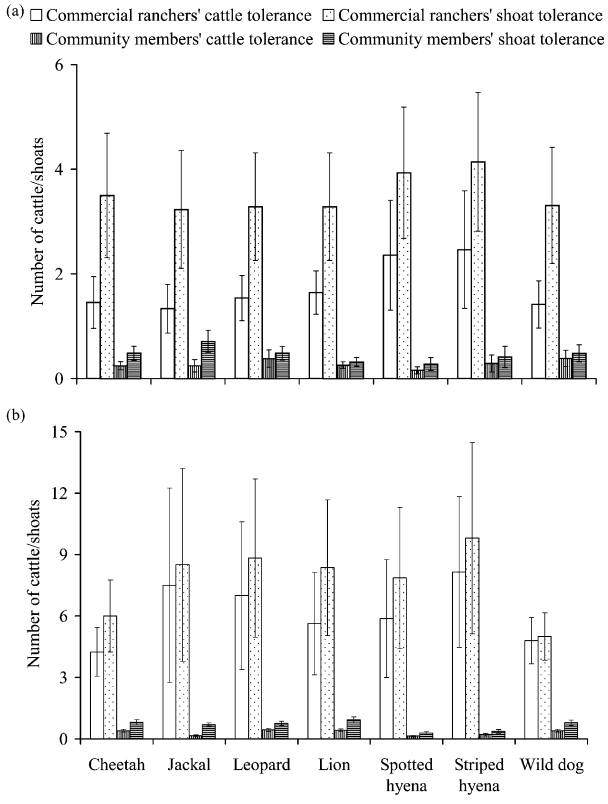

Fig. 4 Mean (+ SE) numbers of cattle, and sheep and goats (shoats) that commercial ranchers and community members were willing to tolerate losing to predators before trying to kill the predator responsible (a) 20 years ago, and (b) at the time of the interviews in 2004/5.

not want hunting (χ^2 = 14.39, P <0.01; whole model χ^2 = 39.65, P <0.01) for fear that hunting would kill all wildlife and leave nothing to show tourists.

Discussion

Attitudes were most positive and tolerance was highest among commercial ranchers. These findings are not surprising given the relative wealth of commercial ranchers compared to community members. Commercial ranchers in the study area own an average of 1,536 cattle and 310 shoats, whereas community members own an average of 8 cattle and 64 shoats (R. Woodroffe, unpubl. data). According to reported losses in the previous year, commercial ranchers lost 1.5% of their cattle and 9.8% of their shoats to predators, whereas community members lost 14.7% of their cattle and 7.9% of their shoats. Community members, therefore, lost 10 times more of their wealth in cattle compared to commercial ranchers. However, 30% of commercial ranchers received no monetary benefits from wildlife and no income subsidies, and livestock ranching was their only source of income.

Commercial ranchers were least positive towards lions. According to rancher reports lions killed three times as many livestock compared to the next most costly predator, spotted hyaena. Ninety six and 11% of ranchers lost livestock to lions and hyaenas, respectively, in the previous year. Our findings accord with results from a 1967–1968 survey of commercial ranchers in Laikipia, which showed that 90% of ranchers stated a generally tolerant attitude towards wildlife in reasonable numbers, with lions being identified as the least popular predator (Denney, 1972).

Commercial ranches are interspersed with communal land, where people are generally less tolerant of predators, highlighting the necessity for outreach to promote survival of wildlife. Commercial ranches cover 40% of Laikipia's 9,667 km^2 but are rare in the neighbouring districts, suggesting that current prospects for predator conservation in Laikipia are higher than elsewhere. Tolerance for predators has increased compared to 20 years ago among both commercial ranchers and community members. Kenyan commercial ranchers hold more positive attitudes than their southern African counterparts (Lindsey *et al.*, 2005). Recently there have been claims to commercial ranch land by Masaai who were moved from their ancestral land during the colonial era. Our data suggest that the conversion of commercial ranch land to communally-owned land or subdivided plots to be utilized for subsistence livestock farming will have negative consequences for predator conservation as community members are likely to be less able to absorb livestock losses.

Granting land ownership may improve attitudes towards wildlife in communally-owned areas. We found positive attitudes and higher tolerance among group ranch members compared to respondents without land ownership, as did Infield & Namara (2001). Promoting group land ownership allows individuals to share risk of loss and could have positive implications for predator conservation over large areas in Africa (Naughton-Treves & Treves, 2005), and is a management strategy that has resulted in improved coexistence between people and wildlife elsewhere (e.g. Peru; Naughton-Treves *et al.*, 2003b). Group landowners can potentially use title deeds as collateral to obtain loans (for example, for the development of tourism infrastructure), and the land area encompassed by a group is more likely to be of suitable size for wildlife conservation than small, individually-owned plots. In our study area NGOs and commercial ranch owners have helped communities gain title deeds to their land. However, land ownership is not sufficient in isolation to promote wildlife conservation. For example, group

Table 3 Tolerance of commercial ranchers and community members for cattle losses to seven predators as they relate to property and socioeconomic characteristics. Multiple regression results presented for the whole model with only significant variables included. Empty cells represent non-significance.

	Cheetah	Jackal	Leopard	Lion	Spotted hyena	Striped hyena	Wild dog
Commercial ranchers							
Property characteristics	$F = 11.39$			$F = 6.57$		$F = 15.49$	
Primary income source	$P = 0.01$			$P = 0.02$		$P < 0.01$	
Community members							
Property characteristics	$F = 6.55$	$F = 8.85$	$F = 7.74$	$F = 8.18$	$F = 8.34$	$F = 3.76$	$F = 18.89$
	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P = 0.01$	$P < 0.01$
Land use	$F = 6.55$	$F = 8.85$	$F = 7.74$	$F = 8.18$	$F = 8.34$	$F = 3.76$	
	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P = 0.01$	
Tourism							$F = 18.89$
							$P << 0.01$
Socioeconomic characteristics	$F = 4.02$			$F = 3.70$	$F = 5.88$		$F = 4.80$
	$P = 0.05$			$P < 0.01$	$P < 0.01$		$P < 0.01$
Age					$F = 6.81$		
					$P < 0.01$		
Ethnic group				$F = 3.70$			$F = 2.56$
				$P < 0.01$			$P < 0.01$
Primary income source							$F = 7.11$
							$P < 0.01$
Livestock killed by any predator in previous year	$F = 4.02$				$F = 5.92$		
	$P = 0.05$				$P = 0.02$		

Table 4 Tolerance of commercial ranchers and community members for shoat losses as they relate to property and socioeconomic characteristics. Multiple regression results presented for the whole model with only significant variables included. Empty cells represent non-significance.

	Cheetah	Jackal	Leopard	Lion	Spotted hyena	Striped hyena	Wild dog
Commercial ranchers							
Property characteristics		$F = 8.03$	$F = 189.26$	$F = 203.77$	$F = 177.62$	$F = 198.38$	
Primary income source		$P = 0.02$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	
Community members							
Property characteristics	$F = 4.89$	$F = 2.67$	$F = 5.00$	$F = 5.59$	$F = 3.96$	$F = 4.29$	$F = 7.26$
	$P < 0.01$	$P = 0.05$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$
Land use	$F = 4.89$	$F = 2.67$	$F = 5.00$	$F = 5.59$	$F = 3.96$	$F = 4.29$	
	$P < 0.01$	$P = 0.05$	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$	
Wildlife conservation area							$F = 7.26$
							$P < 0.01$
Socio-economic characteristics		$F = 3.54$	$F = 2.23$	$F = 5.56$	$F = 2.76$		
		$P < 0.01$	$P < 0.01$	$P = 0.02$	$P < 0.01$		
Education		$F = 5.82$	$F = 5.16$	$F = 5.56$			
		$P = 0.02$	$P = 0.02$	$P = 0.02$			
Ethnic group		$F = 3.44$			$F = 2.76$		
		$P < 0.01$			$P < 0.01$		
Livestock killed by any predator in previous year			$F = 7.24$				
			$P < 0.01$				

land ownership near the Maasai Mara in Kenya led to land development and reduction in wildlife numbers caused by landowners not receiving adequate economic return from wildlife (Norton-Griffiths, 1996, 1997).

All native large predator species are present on communal lands in the study area, despite reported low tolerance. Fifteen percent of community members reported that they had killed predators in the previous year, a figure much lower than the 79% claiming to kill predators on sight. In recent years lions have suffered high mortality from poisoning on community land (L. Frank, pers. comm.). However, wild dogs show

comparable population densities and mortality rates on communal lands and commercial ranches, and populations are expanding on both land use types (Woodroffe *et al.*, 2007b). The discrepancy between stated intentions and actions could result from a number of causes; for example, people may not often encounter predators, they may be unsuccessful in their attempts or unable to kill predators, or they may fear legal recriminations.

Our results highlight some potential ways to improve attitudes to and tolerance for predators. Community members indicated their attitudes towards predators would improve if they were to receive income from ecotourism, and community members with tourism had positive attitudes. Charismatic megafauna are the most popular species among foreign visitors to wildlife areas (Goodwin & Leader-Williams, 2000), and thus communities with predators on their land and viewable wildlife have potential to generate income from tourism. However, areas lacking high densities of wildlife or spectacular scenery may not be able to benefit, and initiating ecotourism on communal land generally requires significant donor input to permit the development of infrastructure and provide training (Kiss, 2004).

Trophy hunting is another means of generating income and thus incentives for conservation, and can be conducted in areas with relatively low densities of wildlife and where people and livestock occur (Lindsey *et al.*, 2006). Trophy hunting has particular potential in Kenya because the country is viewed as the home of trophy hunting in Africa (Lindsey *et al.*, 2006). Such hunting has the potential to improve tolerance towards predators, given their high trophy values (e.g. USD 23,646 trophy fee for a lion in South Africa; Damm, 2005). We found that younger community members had mixed views regarding trophy hunting, which may have arisen from anecdotes about the previous poorly-regulated hunting industry in Kenya (Outoma, 2004; Booth, 2005). Trophy hunting has, however, been successful in creating incentives for conservation in communal lands in the Central African Republic, Namibia, Tanzania and Zimbabwe (Lindsey *et al.*, 2007) such that some communities have opted for the formation of wildlife areas for trophy hunting instead of agriculture (Lewis & Alpert, 1997). Furthermore, there is considerable interest among US hunting clients in hunting problem animals, such as repeat livestock killers, in Africa (Lindsey *et al.*, 2006).

We found no influence of benefits shared among the community as a whole on tolerance towards predators. When people do not receive benefits they have been promised, or perceive that only outsiders are benefiting, attitudes may become worse (Western, 1994; Walpole & Goodwin, 2001; Mishra *et al.*, 2003; Walpole & Thouless, 2005), and there is an increased understanding that benefits must accrue to individuals to be effective (Archabald & Naughton-Treves, 2001; Walpole & Goodwin, 2001; Walpole & Thouless, 2005).

Providing financial compensation to alleviate livestock losses to predators has been undertaken because it could improve attitudes and increase tolerance (Nyhus *et al.*, 2005). In Kenya, compensation was awarded by the government, private donors, and NGOs but such programmes are no longer in existence (Outoma, 2004). In some areas in Kenya compensation policies led to overstocking and, as a result, increased conflict with predators and wild ungulates for grazing (Prins, 2000; Bulte & Rondeau, 2005). In the USA compensation for wolf depredation did not increase tolerance (Naughton-Treves *et al.*, 2003a). Ferraro (2001) suggested that direct payments (e.g. paying for occupied wild dog dens) can have the largest impact on individuals' conservation-related behaviours, and can give more cost-effective conservation outcomes than trophy hunting or ecotourism (Ferraro & Kiss, 2002).

Finding methods to reduce livestock losses to predators may improve predator tolerance. Community members who lost livestock to predators in the previous year killed more predators (see Ogada *et al.*, 2003 for similar findings from commercial ranchers), which suggests that lethal control is not simply because of an unjustified dislike for predators. Half of community members would use carcass poisoning to kill predators, which typically affects many more species and individuals than the target animal, and has serious negative implications for wildlife conservation. Thus, finding methods to reduce livestock losses (e.g. livestock husbandry, Kruuk, 1981; Ogada *et al.*, 2003; Treves & Karanth, 2003; Jackson & Wangchuk, 2004; Woodroffe *et al.*, 2007a) is of key importance for the conservation of predators and wildlife in general. Setting aside small conservation areas to conserve wild prey is another potential means of reducing livestock losses (Woodroffe *et al.*, 2005a).

Predators have been found to kill livestock in areas where livestock densities are higher than wild prey densities (Woodroffe *et al.*, 2005a; Bagchi & Mishra, 2006) and therefore reducing livestock densities could reduce attacks by predators. Reducing stocking densities has the potential to increase the sustainability of livestock production, improve the quality of livestock, increase the carrying capacity for wild prey, and thus increase the potential to generate revenues from tourism or hunting. High stocking rates often result in overgrazing, decreased vegetation, and reduced carrying capacity (Hardin, 1992; Pimentel & Kounang, 1998). However, livestock has been an integral part of African cultures and economies for centuries, and thus encouraging reduced stocking densities would be difficult, especially in communally-owned land (Dregne, 1983)

and may require educational campaigns to show that wildlife-based land uses such as tourism and hunting have the potential to generate greater revenues than livestock rearing alone (Prins, 2000).

Our study has revealed potential means to promote coexistence between predators and local people in Africa's rangelands. Improved attitudes and increased tolerance may be best achieved through conservation education, developing means to reduce livestock losses, and generation of financial incentives for predator conservation that reach individuals. Our results are timely as they coincide with Kenya's wildlife policy review. We have used our results as a basis for urging policy makers to consider options for its citizens to benefit from wildlife, thus providing incentives for conservation.

Acknowledgements

We are grateful to the commercial ranchers and community members for answering our questions, our assistants (N. Gitonga, M. Kahindi, D. Lomoe, P. Lekitasharan, B. Lengalen, S. Lesowapir, D. Masere, J. Musiany, and S. ole Ranah) who conducted interviews with community members, J.G.N. Olwero for computer and graphics support, and N. Georgiadis and J. Moss for answering questions about their work and experiences in the region. Thanks to the Mpala Research Centre, its staff, and especially to K. Outram and J. Petters for logistical support. We are grateful to L. Naughton-Treves, P. Nyhus, and an anonymous reviewer for helpful comments on earlier versions of this manuscript.

References

Archabald, K. & Naughton-Treves, L. (2001) Tourism revenue-sharing around national parks in Western Uganda: early efforts to identify and reward local communities. *Environmental Conservation*, **28**, 135–149.

Awere, G. (1996) *National Land Use Patterns and Trends*. Kenya Wildlife Service, Nairobi, Kenya.

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

Bauer, H. (1995) *Carnivores and Cattle-raising: Report of a Survey on Predation by Carnivores of Waza National Park on Livestock in the Surroundings*. Report for IUCN Waza Logone Project, Adamaoua, Cameroon.

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

Bjerke, T. & Kaltenborn, B.P. (1999) The relationship of ecocentric and anthropocentric motives to attitudes towards large carnivores. *Journal of Environmental Psychology*, **19**, 415–421.

Bond, I., Child, B., de la Harpe, D., Jones, B., Barnes, J. & Anderson, H. (2004) Private land contribution to conservation in South Africa. In *Parks in Transition: Biodiversity, Rural Development, and the Bottom Line* (ed. B. Child), pp. 29–62. Earthscan Publications, London, UK.

Booth, V. (2005) *International and Regional Best Practice and Lessons Applicable to Sport and Recreational Hunting in Southern Africa*. Report for Department of Environmental Affairs and Tourism, Pretoria, South Africa.

Buk, K. (1995) African wild dog survey in Zambia. *Canid News*, **3**, 46–49.

Bulte, E.H. & Rondeau, D. (2005) Why compensating wildlife damages may be bad for conservation. *Journal of Wildlife Management*, **69**, 14–19.

Chardonnet, P. (2002) *Conservation of the African Lion: Contribution to a Status Survey*. International Foundation for the Conservation of Wildlife, Paris, France, and Conservation Force, Metairie, USA.

Damm, G. (2005) Irregularities on Zimbabwe's hunting scene. *African Indaba*, **2**, 8–11.

de Boer, W.F. & Baquete, D.S. (1998) Natural resource use, crop damage and attitudes of rural people in the vicinity of the Maputo Elephant Reserve, Mozambique. *Environmental Conservation*, **25**, 208–218.

Denney, R.N. (1972) Relationships of wildlife to livestock on some developed ranches on the Laikipia Plateau, Kenya. *Journal of Range Management*, **25**, 415–425.

Dregne, H.E. (1983) *Desertification of Arid Lands*. Harwood Academic Publishers, New York, USA.

Ericsson, G. & Heberlein, T.A. (2003) Attitudes of hunters, locals, and the general public in Sweden now that the wolves are back. *Biological Conservation*, **111**, 149–159.

Ferraro, P.J. (2001) Global habitat protection: limitations of development interventions and a role for conservation performance payments. *Conservation Biology*, **15**, 990–1000.

Ferraro, P.J. & Kiss, A. (2002) Direct payments to conserve biodiversity. *Science*, **298**, 1718–1719.

Frank, L.G. (1998) *Living with Lions: Carnivore Conservation and Livestock in Laikipia District, Kenya*. Unpublished Report, Development Alternatives, Bethesda, USA.

Gillingham, S. & Lee, P.C. (1999) The impact of wildlife-related benefits on the conservation attitudes of local people around the Selous Game Reserve, Tanzania. *Environmental Conservation*, **26**, 218–228.

Goodwin, H.J. & Leader–Williams, N. (2000) Protected area tourism – distorting conservation priorities towards charismatic megafauna? In *Priorities for the Conservation of Mammalian Diversity: Has the Panda Had Its Day?* (eds A. Entwistle & N. Dunstone), pp. 257–275. Cambridge University Press, Cambridge, UK.

Grunblatt, J., Said, M., Wargute, P. & Kifugo, S.C. (1995) *Department of Resource Surveys and Remote Sensing Aerial Surveys Databases: Methods and Products*. Ministry of Planning and National Development, Department of Resource Surveys and Remote Sensing, Nairobi, Kenya.

Hardin, G. (1992) Cultural carrying capacity: a biological approach to human problems. *Carrying Capacity Network Focus*, **2**, 16–23.

Infield, M. (1998) Attitudes of a rural community towards conservation and a local conservation area in Natal, South Africa. *Biological Conservation*, **45**, 21–46.

Infield, M. & Namara, A. (2001) Community attitudes and behaviour towards conservation: an assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Oryx*, **35**, 48–60.

Jackson, R.M. & Wangchuk, R. (2004) A community-based approach to mitigating livestock depredation by snow leopards. *Human Dimensions of Wildlife*, **9**, 307–315.

Kiss, A. (2004) Is community-based ecotourism a good use of biodiversity conservation funds? *Trends in Ecology and Evolution*, **19**, 232–237.

Kruuk, H. (1981) *The Effects of Large Carnivores on Livestock and Animal Husbandry in Marsabit District, Kenya*. Integrated Programme on Arid Lands Technical Report E-4, United Nations Environment Programme (UNEP)-Man and the Biosphere (MAB), Nairobi, Kenya.

Lang, H. & Bolig, M. (2005) *Demography of Human Populations in Arid Areas*. ACACIA, Köln, Germany [http://www.uni-koeln.de/inter-fak/sfb389/index.htm, accessed 11 January 2006].

Lewis, D. & Alpert, P. (1997) Trophy hunting and wildlife conservation in Zambia. *Conservation Biology*, **11**, 59–68.

Lindsey, P.A., Alexander, R., Frank, L.G., Mathieson, A. & Romañach, S.S. (2006) Potential of trophy hunting to create incentives for wildlife conservation in Africa where alternative wildlife-based land uses may not be viable. *Animal Conservation*, **9**, 283–291.

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**, 456–467.

Lindsey, P.A., du Toit, J.T. & Mills, M.G. (2005) Attitudes of ranchers towards African wild dogs *Lycaon pictus*: conservation implications for wild dogs on private land. *Biological Conservation*, **123**, 339–348.

Linnell, J.D.C., Swenson, J.E. & Andersen, R. (2001) Predators and people: conservation of large carnivores is possible at high human densities if management policy is favourable. *Animal Conservation*, **4**, 345–349.

Macdonald, D.W. & Sillero-Zubiri, C. (2002) Large carnivores and conflict: lion conservation in context. In *Lion Conservation Research. Workshop 2: Modelling Conflict* (eds A.J. Loveridge, T. Lynam & D.W. Macdonald), pp. 1–8. Wildlife Conservation Research Unit, Oxford, UK.

Madden, F. (2004) Creating coexistence between humans and wildlife: global perspectives on local efforts to address human–wildlife conflict. *Human Dimensions of Wildlife*, **9**, 247–257.

Marker, L.L., Dickman, A.J., Mills, M.G.L. & Macdonald, D.W. (2003a) Aspects of the management of cheetahs, *Acinonyx jubatus jubatus*, trapped on Namibian farmlands. *Biological Conservation*, **114**, 401–412.

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

Mishra, C., Allen, P., McCarthy, T., Madhusudan, M.D., Bayarjargal, A. & Prins, H.H.T. (2003) The role of incentive programs in conserving the snow leopard. *Conservation Biology*, **117**, 1512–1520.

Mizutani, F. (1999) Biomass density of wild and domestic herbivores and carrying capacity on a working ranch in Laikipia District, Kenya. *African Journal of Ecology*, **37**, 226–240.

Naughton-Treves, L., Grossberg, R. & Treves, A. (2003a) Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. *Conservation Biology*, **17**, 1500–1511.

Naughton-Treves, L., Mena, J.L., Treves, A., Alvarez, N. & Radeloff, V.C. (2003b) Wildlife survival beyond park boundaries: the impact of slash-and-burn agriculture and hunting on mammals in Tambopata, Peru. *Conservation Biology*, **17**, 1106–1117.

Naughton-Treves, L. & Treves, A. (2005) Socioecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa. In *People and Wildlife: Conflict or Coexistence?* (eds R. Woodroffe, S.J. Thirgood & A. Rabinowitz), pp. 252–277. Cambridge University Press, Cambridge, UK.

Norton-Griffiths, M. (1996) Property rights and the marginal wildebeest: an economic analysis of wildlife conservation options in Kenya. *Biodiversity and Conservation*, **5**, 1557–1577.

Norton-Griffiths, M. (1997) Why Kenyan conservation is failing. *Swara*, **20**, 6–8.

Nyhus, P.J., Osofsky, S.A., Ferraro, P., Fischer, H. & Madden, F. (2005) Bearing the costs of human-wildlife conflict: the challenges of compensation schemes. In *People and Wildlife: Conflict or Coexistence?* (eds R. Woodroffe, S.J. Thirgood & A. Rabinowitz), pp. 107–121. Cambridge University Press, Cambridge, UK.

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

Ottichilo, W.K., Grunblatt, J., Said, M.Y. & Wargute, P.W. (2000) Wildlife and livestock trends in the Kenya rangeland. In *Wildlife Conservation by Sustainable Use* (eds H.H.T. Prins, J.G. Grootenhuis & T.T. Dolan), pp. 203–218. Kluwer Academic Publishers, London, UK.

Outoma, J. (2004) *The Effects of Wildlife-Livestock-Human Interactions on Habitat in the Meru Conservation Area, Kenya*. Land Use Change Impacts and Dynamics Working Paper 39, Nairobi, Kenya.

Pate, J., Manfredo, M.J., Bright, A.D. & Tischbein, G. (1996) Coloradan's attitude toward reintroducing the gray wolf into Colorado. *Wildlife Society Bulletin*, **24**, 421–428.

Picard, C.H. (2003) Post-apartheid perceptions of the Greater St Lucia Wetland Park, South Africa. *Environmental Conservation*, **30**, 182–191.

Pimentel, D. & Kounang, N. (1998) Ecology of soil erosion in ecosystems. *Ecosystems*, **1**, 416–426.

Prins, H.T. (2000) Competition between wildlife and livestock in Africa. In *Wildlife Conservation by Sustainable Use* (eds H.H.T. Prins, J.G. Grootenhuis & T.T. Dolan), pp. 51–80. Kluwer Academic Publishers, London, UK.

Rasmussen, G.S.A. (1999) Livestock predation by the painted hunting dog *Lycaon pictus* in a cattle ranching region of Zimbabwe: a case study. *Biological Conservation*, **88**, 133–139.

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

Walpole, M.J. & Goodwin, H.J. (2001) Local attitudes towards conservation and tourism around Komodo National Park, Indonesia. *Environmental Conservation*, **28**, 160–166.

Walpole, M.J. & Thouless, C.R. (2005) Increasing the value of wildlife through non–consumptive use? Deconstructing the myths of ecotourism and community–based tourism in the tropics. In *People and Wildlife: Conflict or Coexistence?* (eds R. Woodroffe, S.J. Thirgood & A. Rabinowitz), pp. 122–139. Cambridge University Press, Cambridge, UK.

Weladji, R.B. & Tchamba, M.N. (2003) Conflict between people and protected areas within the Bénoué Wildlife Conservation Area, North Cameroon. *Oryx*, **37**, 72–79.

Western, D. (1994) Ecosystem conservation and rural development: the case of Amboseli. In *Natural Connections: Perspectives in Community-Based Conservation* (eds D. Western & R.M. Wright), pp. 15–52. Island Press, Washington, DC, USA.

Woodroffe, R. & Frank, L.G. (2005) Lethal control of African lions (*Panthera leo*): local and regional population impacts. *Animal Conservation*, **8**, 91–98.

Woodroffe, R., Frank, L.G., Lindsey, P.A., ole Ranah, S. & Romañach, S.S. (2007a) Tools for conserving large carnivores

in Africa's community rangelands: a case-control study of livestock husbandry. *Biodiversity and Conservation*, DOI: 10.1007/s10531-006-9124-8.

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

Woodroffe, R., Lindsey, P.A., Romañach, S.S. & ole Ranah, S.M.K. (2007b) African wild dogs (*Lycaon pictus*) can subsist on small prey: implications for conservation. *Journal of Mammology*, **88**, 181–93.

Woodroffe, R., Lindsey, P.A., Romañach, S.S., Stein, A. & Ole Ranah, S.M.K. (2005a) Livestock predation by endangered African wild dogs *Lycaon pictus* in northern Kenya. *Biological Conservation*, **124**, 225–234.

Woodroffe, R., McNutt, J.W. & Mills, M.G.L. (2004) African wild dog *Lycaon pictus*. In *Canids: Foxes, Wolves, Jackals and Dogs, IUCN Status Survey and Conservation Action Plan* (eds C. Sillero-Zubiri, M. Hoffmann & D.W. Macdonald), pp. 174–183. IUCN, Cambridge, UK.

Woodroffe, R., Thirgood, S.J. & Rabinowitz, A. (2005b) *People and Wildlife: Conflict or Coexistence?* Cambridge University Press, Cambridge, UK.

Appendix

The Appendix for this article is available online at http://journals.cambridge.org

Biographical sketches

Stephanie Romañach's research includes developing tools to mitigate the negative impacts of the bushmeat trade, and working to identify benefits to local people from trophy hunting and ecotourism as incentives for wildlife conservation.

Peter Lindsey's research interests include the role of ecotourism and trophy hunting in conservation as a means of mitigating human-wildlife conflict, as well as assessing the scale of the bushmeat trade in Zimbabwe and identifying potential methods to alleviate the negative impacts on wildlife populations.

Rosie Woodroffe's research focuses on conflict resolution between predators and people, encompassing conservation biology and wildlife management.