CHAPTER 14

An adaptive management approach to trophy hunting of leopards (*Panthera pardus*): a case study from KwaZulu-Natal, South Africa

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A radio-collared female leopard in the Phinda-Mkhuze ecosystem, South Africa. © Brett Pearson.

In principle, the trophy hunting of large carnivores has substantial potential to foster their conservation (Lindsey *et al.* 2007; Loveridge *et al.* 2007b). Predators may be tolerated to a greater extent when they augment human livelihoods, and hunting may be a means by which private landowners and local communities can generate revenue from the presence of carnivores (Leader-Williams and Hutton 2005). If the profits realized from harvesting a few individuals are sufficient incentive for people to tolerate the larger population, the goals of trophy hunting and conservation are compatible. However, poorly managed trophy hunting may produce a variety of deleterious effects on carnivore populations. Excessive and sustained harvesting of a species can lead to its local extinction, or reduce numbers to such an extent that a population is no longer viable in the long term (Treves and Karanth 2003). Similarly, even when quotas for trophies appear conservative, hunting may constitute additive rather than compensatory mortality, particularly given that other anthropogenic sources of mortality are rarely included in the calculation of quotas (Caro *et al.* 1998). Additionally, uncontrolled trophy hunting may erode the genetic diversity of a species by consistently selecting the fittest individuals in a population that would normally survive to propagate the species, particularly adult breeding males and females (Harris *et al.* 2002; Coltman *et al.* 2003). Finally, hunting can alter demographic patterns in carnivore populations, resulting in impacts on non-hunted cohorts (Tuyttens and Macdonald 2000). Accordingly, for trophy hunting to be considered a legitimate tool in the management and conservation of carnivores, it is essential that hunting practices avoid detrimental impacts on populations and are demonstrated to be biologically sustainable.

The African leopard is one of the most sought-after big game trophies (Turnbull-Kemp 1967; Grobbelaar and Masulani 2003). Although resilient in the face of human pressure, leopards have been eradicated from vast tracts of their former range due mainly to loss of habitat, depletion of natural prey, and direct persecution by people (Nowell and Jackson 1996). Leopards once occurred throughout most of the African continent with the exception of the hyper-arid interiors of the Sahara and Namib deserts (Fig. 14.1). They are now virtually extinct in North Africa, have disappeared from most of the West African coastal belt, and continue to decline outside of protected areas in large parts of East and southern Africa (Hunter *et al.*, in press). Ray *et al.* (2005) estimate that leopards have been eradicated from 36.7% of their historic African range. Notwithstanding these recent declines, leopards are often deemed to warrant low conservation priority. Their wide geographic range and ability to persist in regions where other large carnivores have been extirpated has given rise to a widespread assumption that their conservation status is assured. Although listed on appendix I of the Convention for the International Trade in Endangered Species (CITES) of flora and fauna, 12 African countries are permitted to export a quota of leopard skins procured through trophy hunting (CITES 2007). In 2008, the quota for all states combined was 2648 leopard skins/year, with an additional 10 skins from the Democratic Republic of Congo and Gabon obtained from sources other than hunting (Table 14.1).

Trophy hunting is regulated and accounts for a smaller proportion of leopard deaths than other human-mediated mortality such as problem animal control and illegal persecution; for example, an average of 445 leopards were legally hunted per year in the 1980s compared to an estimated minimum of 770 killed by other anthropogenic sources in South

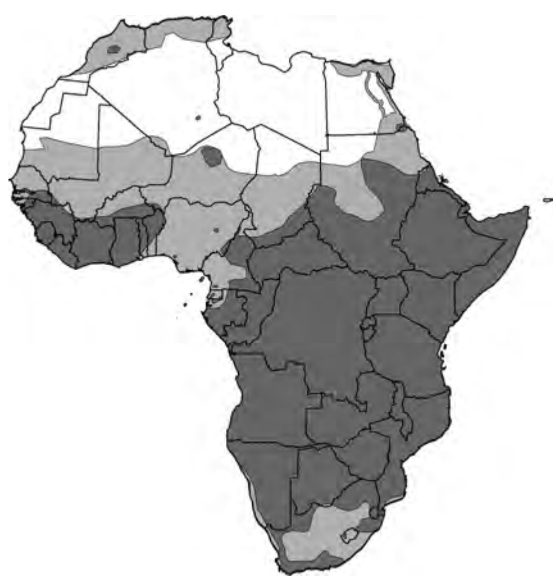

Figure 14.1 Current (dark grey) and historical leopard distribution. (Modified from Ray *et al.* 2005, with permission.)

Table 14.1 The annual CITES quotas for the 12 African countries permitted to export leopard skins procured through trophy hunting in 2008.

Country	Quota
Botswana	130
Central African Republic	40
Ethiopia	500
Kenya	80
Malawi	50
Mozambique	120
Namibia	250
South Africa	150
Tanzania	500
Zambia	300
Zimbabwe	500
Uganda	28

Africa, Botswana, Zimbabwe, and Zambia combined (Martin and de Meulenaer 1988). Nevertheless, there is remarkably little scientific input on the allocation of harvest quotas and the implementation of hunting practices. Population estimates most widely quoted by countries proposing to increase or introduce quotas are derived from an overly simplistic modelling exercise that correlated leopard numbers with rainfall (Martin and de Meulenaer 1988). This model was widely criticized for omitting critical factors such as anthropogenic mortality and prey availability, and for relying upon questionable assumptions, for example, that leopards occur at maximum densities in all available habitats. Accordingly, the final estimate of 714,000 leopards in sub-Saharan Africa was considered an impossible overestimate (Jackson 1989; Norton 1990; Bailey 2005). Despite recent advances in survey techniques that furnish accurate estimates of leopard numbers at moderate cost (Henschel 2001; Balme *et al.*, 2009a), few authorities employ these techniques in routine management activities such as setting hunting quotas.

Despite the lack of data, the demand for leopard hunting in Africa appears to be growing. The annual quotas of four countries (Namibia, South Africa, Tanzania, and Mozambique) have increased since 2002, and Uganda recently introduced trophy hunting of the species, raising the combined quotas of these countries from 485 to 1048 (CITES 2007). Further potential for over-exploitation exists where regulations are abused or ignored. In Tanzania, females comprised 28.6% of 77 trophies shot between 1995 and 1998, even though only males are legally hunted there (Spong *et al.* 2000a). In Zimbabwe, excess skins from illegal hunts are reportedly smuggled into Zambia and Mozambique to be exported under the quotas of those countries (I. A. Caldwell, personal communication). As an explicit condition of CITES certification, African countries that allow leopard hunting commit to do so in a way that is compatible with national and sub-national conservation objectives for the species. However, there remains (1) no rigorous data on the numbers, densities, or population trends of leopards anywhere they are hunted; (2) few empirical data on the impact of hunting on leopard populations; and, finally, (3) no national, provincial, or local regulatory framework for harvesting leopards established by an assessment and consideration of numbers 1 and 2.

A variety of management strategies have been proposed to regulate trophy hunting of comparable carnivore species that have similar lacunae in knowledge (Logan and Sweanor 1998; Laundrė and Clark 2003). In lieu of detailed demographic data, any sensible approach must incorporate an understanding of the basic population dynamics of the target species. In particular, the source–sink metapopulation structure of large felid populations has been used as a proxy to partition areas into subpopulations, each with distinct management objectives (Cougar Management Guidelines Working Group 2005). In this context, source areas are closed to hunting and function as inviolate refuges where natural population dynamics can occur without being affected by human influence. They serve as robust biological savings accounts that ensure long-term population persistence and provide dispersing animals for numeric and genetic augmentation of neighbouring sinks and other, more distant sources (Weaver *et al.* 1996). Sink areas, in contrast, are those sub-populations where harvesting is permitted. They are generally, but not always, less suitable for carnivores due mainly to the presence of people, and concomitant ecological changes such as reduced prey availability and habitat quality (Cougar Management Guidelines Working Group 2005).

We adopted a similar approach to develop a novel protocol for the trophy hunting of leopards in KwaZulu-Natal (KZN), South Africa. We previously demonstrated that poorly regulated harvesting contributed to the low reproductive output of leopards in the Phinda-Mkhuze ecosystem, one of the largest leopard populations in the province (Balme and Hunter 2004; Balme *et al.*, 2009b). In that context, we developed a new protocol for the trophy hunting of leopards in KZN, intended to be compatible with both the conservation objectives for the species as defined by the statutory conservation authority, Ezemvelo KwaZulu-Natal Wildlife (EKZNW), and the desire of private landowners and the hunting industry to utilize leopards. The chief objectives of the new hunting protocol were to (1) mitigate the detrimental effects of leopard hunting in KZN; (2) enhance both the sustainability and economic productivity of leopard hunting in KZN; and (3) ensure compliance with international and national norms and standards for leopard hunting (Department of Environmental Affairs and Tourism, South Africa 2006). In this chapter, we review the historical background of leopard hunting in KZN, summarize the biological impacts of hunting on a local leopard population, and present the new protocol for trophy hunting of the species in the province.

Trophy hunting of leopards in KwaZulu-Natal

KZN province is situated on the eastern side of South Africa (26° 45′–31° 10′ S and 28° 45′–32° 50′ E; Fig. 14.1) in the biologically rich transition zone between the Indian Ocean and the Drakensberg escarpment. Although it is only the sixth largest (92,100 km^2) of South Africa's nine provinces, it contains the most people (estimated at 9.5 million in August 2001; Statistics South Africa 2005). Altitude ranges from sea level in the east to over 3450 m above sea level in the west. Vegetation types vary from tropical dune forests near the coast to moist lowland and upland grasslands, a variety of subtropical forests, and semi-arid savannas further inland, all of which contain the megafauna typical of these habitats in Africa, though many now occur only in protected areas (Goodman 2003). Approximately 58% of the land area in KZN is used for stock farming (including of wild game), 17% for crops, 8% for commercial forestry, and roughly 7% is set aside for conservation (South African National Biodiversity Institute 2005).

The most suitable leopard habitat in KZN is found in the mesic northeastern parts of the province on commercial game ranches, cattle farms, and within state-managed protected areas. Leopards also occur on communally owned Zulu lands but generally at lower densities, chiefly due to habitat degradation and lack of natural prey (Balme and Hunter 2004). We refer to both private and communal land as 'properties'. Legally, leopards are categorized as 'specially protected game' and fall under the mandate of EKZNW on public, private, and communal lands. They are strictly protected inside provincial public parks (IUCN Protected Areas Management Category II), and all trophy hunting of the species currently takes place on privately owned land. Otherwise, leopards cannot legally be destroyed, unless they represent a threat to life or property, and then only if the affected party has applied for and been granted a 'destruction permit' by EKZNW. Despite these restrictions, leopards are killed opportunistically and illegally on private and communal lands in the province by livestock owners and game ranchers (Balme *et al.* 2009b).

From 1996 onwards, the annual quota of CITES permits allocated for trophy hunting in KZN has varied between 5 and 10 leopards (Burgener *et al.* 2005). Since 2003, it has been stable at 5 animals/year. By comparison, in 2006, Limpopo Province was allocated 50 permits, North West Province received 20 permits, and the adjoining Mpumalanga Province received 10 permits (Burgener *et al.* 2005). Prior to 2006, CITES permits were allocated in KZN using a random draw process whereby the first five applicants drawn received a permit and the remaining applicants were placed sequentially on a waiting list. If a leopard was not successfully hunted within 2 weeks, the permit defaulted to the next person on the waiting list, and so on.

For such a widespread species, removing five animals from the provincial population does not seem excessive. However, hunting effort was not evenly distributed throughout KZN. Only 5 of the 22 conservation districts that fall within potential leopard range in the province were awarded CITES permits between 2000 and 2005 (Table 14.2). The distribution of tags across these five districts was also uneven, with most (79%) allocated to the neighbouring Nyalazi and Mkhuze districts (Table 14.2), and specifically to private land surrounding the Phinda-Mkhuze Game Reserves, which constitute a single contiguous leopard population. During the same period, Nyalazi had more than double the amount of leopards shot on CITES hunts than any other district (Table 14.2). Sixteen properties in the province were allocated CITES permits between 2000 and 2005; however, leopards were successfully hunted in only seven of them. The number of leopards shot per property during this period ranged from 1 to 4 (mean = 2.29 ± 1.21 SE). Additionally, and contrary to national stipulations (Department of Environmental Affairs and Tourism, South Africa 2006), leopards were frequently hunted on the same property in consecutive years. Three privately owned game farms hunted leopards for 2 successive years and another game farm hunted leopards for 4 consecutive years. None of these properties was larger than 25 km^2, which is slightly less than the mean home range size of female leopards resident in protected areas in the region (mean = 27.57 ± 5.72 SE km^2; G.A. Balme, University of KwaZulu-Natal, unpublished data).

This high offtake contributed to a significant local effect on the leopard population. The average annual mortality rate (AMR) of this population between 2002 and 2005 was 0.401 ± 0.070 SE (Balme *et al.* 2009b), more than double that recorded for the species in similar habitat under protection (Bailey 2005). Male leopards suffered particularly high mortality (AMR = 0.538 ± 0.023 SE), due partly to their higher vulnerability to trophy hunting (Balme *et al.* 2009b). Males are more desirable to trophy hunters because of their larger size, and males also utilize larger home ranges and cover greater daily distances than females (Mizutani and Jewel 1998; Bailey 2005), increasing their chances of moving into areas where they can be hunted. In some felid and ursid species, unnaturally high turnover among males can result in elevated levels of infanticide (Swenson et al. 1997; Wielgus and Bunnell 2000; Logan and Sweanor 2001; Whitman *et al.* 2004). Although infanticide is a natural event in leopards (Ilany 1986; Scott and Scott 2003), high levels of male turnover promotes a situation in which females cannot successfully raise cubs because of constant incursions by new males. The consequences of this in the Phinda-Mkhuze population included low survival rates among cubs (AMR = 0.574 ± 0.089 SE), delayed age at first parturition (45.33 ± 1.76 SE months), reduced conception rates (19%), and low annual litter production (0.643 ± 0.127 litters/female/year; Balme *et al.*, 2009b). The combined effects of high mortality and depressed reproduction led to a negative population growth rate during the study period ($\lambda = 0.978$). It is important to note that human hunting was not the only source of leopard mortality and many losses in the

Table 14.2 The number of CITES permits allocated to, and the relative success of, hunts within conservation districts in KwaZulu-Natal (KZN) province, South Africa, from 2000 to 2005.

	Number of permits allocated		Successful hunts		
Conservation district	*n*	%	*n*	%	Hunt success per district (%)
Dundee	1	2	0	—	0
Mdletshe Tribal Authority	1	2	0	—	0
Mkhuze	15	32	4	25	27
Nyalazi	22	47	9[a]	56	41
Vryheid	8	17	3	19	38
Total	47		16		Mean = 34

[a] In addition to this total, an adult female leopard was critically wounded in a hunt in the Nyalazi district in 2003 but not recovered; she is unlikely to have survived.

population were the result of illegal persecution rather than legal trophy hunting (Balme *et al.*, 2009b). Nevertheless, the concentration of trophy hunting effort on a single population contributed to higher AMRs than previously documented for the species, prompting EKZNW to ratify the new protocol towards the end of 2005.

Protocol

Our protocol was based on five key recommendations intended to achieve objectives 1–3 listed earlier. These recommendations, and the rationale behind them, were as follows:

1. Cap the number of CITES permits allocated in KZN to five each year. When South Africa's annual CITES quota of 75 leopards was doubled in October 2004, 10 permits were made available for trophy hunting in KZN. A population and habitat viability analysis (PHVA) which evaluated the possible effects of increasing the leopard harvest suggested that the KZN population had a much greater likelihood of suffering significant impacts from hunting than did more robust populations elsewhere in South Africa (Daly *et al.* 2005). This was primarily because the level of illegal killing of leopards by humans was estimated to be among the highest in the country. According to the PHVA, the risk of extinction rose from 11% to 62% and the mean population size declined from an estimated 393 animals to 217 with a quota of 10 leopards (Fig. 14.2; Daly *et al.* 2005). Thus, despite the relatively large estimated population size and carrying capacity, the removal of just five additional leopards per year put this population at substantially greater risk (Daly *et al.* 2005).
2. Allocate applications for leopard hunts to individual properties rather than hunting outfitters. In the past, any number of hunting outfitters could apply to hunt leopards on the same property, with potential for consecutive hunts during the year and multiple animals being removed from a single farm in a year. Under the new protocol, landowners applied for a hunt to take place on a particular property (this applies whether the land is privately or communally owned). If successful, the property, not the property owner or hunting outfitter, was allocated the leopard hunt. It then fell to the property owner to negotiate the best deal from an outfitter and inform EKZNW of the name of the outfitter and timing of the proposed hunt so that the CITES permit could be issued.
3. Ensure a more even distribution of CITES permits across the province. As discussed earlier, CITES permits were formerly allocated unevenly across the province where it was both feasible to hunt leopards and where landowners sought to host hunts. To distribute hunting opportunities more evenly, we demarcated five leopard-hunting zones (LHZ), each with a population considered extensive and robust enough to sustain hunting (Fig. 14.3). Each LHZ covered an area of at least 600 km^2 and lay adjacent to a protected area of at least 290 km^2 in which hunting was prohibited. Based on density estimates from mark–recapture statistics applied to camera trapping we conducted in the main land use types in which leopards occur in KZN (11.11 leopards/100 km^2 in protected areas, 7.17 leopards/100 km^2 in game ranches, and 2.49 leopards/100 km^2 in non-protected areas; Balme *et al.* 2009b), we estimated that each LHZ contained at least 25 adults and was adjacent to a protected source population with at least 32 adults. Each LHZ qualified for a single permit (i.e. only one animal can be hunted each year) and had its own individual draw and waiting list. A CITES permit allocated to one LHZ could not be used in another LHZ, regardless of demand, or of the success of hunts. If a leopard was not shot on the first allocated property within 1 month (rather than the previously stipulated 2 weeks), the permit was moved to the next property on the waiting list of that particular LHZ, and so on.
4. Link the likelihood of obtaining a tag to the size of the property on which the hunt will take place. Properties within an LHZ were still drawn at random; however, the chance of a property being selected was weighted according to its size. This was based on the assumption that, in the same area, larger properties are likely to sustain more

leopards. Therefore, for every 1.0 km^2 of land per property, that property qualified for a single 'ticket' in the draw for that LHZ. Thus, a 5 km^2 property was eligible for 5 tickets, a 25 km^2 property was eligible for 25 tickets, and so on. In any one draw, the probability of any property being selected increased with its size. Once a property had been allocated a CITES tag, all of its tickets were removed before the next draw which established the first property on the waiting list, and so on.

5. Restrict the trophy hunting of leopards in KZN to adult males. South Africa is one of the few countries that have historically allowed the hunting of female leopards. The PHVA demonstrated that harvesting only males resulted in lower extinction rates for all provinces but was most beneficial in KZN, where the risk of extinction decreased by almost half (Daly *et al.* 2005). Therefore, it was proposed that only adult male leopards over 3 years old should be legally hunted in KZN. At this age, male leopards are easily distinguishable from females; the majority of 3-year-old males weigh over 60 kg (mean $= 64.50 \pm 3.7$ SE kg and $n = 10$; G.A. Balme and L.T.B. Hunter, Panthera, unpublished data) which is considerably heavier than females (mean $= 35 \pm 3.5$ SE kg and $n = 7$) and they show numerous obvious physical differences (Fig. 14.4). All hunters taking leopards in South Africa are required to be accompanied by a professional hunter (PH) who is responsible for reporting the hunt to EKZNW. An EKZNW officer is required to inspect the trophy within 24 h of the hunt and, provided all legal stipulations are met, issue a CITES tag so that the trophy can be exported. It is the responsibility of the PH conducting the hunt to judge whether the animal to be shot is an adult male. A printed guide is provided by EKZNW (Balme and Hunter, in press) to PHs and hunting clients to assist them in sexing and aging animals so that the likelihood of shooting females is reduced.

Discussion

This protocol represents the first rigorous effort to ensure that trophy hunting of leopards in South Africa is sustainable. Prior to this, and presently elsewhere in South Africa, CITES permits were allocated on a relatively *ad hoc* basis that resulted in a concentration of hunting effort on a single leopard population. Our protocol addressed this problem by distributing hunts over a much larger area and is based on the meta-population management approach used to manage puma (*Puma concolor*) and grizzly bear (*Ursus arctos horribilis*) populations in North America (Servheen *et al.* 1999; Laundrė and Clark 2003). All LHZs in KZN adjoin large protected areas that potentially act as source populations to replace animals shot on surrounding farms and game ranches. The implicit assumption is that each LHZ is capable of sustaining the removal of one leopard a year to trophy hunting without threatening the demographic or genetic viability of that sub-population or the larger regional population. In other parts of South Africa, source populations that are not found on formally protected land may need to be identified. In this context, there is considerable scope for the private sector to contribute; for

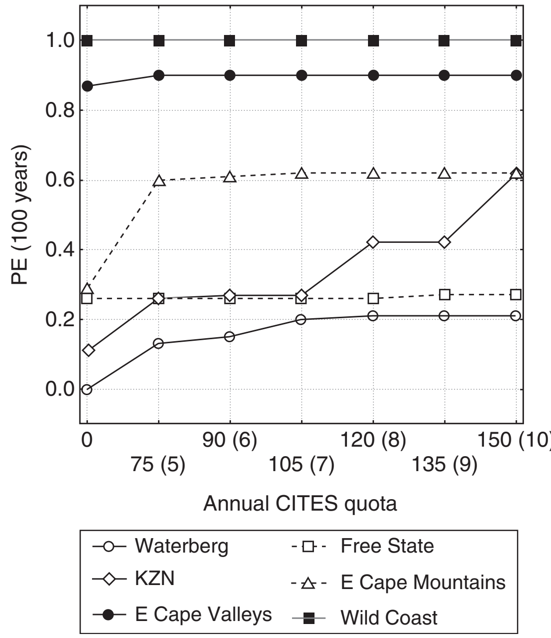

Figure 14.2 Effects of CITES quota on probability of extinction of leopard populations in South Africa. (From Daly *et al*. 2005, used with permission.) KwaZulu-Natal quota in parentheses.

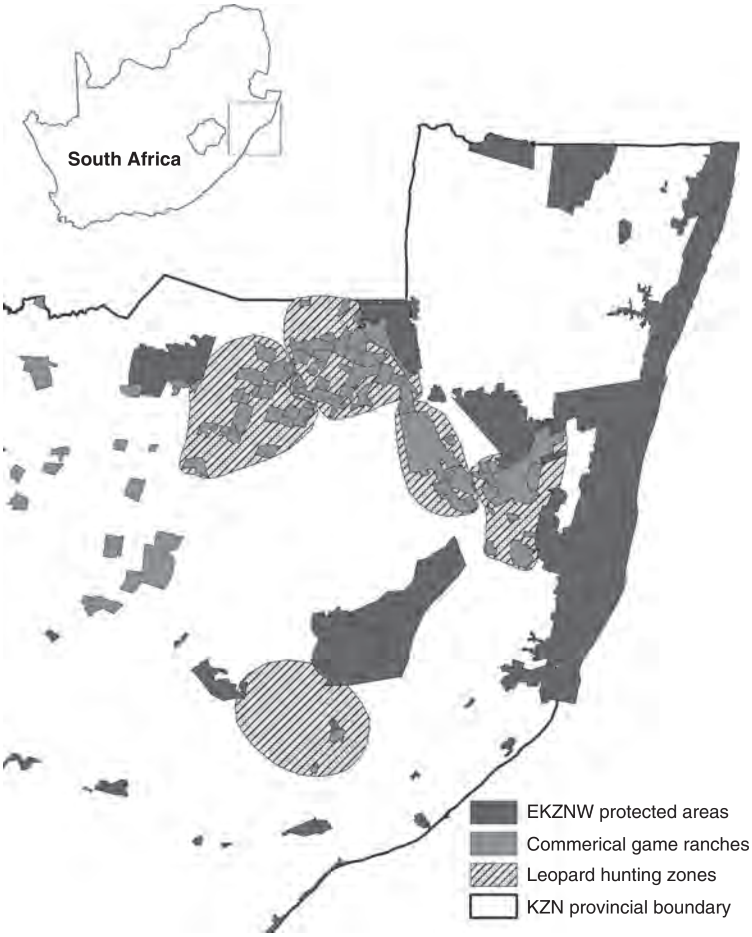

Figure 14.3 The location of designated leopard-hunting zones (LHZ) in relation to commercial game ranches and Ezemvelo KwaZulu-Natal Wildlife (EKZNW) protected areas and conservation districts in KwaZulu-Natal (KZN) Province, South Africa.

example, by the consolidation of commercial game ranches and private reserves that do not rely on consumptive utilization of leopards into 'conservancies', in which multiple, private landowners develop agreements to manage and conserve their combined areas as a single unit (the 'conservancy model'; Hunter *et al.* 2003). However, it is critical that source areas are large enough that losses in adjacent sinks do not have detrimental effects on the source population. Determining the size of a source area depends on various factors such as prey density, habitat quality, and harvest rates in neighbouring sink populations. Beier (1993) and Logan and Sweanor (2001) suggested that a minimum size of 1000–2200 km^2 was needed to sustain a viable puma population for 100 years. In KZN, only two protected areas (Hluhluwe-Imfolozi Game Reserve and the Mkhuze/Mun-Ya-Wana/Makhasa/St Lucia Complex) adjoining a LHZ were this size, but leopards reached higher densities in these areas than pumas in the above examples and all sub-populations were likely large enough to withstand the removal of a single animal by hunting.

Although sink areas in our protocol comprised non-protected farm land, commercial game ranches, and communal lands, leopard population growth rate need not be negative and, if the management objective is to maintain hunting, harvest levels must not exceed immigration rates (Cougar Management Guidelines Working Group 2005). Indeed, provided other anthropogenic sources of leopard mortality are curtailed, populations occupying game-ranching areas have the potential for positive growth given the widespread availability of natural prey and habitat (Lindsey *et al.* 2005). This may benefit ranch

(a)

(b)

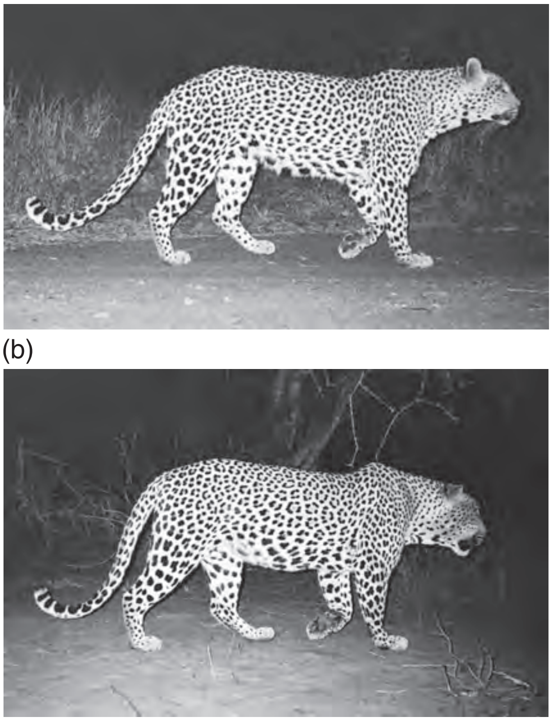

Figure 14.4 Extract from a guide for PHs to assist in the accurate identification of suitable leopards for hunting (G.A. Balme and L.T.B. Hunter, Panthera, unpublished report): a) adult female leopard highlighting narrower chest area and proportionally smaller head; and b) adult (> 3-years-old) male leopard showing developed neck region with prominent dewlap and much larger head.

owners seeking to profit from hunting leopards but will only be realized when removal of leopards for other reasons (primarily by illegal shooting and trapping in retribution for real and perceived losses of livestock) are reduced. Most importantly, we do not accept that a sink is an area where uncontrolled removal of leopards is permissible. Private landowners who hunt leopards and benefit financially from their presence must foster populations on their lands if both hunting and leopards are to persist in those areas. This may be assisted by our recommendation of linking leopard hunting to the size of properties. As well as rewarding larger landowners with an increased opportunity of hosting a hunt, this may encourage smaller landowners with an interest in hunting leopards to increase the size of their land or consolidate neighbouring properties, and therefore foster the growth of larger contiguous areas of suitable habitat for leopards.

While we believe we have been conservative in planning LHZs, we have not addressed a prevailing problem anywhere that leopard quotas are assigned, which is the quantification of additional leopard deaths due to people. Caro *et al.* (1998) warned that high levels of traditional hunting by resident communities and illegal poaching probably resulted in unsustainable trophy hunting quotas for leopards in Tanzania, though that country subsequently doubled its quota to 500 in 2002. In KZN and South Africa generally, leopards are illegally killed primarily by pastoralists and farmers, though there is some evidence for organized poaching; for example, skins of at least 58 individuals were seized in the Mkhuze district in July 2004, apparently destined for international markets (Hunter *et al.*, in press). During a 6-year period, 52.6% of all anthropogenic leopard mortality (n = 19) recorded in the Nyalazi district was illegal (Balme *et al.*, 2009b). This is undoubtedly a minimum estimate given that most illegal killings are concealed and even accidental deaths of leopards such as road deaths are rarely reported. The ongoing sustainability of leopard hunting in each LHZ will depend on increased quantification and mitigation of the numbers of individuals killed illegally.

In addition to illegal persecution, significant numbers of leopards are legally destroyed every year through problem animal control usually undertaken by the landowner. In principle, landowners wishing to destroy a damage-causing leopard must demonstrate that a particular individual is preying upon livestock or creating some other form of damage and that steps have been taken to bring about a non-lethal solution to the problem (Ferguson 2006). In practice, destruction permits are regularly awarded on the basis of little evidence and there is no mechanism to ensure that landowners remove the individual responsible for the damage (G.A. Balme and L.T.B. Hunter, unpublished data). Although recent policy changes by EKZNW attempt to address this (Ferguson 2006), the number of leopards killed as problem animals (3.42 ± 1.21 SE; EKZNW, unpublished data) generally exceeds the numbers hunted legally every year and often occurs on the same properties as trophy hunting. Ideally, damage-causing leopards could be hunted under the CITES quota (Daly *et al.* 2005) but this is not a viable option in KZN. Trophy hunts are planned months and sometimes years in advance, while stock-killing incidents are largely unpredictable. With only five hunts taking place during the course of a year, it is unlikely that the two events will occur concurrently. Additionally, for this to work, the allocation of CITES permits would have to be linked to complaints, rather than by the existing lottery process. Such a system might foster incentives for false claims about damage-causing leopards to increase the chances of receiving a CITES tag. Similarly, landowners with a genuine problem of losing livestock would be rewarded, potentially promoting lax husbandry. It is possible that this idea may be more applicable elsewhere such as in the Limpopo Province where there is both a larger quota and greater conflict between leopards and farmers (Daly *et al.* 2005). In Namibia, a 'Hunters' Hotline' was established to link farmers that were losing livestock to leopards with the Professional Hunters Association (Stein 2008). While this partially overcame the problem of sourcing clients available at short notice, it did not encourage farmers to improve their management techniques. Furthermore, a questionnaire survey revealed that only 12% of farmers were willing to use the hotline (Stein 2008). Most farmers thought it was easier and more beneficial to destroy the problem leopard themselves. In Namibia, a destruction permit can be obtained after a damage-causing animal has been killed.

Our protocol was not created to disadvantage hunters or prevent the consumptive utilization of leopards. In fact, the new system may improve the overall economic productivity of hunting as more professional hunters and landowners stand to benefit from the limited CITES permits available. Previously, the industry was monopolized by a small number of outfitters operating in the Nyalazi and Mkhuze districts. By distributing permits evenly across the province, it gives a larger number of outfitters the opportunity of hosting a leopard hunt. Additionally, extending the validity of a permit from 2 weeks to 1 month greatly improves the chance of any individual hunt being successful without increasing the harvest quota. Individual outfitters therefore stand to gain as their clients are typically charged a daily rate and there is now potential for longer visits. Similarly, there is increased potential for more property owners to benefit financially over time from having leopards on their land. The prospect of receiving revenue from a trophy hunt every few years may mitigate damage caused by leopards and encourage landowners to allow the continued presence of leopards on their farms where formerly they stood no chance to host a hunt. Thirty-nine percent of landowners interviewed in the Nyalazi district ($n = 18$) supported the new protocol, 11% felt that the allocation of CITES permits should be linked to the control of damage-causing leopards, 11% preferred the old process, and 39% showed no interest in hunting leopards (Balme *et al.*, 2009b). More widely, if applied correctly, this framework may ultimately permit increased quotas and hunting in more areas of the province. If landowners benefiting from hunts reduce the persecution of leopards and foster population growth on their lands, the potential exists to increase quotas and expand or add LHZs to new areas.

Under our protocol, the potential also exists for a wider cross-section of the community to benefit from leopard hunts. Historically, leopard hunting has been restricted largely to private farms and game ranches and has rarely taken place on communally owned Zulu land. Hunting outfitters had little incentive to develop wider relationships as they were guaranteed access to a small number of private landowners mostly within the Nyalazi and Mkhuze districts. Under the new system, outfitters who negotiate with local tribal authorities (TAs) to conduct hunts will increase their chances of securing access because communal lands are generally much larger than individual private holdings and therefore stand a greater likelihood of being drawn in the lottery. At least two TAs, the Mdletshe TA and the Mthembeni TA, already have a system in place for such negotiations and received a CITES permit for a leopard hunt in 2001 and 2007, respectively. Other communities have developed structures for hunting other trophy species that could easily be extended to include leopards. For example, the Makhasa TA hosted a black rhino (*Diceros bicornis*) hunt in 2006 that generated almost US $11,000 for the community (EKZNW, unpublished data). Communal areas in KZN comprise approximately 30,000 km^2, much of it with considerable potential to be important leopard habitat (McIntosh *et al.*

1996). This will only likely be realized when communities are encouraged to change current land-use practices that limit the viability of the land to harbour leopards and other wildlife. With its low operating costs and high profit margin, trophy hunting may provide one such incentive (Lewis and Jackson 2005).

The implementation of our protocol is only the start of an adaptive process that will rely upon careful monitoring of leopard numbers and losses to people. This currently takes place in only one LHZ as part of a long-term ecological study on the species (Hunter *et al.* 2003; Balme and Hunter 2004; Balme *et al.* 2009a, b). Data from this study suggest that the new protocol has been successful in facilitating the recovery of the Phinda-Mkhuze leopard population (Balme *et al.*, 2009b). Since its implementation in 2006, estimated population growth has increased by 16% ($\lambda = 1.136$), annual mortality rate has dropped to 0.134 ± 0.016 SE, and the reproductive output of the population has improved (Balme *et al.*, 2009b). Specifically, mean age at first parturition has decreased (33.67 ± 1.85 SE months), conception rates have improved (39%), and annual litter production has increased (0.709 ± 0.135 SE litters/female/year; Balme *et al.*, 2009b). Most notably, all cubs ($n = 14$) born to radio-collared females survived to independence after the change in hunting protocol. As a result of lowered harvest rates and increased social stability, population density increased from 7.17 ± 1.12 SE leopards per 100 km^2 in 2005 to 11.21 ± 2.11 SE leopards per 100 km^2 in 2009 (Balme *et al.*, 2009b).

Although it is unlikely that such intensive monitoring could be extended to other LHZs, the process may be assisted by recent improvements in survey methodologies for cryptic species. Camera trapping is one such method that furnishes accurate density estimates for leopards with modest financial resources and relatively little technical expertise (Henschel and Ray 2003; Balme *et al.*, 2009a). The monitoring of trophy quality and composition will also help gauge whether there are any undesirable demographic shifts within a population (Anderson and Lindzey 2005). The new reporting requirement for trophy age and sex will improve monitoring of trophy quality across all LHZs in KZN. In Botswana and the Niassa Province in Mozambique, assessments of trophy quality are used to promote sustainable leopard hunting (Begg and Begg 2007; Funston, personal communication). Quotas are assigned independently to regions, depending on the sex and age of animals taken in the previous hunting season. These systems are self-regulating and encourage ecologically sound hunting by penalizing hunters that shoot females or under-age leopards. Although no similar penalties are currently in place for hunters in KZN and the hunting of males only (recommendation 5) is simply advised as best practice, more stringent control is likely in the near future; for example, a policy is being drafted that will prevent PHs receiving a CITES permit for a period of 3 years if they hunt female or subadult (<3 years old) leopards (EKZNW, unpublished data). Evaluating and incorporating the socio-economic attitudes of human communities coexisting with leopards will also be crucial in successfully implementing this protocol. Aside from anecdotal information (e.g. Hunter *et al.* 2003), there are no data available on the attitudes of local communities towards leopards and their management, nor on the underlying factors influencing attitudes. Practical solutions exist for conducting widespread surveys in the region (Lindsey *et al.* 2005) and should be adopted more widely in parallel with the implementation of the new protocol in all LHZs.

Our protocol has potential to act as a standard for hunting the species in other provinces of South Africa, and further afield in Africa. Currently, no other national or regional authority assigns quotas based on a detailed understanding of the species' ecology and the potential impacts of hunting as we have attempted here. Implementing this approach on a national scale will require that local conservation authorities clarify leopard population status and distribution within each province of South Africa. As a first step, we recommend the delineation of leopard sub-populations that could act as source or sink areas utilizing GIS coverages that include habitat and land-use type, records of leopard presence, patterns of problem-leopard complaints, historical utilization patterns of leopards, and the demand for CITES tags (Cougar Management Guidelines Working Group 2005). Although parameters will vary, this approach is relevant to most countries that permit sport hunting of leopards. Similarly, our approach may have value for other large, wide-ranging felids that are sport-hunted, for example, cheetahs (*Acinonyx* *jubatus*) in Namibia which are hunted exclusively on private land (CITES 1992), pumas in Latin American populations, where sport hunting is growing (Ojasti 1997), and Eurasian lynx (*Lynx lynx*) in Norway, where quotas are assigned on the basis of depredation complaints (Andrèn *et al*. 2006). Except for a handful of sites where lions have been reintroduced (Hunter *et al*. 2007c), the leopard is the apex predator in many landscapes in KZN and, as such, fulfils a vital role in functioning ecosystems. We believe the implementation of this protocol will be a key factor in maintaining leopards in those landscapes by balancing the ecological requirements of the species with the needs of multiple stakeholders.

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