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People and predators in Laikipia District, Kenya

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INTRODUCTION

In this century, only in Africa do substantial numbers of people and livestock still live alongside sizeable populations of large carnivores. Predators are rarely a threat to humans in modern Africa, but they are a significant source of livestock losses to both commercial and subsistence livestock producers. Killing of predators has been documented for as long as there has been literature (see Homer, *The Iliad*), but a small human population would have had an insignificant effect on total carnivore numbers. However, the press of a very large human population well equipped with firearms and poison has seriously reduced predators even in Africa, a relatively sparsely populated continent (Nowell and Jackson 1996; Woodroffe *et al.* 1997; Mills and Hofer 1998). Few protected areas are large enough to guarantee long-term survival of wide-ranging carnivores (Woodroffe and Ginsberg 1998), as most parks are small and widely separated.

In much of Kenya, wildlife has been eliminated as habitat is converted to cultivation. A growing bushmeat trade has eliminated wildlife from vast regions of southeast Kenya that are unsuitable for agriculture (World Wildlife Fund, 2000a). Even the semi-arid northern half of the country, sparsely populated and once rich in wildlife, has been nearly cleared of large mammals by over-grazing, poison and the ubiquitous assault rifle. Outside protected areas, substantial predator populations persist only in the rangelands north of Mount Kenya (particularly Laikipia District), and in the south close to the border with Tanzania.

Laikipia District and the Laikipia Predator Project

The Laikipia Predator Project started in 1997, in an effort to identify the forces that make African predators vulnerable to local extinction, and to

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find practical measures to counteract them. Although Laikipia is socio-economically unusual in East Africa, it is an excellent laboratory in which to study the biology of large carnivores outside protected areas, and to find ways of reducing their impact on the human economy.

Laikipia District covers 9700 km^2 of semi-arid bushland. About 35% of the area has been converted to settlement or small-scale urbanization, but the rest is still wildlife habitat. Except for some forest reserves, there are no formally protected areas. Livestock production is the economic base of the district, in the form of both commercial ranching of beef cattle and traditional pastoralism based on goats, sheep and cattle. Both commercial farmers and subsistence pastoralists use traditional livestock husbandry practices: stock are closely herded by day and penned at night in stout thornbush corrals ('bomas': Ogada *et al.* 2003). On most commercial ranches, livestock densities are comparatively low and wildlife is abundant. Our study area encompasses 25 commercial ranches (out of 30 in the district), of which 14 receive non-ranching subsidies in the form of tourism or wealthy owners; the others are largely dependent upon their livestock. We also work on 14 group ranches, communities of pastoralist Mukogodo Masai; both human and livestock densities are higher in these areas, habitat degradation from over-grazing is sometimes severe, and wildlife (particularly lions) are typically more scarce than on commercial ranches (Khaemba *et al.* 2001). Tourism is expanding on both commercial and pastoral lands, and this has involved setting aside land exclusively for wildlife.

Laikipia District supports populations of all the native large carnivore species, most of which are considered globally threatened (IUCN 2002): lions (*Panthera leo*; vulnerable), leopards (*P. pardus*; not listed), cheetahs (*Acinonyx jubatus*; vulnerable), spotted hyaenas (*Crocuta crocuta*; conservation dependent) and striped hyaenas (*Hyaena hyaena*; near threatened) have all persisted, and African wild dogs (*Lycaon pictus*; endangered), which became locally extinct in the early 1980s (Fanshawe *et al.* 1997), recolonized naturally in 2000 and are already well established (Woodroffe 2003). With the exception of wild dogs, all predators can be killed legally if they take livestock (though people who kill big cats are required to report this, and to submit the skins to the Kenya Wildlife Service). Sport hunting is not permitted in Kenya. Predators are killed if they become chronic livestock raiders, but tolerance among commercial ranchers is high; predators are not shot on sight. Although a few ranchers will eliminate a stock-killing lion after the first incident, most ignore low levels of depredation until an individual or group of predators becomes a chronic problem (Frank 1998; Ogada *et al.* 2003). Tourism is growing in importance, and as most tourists

to Africa want to see large carnivores, in some areas there is a financial motivation to preserve predators despite livestock depredation (Western and Henry 1979).

METHODS

In 1997, we interviewed the owners or managers of 18 commercial ranches, three group ranches and a sample of eight individual Masai pastoralists on three group ranches (see Frank (1998) for questionnaire). Efforts were concentrated on the commercial ranches because it was apparent that there were very few lions in the communal areas. Respondents were asked over 800 questions about their land, costs and management of their livestock operations, numbers and trends of predators, economic impact of depredation on livestock by predators, how they dealt with predator problems, and what changes in predator populations they would like to see. Two hundred and eighteen pastoralists were interviewed in 46 small groups in 2001 about recent sightings of predators, predators' impact on livestock, and attitudes toward predators (Woodroffe 2001b).

Fieldwork on predator biology commenced in 1998. We have captured and released 103 lions, of which 37 males and 39 females were radio-collared; five of these were translocated out of Laikipia by a conservation group and soon died. Collars are monitored weekly from the air and opportunistically from the ground, especially following depredation incidents. We have examined 52 lions shot or poisoned after killing livestock.

Fieldwork also involves daily interactions with ranchers and pastoralists, usually in informal settings, but also in organized gatherings at group ranches or in meetings of the Laikipia Wildlife Forum, which include both ranchers and pastoralists. Formal interviews are inappropriate in these contexts, but these discussions are frank and forthright; we have confidence in our understanding of the varying attitudes toward predators. Moreover, attitudes appear to be relatively homogeneous within both groups of livestock producers.

PATTERNS OF LIVESTOCK DEPREDATION

The different species of predators take livestock in distinctive ways; this influences the methods that can be used to prevent losses. Lions, leopards and hyaenas will take livestock from bomas at night (Fig. 18.1); 72% of cattle kills occur in this way (Frank 1998). Both lions and leopards can enter

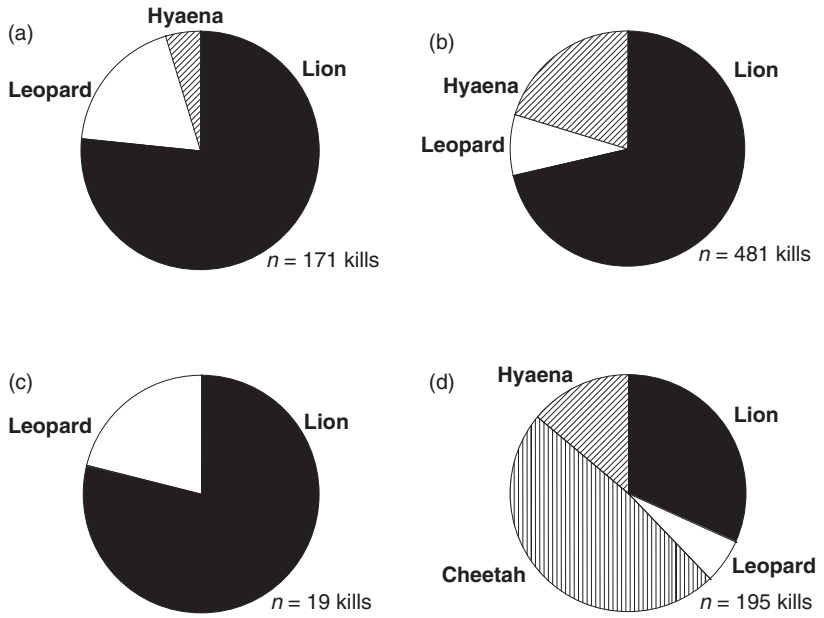

Figure 18.1 Variation in depredation frequency by four predator species in 1999–2000, largely from commercial ranches: proportions of recorded livestock kills attributed to lions, leopards, cheetahs and hyaenas for (a) cattle and (b) sheep and goats by night at bomas (night-time corrals) and (c) cattle and (d) sheep and goats by day away from the boma. Note that these data were gathered before wild dogs recolonized the study area. (Modified from Ogada *et al*. 2003.)

bomas by leaping over the wall, whereas hyaenas crawl through or under the boma wall. Predators confined in a boma with livestock that cannot escape often kill multiple animals – this helps to explain why attacks on livestock in bomas typically lead to the deaths of more individual animals than when herds are attacked while out grazing (Table 18.1). Cattle panic and break out when lions approach bomas at night. Multiple animals are often killed in such circumstances, and livestock from the scattered herd may also be killed by hyaenas once they are out of the boma. Sixteen per cent of cattle losses to lions involve stray animals inadvertently left outside the boma at night, and only 12% are killed by day (Frank 1998). By contrast, cheetahs and wild dogs are diurnal, and take small stock from herds grazing by day R. Woodroffe *et al*. unpubl. data) (Fig. 18.1). Despite the fact that they kill grazing livestock, wild dogs often kill multiple animals when they attack (Table 18.1), presumably because of the high concentration of vulnerable prey.

Table 18.1. *Mean number of livestock killed per attack, when livestock are taken from bomas, at night, and from herds out grazing, by day*

		Mean number killed per attack (range)		
Predator	Livestock	From boma	While grazing	Difference[a]
Lion	Cattle	1.38 (1–6)	1.0	$p = 0.047$
	Sheep and goats	2.06 (1–18)	1.35 (1–5)	$p = 0.087$
Leopard	Cattle	1.07 (1–3)	1.0	$p = 0.71$
	Sheep and goats	2.1 (1–15)	1.5 (1–3)	$p = 0.72$
Cheetah	Sheep and goats	–	1.2 (1–5)	–
Hyaena	Cattle	1.14 (1–2)	–	–
	Sheep and goats	1.43 (1–6)	1.08 (1–2)	$p = 0.029$
Wild dog	Sheep and goats	–	5.9 (1–19)	–

[a] Results of Mann–Whitney *U*-tests.

IMPACTS OF PREDATORS ON LOCAL PEOPLE'S LIVELIHOODS

Each year, carnivores kill approximately 0.8% of cattle and 2.1% of sheep on commercial ranches, and 0.7% of cattle and 1.4% of sheep and goats on pastoralist group ranches (Frank 1998). The slightly lower loss rates in community areas probably reflect both the higher numbers of livestock and lower numbers of predators on these lands. The impact of predation is fairly small in comparison with that of disease (Fig. 18.2); nevertheless, losses to predation are serious, and may have an important impact on the livelihoods of individual pastoralists, and on farm incomes of commercial ranches.

The cost of maintaining stock in the presence of large carnivores can be assessed in two ways. Clearly, the value of livestock killed by predators contributes to overall losses. In addition, costs may also include the infrastructure and staff time required to reduce depredation (e.g. through building bomas and herding livestock). However, while commercial ranches spend considerable money and effort on their herding and security staff, those workers are also required for general husbandry and protection against livestock theft; managers of commercial ranches argued that a total lack of predators would reduce staffing and infrastructure requirements by only 3% (Frank 1998). Hence, the actual cost of maintaining predators reduces essentially to the value of livestock production lost to predators.

Costs are most easily assessed on commercial ranches, which keep systematic records of livestock losses; few group ranches keep records. Since compensation for livestock or crop losses was abandoned due to corruption

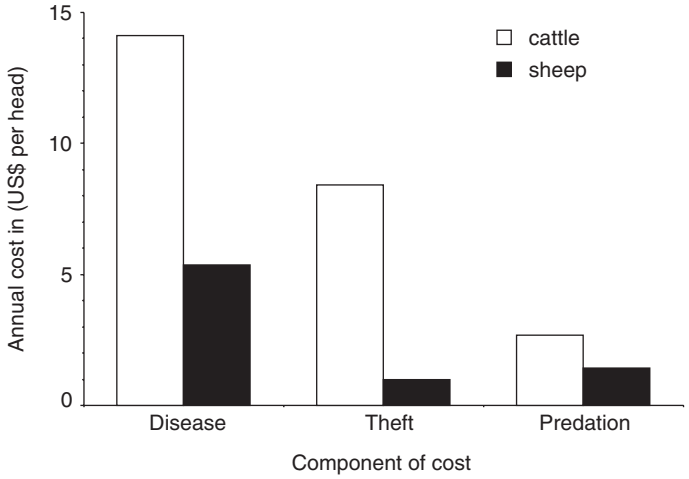

Figure 18.2 Cost of livestock depredation on commercial ranches, in comparison with the costs of losses (and measures to prevent losses) to theft and disease. Costs are calculated in US$, per head of livestock.

(Western and Waithaka, Chapter 22), ranchers have little motivation to misrepresent their losses (indeed, Woodroffe *et al.* (unpubl. data) confirmed the reliability of farmer reports by showing that the number of reported depredation events was closely correlated with the proportion of wild dog scats containing livestock remains). Fig. 18.2 shows the cost of livestock depredation in comparison with the costs of losses (and measures taken to prevent losses) to disease and theft. On commercial ranches, costs of depredation in terms of lost stock amount to about 6% of the cost of raising cattle, 10% of the costs of raising sheep and 11% of the cost of raising camels in Laikipia (Frank 1998). These costs can be converted into approximate costs per predator by comparing them with rough estimates of the number of predators occupying each ranch. As shown in Fig. 18.3, lions are the most costly animals to maintain, costing about US$360 per lion per year, the approximate value of 1 cow, or 9.3 sheep (Frank 1998). Hyaenas, by contrast, are the cheapest to maintain, at about US$35 (about 0.1 cow, or 0.9 sheep) per hyaena per year (Frank 1998). The estimated annual cost of supporting each leopard (US$211) compares well with Mizutani's estimate of US$190 per leopard per year on Lolldaiga Hills ranch in Laikipia (Mizutani 1999).

One group ranch which has a lion population kept written records of livestock loss. Here, depredation losses amounted to US$40 per household per year. While small by Western standards, this amount represents 11% of the average per capita income in Kenya (World Bank 2003). Woodroffe *et al.*

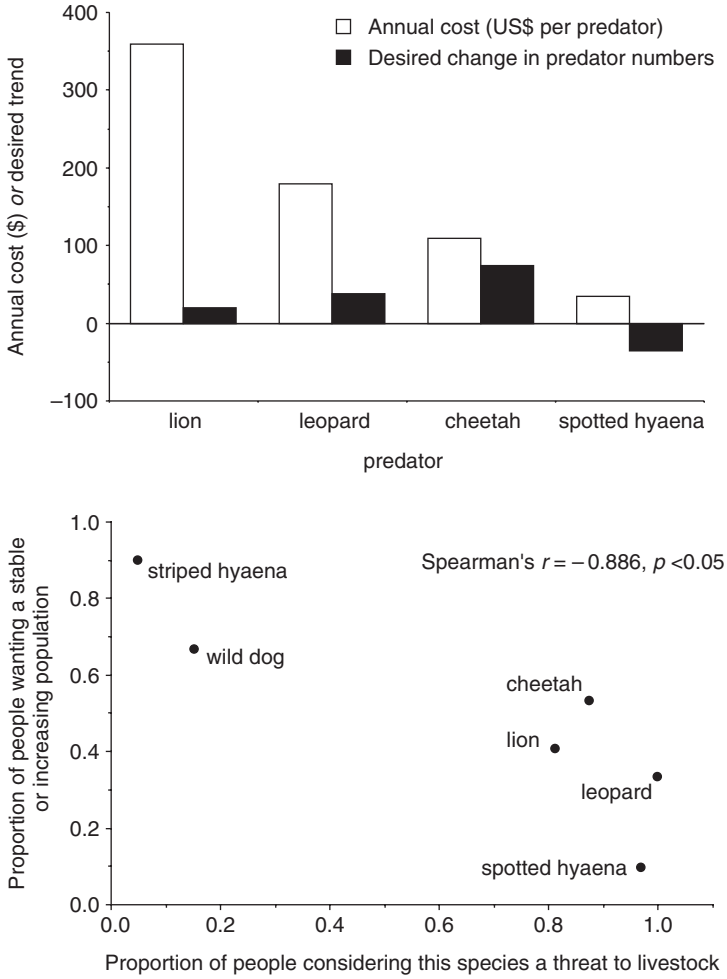

Figure 18.3 Comparison of local people's desired change in predator abundance with assessments of predator impact on (a) commercial ranches (Frank 1998) and (b) pastoralist communities (Woodroffe 2001b). Data from commercial ranches represent the annual cost of depredation by each predator species, calculated from ranch records; data from pastoralists give perceived impacts only.

(unpubl. data) estimated the impact of predation by wild dogs on pastoral lands at less than US$3 per wild dog per year where wild prey remained.

These average figures mask a high variance, and problems may be locally severe. For example, one commercial rancher lost 15 cattle (1% of his herd) and 82 sheep (1.4% of his herd) in a single month. On a recent night in 2004, one Laikipia ranch lost two cows to lions, two goats to hyaenas, two

sheep to a cheetah and two sheep to a leopard (A. Mathieson pers. comm.). Wild dog predation is particularly uneven in its distribution. Woodroffe *et al.* (unpubl. data) estimated the average rate of wild dog predation as 0.48 attacks per 100 km^2 per year, but this rose to the equivalent of 310 attacks per 100 km^2 per year in the vicinity of the den of the one pack that chronically killed livestock.

Local people's tolerance for predators is not always closely related to the true impact that those predators have on their livelihoods. To assess attitudes, we asked managers/owners of commercial ranches and individual pastoralists if they would prefer to have more, fewer, or the same number of each predator (Frank 1998). Fig. 18.3a) compares the cost of maintaining four large predator species on commercial ranches with the change in predator abundance that ranchers said that they would wish to see over a five-year period. On average, ranchers wished to see population increases of all three big cat species, but wanted a 35% decline in hyaenas, even though they caused the least damage (Frank 1998). Local pastoralists showed a stronger antipathy toward hyaenas, unanimously wishing that there were none. They were also reluctant to tolerate leopards, which they perceive to cause equivalent damage (Fig. 18.3b). Interestingly, however, pastoralists' stated attitudes to predators were greatly improved where they received, or were expecting to receive, income from ecotourism (Fig. 18.4), even though such people were equally likely to experience losses to predators (Woodroffe 2001b). Pastoralists' desire to augment local populations of particular predators was influenced by their perceptions of what foreign tourists would wish to see: hence they were particularly keen to see increases in big cats, but tended not to want spotted hyaenas to increase in number because they did not expect that tourists would wish to see them (Woodroffe 2001b).

IMPACTS OF LOCAL PEOPLE ON PREDATORS

Local people in Laikipia have an unbroken history of coexisting with large carnivores, and compared to livestock producers in most of the world, are remarkably tolerant of them. Only a tiny minority of people would shoot a predator on sight, and two-thirds say that they tolerate some level of loss before attempting to kill offending predators (Frank 1998). When commercial ranchers decide to eliminate a problem animal, they usually track it from a livestock kill, or sit up by a carcass the following night, waiting for the predator (usually lions) to return. Of 27 lions shot in association with attacks on livestock on commercial ranches (including 14 radio-collared adults), we were able to confirm that 26 (96%) had been present at livestock kills as these were shot upon returning to kills, and most had livestock remains in

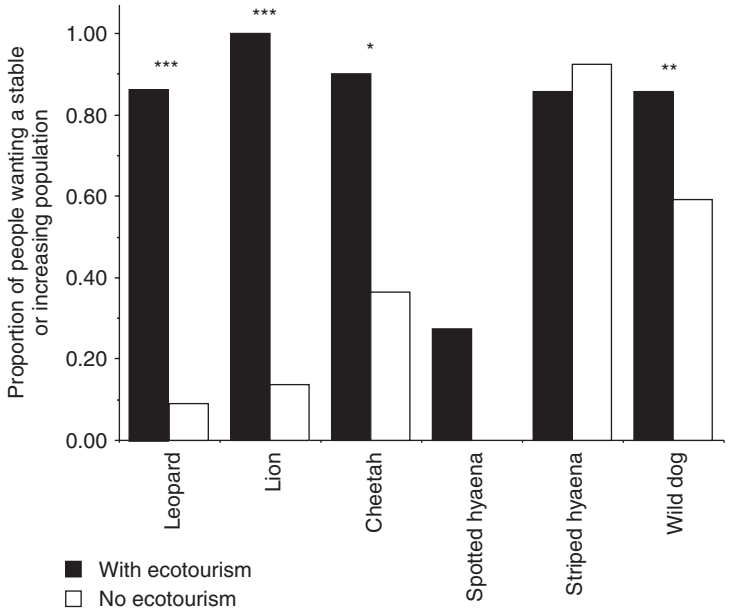

Figure 18.4 Relationships between ecotourism and pastoralists' desired trends in predator numbers. Data give the proportion of people interviewed who wished the predator species listed to increase or remain stable. Asterisks indicate statistically significant differences by χ^2 tests (* $p < 0.05$, ** $p < 0.005$, *** $p < 0.0001$).

their stomachs (R. Woodroffe and L. G. Frank unpubl. data). The number of lions, leopards, cheetahs and hyaenas killed on each ranch was positively correlated with the number of livestock killed by those predators (Ogada *et al.* 2003). This shows that lethal control of carnivores is not indiscriminate, but carried out only in response to depredation and effectively targeted at the individual predators involved.

The situation is quite different on communal lands, however, in which poisoning appears to be on the increase. In the last two years, at least 17 lions, two leopards, and an unknown number of hyenas and jackals have been poisoned in the communities of Laikipia. A similar trend is evident elsewhere in Kenya: a minimum of 49 lions and many other predators have been speared and poisoned in a 2900-km^2 complex of group ranches in southeast Kenya since 2002 (R. Bonham pers. comm.). Lions were abundant there five years ago, but have since become rare. There has been a surge of similar reports of poisoning and spearing elsewhere in southern Kenyan and northern Tanzanian (S. Dloniak pers. comm.; C. Packer pers. comm.), suggesting that the problem is rapidly increasing through much of Masailand. It is worth noting that, paradoxically, this may have benefited

wild dogs, which are difficult to poison because they rarely scavenge, and appear to favour pastoral lands over commercial ranches where competitors are more abundant (Woodroffe 2001a).

Although lions on commercial ranches are killed only when they kill livestock, lethal control probably does limit their population size. Based on known numbers and home range sizes, lion density is estimated at approximately 5–6 /100 km^2 in the area of Laikipia that is wildlife habitat (L. G. Frank *et al.* unpubl. data), generally lower than that recorded in undisturbed habitats such as Masai Mara (29/100 km^2: Ogutu and Dublin 2002), Serengeti Plains (10/100 km^2: Hanby *et al.* 1995), Ngorongoro Crater (40/100 km^2: Hanby *et al.* 1995) and Kruger (6.5/100 km^2: Mills and Biggs 1993), or even in a sport-hunted population (Selous, 13/100 km^2: Creel and Creel 1997). Lions in Laikipia are well fed and in excellent physical condition: only two of the approximately 140 lions examined has been starving, and these were old, lone individuals (one male, one female) with very worn teeth. We have never seen cub starvation. Of 18 radio-collared lions that died in the course of the study, only one died of natural causes (R. Woodroffe and L. G. Frank unpubl. data). The annual mortality of radio-collared adults, at 19.4%, was substantially higher than that recorded in undisturbed populations such as Serengeti (7–10%: Packer *et al.* 1988), Etosha (3–10%: Orford *et al.* 1988) or the Okavango Delta (5%: Winterbach and Winterbach 2002). A simple model of the Laikipia study population projects an annual decline of approximately 4% (range 12% decline – 3% increase), primarily because of unsustainably high adult mortality (R. Woodroffe and L. G. Frank unpubl. data).

Demographic analysis highlights very strong selection against lions that kill livestock. Sixteen lions that were originally radio-collared returning to livestock kills experienced annual mortality almost four times as high as that of 42 lions collared under other circumstances (49.0%, compared with 12.9%; $\chi^2 = 12.85$, df = 1, $p = 0.0003$). Since farmers had no way of distinguishing radio-collared lions marked under different circumstances, this suggests that some lions were habitual stock-killers; lions originally collared on a livestock kill tend to keep killing stock until they are eliminated (L. G. Frank unpubl. data). As well as experiencing elevated mortality, females originally collared after killing livestock tended to produce fewer cubs than did females with no known history of stock killing at the time of capture (0.231 cubs/female/year, compared with 0.981; $\chi^2 = 4.75$, df = 1, p=0.029), and those cubs were less likely to survive (17% survival to 30 months, compared with 75%; $\chi^2 = 4.75$, df = 1, $p = 0.029$). Hence, while the portion of the lion population not collared as stock-killers (and which rarely killed livestock) was projected to increase at approximately 6% annually, the subpopulation of stock-killers was projected to decline by 46% each year

(R. Woodroffe and L. G. Frank unpubl. data). However, ready availability of livestock, especially on ranches with poorer anti-predator measures, ensures that new lions learn to take stock. If, as seems likely, young lions learn stock-killing behaviour from their mothers, this strong selection may help to explain why most lions in fact kill livestock comparatively rarely.

We have insufficient data to assess the impact of lethal control on populations of leopards, cheetahs and hyaenas. However, spotted hyaenas are virtually absent from some parts of the study area. As hyaenas are slow to recolonize areas where they have been eradicated (Smuts 1978), this almost certainly reflects historic control. The wild dog population in Laikipia is still expanding following natural recolonization in 2000. To date, only two of seven radio-collared wild dogs that have died were killed by people, although several cases of deliberate disturbances of wild dog dens have been recorded (R. Woodroffe unpubl. data).

Human activities also influence predator populations less directly, through their impact on habitat suitability. Ninety-seven percent of 2735 aerial locations of 71 radio-collared lions fell on commercial ranches (Fig. 18.5). The majority of locations from adjoining communal lands were virtually on the boundaries, within the margin of error of the location. This

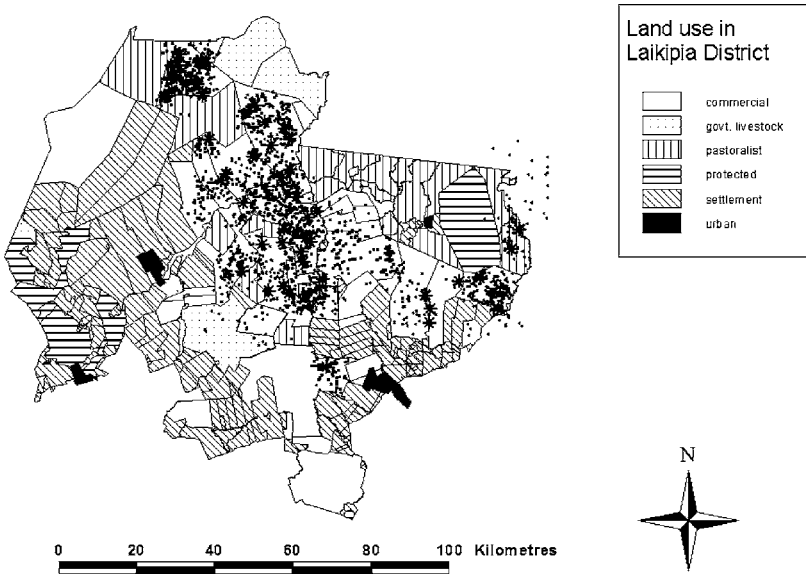

Figure 18.5 Movements of 71 radio-collared lions in relation to patterns of land use, 1998–2004. Black squares indicate locations of lions ($n = 33$ males (1026 fixes) and 38 females (1709 fixes)); indicate original capture sites. One female collared in eastern Laikipia moved widely in neighbouring Samburu District.

does not result from the fact that most lions were collared on commerical ranches. Most commerical ranches adjoin communal lands, and lion home ranges are much larger than the ranch sizes (L. G. Frank unpubl. data). The average lion home range encompasses four to six commerical ranches; they move freely between commerical ranches but rarely stray over the boundaries onto communal lands. This suggests that lions strongly prefer the commercial ranches, where human and livestock densities are low, and wild prey densities are relatively high, over adjoining community lands. The low densities of lions on community lands probably reflects this behavioural choice by lions, rather than high levels of lethal control by pastoralists: in 1998–2002 only one collared lion was known to have been poisoned on community lands (but this pattern changed drastically in 2003), whereas 14 were shot on commercial ranches. Interestingly, wild dogs show no such preference for commercial ranches over pastoralist areas (Woodroffe 2003).

ECOLOGICAL CAUSES UNDERLYING THE PROBLEM

As mentioned above, with few exceptions, in Laikipia people kill predators only when predators kill livestock. But predation on livestock depends on a variety of factors including ecological conditions, livestock husbandry and individual behaviour.

During 1999–2000, Laikipia experienced a severe drought. Throughout this period, livestock depredation was minimal; lion mortality was comparatively low (R. Woodroffe and L. G. Frank unpubl. data), and wild dogs to the north presumably fared well enough to produce a crop of dispersers that rapidly recolonized the study area (Woodroffe 2001a). However, at the end of the drought, lion predation on livestock increased markedly, and, as a consequence, lion mortality also rose (R. Woodroffe and L. G. Frank unpubl. data). Saberwal *et al.* (1994) described a similar phenomenon, in which lions around the Gir Forest, in India, increased predation on people following periods of drought. Preliminary analyses suggest that, in Laikipia, drought affects livestock depredation through its impact on the availability of wild prey. Dead and dying wildlife and livestock were abundant during the drought, and predators were presumably well fed. When the rains came and forage recovered, ungulates regained condition and probably became more difficult to capture, leading more lions to turn to stock. Similarly, Laikipia Masai state that hyaena depredation rises with the onset of the rainy seasons (L. G. Frank unpubl. data). Comparison of long-term records of depredation rates on commercial ranches (R. Woodroffe unpubl. data) with data from regular aerial censuses of ungulate prey (Georgiadis and Ojwang'

2001) suggest that losses to lions are more severe where wild prey are scarce. Hemson and Macdonald (2002) described a similar pattern of livestock depredation by lions in dry land areas of Botswana: losses were most severe when prey had migrated away, and least serious when wild prey returned.

Livestock depredation by wild dogs also appears to be influenced by the abundance of wild prey. Woodroffe *et al.* (unpubl. data) showed that wild dog predation on livestock occurred almost entirely in areas where wild prey had been very seriously depleted. Interestingly, the threshold prey density to avert wild dog depredation was very low; attacks on livestock were extremely uncommon in pastoralist areas, but severe in a neighbouring area occupied by Pokot people who traditionally hunt wild dogs' natural prey.

TECHNICAL SOLUTIONS TO RESOLVING THE CONFLICT

Effective technology for minimizing livestock depredation has been used in eastern Africa for many centuries. In an 18-months study on nine commercial ranches and one community area, we looked at the efficacy of local livestock management practices, all of which are based on traditional Masai techniques (Ogada *et al.* 2003). This showed that traditional husbandry is a powerful tool for reducing depredation on herds, both at night and by day.

As described above, the vast majority of livestock in Laikipia are confined to bomas at night. The construction of such bomas varies: traditionally, they are built from *Acacia* brush, but enclosures may also be built from stones, wooden posts, or woven branches. Rearing of merino sheep for wool production demands bomas that can be moved every few days (*Acacia* thorns damage the wool, and accumulation of faeces in stationary bomas causes disease problems: G. Powys pers. comm.); hence, these sheep were kept overnight in small, portable bomas made from wire mesh that can be rolled up and moved. Comparison of livestock loss rates experienced at different bomas showed that wire enclosures provided the least protection from predators, with up to five times the depredation rate seen at more traditional bomas (Ogada *et al.* 2003). Recent replacement of rolled mesh with bomas made of portable, inflexible reinforced mesh panels have nearly eliminated losses to predators (G. Powys pers. comm.). Surprisingly, we could detect no effect of the thickness, height or complexity of boma walls on the rate of livestock loss (Ogada *et al.* 2003).

While boma construction did influence predation risk, the level of human activity around the boma had a stronger effect (Fig. 18.6). Lions, leopards and hyaenas were all markedly less likely to attack bomas where large numbers of people were routinely present (Ogada *et al.* 2003). Domestic dogs are also kept at some bomas as a deterrent to both predators and cattle thieves. These dogs are not trained as guards and do not chase

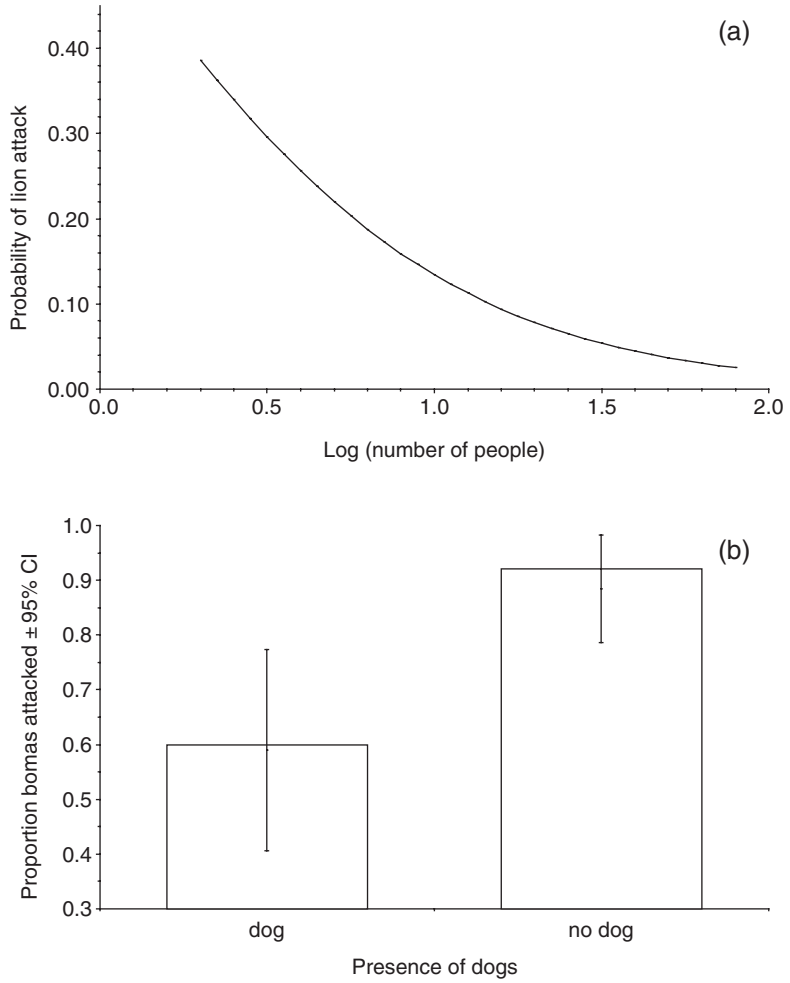

Figure 18.6 Characteristics of bomas (night-time corrals) associated with probabilities of any attack by lions, based on multivariate logistic regression. (a) Effect of log (people); and (b) effect of domestic dogs' presence. Overall $r^2 = 0.28$; effect of log (people) $\chi^2 = 8.36$, $p < 0.005$; effect of dogs' presence $\chi^2 = 8.22$, $p < 0.005$.

predators; rather, they serve to alert people of the presence of predators. Dogs are an effective deterrent against lion attack (Fig. 18.6), although they are less effective in discouraging other predators on commercial ranches. However, pastoralists universally agree that dogs are very effective at warning of hyaena incursions into small stock bomas.

The severity of livestock depredation on herds out grazing by day is also influenced by husbandry practices. Both lion and cheetah attacks were less

severe when the number of herders per sheep or goat was higher (Ogada *et al.* 2003). However, there was no such effect for either hyaenas or leopards (and wild dogs had not recolonized the study area when these data were gathered).

ECONOMIC SOLUTIONS TO RESOLVING THE CONFLICT

In today's Kenya, tourism is seen as the only potentially profitable way to recoup the costs of depredation. Compensation was abandoned by the government due to poor infrastructure and corruption (Western and Waithaka, Chapter 22), and sport hunting was banned in 1977. Tourism plays a significant – though not decisive – role in the recovery of wildlife in Laikipia. Several of the commercial ranches gain significant income from tourism, and a number operate smaller ventures such as campsites or camel safaris. However, an equal number of ranches encourage wildlife and tolerate predators out of a conservation ethic not driven by economic considerations. Some of these ranches are owned by wealthy foreigners, but this is by no means the rule. Most encouragingly, several group ranches are developing their own tourism operations. They have built lodges, campsites and 'cultural manyattas' (traditional villages for paying tourists to visit), and have even set aside land for wildlife from which livestock are excluded. Thus far, these efforts have required heavy subsidies from commercial ranches and non-governmental organizations, and it will be some time before local people gain the expertise to raise capital and organize their own ventures. However, the initial successes have stimulated widespread interest and expectations throughout the pastoralist communities of Laikipia, and more ventures are planned.

Tourism, however, is a fragile business; the 2003 terrorism events in Kenya and subsequent warnings by the US and UK governments proved disastrous to tourism (Wallis 2003; see also Walpole and Thouless, Chapter 8). An alternative source of income – not currently an option in Kenya – might come from trophy hunting (Leader-Williams and Hutton, Chapter 9, Lewis and Jackson, Chapter 15). Tanzania has designated 195 000 km^2 for hunting concessions (Leader-Williams, 1993). In 1990, government revenues from hunting licenses alone amounted to some US$4500 000, compared to $1900 000 earned from the national parks system (Makombe 1994). Of course, license fees are a small part of what a hunter pays for a safari: in 2004, a one-month safari that includes lion costs well over US$100 000 in Tanzania (Safari consultants 2004). Note, however, that non-consumptive tourism has flourished since the border with Kenya was reopened in 1986, and by 1998 contributed $570 million

(16% of GDP) to Tanzania (Thirgood *et al.* in press); accurate figures for the current value of consumptive tourism are not available. Also in the early 1990s, the CAMPFIRE programme in Zimbabwe earned $4 000 000 for participating communities from sport hunters, representing about $400 per household (Edwards and Allen 1992; see also Leader Williams and Hutton, Chapter 9, for more details). Hunters pay US$30 000–45 000 for the opportunity to take aged wild male lions and $12 000 to take females from reserves in South Africa (J. Anderson pers. comm.; C. Vermaak pers. comm.). Moreover, trophy hunters do not require scenery to compete with Serengeti or the Okavango, and are often less concerned by politics than are tourists: safari hunting has withstood the political crisis in Zimbabwe, while tourism is essentially extinct (Grobbelaar 2004).

Many Laikipia residents, both ranchers and Masai, have expressed frustration at their inability to offset predator losses through some form of sport hunting (Frank 1998). Every year, about 30 problem lions are killed and left to rot. Given the value of lions in South African and Tanzania, these animals might be worth over one million dollars if they were taken by trophy hunters, many times the value of livestock taken annually by predators.

Trophy hunting of predators may prove difficult to administer. Although appealing in theory, the use of sport hunting as a conservation tool is far from simple, especially in the African context (Lewis and Jackson, Chapter 15). To be sustainable, hunting must be carefully monitored and regulated, and proceeds must be distributed in a transparent manner such that that all community members benefit. This is difficult to achieve, especially where corruption is widespread. Trophy hunting in South Africa has been disgraced by the widespread 'canned' shooting of captive-reared lions in small enclosures. Traditionally, however, hunters in Kenya policed themselves effectively through the East African Professional Hunters Association, possibly a useful template for the future (Dyer 1996; Herne 2001; Parker and Bleazard 2001). Further, a recent model and accompanying recommendations by Whitman *et al.* (2004), may simplify regulation of trophy hunting by confining it to males that are recognizably above 5–6 years of age. Achieving sustainability might prove difficult if attempts were made to target trophy hunting at specific 'problem animals' outside the accepted trophy category: bogus claims of depredation incidents would certainly occur, as would arguments between neighbouring communities concerning who should receive proceeds. Since Laikipia's lion population is currently small and largely confined to the commercial ranches, while the most urgent demand for income from wildlife comes from community lands, it would seem prudent to 'test

the waters' of trophy hunting by starting with species such as kudu (*Tragelaphus strepsiceros*), zebra (*Equus burchelli*) and leopards, which have fared much better in pastoral areas. This might encourage recovery of both wild prey and lion populations in community lands, eventually allowing lion hunting to be considered in those areas.

CONCLUSIONS: CAN AFRICAN PREDATORS PERSIST OUTSIDE PARKS?

Our results show that conflicts between people and predators are successfully mitigated on those properties that put effort into careful livestock husbandry. Our results also show that traditional methods, perhaps supplemented by modern modifications, can significantly reduce conflict. Even if predators were eliminated from the rangelands of Kenya, some variant of these methods will be necessary as long as traditional cultures maintain cattle raiding as a way of life.

Until the last hundred years, Africans had coexisted with predators out of necessity, because they lacked the technology to eliminate large carnivores. The Laikipia experience shows that modern people can also coexist with predators, if they are willing to make efforts to protect their livestock and tolerate some losses. However, that coexistence is labour-intensive; since herdsmen and farm workers in Kenya are paid only about $30/month, labour costs are low, but they would be prohibitively high in a Western country. Even in parts of Africa, economic expectations have risen to the point that people are no longer willing to tolerate the difficult and uncomfortable life of a pastoralist. In relatively affluent Botswana, for instance, younger people refuse to become herders. As a result, cattle are allowed to wander in the bush untended and are taken by lions. Lion-killing has increased, causing the population to decline (Hemson and Macdonald 2002).

However, there is more to coexistence than economics. Even with the best husbandry, depredation is still a significant economic force throughout the district. Large carnivores persist in Laikipia because the people – of all races – tolerate a level of uncompensated livestock loss that would be unacceptable in the West. For example, in spite of assured compensation, the livestock industry in the Northern Rockies of the USA vigorously resisted the 1995 reintroduction of wolves to Yellowstone National Park (Halfpenny 2003). Between 1996 and 2003, in the Yellowstone ecosystem outside the National Park, Defenders of Wildlife has compensated ranchers for 103 cattle and 568 sheep, an average of 12.9 cattle and 71 sheep per year in an area of 6790 000 ha (Defenders of Wildlife 2004). By contrast, in 1995 alone, 19 ranches in Laikipia, covering 283 000 ha (4% the size of the

Yellowstone area), lost 202 cattle and 993 sheep to lions, leopards and hyaenas, or a mean of 10.6 cattle and 52.3 sheep per ranch (Frank, 1998). Thus, the average ranch in Laikipia loses nearly as much stock each year to predators as all the ranches in the entire Yellowstone ecosystem lose to wolves, yet few inhabitants of Laikipia share Yellowstone ranchers' vehement opposition to predators, and retributive killing is remarkably uncommon, given predators' impacts.

Many factors no doubt influence the difference in attitudes between the two areas. Ranches that host tourism or are subsidized by wealthy owners are clearly more able to bear the costs of coexisting with wildlife than those that are wholly dependent on livestock income. However, many Laikipia ranchers do not have these advantages, and still encourage robust wildlife populations, including predators. Out of a love of the land, the wildlife and their way of life, these people have stayed in their native country under often difficult political and economic circumstances. Of course, the same can be said of their American counterparts. Moreover, the fathers of current Laikipia ranchers had little more tolerance for depredation losses than do American ranchers today: in 1908 alone, 150 lions were shot on licence in Laikipia District (Playne 1909). However, on Kenyan ranches there has been a sea change in attitudes that is not readily explained by either economics or experience. The difference may be historical. America was settled by pioneers with a strong sense that they were conquering a hostile Nature, in which predators and Native Americans epitomized the forces that had to be overcome in order to civilize the land (Quammen 2003). East Africa was settled in large part by adventurers and big-game hunters who were attracted rather than repelled by wildness (Trzebinski 1988; Herne 2001). Although they had to eliminate wildlife where they created farms and ranches, there were always vast expanses of wilderness into which they safaried to hunt. These people valued wild land, wild animals and traditional peoples in a way that few American pioneers did (after all, the settlers in Kenya did not even exterminate the natives). The Kenyan settlers may have left a psychological legacy to their descendants that American settlers did not. Further, the loss of Kenyan wildlife has been so fast that each human generation has seen dramatic losses, and may thus be more strongly motivated to reverse that process.

However, as in most of the world, the majority of people must be financially motivated if they are to preserve wildlife. As long as livestock production, either through pastoralism or ranching, remains the primary use of semi-arid African rangeland, some combination of ecotourism and soundly managed sport hunting are probably the only solutions to preserving wildlife on an ecologically meaningful scale.

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