WILDLIFE CONSERVATION SOCIETY

SETTING CONSERVATION AND RESEARCH PRIORITIES FOR LARGER AFRICAN CARNIVORES

Justina C. Ray, Luke Hunter, and Joanna Zigouris

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ACKNOWLEDGEMENTS

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FOREWORD

by George B. Schaller

Denigrated or exalted, treated as vermin or icon, carnivores have had a long and uneasy relationship with humans. We evolved with the lion and spotted hyena and hunting dog as competing predators and occasionally as prey. Now, as a swelling human tide engulfs ever more natural habitat, carnivores are killed for various reasons, and demands for resources have become insatiable, the geographic range of most carnivores, large and small, is shrinking and populations are fragmented. The lion and cheetah have captured the imagination of tourists, so much so that to see these cats in their natural environment is a main reason to visit Africa's reserves, thereby contributing greatly to a country's economy. Yet few visitors realize how vulnerable these and other species are, how tenuous their future. Carnivores tend to exist at low densities and in small populations, making them blueprints for local extinction. The authors of this publication offer a valuable synthesis of knowledge about twenty African carnivore species, and, more important, they provide valuable insights and analyses concerning research priorities to assure the animals a future.

To help a species endure, we need good science, management, policy, and public support, something not adequate for the carnivores. As the authors emphasize, even science has greatly lagged in that only a few species, mostly large and easily observed ones, have had long-term studies at certain sites. The status of species throughout their African range remains obscure. Furthermore, studies have concentrated on individual species rather than on whole assemblages or guilds of carnivores inhabiting an area. Such guilds—which may include ten or more species—remain intact in relatively few places, and the authors have provided a significant service to conservation by revealing those and encouraging critical research there. We still know too little about carnivores, about habitat requirements, adaptation to and tolerance of human encroachment, food habits, and interactions with other guild members, to name just four issues. As studies in various parts of the world have shown, carnivores help to structure an ecosystem through their impact on prey and each other and ultimately on the vegetation. The removal of a carnivore species may have a far-reaching and unanticipated impact on the habitat as a whole. To conserve and manage natural landscapes, and to evaluate human influence on them, the full assemblage of carnivores and their prey is essential. This publication offers basic guidelines for action. If implemented, they will have a major influence on the survival of

carnivores and on the complex problem of conserving the country's natural heritage. But beyond research there is the moral imperative that we must guarantee the carnivores, these varied and beautiful creatures, these symbols of wildness and wilderness, the right to exist.

As Vice-President of the Wildlife Conservation Society's Science and Exploration Program and holder of the Ella Millbank Foshay Chair in Wildlife Conservation, Dr. George Schaller spends at least eight months each year in the field. Born in 1933, Dr. Schaller attended universities in Alaska and Wisconsin, earning his doctorate at the University of Wisconsin. He is renowned for initiating seminal research and conservation efforts on species that are particularly challenging to protect, including mountain gorillas, giant pandas, tigers, lions, Asiatic cheetahs, Tibetan antelope and Marco Polo sheep. Schaller's studies have been the basis for his numerous scientific and popular writings; his 15 books include The Serengeti Lion, The Year of the Gorilla, and The Last Panda. His two most recent books, Tibet's Hidden Wilderness and Wildlife of the Tibetan Steppe, focus on his efforts of the last decade to set aside a protected area in Tibet spanning more than 200,000 square miles. George Schaller is the recipient of many dozens of scientific and conservation awards including the International Cosmos Prize (Japan) and the Tyler Prize for Environmental Achievement (USA).

EXECUTIVE SUMMARY

Large carnivores present enormous challenges to conservation. The expansive wild areas that are often needed to conserve intact carnivore communities are becoming increasingly scarce on the African continent. As human pressure for natural resources mounts, combined with scarce resources spread over a large land area, effective conservation in Africa calls for a rigorous approach to setting priorities, both for the conservation of carnivores and of biodiversity overall.

There are three major reasons why focusing a priority-setting exercise on carnivores holds significant promise for conservation benefits. First, there have been few efforts to assess priorities for action on a continental scale and across all species – an exercise made all the more necessary in the face of dwindling resources available to devote to conservation action. Second, carnivores deserve primary focus as some of the most vulnerable elements of biodiversity. Third, because intact carnivore communities signify those biological communities that have been the least affected by human-induced landscape change, carnivores might be useful instruments for identifying geographic areas that offer prime opportunities for biodiversity conservation, or alternatively where the battle is being lost in the absence of intervention. Such background knowledge can inform: 1) priorities for action, 2) where an expansion of programs into new areas might be of value, and 3) where existing programs might be strengthened.

This report incorporates the strengths of several previously published works that have evaluated objective sets of criteria for evaluating species, community, and geographic conservation priorities. Specifically, this exercise evaluates the 20 largest species of African carnivores from five families (Canidae, Felidae, Hyaenidae, Mustelidae and Viverridae), in order to ascertain which taxa or regions are inherently vulnerable and/or require further investigation and conservation action. We anticipate that this Priority Setting Exercise, aimed at managers, researchers, and other conservation practitioners, will direct attention to those species or areas that are not readily apparent during decision making processes. This exercise also provides us the opportunity to reach beyond a species level focus, to a framework that has the prospect of being more comprehensive in nature by including a spatially-explicit component.

Focal species for this effort were selected based on the following rationale: 1) Since all 20 species have been subjected to some degree of the IUCN planning process, baseline data are available for most of the species in this subset; 2) larger-bodied species are assumed to have the greatest impact on other components of biodiversity, thus conservation actions directed to these species is likely to have the greatest overall value; 3) human activity is more likely to threaten larger-bodied carnivores than small ones; and 4) larger carnivores tend to excite more interest so they may catalyze action more easily.

The two components of this priority setting exercise are:

1) a scoring system in which individual species comprise the unit of analysis, and are assessed through a combined evaluation of intrinsic (biological vulnerability), extrinsic (threats), and knowledge (extent of current knowledge on baseline ecology and conservation status); and

2) the geographic portion of the exercise, in which carnivores are used to identify priority conservation areas on the continent, chiefly on the grounds of species loss rather than diversity hotspots.

Setting Species Priorities

This exercise first addresses species prioritization through the application of a scoring system where the unit of focus was the species, and an evaluation process that integrated three categories of prioritization:

1) *Vulnerability:* based on innate biological characteristics that decrease species resilience to change and/or recovery from declines, and comprising six variables: current distribution, percent range loss, fecundity (taking into account minimum age of first reproduction, litter size, and average inter-birth interval), ecological specialization, body size, and home range size;

2) *State of Knowledge:* addressing how much is known about each species, and comprising five variables: knowledge of distribution in Africa, knowledge base of ecology, requirements and population limitations, knowledge of population trend, relative degree of study (number of academic papers in Web of Science®), and geographic scope of study; and

3) *Threats:* One overall threats score was derived by an assessment of the degree to which each species is differentially affected by a set of ten threats (human conflict, habitat decline, disease risk, human hunting, interspecific strife, genetic impoverishment, tourism, climate change, road kill, and insect control) commonly encountered by African carnivore species.

Twenty carnivore species were individually scored for each of the 12 variables, which were based on quantitative and objective data wherever possible, and assigned equal weight. The score for a specific category was derived from the aggregate of variable scores from that category. Under the recognition that species that were ranked in one category may not be in others, we evaluated categories separately and used multivariate analyses to explore the interrelationships between them. This approach incorporating all three factors is the first to be applied for carnivores and for any African taxa.

Cheetah, African wild dog, Ethiopian wolf, and lion were consistently among the top four ranked species in all three categories, indicating that they were broadly the most intrinsically vulnerable and the most impacted by the suite of external threats, while at the same time subjected to the most monitoring and research. Patterns were not as obvious among the bottom rankings, with only golden jackal consistently appearing among the bottom five species in each category. At the family level, mustelids had lower mean scores than other families in vulnerability and knowledge categories, but other mean family threat scores were not significantly different from one another. Larger carnivores (> 25 kg) had significantly higher mean scores than the smaller carnivores for all three categories.

All of the highest scoring species for Vulnerability displayed high degrees of range loss, relatively high degrees of specialization, and low reproductive rates. The State of Knowledge category revealed that although various carnivore species were well studied, information regarding their status was generally incomplete. While there was no difference in the relative degree of knowledge of status at the family level, mustelids were found to be significantly less studied. Overall, larger carnivores scored higher knowledge variable scores than smaller ones, and a strong geographic bias for carnivore research became evident, with the majority of studies taking place in the southern and eastern regions of Africa. Most of the research efforts evaluated in this report are directed to only a

quarter of these 20 species, with most species being mentioned in fewer than 50 papers. Almost all of the species scored moderately high to high for the human conflict variable under the Threat category, suggesting human conflict to be the most important identified threat facing African carnivores and resulting in direct impacts on species distribution and populations. For those species encountering habitat decline and human conflict, it was found that they experienced this at an extreme intensity of severity and pervasiveness, in comparison to more localized threats such as road kill.

The twenty carnivores fell into several groupings that highlighted commonalities among species, thereby enhancing the potential to formulate conservation approaches targeted towards multiple species that might not otherwise be considered in tandem. These groupings are as follows: [note a species can appear in several groups]

Species in crisis: Ethiopian wolf, African wild dog, cheetah, lion
Species of concern: leopard, spotted hyena, brown hyena, caracal, serval, golden cat
High-profile data-rich species: Cheetah, lion, African wild dog, leopard, spotted hyena
Externally threatened, but not highly vulnerable: Cape clawless otter, spotted neck otter, serval, caracal
Inherently vulnerable, but with few documented threats: African golden cat, Congo clawless otter, striped hyena, brown hyena
Species that thrive in human landscapes: Black-backed jackal, golden jackal, side-striped jackal, African civet.
Are these species really ok, or do we just not know? Aardwolf, honey badger

Setting Geographic Priorities

The second objective of the priority-setting exercise was to determine the extent of carnivore species loss in Africa and pinpoint the location of intact and depleted carnivore communities. We further sought to assess the relative loss of carnivore species by three geographic units: georegion (east, west, south, north, central), biome and country. This was useful for providing alternate foci for establishing geographic priorities, for example, by assessing i) which geographic areas have suffered the greatest loss of carnivore species and are therefore in urgent need of conservation action, or alternatively, ii) which have experienced the least loss of carnivore species and therefore represent excellent opportunities for shoring up conservation efforts.

For each species, historic (100-150 years ago) and current distribution maps based on published knowledge of species distribution were compiled and later modified via peer review. Overall, well studied species yielded more detailed maps in comparison to lesser known species whose distribution maps were characterized by holes and uncertain boundaries. A lack of change between past and current distribution maps often reflected the lack of knowledge rather than any certainty in distributional trends. Using a grid size of 10km², GIS analysis was used to calculate the number of species lost per pixel by subtracting current distribution maps from historical ones for 17 of the 20 carnivore species. Otters were excluded from this process due to the elusiveness of actual historic

distributions. Relative species loss was calculated as the mean number of species lost relative to the maximum historical number of species for the area under analysis.

At the species level, mean range loss within Africa was 35.8%, and ranged from 0% (civet and side-striped jackal) up to 98% (Ethiopian wolf). A closer look revealed at least 75% loss of range each for Ethiopian wolf, African wild dog, lion and cheetah, with the remaining 12 species experiencing at least 10% reduction in range size. Although all three families (Felidae, Canidae, Hyaenidae) exhibited no significant difference between one another in mean species range loss, there was a marked difference in the patterns of loss among the groups. While 44% and 65% of the continent has experienced no loss of larger canid and hyenid species, respectively, only 14% of the total land area is currently comprised of intact large and medium felid communities. Presently, only 17% of the continent has 9 or more carnivore species; this is in sharp contrast to historical patterns where 60% or more of Africa had 9 or more sympatric larger species. When only considering areas having intact carnivore communities (i.e., areas with zero species loss occurring) this value becomes further reduced to 10% for all of continental Africa.

Historical diversity hotspots for all carnivore species combined spanned eastern Africa and the south-central portion of the continent. Although present-day species diversity hotspots are located in the same general areas, they are significantly more fragmented due to the range retractions of most of the species. The far northern and southern regions of the continent have experienced the highest extent of species loss, while Africa's central forest belt (where there were fewer species to begin with) has experienced the lowest.

The greatest species loss at the biome level has occurred in Mediterranean and montane biomes, with the forest biome having experienced the least. At the georegion level most species loss has occurred in the West georegion, while the central part of the continent experienced the lowest loss of species. The greatest species loss across all biomes and georegions has been experienced by the felids.

These geographic analyses of species loss and location of intact or eroded carnivore communities aid in the identification of some of the most severely impacted regions and biomes. While the prospects for large carnivore conservation in certain areas look bleak, (such as remaining scattered refugia of carnivore guilds surrounding the Sahara), we identified other regions suffering as profound impacts which hold better promise for conservation. The relatively high degree of range loss at the family level by the felids can be in part attributed to the extensive range loss of both lion and cheetah. Due to persecution leveled at them in retribution for livestock depredation, these two species are among the most difficult to conserve. In contrast, the least relative species loss was experienced by the hyenids, while the canid family contains some of the most and least affected species.

Species Conservation Profiles

Profiles are presented for each of the 20 focal species in this report, summarizing information pertinent to their conservation status in Africa. A summary of habitat associations, degree of ecological specialization, trend in distribution, as well as the extent to which it is affected by ten key threats is provided for each of

the 20 species. An overview based on a literature review for each of the threats is presented to accompany the scores provided in Part 1. Maps depicting current and historical distributions in addition to locations of completed or ongoing field studies follow each family group.

Conclusions and Recommendations

Our species-specific and geographic analyses of carnivore conservation on the African continent revealed a subset of species from our list of 20 carnivores that rose to the top in priority in terms of vulnerability and extent of threats. Most of these are currently benefiting from conservation and research based initiatives. However, there still remains a significant lack of research geared towards addressing conservation and management issues for all species in addition to a geographic bias towards East and southern Africa.

This section concludes with discussions of key recommendations for carnivore conservation on the African continent:

1) *Improve range-wide knowledge on key species*
2) *Improve overall distributional knowledge*
3) *Focus conservation action and research on addressing threats*
4) *Refine tools for conservation planning outside protected areas*
5) *Develop models and methodologies for connecting carnivore populations*
6) *Work towards redressing the geographical bias towards carnivore research and conservation*
7) *Groundtruth carnivore "hotspots"*
8) *Focus carnivore conservation and monitoring efforts on practical "indicator" species*
9) *Improve knowledge on mesocarnivores*
10) *Coordinate research and conservation efforts to focus on carnivore guilds rather than single species*

PART I:
INTRODUCTION

Large carnivores present enormous challenges to conservation. For most viable populations to endure, they need extensive, wild areas with an ample prey base and relatively few people. Such expansive wilderness goes beyond the protection of carnivores by helping to conserve biodiversity in general, but these wild areas are becoming increasingly scarce. Retaining some of the largest, wildest places on earth, Africa presents unique opportunities for conservation, yet it also contains the fastest growing human population of any continent. As human pressure for natural resources mounts, those people devoted to the study and conservation of carnivores are witnessing, in many cases, the leading edge of a storm signaling the erosion of biodiversity. With scarce resources spread over a large land area, effective conservation in Africa calls for a rigorous approach to setting priorities, both for the conservation of carnivores and of biodiversity overall.

There are three major reasons why focusing a priority-setting exercise on carnivores holds significant value for realizing conservation benefits. First, carnivore-focused research and conservation efforts are often commenced in reaction to a local crisis, in an opportunistic fashion or as an addendum to an established research program. As a result, there have been few efforts to assess priorities for action on a continental scale and across all species. This exercise is made all the more necessary in the face of dwindling resources available to devote to conservation action. Second, carnivores deserve primary focus as some of the most vulnerable elements of biodiversity (Woodroffe 2001; Linnell *et al*. 2001; Ray *et al*. 2005). Carnivores can be sensitive to human disturbance due to their area needs, relatively slow reproductive rates and incompatibility with people. Carnivores (especially larger-bodied species) are generally among the first taxa to disappear from a site and most large mammalian carnivores are in global decline. Most large carnivores now require dedicated conservation efforts to avert local and, in some cases, global extinction (Linnell *et al*. 2001; Ray *et al*. 2005). Third, by virtue of this sensitivity, intact carnivore communities (i.e., ones that have experienced no discernible species loss over the past 100-150 years), signify those biological communities that have been the least affected by human-induced landscape change during the same time period. Consequently, carnivores might be useful instruments for identifying geographic areas that offer prime opportunities for biodiversity conservation, or alternatively where the battle is being lost in the absence of intervention.

Accordingly, focusing a priority-setting exercise on carnivores can:
1) help to pinpoint priorities for action,
2) inform where an expansion of programs into new areas might be of value, and
3) inform where existing programs might be strengthened.

Furthermore, a spatially explicit priority-setting exercise will assist conservation planners in deciding where to invest effort depending on their preferred intervention. For example, such an analysis will assist in distinguishing the strongholds of conservation targets from isolated patches of the same target. Practitioners will be able to devote action and resources accordingly, depending on whether the goal is to fortify the last strongholds or reconnect isolated patches.

PREVIOUS PRIORITY-SETTING

This effort is not the first attempt at priority-setting for carnivores, even within Africa. Mills *et al*. (2001) adopted a common approach in conservation circles, by identifying sites with the greatest diversity (in this case, of carnivores) to guide both conservation action and reserve placement. Other priority-setting exercises focusing on carnivores have generally been executed for narrow taxonomic groups (e.g., Canidae, Felidae, Hyaenidae) via the IUCN action planning process, of which African species are a subset. Increasingly, scientists are focusing priority setting activities on individual species, similar to what has been undertaken for the tiger (Wikramanayake *et al*. 1998) and jaguar (Sanderson *et al*. 2002). Only two gravely endangered African carnivores, the Ethiopian wolf and African wild dog, have been the focus of specific action plans (Woodroffe *et al*. 1997; Sillero-Zubiri & MacDonald 1997).

The present effort steps back to examine a subset of large and medium-sized African carnivores (defined as those with average body weights of at least 7 kg) using a variety of criteria to identify those that are inherently vulnerable and/or in need of research and conservation action. This exercise is not intended as a tool to evaluate existing carnivore-focused initiatives. Rather it is meant to steer attention to taxa or geographic region that may or may not be intuitively obvious when making decisions about the allocation of finite conservation and research resources. It capitalizes on the strength of several previous works that have evaluated objective sets of criteria for scoring frameworks, notably priority setting for vertebrates in Florida (Millsap *et al*. 1990) and the Partners in Flight approaches (Beissinger *et al*. 2000; Carter *et al*. 2000). It also builds upon the sole Africa-wide priority setting exercise to date (Mills *et al*. 2001).

The two components of this priority setting exercise are:

1) a scoring system in which individual species comprise the unit of focus, and are assessed through a combined evaluation of intrinsic (biological vulnerability), extrinsic (threats), and knowledge variables; and

2) the geographic portion of the exercise, in which carnivores are used to identify priority conservation areas on the continent, chiefly on the grounds of species loss rather than diversity "hotspots." Such an approach serves to pinpoint the location of both intact and depleted carnivore communities that warrant conservation attention for different reasons.

THE SPECIES FOCUS

This priority setting exercise focuses on the 20 largest species of felids, canids, hyenids, mustelids, and viverrids of Africa, (Table 1.1). We have included all species >7kg, although for the sake of completeness, we added the spotted-necked otter (4.-6.5kg). We acknowledge that by choosing a subset of carnivores, we have already engaged in some subjective priority setting. However, our decision was based on:

1) The existing information base. At the very least, all 20 species have been subjected to IUCN action planning processes. As a result, the baseline data required by our approach are available for most. This contrasts with the multitude of smaller carnivores on which the most basic data have never been collected (Ginsberg 2001);

2) the assumption that the relative impact of the species on other components of biodiversity is likely to be greatest with larger-bodied species. Therefore, conservation action directed toward those species might be expected to have the greatest overall value when considered in conjunction with other factors (Ray 2005);

3) larger-bodied species are more likely to be threatened by human activity than small ones (Linnell *et al*. 2001; Mills *et al*. 2001; Woodroffe 2001; Treves & Karanth 2003); and

4) larger carnivores tend to excite more interest and trigger emotional responses in people at local, national and international levels, so they may catalyze action more easily.

THE GEOGRAPHIC FOCUS

Continental Africa serves as the focal region. All islands including Madagascar are excluded from analyses; the unique assemblage of Malagasy carnivores is a priority in and of itself, by virtue of the endemic and endangered status of most of them and the landscapes they inhabit.

We assessed the relative loss of carnivore species from continental Africa by three geographic units: georegion (whereby the continent was divided into 5 parts: east, west, south, central, and north; Fig. 1.1), biome (8 principal biome types; Fig. 1.2) and country (Fig. 1.3). This provides alternate foci for establishing geographic priorities, for example, by determining i) which geographic areas have suffered the greatest loss of carnivore species and are therefore in urgent need of conservation action, or alternatively, ii) which have experienced the least loss of carnivore species and therefore represent excellent opportunities for fortifying conservation efforts.

Table 1.1 20 African carnivores considered in this priority-setting exercise

Scientific Name	Common Name	Species Code	Family	Body weight (kg)	Endemic to Africa?
Lycaon pictus	African Wild Dog	AWD	Canidae	20-34	Yes
Canis simensis	Ethiopian Wolf	ETW	Canidae	11-16	Yes
Canis mesomelas	Black-backed Jackal	BBJ	Canidae	6-10	Yes
Canis adustus	Side-striped Jackal	SSJ	Canidae	8-12	Yes
Canis aureus	Golden Jackal	GOJ	Canidae	7-10	No
Acinonyx jubatus	Cheetah	CHE	Felidae	35-65	No
Panthera leo	Lion	LIO	Felidae	120-180	No
Panthera pardus	Leopard	LEO	Felidae	30-60	No
Leptailurus serval	Serval	SER	Felidae	11-13	Yes
Profelis aurata	African Golden Cat	AGC	Felidae	11-14	Yes
Caracal caracal	Caracal	CAR	Felidae	10-18	No
Proteles cristatus	Aardwolf	AAR	Hyaenidae	8-10	Yes
Crocuta crocuta	Spotted Hyena	SPH	Hyaenidae	46-70	Yes
Hyaena brunnea	Brown Hyena	BRH	Hyaenidae	28-47	Yes
Hyaena hyaena	Striped Hyena	STH	Hyaenidae	26-41	No
Aonyx congicus	Congo-clawless Otter	CGO	Mustelidae	13-34	Yes
Aonyx capensis	Cape clawless Otter	CCO	Mustelidae	13-34	Yes
Lutra maculicollis	Spotted-necked Otter	SNO	Mustelidae	4-7	Yes
Mellivora capensis	Honey Badger	HOB	Mustelidae	7-16	No
Civettictis civetta	African Civet	AFC	Viverridae	10-17	Yes

Fig. **1.1** Georegion units of analysis

NORTH

WEST

CENTRAL

EAST

SOUTH
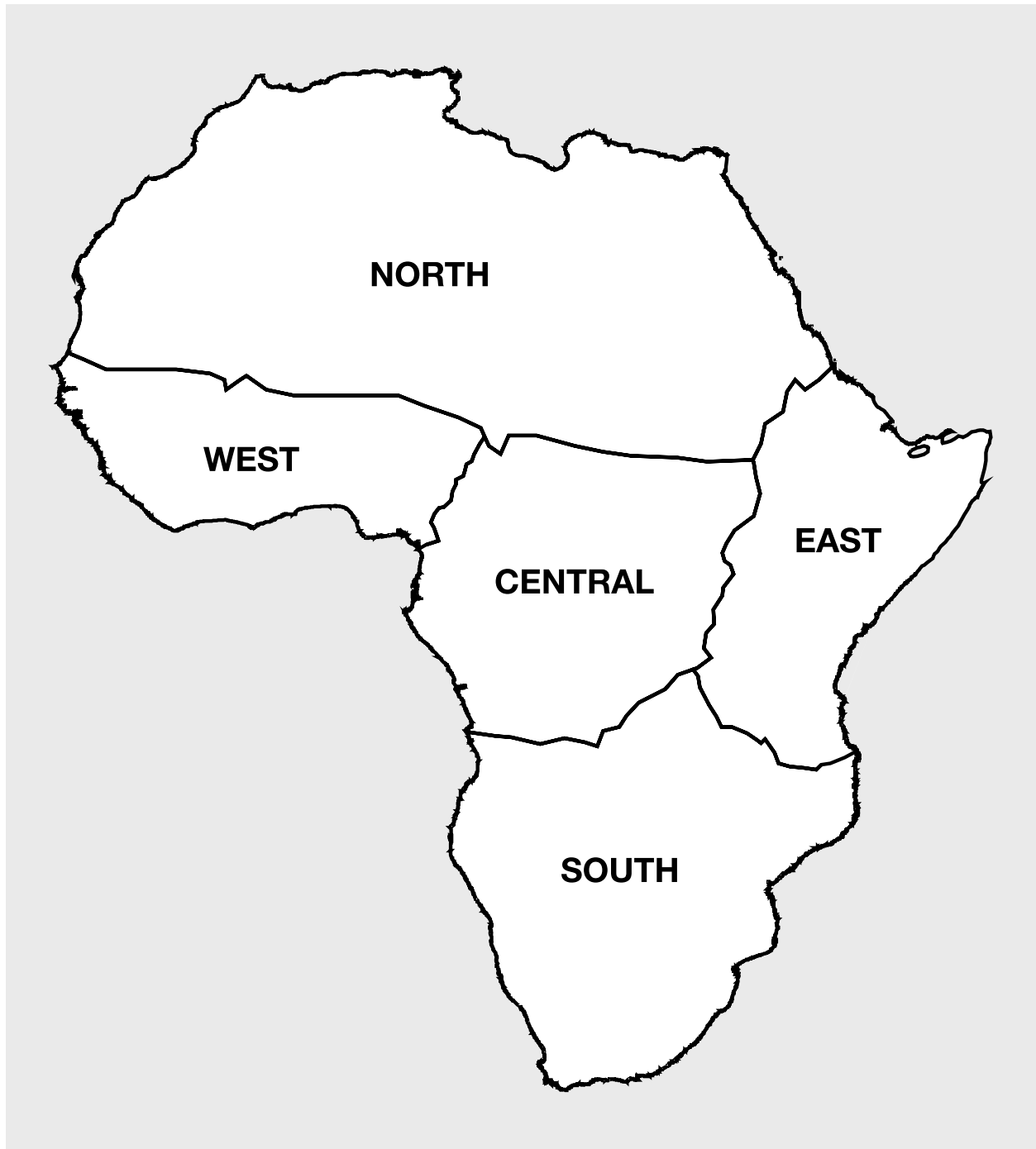
Fig. 1.2 Biome units of analysis. See Appendix 5 for details on classification scheme.

Desert
Flooded grassland
Forest
Lake
Mangrove
Mediterrean
Montane
Savanna

0   500   1000   Kilometers
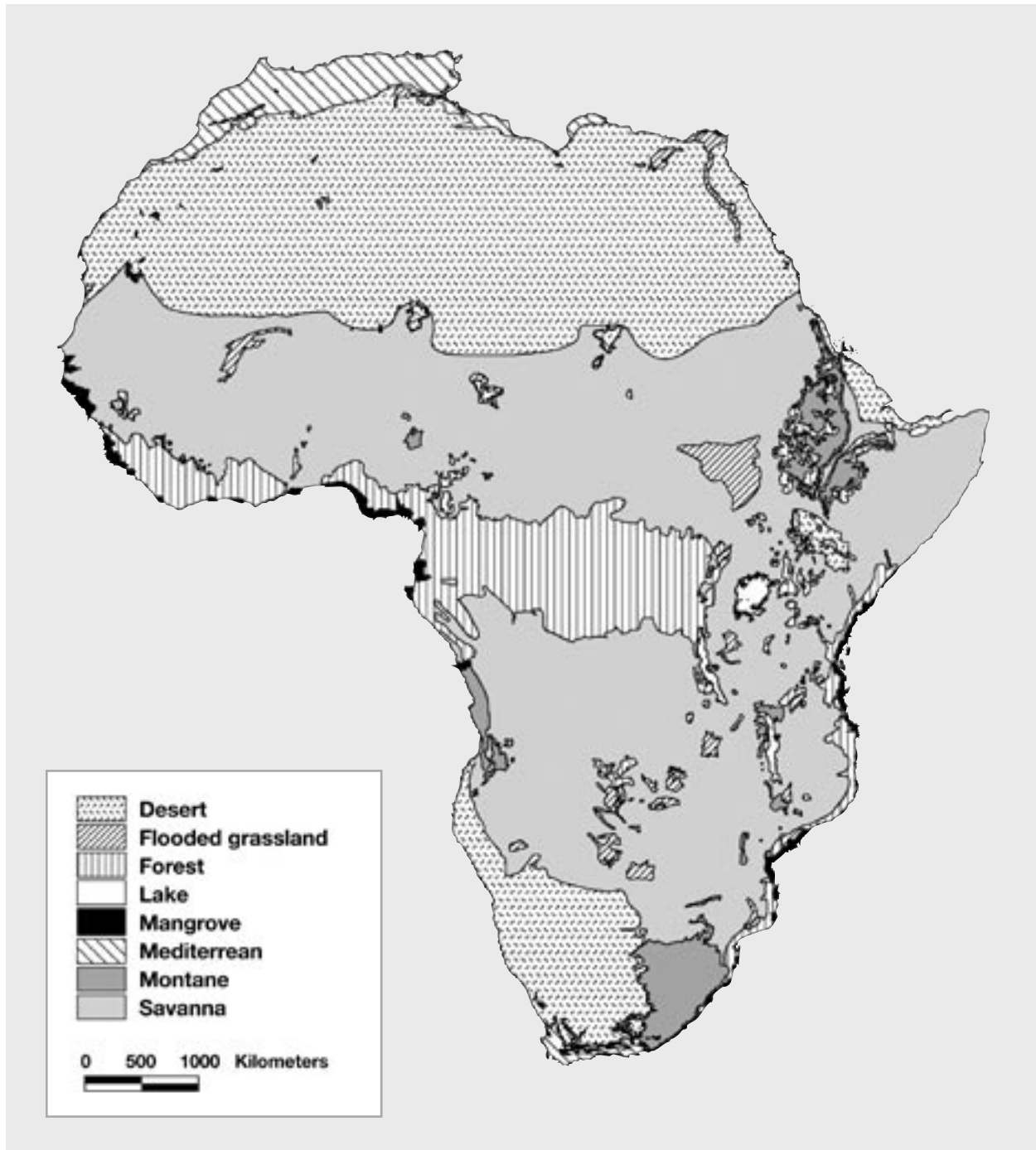
Fig. 1.3 Country units of analysis.

PART II:
SETTING SPECIES PRIORITIES

INTRODUCTION

Species prioritization is a critical component of the conservation planning process. There are a variety of ways by which one might prioritize action at the species level. These include:

- *Vulnerability* – action is directed towards species with innate biological and ecological characteristics that render them less resilient to changes in the environment and/or less able to recover from population declines;
- *Lack of knowledge and/or attention* – action is directed towards species that have received the least amount of research or survey attention and are most in need of expended efforts in these directions; and
- *Threats* – the scope and need for action is dictated by the particular characteristics of predominantly external threats to individual species.

Efforts to predict extinction probability of species or species groups in a general sense tend to focus on the first category, under the recognition that external factors that might contribute to a species' status are context-driven. The IUCN Red List categorization process, for example, employs demographic and ecological parameters as a basis by which to assign threat rankings to various taxa (IUCN 2004). Setting priorities for conservation of wildlife species generally occurs within a defined geography, at which point factors beyond the species' biology can be incorporated to evaluate relative risk and assign priorities for action. For example, when prioritizing future action it is helpful to assess the extent to which the most inherently vulnerable species are already the subjects of conservation and research attention (Millsap *et al.* 1990). "Local" threats also figure prominently in conservation planning (Coppolillo *et al.* 2004). The approach adopted in this report incorporates state of knowledge and threats in addition to intrinsic vulnerability to set conservation priorities for 20 medium and large-bodied carnivores on the African continent — the first to do so for carnivores and for any African taxa. Recognizing that species that are highly ranked in one category may not be in others, we evaluated categories separately and attempted to assess the interrelationships between them.

METHODS

Description of the Species Prioritization System

We assigned a series of scores to each species for multiple variables in three general categories: 1) vulnerability, 2) state of knowledge, and 3) threats.

We restricted our attention to vulnerability, knowledge, and threat variables that were known or could be estimated for the majority of taxa, and were meaningful for most. This eliminated several important variables that would have been valuable to include, but for which information was incomplete across the species or geographical spectrum. For example, while population size and trend is widely recognized as one of the most important predictors of extinction risk (O'Grady *et al.* 2004), detailed information is not available for most of

the species considered here. Where information was available, it was restricted largely to localized areas such that extrapolation across the entire range would be meaningless. The same can be said of other, potentially useful variables such as estimates of density and dispersal ability.

Within each category, we assigned equal weight to each of the variables considered, because the relative contribution of variables to the overall priority ranking of a species is generally unclear (Carter *et al.* 2000). Variable scores were based on quantitative and objective data, and care was taken to minimize redundancy, i.e. variables indirectly considered when scoring other variables. We evaluated each carnivore species for a total of 12 variables in the three categories, deriving scores for each (see below). The use of multiple variables allowed species to be ranked and filtered in a variety of ways to explore various means of prioritization. We assigned scores to each variable in a two-stage process, based on a comprehensive literature review, followed by expert input.

For each of the three main categories, we developed aggregate scores. For example, a total score for a species' vulnerability was derived from the sum of the scores for the six variables contained in that category. Relationships between variable scores and among taxa were of equal interest for developing profiles and patterns of need for both individual species and species groups. This type of approach determines an overall level of priority based on combinations of scores (Beissinger *et al.* 2000). In other words, priority could be attached to different species or sets of species for different reasons, which we tried to capture in the overall framework. Species scores in multiple parameters, therefore, could yield either compounding or conflicting evidence relevant to priority setting (Carter *et al.* 2000). We did not attempt to achieve an overall "priority score" for each species, instead choosing to consider the three categories separately.

Description of Scoring Categories and Variables

1. Vulnerability

There has been much discussion in the literature on the intrinsic or biological characteristics of a species that lend themselves to extinction risk. In other words, certain species will, by virtue of inherent morphological, demographic, and ecological features, be predisposed to be at the highest risk. The main intrinsic factors, pertaining to ecology and life history of a species are large body size, low reproductive rate, high trophic level, and small geographic range size (Fisher *et al.* 2003; Purvis *et al.* 2001; 2004). Particular to larger carnivores, home range size has also been cited as a strong factor correlating with local extinction risk (Woodroffe & Ginsberg 1998; Woodroffe 2001).

The first category consisted of six "vulnerability" variables (described in turn below), each of which measured some aspect of the species' distribution, life history, or ecology that might contribute to its vulnerability to population declines (Table 2.1). Scores for these variables were summed to yield an overall vulnerability score for each species, with the highest scores indicating those that were most vulnerable (Table 2.1; Appendix 1).

Current Distribution. We created current distribution maps for each species using ArcView GIS, following a literature review and modifications of experts (see details in Part III). This variable scored highest for those species whose distribution made up the smallest proportion of the African continent, under the

assumption that those species with smaller ranges would be more vulnerable to extinction than those with larger ranges (Mills *et al*. 2001; Purvis *et al*. 2000; Cardillo *et al*. 2004).

Percent Range Loss. In addition to maps depicting current distribution, we also created maps of historical distribution (ca. 100-150 years ago), and used ArcView GIS to calculate the percentage of range lost from historical to current time (see details in Part III). Scores were highest for those species that had experienced the greatest extent of range loss during the past century, assuming that species with contracting or fragmenting ranges are more vulnerable to extinction than those with stable or even expanding ranges (Purvis *et al*. 2000). We were never confident enough about the extent to which current distribution differs from historical for the three otter species, so were unable to include this information. Extent of range loss for all three otter species, therefore, was considered to be zero.

Fecundity. Fecundity as a measure of reproductive potential consisted of three parameters: 1) minimum age of first reproduction, 2) litter size adjusted by proportion of breeding females, and 3) average interval between births. A composite score of all three parameters yielded an overall fecundity score (see Table 2.1). This variable considered the potential number of offspring that could be produced in an individual's lifetime, with low scores indicating the potential resiliency of a species (Pimm *et al*. 1988; Weaver *et al*. 1996; Purvis *et al*. 2000). Taxa with the lowest reproductive potential (slowest female maturity, lowest litter size per breeding female, and longest inter-birth interval) received the highest scores. Each of the three reproductive parameters was standardized by dividing values for each species by the highest in that category to generate scores scaled from 0-1.

Ecological Specialization. Under the assumption that nearly all specialized species are most vulnerable to environmental changes (McKinney 1997), assessing this variable would preferably take into account both habitat and dietary specialization. Evaluating specialization among members of the Carnivora is not the most satisfying enterprise, as they are known for general dietary flexibility. In addition, we were faced with the challenge of devising variables that would be meaningful at a continental scale. Accordingly, we scored species for their presence in different habitats as an indication of their relative specialization using the habitat-specialization index (HSI) devised by Brashares (2003), calculated as the total number of distinct habitat types (maximum 10) in which a carnivore occurs. The highest score (i.e. most specialized) represented those species present in the least number of habitats (1-HSI; Appendix 1).

Body Size. Among diverse animals, body size is often an excellent indicator of vulnerability (Cardillo 2003; Fagan *et al*. 2001). Among carnivores, which exhibit tremendous size diversity, larger species are likewise at greater extinction risk due to their greater space and prey requirements combined with their increased tendency to come into conflict with people or livestock (Mills *et al*. 2001). Real or perceived conflict of this nature will lead to a tendency of people to retaliate lethally or destroy habitat in response (Treves & Karanth 2003). For this variable, we used three size class categories (small, medium, and large) from Mills *et al*. (2001).

Home Range Size. The more widely a species ranges, the higher proportion

of its population is likely to be exposed to inhospitable terrain where mortality factors, particularly human conflict, are apt to be high (Woodroffe & Ginsberg 1998; Woodroffe 2001). Average female home range, therefore, has been demonstrated to be a better predictor of extinction than body or population size in large carnivores inhabiting protected areas (Woodroffe & Ginsberg 1998; Woodroffe 2001). For this variable, we collected data from the published literature to estimate the average female home range sizes for each of the 20 species and assigned each into one of five home range classes (Table 2.1). Those species for which home range data were not available (African golden cat, Congo clawless otter) were assigned to the same class as similar-sized species within their taxonomic group.

2. State of Knowledge

The set of variables in the knowledge category addresses how much is known about each species. We used five knowledge variables (described in turn below), reflecting that different types of information contribute to our understanding

Table 2.1 Scoring description and criteria for vulnerability category (see Appendix 1 for details)

Variable Name	Description	Score Type	Score	Highest score (1) assignment
Range - current	Proportion of African continent in which species presently occurs	absolute	0-1	narrowest distribution
Distribution change	Percent range loss	absolute	0-1	largest range loss
Fecundity	1. Average minimum age of first reproduction (MAR) 2. Size of average litter adjusted for proportion of breeding females (LIT) 3. Mean interval between births (IBI)	scored[1] then standardized	0-1	1. highest age of first reproduction 2. smallest adjusted litter size 3. longest inter-birth interval
Degree of habitat specialization	Number of habitats (max=10) present	standardized	0-1	least number of habitats (most specialized)
Body size	Body size category taken from Mills (2001)	score	0.50-small; 0.75-medium; 1.0-large (>12 kg)	largest body size
Home range size	Mean home range size	score	$0.20 = <5$ km^2; $0.40 = 5$-30 km^2; $0.60 = 30$-100 km^2; $0.80 = 100$-500 km^2; $1.0 \geq 500$ km^2	largest home range
Maximum Total Score	Aggregate of above	aggregate	**6**	**Greatest vulnerability**

1. Fecundity= MAR + IBI + (LIT x proportion breeding females); see details in Appendix 1.

and overall knowledge of species, some of which are more pertinent than others to achieving effective conservation. The general framework was adopted from Millsap *et al.* (1990), and is described in Table 2.2. Three of the variables relied on expert opinion and knowledge of the breadth and scope of the published literature and conservation activities affecting African carnivores. The last two categories were scored objectively based on the number of published studies and the proportion of the species range in which it has been the focus of research or conservation effort (Table 2.2; Appendix 2). The highest scores for the sum of the five variables reflect the most comprehensive state of knowledge that can be attributed to the species in question.

Knowledge of Distribution in Africa. Knowledge of distribution is fundamental for taking effective conservation action, yet it is poor for many species. The highest score for this variable was given to those taxa for which distribution knowledge is the best known across the full African range of the species.

Knowledge base of Ecology, Requirements and Population Limitations. Baseline ecological knowledge of a species is important for understanding, forecasting, and mitigating deleterious impacts of environmental change. The highest score for this variable was given to those taxa for which such baseline knowledge is the most developed throughout their range in Africa.

Knowledge of Population Trend. It is one thing to have knowledge of the distribution for a given species, and quite another to have assessed population trends. Additionally, trends are variable throughout the range of a species, due to differences in habitat quality or threats. The highest score for this variable was given to those taxa that have received the highest degree of monitoring attention throughout their range, and for which knowledge of population trends over time is the best known.

Number of Studies. Recognizing that research that is not directly relevant to conservation or ecology of a species nonetheless signifies an improvement of knowledge, we included a variable that represents the relative degree of study, irrespective of topic. For this, we used Web of Science®, an academic search engine that searches the titles and abstracts of approximately 8,700 research journals as far back as the 1940s. While Web of Science® only covers work that has been already published, and does not cover all published works, it provides an unbiased index of the relative research effort devoted to each species. The highest score for this variable was given to those taxa with the highest number of papers published. For further analysis unrelated to the scoring process, each record for each species was assigned a subject category (see Appendix 2).

Geographic Scope of Knowledge. The final variable adds further information on how comprehensively each species has been studied or surveyed throughout its range. We mapped centroid point locations of research and conservation effort for each species using ArcView. These points

Table 2.2 Scoring description and criteria for knowledge category.

Knowledge of distribution – surveys	
a) distribution is extrapolated from a few locations and/or museum specimens	0.25
b) broad range limits or habitat associations well known but local occurrence cannot be accurately predicted	0.5
c) some detailed surveys have been done in certain regions	0.75
d) distribution is well known and occurrence can be accurately predicted throughout range	1
Knowledge base of ecology, requirements and population limitations	
a) factors affecting population size/distribution unknown or unsubstantiated	0.25
b) some factors known, but not all	0.5
c) all factors known in some places, but none or some in others	0.75
d) all major factors known/understood throughout range in Africa	1
Knowledge of population trend	
a) not currently monitored anywhere	0.25
b) monitored locally	0.5
c) coordinated regional (multi-site monitoring)	0.75
d) coordinated continental monitoring	1
Number of studies (#studies) (Web of Science)	
a) <10	0
b) 10-25	0.25
c) 26-100	0.5
d) 100-200	0.75
e) >201	1
Geographic scope of knowledge	
$\sum$ (#studies x proportion of species' range in georegion[1])/# georegions[1,2]	Index derived from score[2]
Maximum aggregate knowledge score (=the most comprehensive knowledge base attributable to species)	**5**

1. Only georegions comprising at least 5% of the species' range were counted for this analysis.
2. See details in Appendix 2.

were comprised of: 1) locations of studies assembled from the Web of Science® search described above, and 2) other conservation activities, such as comprehensive surveys or site-specific conservation efforts focused on one or more target carnivores as gleaned from a Google® search on each species' scientific and common names. The resultant map for each species (see Part IV) enabled us to analyze how research/conservation effort has been distributed throughout the range of each species. The highest scoring species for this variable were those that have received research and/or conservation attention in most of their current ranges, with no significant gaps in geographic representation (see Table 2.2, Appendix 2 for scoring methodology).

3. Threats
The final category assessed how each species is differentially impacted by a set of external threats commonly encountered by African carnivores. Following a comprehensive literature review, we compiled a list of 10 major threats from which at least one of the species considered here has experienced some significant documented impact. Each species was subjected to a scoring process for each threat (Table 2.3) that assessed the relative severity (its effect on the species), urgency (timescale over which it is most likely to occur), probability (likelihood of occurrence), and geographical extent of the threat through the species range in Africa (modified from Coppolillo *et al*. 2004). These four were multiplied together (rather than added) to derive a total score for each threat in order to ensure that the lowest scores did not contribute disproportionately to the overall threat index (Coppolillo *et al*. 2004). The highest scores indicated the highest impacts from that threat; a summed score for all ten threats represented a measure of the total degree of threat to that species. In addition to scores, we have presented a summary of the extent of these 10 threats to each species in separate profiles in Part IV.

We conducted the scoring process in a manner that kept the degree of subjectivity as constant as possible. This meant that while it would appear to make sense to have individual species assessments conducted by experts for those species, we limited the number of evaluators to two of us (JR and LH), to allow all the scoring to proceed in a relative sense, thereby lessening the risk of employment of different standards.

Analyses
The general scoring process was largely descriptive in nature. To explore relationships among the 12 variables, we applied multivariate analyses, specifically employing principle component analysis and multiple regression. Univariate correlations were conducted using Spearman's rank correlations. The twenty carnivore species were divided into families and size groups (larger [>12 kg] and smaller [≤ 12 kg) as a further basis of analysis. Comparisons of means were made using ANOVAs on rank-transformed data, using Tukey's Range Test to test means.

Table 2.3 Scoring description and criteria for threats category
(modified from Coppolillo *et al.*, 2004, Table 1).

Threats	Component	Score	Scoring Criteria
1. Habitat decline 2. Human hunting 3. Human conflict 4. Interspecific conflict 5. Disease 6. Genetic poverty 7. Road kill 8. Climate change 9. Insect control 10. Tourism	**SEVERITY (S)**	0	No or positive effect on the species (in terms of effects on density/distribution)
		1	Little measurable but small effect on density or distribution
		2	Measurable effect on density or distribution, but eradication unlikely
		3	Serious effects, eradication a possibility
	URGENCY (U)	0	Will not happen in >10 years
		1	Could happen over 3-10 years
		2	Could (or will) happen within 1-3 years
		3	Must act immediately (threat is already happening)
	PROPORTION (P_a)[1]	0	0
		1	0.01-0.1
		2	0.1-0.25
		3	0.25-0.5
		4	>0.5
	PROBABILITY (P_o)	0-1	0-100%
	THREAT SCORE ($S \times U \times P_a \times P_o$)	0-36	An aggregate score of the above reflects the seriousness that threat poses to a given species

1. proportion of species range in Africa affected

| SPECIES[1] | VULNERABILITY | | | | | | | KNOWLEDGE | | | | | | THREAT |
	BODY	FECUND	SPECIAL	PROPDIS	LOSS	HR	TOTAL	SURVEY	MONITOR	BASELINE	STUDIES	SCOPE	TOTAL	
AAR	0.75	0.6197	0.6667	0.8165	0.1004	0.20	**3.153**	0.5	0.25	0.5	0.5	0.20	**1.95**	**0.279**
AFC	0.75	0.4380	0.2222	0.4732	0.0000	0.40	**2.283**	0.75	0.25	0.5	0.5	0.10	**2.1**	**0.000**
AGC	0.75	0.7051	0.7778	0.9060	0.4421	0.40	**3.981**	0.25	0.25	0.25	0	0.10	**0.85**	**0.270**
AWD	1	0.5444	0.4444	0.9346	0.8953	1.00	**4.819**	1	0.75	0.75	0.75	.6	**3.85**	**1.000**
BBJ	0.75	0.3134	0.2222	0.7852	0.0314	0.40	**2.502**	0.5	0.5	0.5	0.5	0.40	**2.4**	**0.206**
BRH	1	0.8547	0.6667	0.9348	0.3808	0.80	**4.637**	1	0.5	0.75	0.5	1.00	**3.75**	**0.382**
CAR	0.75	0.5342	0.6667	0.5809	0.3768	0.40	**3.309**	0.5	0.25	0.5	0.5	0.10	**1.85**	**0.352**
CCO	0.75	0.5655	0.3333	0.5440	0.0000	0.40	**2.593**	0.5	0.5	0.5	0.25	0.10	**1.85**	**0.415**
CGO	0.75	0.7179	0.4444	0.9108	0.0000	0.40	**3.223**	0.25	0.25	0.25	0	0.10	**0.85**	**0.406**
CHE	1	0.5342	0.7778	0.7913	0.7650	1.00	**4.868**	1	0.75	0.75	1	0.60	**4.1**	**0.941**
ETW	0.75	0.6624	1.0000	0.9995	0.9829	0.40	**4.795**	1	1	1	0.25	1.00	**4.25**	**0.964**
GOJ	0.75	0.2707	0.3333	0.4794	0.0041	0.40	**2.238**	0.25	0.25	0.5	0.5	0.10	**1.6**	**0.040**
HOB	0.75	0.8689	0.0000	0.2193	0.0047	0.80	**2.643**	0.75	0.5	0.5	0.25	0.10	**2.1**	**0.158**
LEO	1	0.8312	0.0000	0.5139	0.3659	0.60	**3.311**	0.75	0.5	0.75	1	0.20	**3.2**	**0.455**
LIO	1	1.0000	0.3333	0.8706	0.8288	0.80	**4.833**	1	0.75	0.75	1	0.80	**4.3**	**0.527**
SER	0.75	0.6902	0.3333	0.6090	0.2392	0.40	**3.022**	0.5	0.25	0.5	0.5	0.10	**1.85**	**0.406**
SNO	0.5	0.2436	0.2222	0.6101	0.0000	0.40	**1.976**	0.5	0.25	0.5	0.25	0.10	**1.6**	**0.418**
SPH	1	0.8547	0.1111	0.5338	0.2662	0.60	**3.366**	0.75	0.5	0.75	1	0.20	**3.2**	**0.276**
SSJ	0.75	0.7051	0.5556	0.6508	0.0000	0.20	**2.861**	0.5	0.5	0.5	0.25	0.10	**1.85**	**0.233**
STH	1	0.6346	0.5556	0.7399	0.3827	0.60	**3.913**	0.5	0.25	0.25	0.5	0.10	**1.6**	**0.348**

1. Species codes as in Table 1.1.

RESULTS

Overall

Final scores for all 12 variables in the three categories are shown in Table 2.4. The overall ranking of the 20 species in each of the three categories, while not identical, was broadly consistent (Table 2.5; Fig. 2.1). Cheetah, African wild dog, Ethiopian wolf, and lion were the top four ranked species in all three categories. This meant that they were broadly the most intrinsically vulnerable and the most impacted by the suite of external threats, while also had been subjected to the most monitoring and research. Patterns were not as obvious among the bottom rankings, with only golden jackal consistently appearing among the bottom five ranked species in each category. Black-backed jackal, golden jackal, African civet, and honey badger were among the six bottom-ranked species in both the vulnerability and threats categories. Correlations between each of the three category scores were significant (Table 2.6; Fig. 2.1). This relationship did not,

Table 2.5 Species ranking in three priority scoring categories.

Rank	Vulnerability	Knowledge	Threats
1	Cheetah	Lion	African wild dog
2	Lion	Ethiopian wolf	Ethiopian wolf
3	African wild dog	Cheetah	Cheetah
4	Ethiopian wolf	African wild dog	Lion
5	Brown hyena	Brown hyena	Leopard
6	African golden cat	Leopard[a]	Spotted-necked otter
7	Striped hyena	Spotted hyena[a]	Cape clawless otter
8	Spotted hyena	Black-backed jackal	Congo clawless otter[f]
9	Leopard	African civet[b]	Serval[f]
10	Caracal	Honey badger[b]	Brown hyena
11	Congo clawless otter	Aardwolf	Caracal
12	Aardwolf	Caracal[c]	Striped hyena
13	Serval	Cape clawless otter[c]	Aardwolf
14	Side-striped jackal	Serval[c]	Spotted hyena
15	Honey badger	Side-striped jackal[c]	African golden cat
16	Cape clawless otter	Golden jackal[d]	Side-striped jackal
17	Black-backed jackal	Spotted-necked otter[d]	Black-backed jackal
18	African civet	Striped hyena[d]	Honey badger
19	Golden jackal	African golden cat[e]	Golden jackal
20	Spotted-necked otter	Congo clawless otter[e]	African civet

a-f. Species with the same letter had equal scores in this category

Fig. 2.1 Relationships among category scores for 20 carnivore species.
A. Vulnerability vs. Threat;
B. Vulnerability vs. Knowledge;
C. Knowledge vs. Threat.
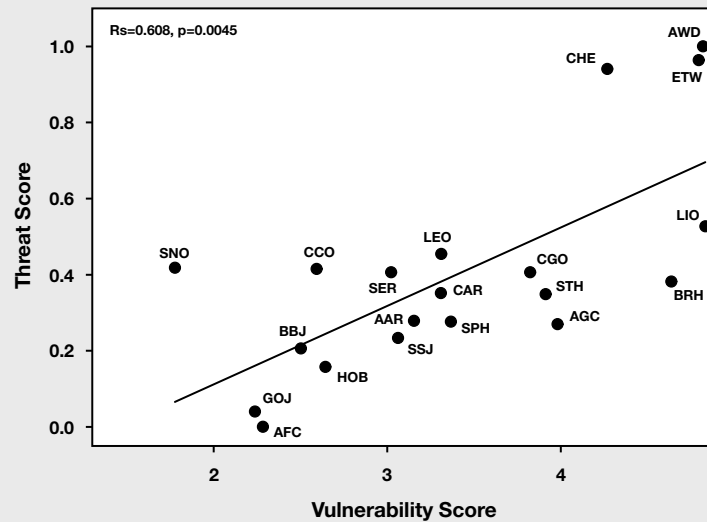
Fig. 2.1a
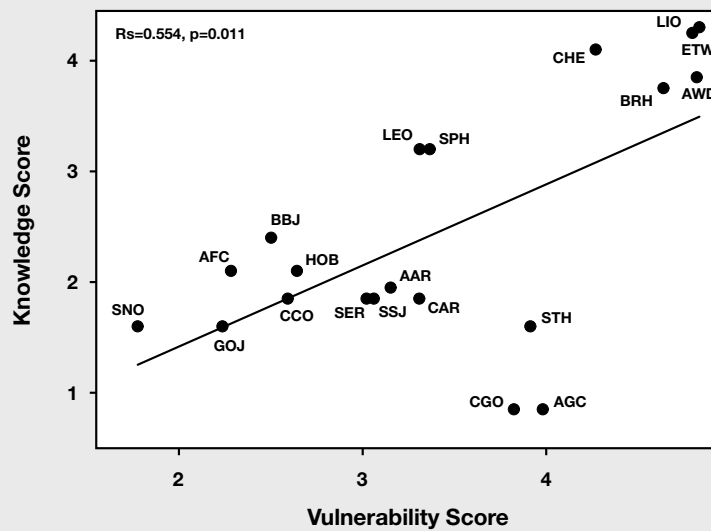
Fig. 2.1b
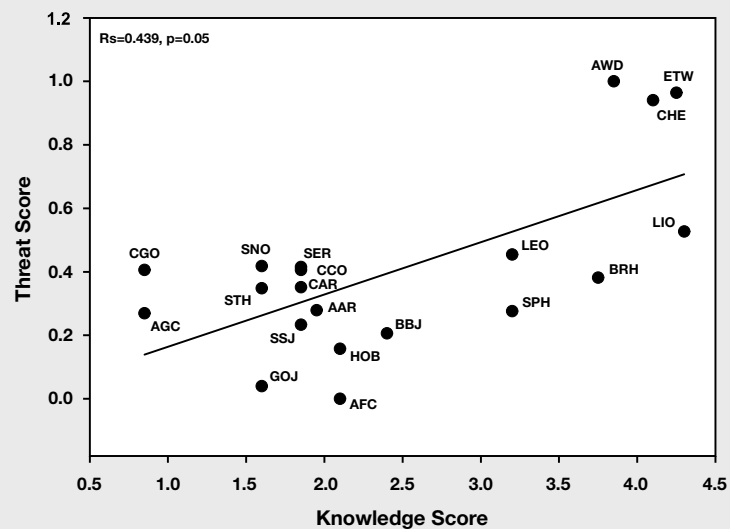
Fig. 2.1c

however, usually hold out within individual families. For hyenids and mustelids, no categories were correlated. For canids only vulnerability and threat scores were correlated, while for felids, knowledge and threat scores were correlated with one another. Within two size categories, vulnerability and knowledge categories were the sole significant relationship for large carnivores ($\geq$ 12 kg) only.

Among families, mustelids had lower mean scores than other families in vulnerability and knowledge categories, mean canid and felid scores were highest in the threat and knowledge categories, while felids and hyenids had the highest mean vulnerability scores (Fig. 2.2a). None of these differences was significant, however, possibly due to low sample sizes. When we tested means of individual variable scores within vulnerability (6 variables) and knowledge (5 variables) categories, the same trends among families were evident (Table 2.7), with mustelid scores in both categories significantly lower than those for the other three families (vulnerability: F=2.83, df=110, p=0.0418; knowledge: F=4.39, df=91, p=0.0062).

Large carnivores had significantly higher mean category scores for vulnerability (Kruskall Wallis: χ^2=9.31, df=1, p=0.0023), knowledge (χ^2=5.92, df=1, p=0.015), and threat (χ^2=3.77, df=1, p=0.05; Fig. 2.2b). Means of individual variable scores within vulnerability and knowledge categories were highly significant (Table 2.7). Species rankings within family and size categories ranged widely for category scores and variables scores within categories alike (Table 2.7).

Table 2.6 Spearman's rank correlations between category scores, overall and for species' groupings. Significant (p<0.05) relationships indicated in bold.

		VULNERABILITY	KNOWLEDGE	THREAT
VULNERABILITY	**Overall (n=20)**	1.00	**R_s=0.554; p=0.011**	**R_s=0.608; p=0.0045**
	Felidae (n=6)		R_s=0.580; p=0.228	R_s=0.600; p=0.208
	Canidae (n=5)		R_s=0.800; p=0.104	**R_s=1.00; p=<0.0001**
	Hyaenidae (n=4)		R_s=0.400; p=0.600	R_s=0.800; p=0.200
	Mustelidae (n=4)		R_s= -0.641; p=0.359	R_s=0.624; p=0.376
	Large (n=7)		**R_s=0.847; p=0.016**	R_s=0.679; p=0.094
	Small (n=13)		R_s=0.003; p=0.993	R_s=0.380; p=0.201
KNOWLEDGE	**Overall (n=20)**		1.00	**R_s=0.439; p=0.05**
	Felidae (n=6)			**R_s=0.928; p=0.008**
	Canidae (n=5)			R_s=0.800; p=0.104
	Hyaenidae (n=4)			R_s=0.200; p=0.800
	Mustelidae (n=4)			R_s= -0.204; p=0.797
	Large (n=7)			R_s=0.739; p=0.058
	Small (n=13)			R_s=-0.140; p=0.648

Fig. 2.2 Comparison of mean category scores by A. carnivore family and B. body size. Asterisks indicate level of significance from rank-transformed ANOVA (family) and Kruskal-Wallis (size) tests (***p<0.001; **p<0.01; *p<0.05).
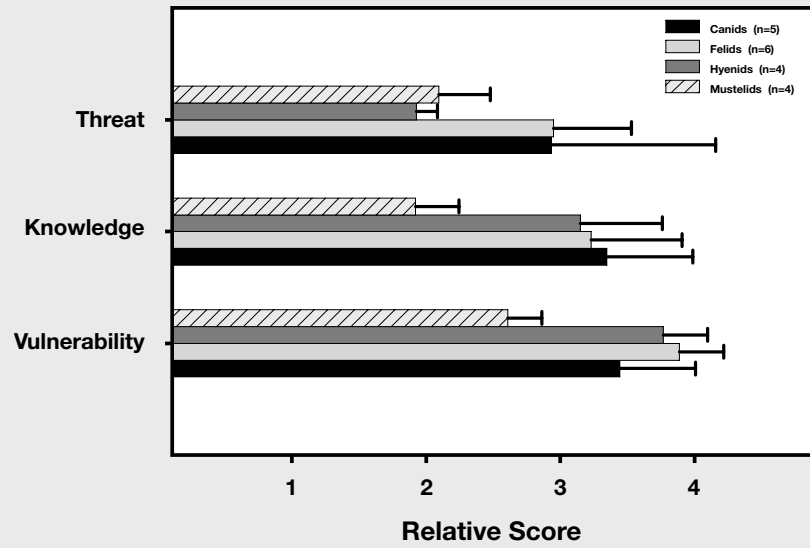
Fig. 2.2a
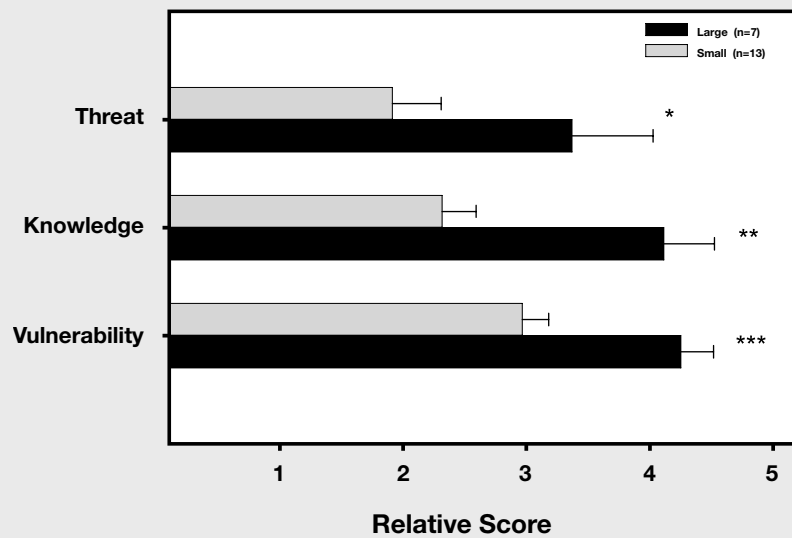
Fig. 2.2b

Table 2.7 Mean vulnerability, knowledge and threat scores and ranks among families and size groups analyzed by: 1) total score, and 2) variable scores within each category.

1. Category Scores

FAMILY	N	VULNERABLITY Mean (±SE) Score (max=6)	Mean (range) Rank	KNOWLEDGE Mean (±SE) Score (max=5)	Mean (range) Rank	THREAT Mean (±SE) Score (max=1)	Mean (range) Rank
Canidae	5	3.44±0.566	11.4 (3-19)	2.79±0.534	8.4 (2-16)	0.489±0.204	11.0 (1-19)
Felidae	6	3.89±0.331	6.83 (1-13)	2.69±0.568	8.83 (1-19)	0.492±0.097	7.67 (3-15)
Hyaenidae	4	3.767±0.331	8 (5-12)	2.625±0.508	9.5 (5-16)	0.321±0.026	12.25 (10-14)
Mustelidae	4	2.609±0.255	15.5 (11-20)	1.6±0.270	14 (9-19)	0.349±0.064	9.75 (6-18)
SIZE							
Large (> 12 kg)	7	4.249±0.266***	5.0 (1-9)	3.429±0.343**	5.86 (1-16)	0.561±0.110*	7 (1-14)
Small (≤ 12 kg)	13	2.968±0.212	13.46 (4-20)	1.931±0.230	12.08 (2-19)	0.319±0.066	12.31 (4-20)

2. Variable Scores

	N	VULNERABILITY Mean (±SE) Score (max=1.0)	Mean (range) Rank	N	KNOWLEDGE Mean (±SE) Score (max=1.0)	Mean (range) Rank	THREAT
Canidae	30	0.574±0.057b	10.03 (1-20)	25	0.558±0.57b	6.72 (1-18)	See above^c
Felidae	36	0.648±0.041b	7.53 (1-19)	30	0.538±0.057b	6.96 (1-19)	
Hyaenidae	24	0.628±0.056b	7.38 (1-19)	20	0.525±0.0612b	6.75 (1-18)	
Mustelidae	24	0.435±0.061a	10.75 (2-20)	20	0.32 ± 0.044a	11.05 (5-19)	
Large (> 12 kg)	46	0.708±0.041****	6.65 (1-19)	35	0.686±0.045****	4.17 (1-18)	
Small (≤ 12 kg)	74	0.495±0.031	10.61 (1-20)	65	0.386±0.029	9.68 (1-19)	

Significance results from Kruskal Wallis: *p≤0.05; **p<0.01; ***p<0.001; ****p<0.0001
a,b Means with same letter are not significantly different from one another according to Tukey's Range Test.
c Threat category composed of one variable only

Vulnerability

Spearman's rank correlations revealed strong associations between several of the six vulnerability variables (Table 2.8). The first axis (43% of the total variance in scores) of a Principal Components Analysis (PCA; Fig. 2.3) contrasted those species with low fecundity scores, large home range and body sizes and those that have experienced a high degree of range loss (e.g., Ethiopian wolf, African wild dog, brown hyena, cheetah and lion) with those with relatively high reproductive potential, and small home ranges and body size (e.g., honey badger, African civet and the three jackal species). The second axis (28.4%) pulled apart the least specialized and widest ranging species — honey badger, spotted hyena, and leopard — from Ethiopian wolf, African golden cat, and Congo clawless otters. This analysis showed that the highest scoring species in the vulnerability category — Ethiopian wolf, African wild dog, cheetah, lion, and brown hyena — all show high degrees of range loss, variable but relatively high degrees of specialization, and low reproductive rates (high fecundity scores). Caracal, serval, and striped hyena tended to have intermediate values in all vulnerability variables. A PCA analyzing the three components of the fecundity score (litter size adjusted for number of breeding females, minimum age of first reproduction, and inter-birth interval) yielded additional information on species' contrasts (Fig. 2.4). The first axis of variation (accounting for 56% of the total variance in scores) distinguished species with long inter-birth intervals and high minimum age at first reproduction (e.g., lion, brown hyena, spotted hyena, and leopard) from those with low values for these variables (particularly African civet). The second axis, explaining an additional 29% of the total variance, contrasted species with high (the three jackal species) vs. low (African golden cat and honey badger) average litter sizes.

In family comparisons of the individual vulnerability scores, significant differences were evident for fecundity (rank-transformed ANOVA F=5.16, df=3, p=0.0120) and range loss (F=3.36; df=3; p=0.047). Canids scored significantly lower (indicating higher reproductive rates) than other families for the former (Fig. 2.5a). In size comparisons of mean vulnerability scores (except body size), range loss and home range scores were significantly higher for large vs. smaller carnivores (range loss: Kruskall Wallis, χ^2=6.73, p=0.0095; home range: χ^2=12.45, p=0.0004; Fig 2.5b). When family comparisons were made for the three variables that composed the fecundity score, only litter size was significant (F=3.39, p=0.0365), with Tukey's Range Test revealing significant differences between mustelids (mean score=0.806±0.0833) and canids (0.299 ± 0.160), but none of the other families. Between the two size classes, however, larger carnivores had significantly higher minimum age to first reproduction (Kruskall Wallis, χ^2=7.21, p=0.0073) and inter-birth interval (χ^2=8.63, p=0.0033), but no differences in litter size.
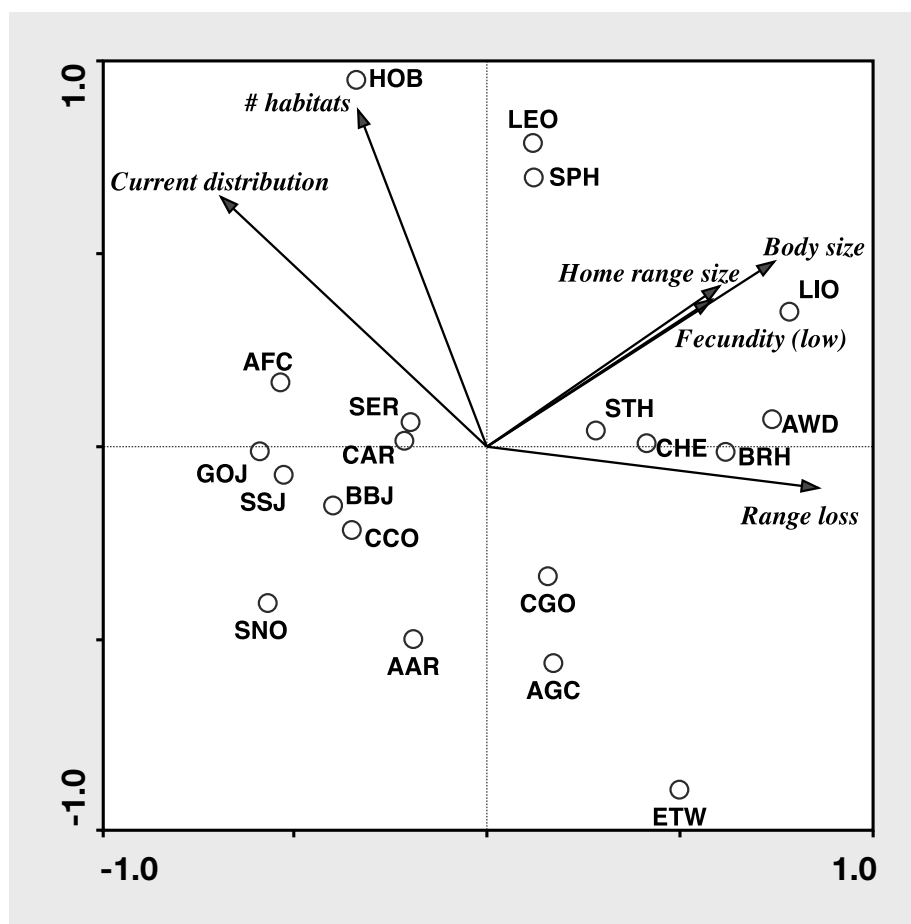
Fig. 2.3 Principal components analysis of species and vulnerability variables. Note that for maximum clarity, raw values of each variable were used, and not scores, with the exception of fecundity, for which long axes indicated high scores (or low reproductive potential). See Table 1.1 for species codes.
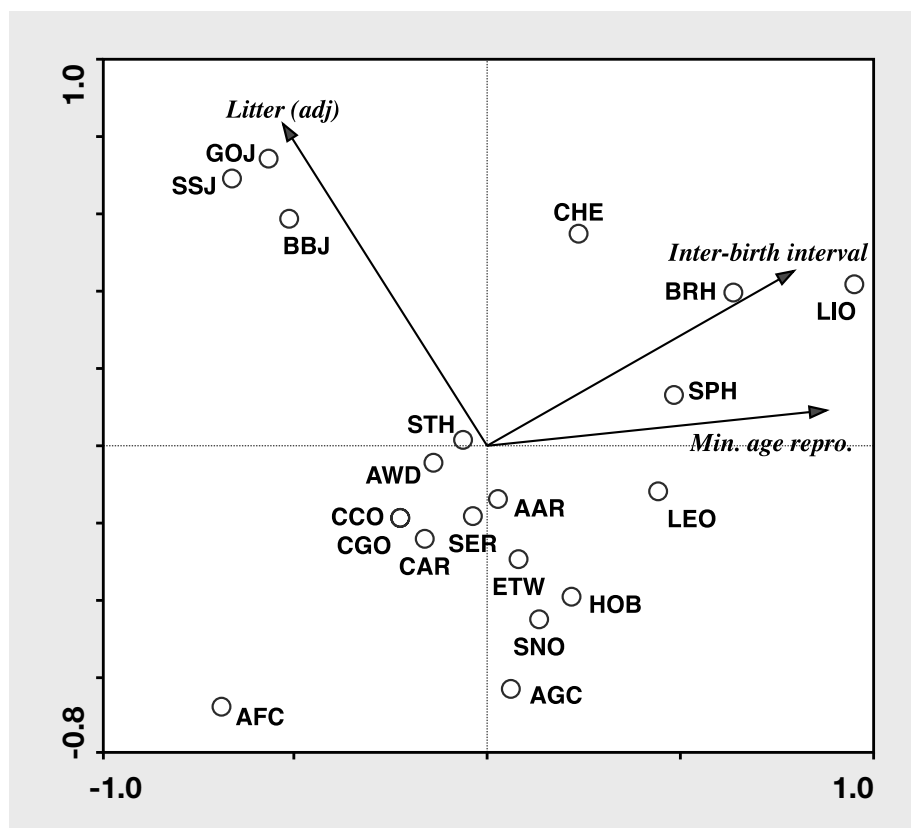
Fig. 2.4 Principal components analysis of species and fecundity variables. See Table 1.1 for species codes.

Table 2.8 Spearman's rank correlations between vulnerability variables. Significant (p<0.05) relationships indicated in bold.

	Fecundity	Body Size	Specialization	Current Distribution	Range Loss	Home Range
Fecundity	1.00	0.440 (ns)	-0.075 (ns)	0.149 (ns)	0.247 (ns)	**0.625 (p=0.0042)**
Body Size		1.00	0.046 (ns)	0.208 (ns)	**0.628 (p=0.003)**	**0.775 (p<0.0001)**
Specialization			1.00	**0.708 (p=0.0005)**	**0.494 (p=0.027)**	-0.135 (ns)
Current Distribution				1.00	**0.558 (p=0.011)**	0.098 (ns)
Range Loss					1.00	**0.565 (p=0.009)**
Home Range						1.00
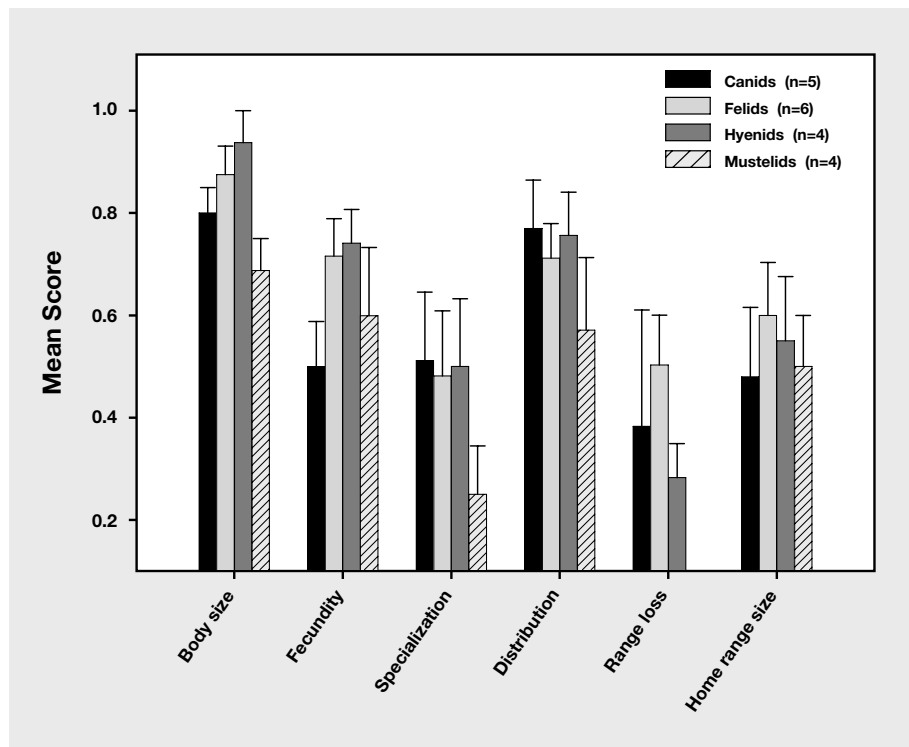
Fig. 2.5 Mean score comparisons of vulnerability variables between
A. carnivore families, and
B. body sizes. Asterisks indicate level of significance from rank-transformed ANOVA (family) and Kruskal-Wallis (size) tests
(***p<0.001; **p<0.01; *p<0.05).

Fig. 2.5a
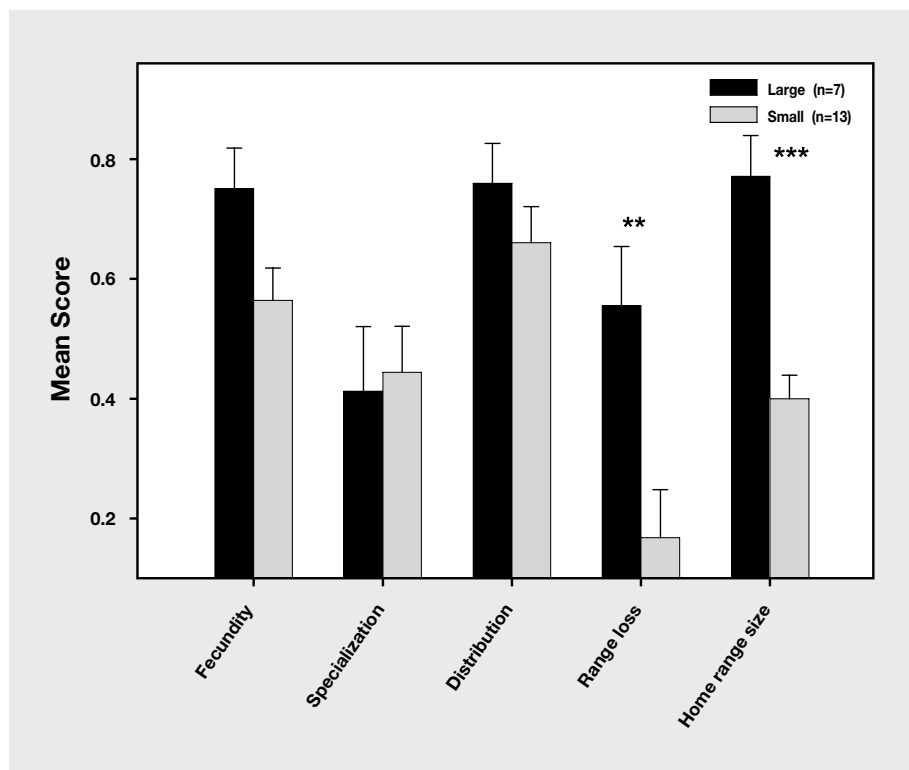
Fig. 2.5b

Knowledge

Spearman's rank correlation showed strong associations between all of the five variables that comprised the knowledge category, with the exception of number of studies and knowledge of population trend, which was nearly significant (Table 2.9). A PCA (Fig. 2.6) revealed the clear contrast between well-studied and data-deficient species. All variables were strongly correlated with the first axis, which accounted for 74.5% of the total variance in scores. Number of studies was correlated with the second axis, which accounted for another 15.4% of the total variation. The PCA demonstrates that while knowledge of population trend, knowledge of baseline ecology and knowledge of distribution go hand-in-hand, the sheer amount of study on species is somewhat separate. The geographic scope of research and conservation attention is related more to knowledge of baseline ecology, distribution, and population trend, than it is to number of studies. In other words, species can be well studied, but with incomplete information on status. This is the case for leopard and spotted hyena, in contrast to Ethiopian wolf. The latter is well-known and monitored, but has few published studies relative to the other two. Most species cluster on the left of this graph indicating that they are neither well-studied, nor is their status well known.

There was no apparent difference between families with regard to any of the knowledge variables. Studies and scope were both higher for larger than smaller carnivores, although this only approached significance (Kruskall Wallis: studies χ^2=3.48, p=0.06; scope χ^2=2.58, p=0.11; Fig. 2.7B).

Research and conservation effort

The Web of Science® literature search uncovered a total of 1716 papers with any of the 20 carnivore species as subject matter (Table 2.10). The category with the highest percentage of publications was Disease/Contaminants (26%), with the next most important category being Ecology (22%) followed by Behavior (14.5%). Five species (lion, cheetah, spotted hyena, leopard, and African wild dog) comprised 79% of all the papers (Fig. 2.8A). The number of papers in conservation, management, or ecology was highly correlated with the total number of papers/species (r^2=0.91; p<0.001; Fig. 2.8B). There was a tendency for those species with fewer numbers of papers to concentrate on ecology and conservation, with two otter species providing the only examples where ecology/conservation papers outnumbered other papers. There was an extremely weak and non-significant relationship, however, between the proportion of ecological/conservation papers and total knowledge score.

Carnivore research also exhibits a strong geographic bias, with the vast majority of studies occurring in the southern and eastern parts of the continent (Fig. 2.9). Points from regional studies are depicted by central range points.

Table 2.9 Spearman's rank correlations between knowledge variables. Significant (p<0.05) relationships indicated in bold.

	Distribution	Population	Ecology	Studies	Scope
Distribution	1.00	**0.788 (p<0.0001)**	**0.863 (p<0.0001)**	**0.562 (p<0.001)**	**0.768 (p<0.0001)**
Population		1.00	**0.802 (p<0.0001)**	0.354 (p=0.126)	**0.761 (p<0.0001)**
Ecology			1.00	**0.607 (p<0.005)**	**0.824 (p<0.0001)**
Studies				1.00	**0.527 (p=0.017)**
Scope					1.00
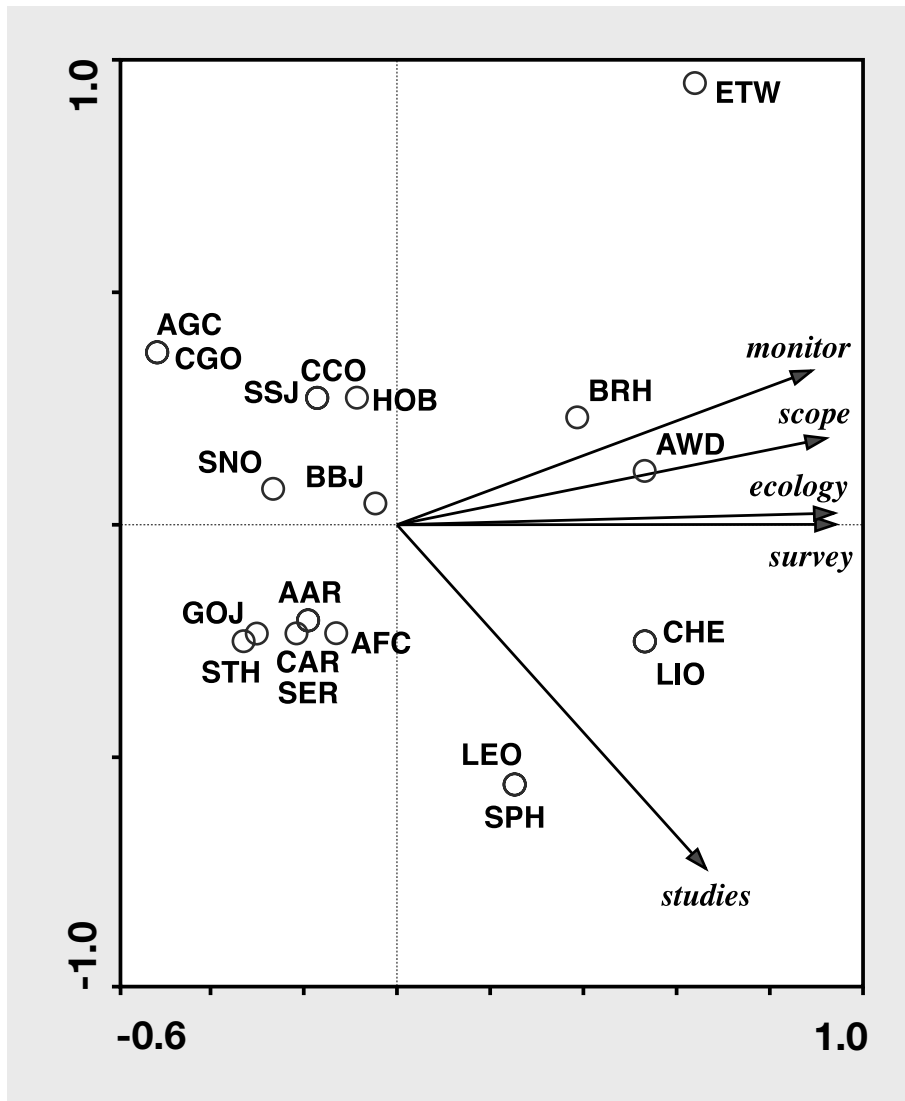
Fig. 2.6 Principal components analysis of knowledge scores. See Table 1.1 for species codes.

Fig. 2.7 Mean score comparisons of knowledge variables between
A. carnivore families, and
B. body sizes. Asterisks indicate level of significance from rank-transformed ANOVA and Kruskal-Wallis tests (***p<0.001; **p<0.01; *p<0.05).
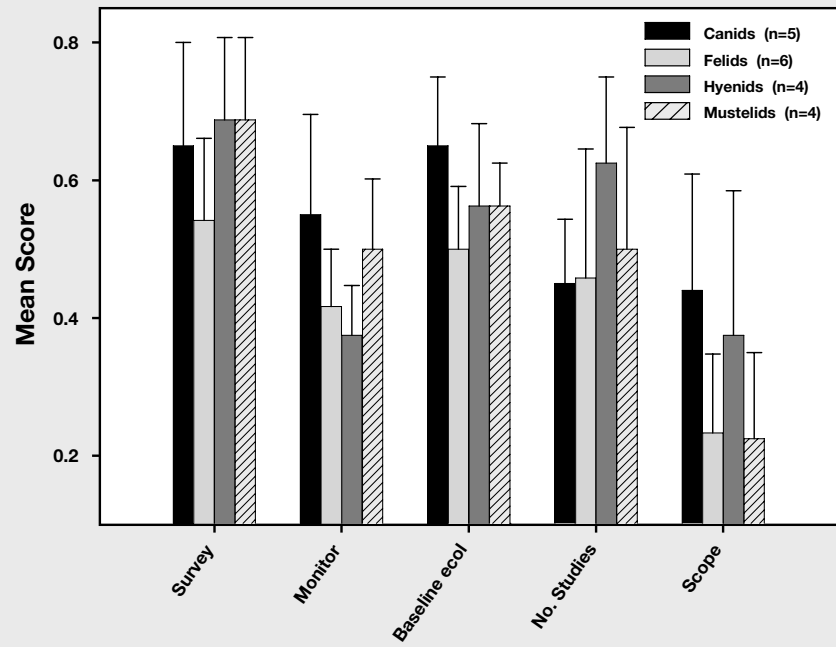
Fig. 2.7a
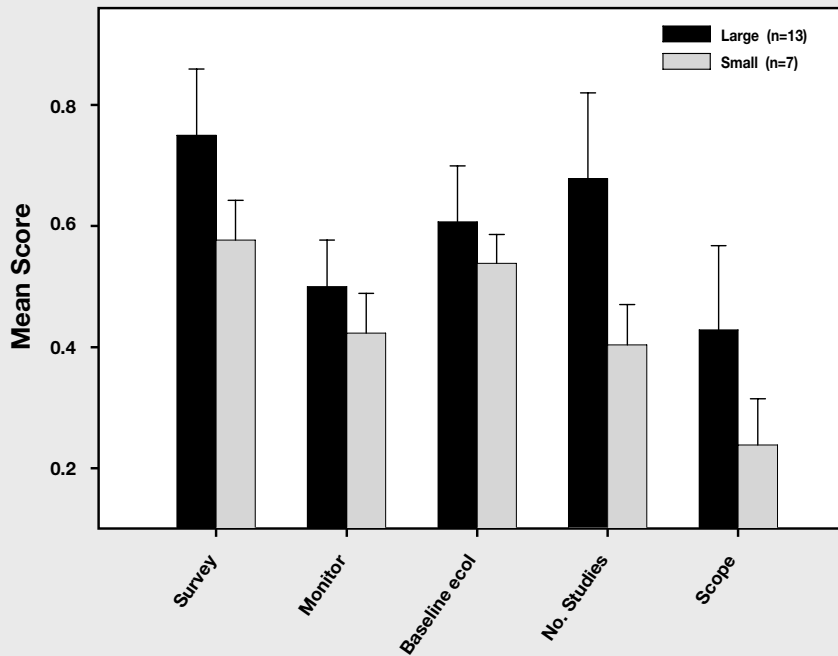
Fig. 2.7b

	Anatomy/ Morphology/ Physiology	Ecology	Conservation/ Management	Methods	Behavior	Genetics	Paleontology and Evolution	Disease/ Contaminants	Other	Total
ETW	0	7	2	3	3	1	0	2	0	**18**
AWD	11	26	13	14	20	5	1	39	3	**132**
BBJ	4	21	3	6	3	1	1	12	0	**51**
SSJ	2	4	0	1	0	0	1	6	0	**14**
GOJ	6	9	7	1	5	0	2	12	1	**43**
CHE	35	44	27	24	28	22	3	119	6	**308**
LIO	43	75	30	38	49	25	29	156	18	**463**
SER	2	5	4	2	1	1	0	9	2	**26**
AGC	1	2	0	0	0	1	0	4	0	**8**
LEO	16	60	29	14	16	16	11	38	9	**209**
CAR	3	10	4	2	4	2	2	2	2	**31**
AAR	8	8	0	1	10	1	3	2	0	**33**
SPH	17	67	2	14	78	5	23	19	3	**228**
BRH	2	8	2	3	14	0	5	2	0	**36**
STH	9	4	2	1	8	2	3	2	0	**31**
CCO	1	18	0	0	1	0	0	2	0	**22**
SNO	0	11	1	1	1	0	0	1	0	**15**
CGO	0	0	0	0	0	0	0	0	0	**0**
HOB	3	1	2	0	4	1	0	4	0	**15**
AFC	1	5	1	0	3	2	2	9	10	**33**
TOTAL	**164**	**383**	**129**	**125**	**248**	**85**	**86**	**440**	**54**	**1716**

Fig. 2.8
A. Piechart depicting proportion of Web of Science papers (n=1716) on each of 20 carnivore species (note that two wedges are too small to register);
B. Distribution of paper subjects into conservation/ management, ecology, and other.
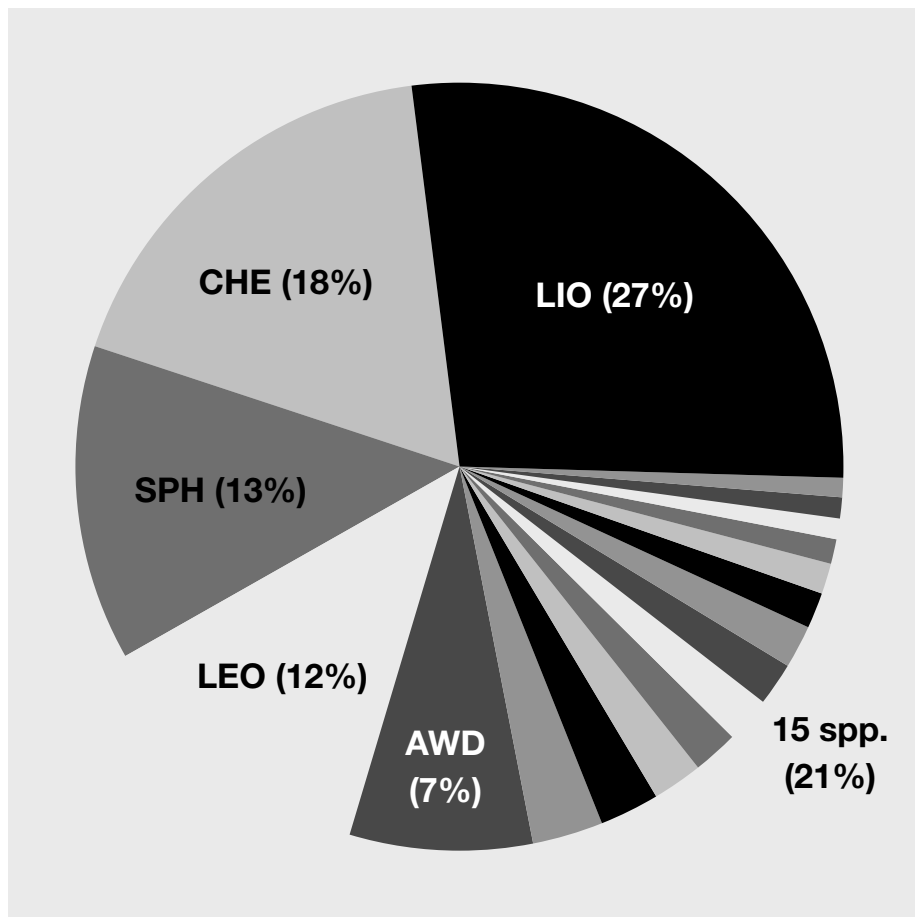
Fig. 2.8a
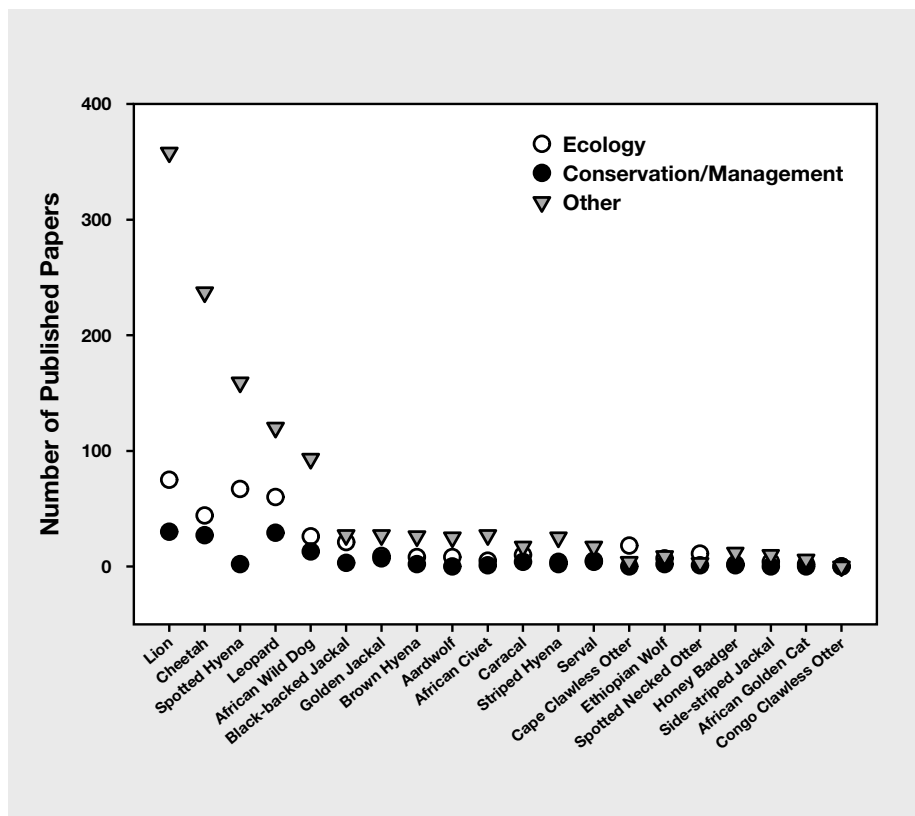
Fig. 2.8b
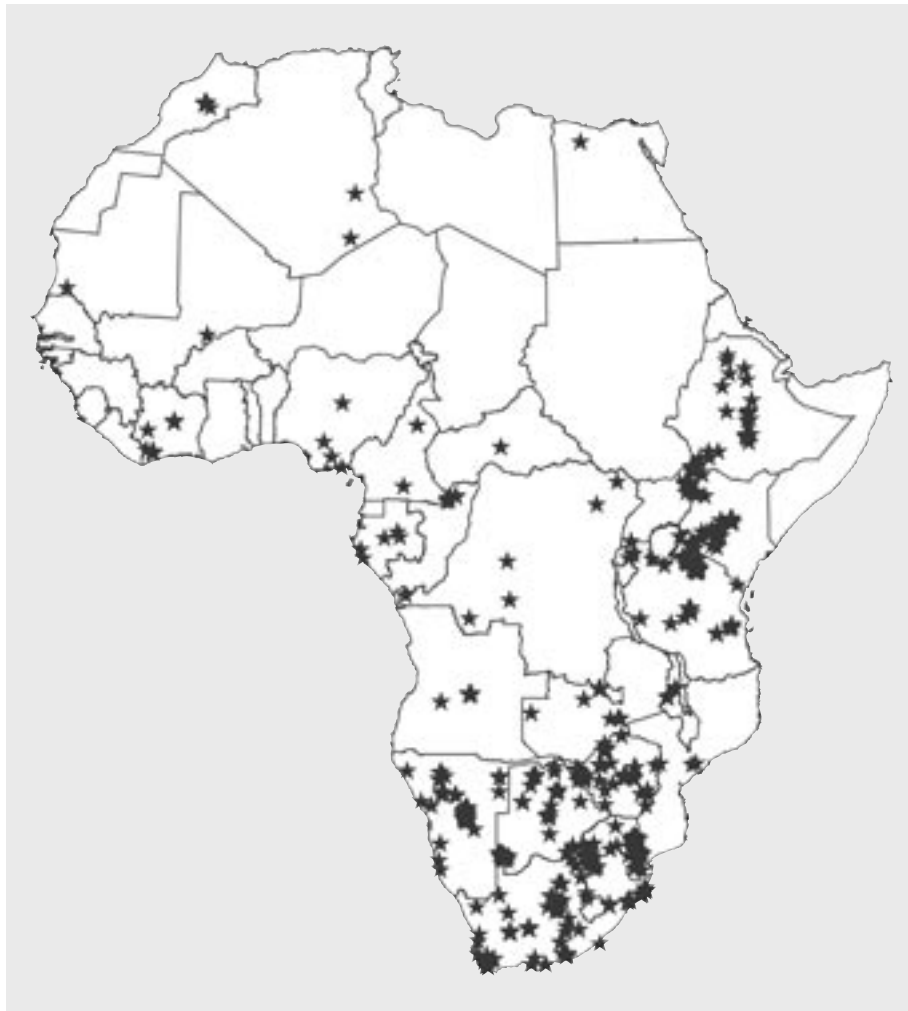
Fig. 2.9 Distribution of carnivore studies in Africa.

Threats

Complete scores for all 20 species relative to the ten threats are presented in Table 2.11 and Appendix 3. A PCA (Fig. 2.10) demonstrated that three species—cheetah, Ethiopian wolf, and African wild dog—were distinct relative to the others due to the high threats that they suffer in several categories. All three (but particularly cheetah) received high scores for human conflict and habitat loss, with African wild dog and Ethiopian wolf further exposed to stresses particularly characteristic of small populations such as human-introduced disease and genetic impoverishment. Other species did not score particularly high in any of the threats, with the exception of lion and leopard, which received moderate scores in human conflict, hunting, and habitat loss.

Table 2.11 Aggregate threats scores for 20 carnivore species. See Appendix 3 for scoring details.

SPECIES	CLIMATE	HABITAT DECLINE	DISEASES	HUMAN CONFLICT	INSECT CONTROL	ROAD KILLS	HUMAN HUNTING	INTERSPECIFIC	GENETIC POVERTY	TOURISM	TOTAL SCORE
AFRICAN WILD DOG	0	24	27	36	0	18	6	36	24	0	171
ETHIOPIAN WOLF	0.8	36	36	36	0	24	0	2.25	24	0	159.05
CHEETAH	0	36	24	36	0	2	6	36	3.2	12	155.2
LION	0	27	18	36	0	0	4	0	2	0	87
LEOPARD	0	27	1	36	0	2	8	1	0	0	75
SPOTTED-NECKED OTTER	0	36	0	12	0	1	2	18	0	0	69
CAPE CLAWLESS OTTER	4.5	18	0	24	0	2	2	18	0	0	68.5
SERVAL	0	36	0	27	0	2	2	0	0	0	67
CONGO CLAWLESS OTTER	0	27	0	36	0	0	4	0	0	0	67
BROWN HYENA	0	12	0	27	0	6	0	18	0	0	63
CARACAL	0	27	0	27	0	2	2	0	0	0	58
STRIPED HYENA	0	27	0	27	0	2	1.5	0	0	0	57.5
AARDWOLF	1	0	0	6	27	3	3	6	0	0	46
SPOTTED HYENA	1	18	1.6	18	0	2	4	1	0	0	45.6
AFRICAN GOLDEN CAT	0	36	0	3	0	5	4	1	0	0	44.5
SIDE-STRIPED JACKAL	0	0	12	12	0	2	0.5	12	0	0	38.5
BLACK-BACKED JACKAL	0	0	12	12	0	2	6	2	0	0	34
HONEY BADGER	0	4	0	12	0	4	6	0	0	0	26
GOLDEN JACKAL	0	0	1.6	1	0	0	0	4	0	0	6.6
AFRICAN CIVET	0	0	0	0	0	0	0	0	0	0	0

Examining the threats themselves, almost every species scored moderately high to high for human conflict, making this without question the most important threat facing carnivores on the continent (Table 2.12), with impacts on distributions and populations. Most species that are exposed to human conflict and habitat decline experience it with a high degree of severity and pervasiveness, as opposed to threats that are clearly localized such as road kill (Fig. 2.11).

Explanatory variables of extinction risk

We combined all 12 variables in a multiple regression analysis to examine the explanatory power of the vulnerability, knowledge, and threats variables used in this exercise to extinction risk. We used a conservation status variable devised by Mills *et al.* (2001) as the measure of risk, under the assumption that the IUCN or CITES conservation status assignment was indeed reflective of true status in the wild. Fecundity and range loss were the best predictors to emerge from this analysis (fecundity: t=13.73, p=0.0018; range loss: t=5.79, p=0.028).

Table 2.12 Sum of threats scores across 20 species.

THREAT	Cumulative Score
Human conflict	424
Habitat decline	391
Interspecific conflict	164.25
Disease	133.2
Road kill	76.5
Human hunting	61
Genetic poverty	53.2
Insect control	27
Tourism	12
Climate change	7.3
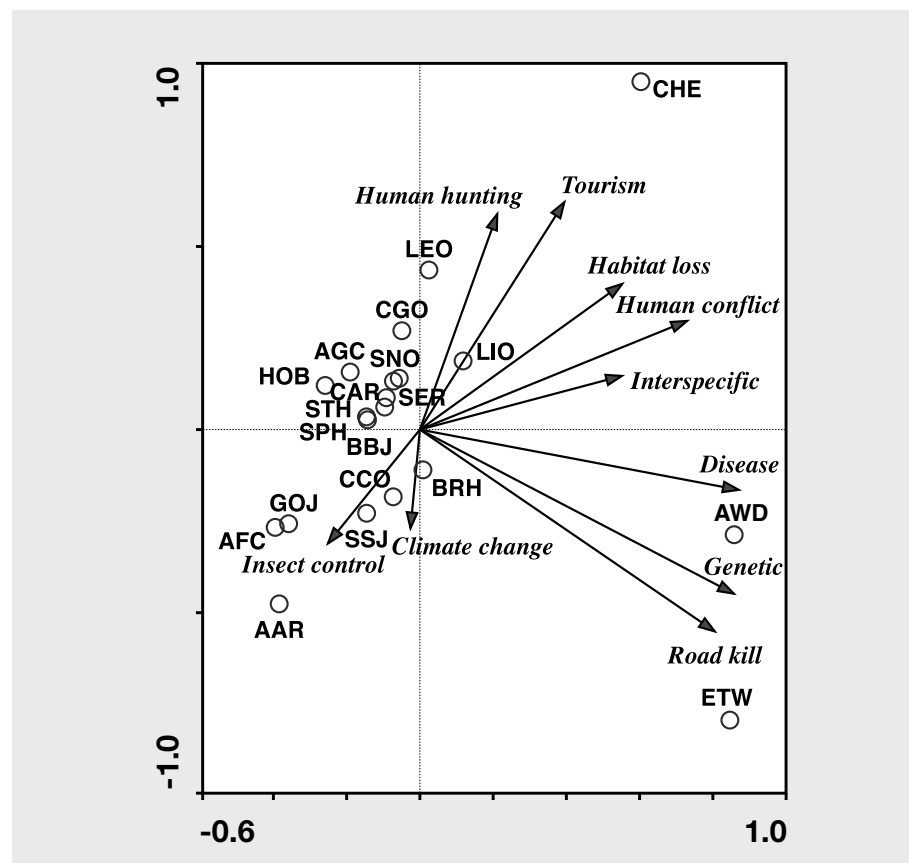
Fig. 2.10 Principal components analysis of threats scores. See Table 1.1 for species codes.

Fig. 2.11 Number of species scoring A. more than 12 and B. more than 0 for each of 10 threats analyzed.
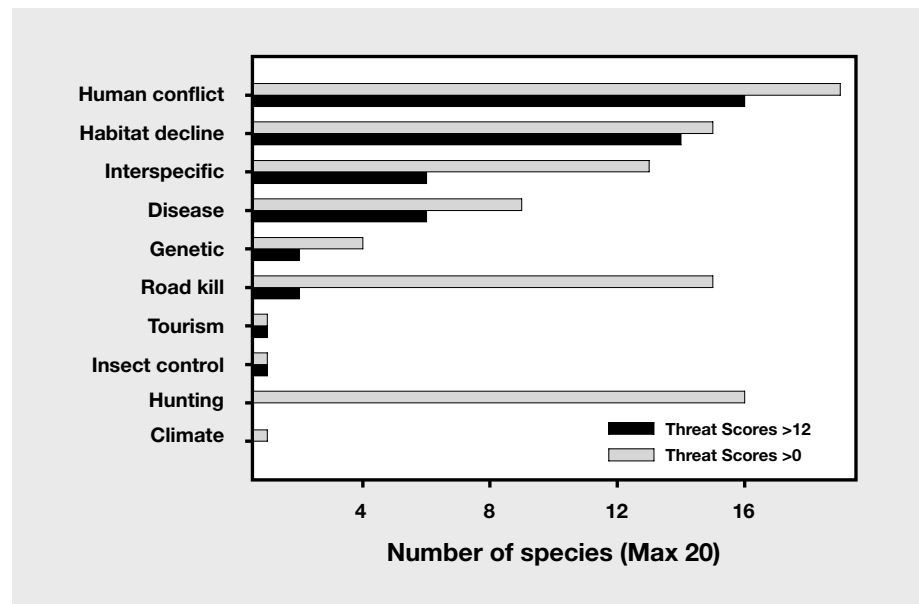
DISCUSSION

Not surprisingly, our results provide corroborating evidence for the well-known plight of several of the larger African carnivores that scored consistently high in most measures of both intrinsic (vulnerability) and extrinsic (threats) factors impacting their persistence. Lion, African wild dog, cheetah, and Ethiopian wolf are clearly the species of greatest concern, and merit the focused attention that they have received. At the same time, this exercise revealed warning signs for several smaller carnivores that exhibit inherent signs of vulnerability, but are receiving minimal attention, such that their declining status may occur unnoticed, if it has not happened already.

Research efforts and attention has been concentrated on only 25% of the species examined in this report. Following these, there is a precipitous drop-off in attention to other species. With the exception of black-backed jackal (51 papers in the Web of Science® search), every other species has been mentioned in fewer than 50 papers, with the Congo clawless otter receiving no mention at all in the published literature to date.

Our measures of vulnerability produced largely intuitive results, notwithstanding the limitations discussed earlier (see Methods). Fecundity and range loss played consistent roles in distinguishing species groups.

General knowledge regarding threats facing African carnivores was sufficient to compile a list of the ten most important threats impacting the suite of species examined here. We are confident that no significant threat has been overlooked though the extent to which identified threats impact some species remains unclear (see below). Our attempt to quantify the degree of threat allowed us to differentiate threats that are particularly pervasive through the range (e.g., human

conflict, habitat decline, and interspecific competition) from those that are more localized (e.g., road kill, tourism), bringing about relatively few adverse impacts to the population or range of a given species.

Nonetheless it is important to reiterate that evaluation of threats impacts relies on knowledge, which was unevenly distributed among the 20 carnivore species examined here. A clear assessment of some impacts can only be determined after detailed behavioral, ecological and demographic studies which have been undertaken to a limited degree or not at all for many of the species considered here. Some low scoring species for which few threats impacts have been documented, likely reflects a lack of attention, rather than a true absence of risk. Including the vulnerability category lends greater clarity regarding potential threat in that measurable intrinsic characteristics may provide a signal of impending or already occurring impacts not yet documented in the literature. In such cases, further evaluation of threats simultaneously with assessments of vulnerability and state of knowledge can be revealing. For example, African golden cats and brown hyenas were both among the top six-ranked species in overall vulnerability, yet both were close to the bottom in threats analysis. They are sharply contrasted from many species, however, with regard to the state of knowledge.

Caveats and limitations of this exercise

We pause to acknowledge some important factors that may affect the results presented here, including: 1) the general nature of the scoring framework, 2) and the variables employed.

Scoring framework

While every effort was made to quantify variables based on empirical data, the scoring process necessarily incorporated a degree of subjectivity. This was least problematic for the Vulnerability category for which scoring relied largely on categorical data with little scope for interpretation. However, assigning scores in the Knowledge and especially in the Threats categories relied upon a combination of interpretation of the published literature, personal experience, and selective expert input. It was impossible to capture such input in a consistent manner across all species and all geographic regions of Africa.

Variables

As discussed above, the inclusion of a number of relatively data-deficient species in our scoring framework caused us to exclude some variables that may have been important, including population trends. Another potential source of error came from our estimates for some variables that were only approximations of the true parameter we were seeking to evaluate. For example, our measures of ecological specialization were unsatisfying in that they incorporated a very coarse scale, and were necessarily tied to extent of current distribution (i.e., those species with the largest ranges were more likely to include multiple habitats as defined here). Nevertheless, it is unlikely that, for carnivores known to display fairly generalist proclivities, a finer-scale evaluation of this parameter would have tilted the results in any different direction.

The Web of Science® index that we deployed was not an absolute representation of the amount of conservation- or scientifically oriented effort being exerted

on the species considered here. For example, The IUCN/SSC Otter Specialist Group has recognized that a lack of knowledge about all African otters is impeding their ability to prescribe conservation action (Foster-Turley *et al.* 1990). As a result, during the past three years, survey efforts have increased, with results appearing more rapidly in unpublished reports or IUCN bulletins than in the published literature. While we attempted to capture such gray literature in our assessment of Threats and four of the five variables in our Knowledge category, this effort is not represented in the number of publications. Similarly, results from planning workshops, and projects that focus purely on conservation and management interventions, are also not often captured in the published literature in a manner representational to the effort expended. Millsap *et al.*'s (1990) priority setting exercise conducted for Florida vertebrates was able to include a measure of management or conservation action, feasible for that exercise given its geographic scale. On a large diverse continent such as Africa, such a view would be inevitably biased towards certain institutions or regions. We therefore made an effort to include knowledge about parameters relevant to conservation, but this exercise was inevitably subjective.

Species Groupings

Carnivore species naturally fall into various groupings that reflect intrinsic and extrinsic factors, and secondarily, according to the amount known about them. In this section, we present a series of species groupings based on the threats experienced by them, their inherent vulnerability and their state of knowledge (Table 2.13). Some groupings are evident without this priority-setting exercise, while others have been highlighted here for the first time. The groups are not intended to be mutually exclusive, so some species appear in more than one. The value of such an approach is to seek commonalities among species that might enhance our ability to formulate conservation approaches that can be targeted at multiple species that might not otherwise be considered in tandem.

Carnivore species in crisis

These species are characterized by a degree of crisis reflected in an elevated risk status and extensive range loss. The Ethiopian wolf is one of the few species considered with a restricted distribution from the outset, and a very high degree of habitat and dietary specialization. This species suffers the same suite of common threats exhibited by other species in this group, further compounded by its restriction to small imperiled populations. The other members of this group–African wild dog, cheetah and lion–are now facing local battles similar to those of the Ethiopian wolf, but differ from this latter species in that they have experienced significant collapse of once vast ranges.

Species of concern

This group contains a suite of species that scored relatively high on threats, and have suffered range retraction exceeding 20%. While none of these species can be considered to be in crisis across their range, they represent the next tier of carnivores that require or will require protected areas and dedicated conservation activity to ensure their persistence across their current range. These species vary considerably in vulnerability, with leopard and brown and spotted

hyenas likely to be more vulnerable than the caracal and serval. Most of these species have historically been considered too resilient or wide-spread to warrant intensive conservation effort but our analyses suggest greater effort may be required.

High-profile data-rich species:
This exercise has highlighted the fact that the most vulnerable species have by and large benefited from the most research attention and requisite conservation action. It is difficult to ascertain whether the level of attention is directly related to their status as species of concern, or whether their demise has merely been well documented because they have received such heightened attention. Leopards and spotted hyenas differ from other members of the group with respect to the degree of conservation crisis, supporting the notion that there is not necessarily a direct relationship between attention and conservation status. Even with the comprehensive amount of study on these species, there are tremendous gaps of knowledge in many parts of their ranges. For example, in almost all cases, detailed population-level data are available for multiple sites in East and southern Africa, while information from the western part of the continent is largely limited to a few opportunistic surveys in some protected areas.

Externally threatened, but not highly vulnerable
This group of species share relatively low intrinsic vulnerability yet clear impacts of threats have been demonstrated. Evaluating members of this group for

Table 2.13 Carnivore species groupings as a function of scores received in this priority setting exercise.

Carnivore Species Grouping	Species	Relative scoring		
		Vulnerability	Knowledge	Threats
Species in crisis	Ethiopian wolf, African wild dog, cheetah, lion	Highest		Highest
Species of concern	leopard, spotted hyena, brown hyena, caracal, serval, golden cat	range retraction > 20%		Intermediate-high
High-profile data-rich species	Cheetah, lion, African wild dog, leopard, spotted hyena		High	
Externally threatened, but not highly vulnerable	Cape clawless otter, spotted necked otter, serval, caracal	Low		Intermediate
Inherently vulnerable, but with few documented threats	African golden cat, Congo clawless otter, striped hyena, brown hyena	High-Intermediate		Low
Species that thrive in human landscapes:	Black-backed jackal, golden jackal, side-striped jackal, African civet.	Low		Low
Are these species really ok, or do we just not know?	Aardwolf, honey badger	Low	Low	Low

conservation need signals the value of combining extrinsic with intrinsic measures (unlike many exercises that only do the latter). Most species in this group (Cape clawless otter, spotted necked otter and serval) would further benefit from greater knowledge on the impacts of threats.

Inherently vulnerable, but few documented threats
As Ginsberg (2001) cautions, a systematic lack of information on a subset of species in any priority setting exercise will bias against establishing those species as priorities at the outset. The Knowledge category was our attempt to address this limitation, if only to focus attention on poorly-known species that likely suffer some effects from threats but are eclipsed by species for which such effects are comprehensively studied and understood. A few species (e.g., African golden cat, striped hyena and the three otters) stood out as relatively high-scoring in vulnerability, but not in the threat categories. They are also ranked low in knowledge, highlighting the real possibility that lack of knowledge is impeding our ability to recognize whether such species are truly imperiled or not. The African golden cat and Congo clawless otter are notable for being the two least known species while also being restricted to the forest biome – a habitat under enormous anthropogenic pressure in Africa, but having received little carnivore-focused attention (Ray 2001). The striped hyena is confined to the northern part of Africa, a region which similarly suffers high human pressures, and relatively little research or conservation attention.

Species that thrive in human landscapes
Several species demonstrate a remarkable ability to live side-by-side with humans, even close to population centers. The three jackal species and the African civet appear to have fared the best of all the species considered here. Clearly, they are not imperiled in the manner of most of the other species we considered, and will likely persist in much of their range without targeted conservation research or activity. Nonetheless, they may warrant a closer examination of the impact of local threats where the level of intensity is likely to climb; for example, the impact of bushmeat hunting on populations of forest civets, and the effects of exotic disease on jackal populations in protected areas surrounded by human populations.

Are these species really ok, or do we just not know?
This study brings attention to those species that scored low on all variables (as did those species that thrive in human landscapes) but for which there is reason not to be complacent lest they fall under the conservation radar. To some extent, evaluation of intrinsic factors provides a glimpse at vulnerability, even if documentation of vulnerability to extrinsic factors is not available. However, because assessment of both vulnerability and threats requires detailed knowledge, there is always the possibility that lack of attention is obscuring a need for greater conservation attention. For both the honey badger and aardwolf there is just enough evidence of local impacts to make it clear that these are not species that thrive among heavily-modified landscapes; however, there are not yet not enough baseline data to be confident about their level of vulnerability or predicting the extent of impacts.

PART III:
SETTING GEOGRAPHIC PRIORITIES

INTRODUCTION

The second objective of the priority-setting exercise was to evaluate the extent of carnivore species loss in Africa and determine the location of intact and depleted carnivore communities. We further sought to assess the relative loss of carnivore species by three geographic units: georegion, biome and country (see Fig. 1.1). This was useful for providing alternate foci for establishing geographic priorities, for example, by assessing i) which geographic areas have suffered the greatest loss of carnivore species and are therefore in urgent need of conservation action, or alternatively, ii) which have experienced the least loss of carnivore species and therefore represent excellent opportunities for targeting conservation efforts.

METHODS

Historical and current distribution maps for each of the 20 species formed the basis of the analyses presented here.

Distribution Maps

We created historical and current distribution maps for each species based on the published knowledge of distribution which we refined and updated via a process of peer review. We sourced base maps from a variety of recent literature sources, and modified them following input by several experts for each species (see Appendix 4). We considered historical distribution to represent conditions around 150 years ago, i.e., before the advent of the colonial era when firearms and pervasive human-induced land-used changes became increasingly prevalent. We used ArcView GIS software to digitize the distribution maps and to conduct the spatial analyses.

Compiling accurate distribution data was a lengthy process. The resulting maps were characterized by a wide range of accuracy, within and among species. Inevitably, well-studied species yielded the most detailed maps, with those for lesser-known species suffering from significant holes in knowledge of distribution and uncertain boundaries. Similarly, data from well-studied regions (chiefly eastern and southern Africa) were more precise than from poorly-studied regions, particularly in the western and northern parts of the continent. Finally, maps developed at the broad scales employed here inevitably contain errors discernible at the local scale.

Further problems arose in comparing historical and current distributions. For example, for some species, a lack of change reflected lack of knowledge rather than distributional trends. Historical distribution information remained particularly elusive for one group, the otters. In some cases, biologists have recently discovered them in areas where they had never been recorded, almost certainly because surveys had never been conducted there previously, as opposed to positive changes in distribution. Accordingly, we exclude otters from the geographic analyses presented here. Having noted these caveats, we are confident

that the maps for the 17 species presented here represent a significant refinement of previously published efforts of all species (e.g., Nowell & Jackson 1996; Kingdon 1997; Woodroffe *et al* 1997; Mills & Hofer 1998; IEA 1999). We hope they compel further refinements from researchers.

Analyses

GIS analyses were executed utilizing grid sizes of 10 km². We calculated the number of species lost per 10 km2 pixel by subtracting current from historical distribution maps of various species groups. These groups comprised: 1) all 17 species, 2) 7 larger carnivores (body size > 12 kg); 3) 10 smaller carnivores (body size ≤ 25 kg); 4) 6 Felidae; 5) 5 Canidae; and 6) 4 Hyaenidae. Hence, each pixel in the resulting layer was assigned a value that indicated the number of species lost. From the resulting layers, we calculated the proportional area covered by 0, 1, 2, or more species lost in the species group, as well as the overall mean pixel value of species lost within the geographic area in question. Percent species loss was calculated as the mean number of species lost relative to maximum historical number of species for the area under analysis. In order to incorporate habitat features into the analyses, we used biome classifications, modified from the WWF ecoregional classification system (Olson *et al*. 2000; Appendix 5). We also divided Africa into five "georegions" (west, central, north, south, and east), to further assess geographic patterns in species loss (see Fig. 1.1). Finally, we conducted further species loss analyses at the country level.

RESULTS

Degree of range loss, as well as extent of current and historical distribution for each of the 17 carnivore species is presented in Table 3.1. Range loss varied from 0 (African civet and side-striped jackal) to 98% (Ethiopian wolf) with a mean of 35.7% for 17 species for which data were available. Four species – Ethiopian wolf, African wild dog, lion and cheetah – have lost at least 75% of their range, and 12 species at least 10%.

About one-third of the continent has lost 34-50%, and approximately 6% of the continent has lost 76-100% of its medium and large-bodied carnivores (Fig. 3.1). Historically, 60% of the African continent had 9 or more sympatric larger carnivore species, whereas only 17% of the continent has 9 or more species today. Only 10% of the African continent contains intact carnivore communities, i.e. areas where zero species loss has occurred (Table 3.2). Although there was no significant difference between the three families (Felidae, Canidae, Hyaenidae; ANOVA on rank-transformed data) in mean species range loss, the patterns of loss differed among the groups. Intact large and medium felid communities currently cover only 14% of Africa, while 44% and 65% of the continent has experienced no loss of larger canid and hyenid species, respectively. The proportion of the continent with zero felid species present jumped from 0 (historical) to 27% (current). For hyaenids the increase was from 18 to 39%, and for canids, the proportional change in area with zero species present has only been 4%, due largely to the persistence of the three jackal species (Fig. 3.2).

The pattern for large carnivore species loss has largely mirrored that for felids. As might be expected, the areas containing fewer than half the maximum number of species in each of the four groups (large carnivores, felids, canids, and hyaenids) are larger currently than they were for the same number of species historically, while the opposite is true for the proportional area with the highest number of species (Fig. 3.2).

The set of maps displayed in Figs. 3.3–3.8 compare the historical and current number of species and species loss within various groups (all, large, and small carnivores, felids, canids, and hyenids). For all species combinations, carnivore species diversity "hotspots" were historically located in eastern Africa and in the south-central portion of the continent. Current species hotspots, following the period of range retraction for many species, are located in the same areas, but are considerably more fragmented. The highest extent of species loss has occurred in the far northern and southern parts of the continent, while the lowest has occurred in the central forest belt (where there were fewer carnivore species to begin with).

Table 3.1 Extent of current and historical distribution and percent of range lost for each of 17 carnivore species.

Species	Current (km²)	Historical (km²)	Percent Loss
Ethiopian wolf	13,990	819,232	0.9829
African wild dog	1,922,372	18,361,733	0.8953
Lion	3,802,873	22,211,935	0.8288
Cheetah	6,131,541	26,090,119	0.7650
African golden cat	2,761,343	4,949,155	0.4421
Striped hyena	7,643,750	12,382,288	0.3827
Brown hyena	1,914,332	3,091,492	0.3808
Caracal	12,313,120	19,757,356	0.3768
Leopard	14,282,699	22,523,935	0.3659
Spotted hyena	13,696,810	18,666,831	0.2662
Serval	11,489,963	15,103,039	0.2392
Aardwolf	5,393,090	5,994,791	0.1004
Black-backed jackal	6,311,236	6,515,874	0.0314
Honey badger	22,939,452	23,048,504	0.0047
Golden jackal	15,296,339	15,359,789	0.0041
Side-striped jackal	10,260,744	10,260,744	0.0000
African civet	15,479,432	15,479,432	0.0000

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Fig. 3.1 Frequency distribution of proportional area from which large carnivore species (maximum 17) have been lost in Africa.
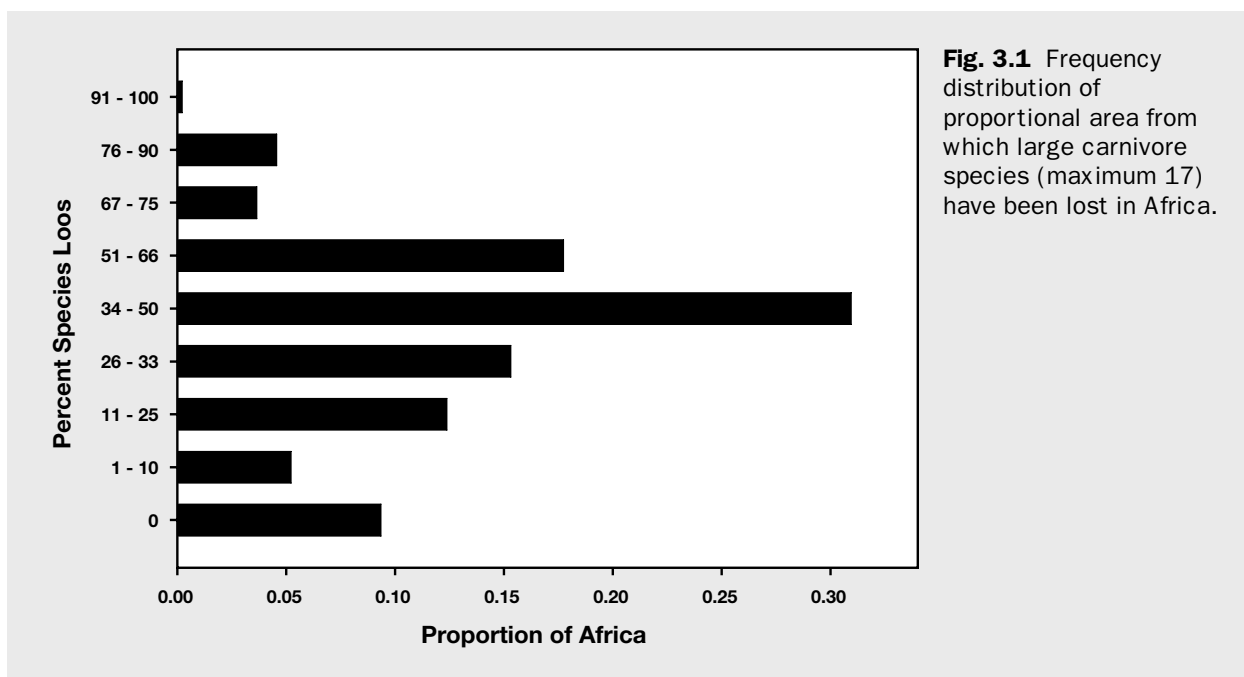
Table 3.2 Proportional area of Africa that has experienced carnivore species loss. Details on georegions and biomes can be found in Appendix 6.

Group	Number Species Lost	Proportion of Africa
All Carnivores (n=17)	0	0.10
	1	0.18
	2	0.12
	3	0.15
	4	0.22
	5	0.12
	6	0.09
	7	0.02
	8	0.00
Large Carnivores (n=7)	0	0.11
	1	0.20
	2	0.13
	3	0.30
	4	0.13
	5	0.10
	6	0.02

Group	Number Species Lost	Proportion of Africa
Small Carnivores (n=10)	0	0.54
	1	0.40
	2	0.06
	3	0.00
	4	0.00
Felids (n=6)	0	0.14
	1	0.24
	2	0.21
	3	0.25
	4	0.15
	5	0.01
Canids (n=5)	0	0.44
	1	0.53
	2	0.03
	3	0.00
Hyenids (n=4)	0	0.65
	1	0.32
	2	0.03
	3	0.00

Fig. 3.2 Proportion of Africa in which 0-6 species occur (historical: open circle vs. current: closed circle): A. Large carnivores (> 12 kg), B. Felidae, C. Canidae, D. Hyaenidae.
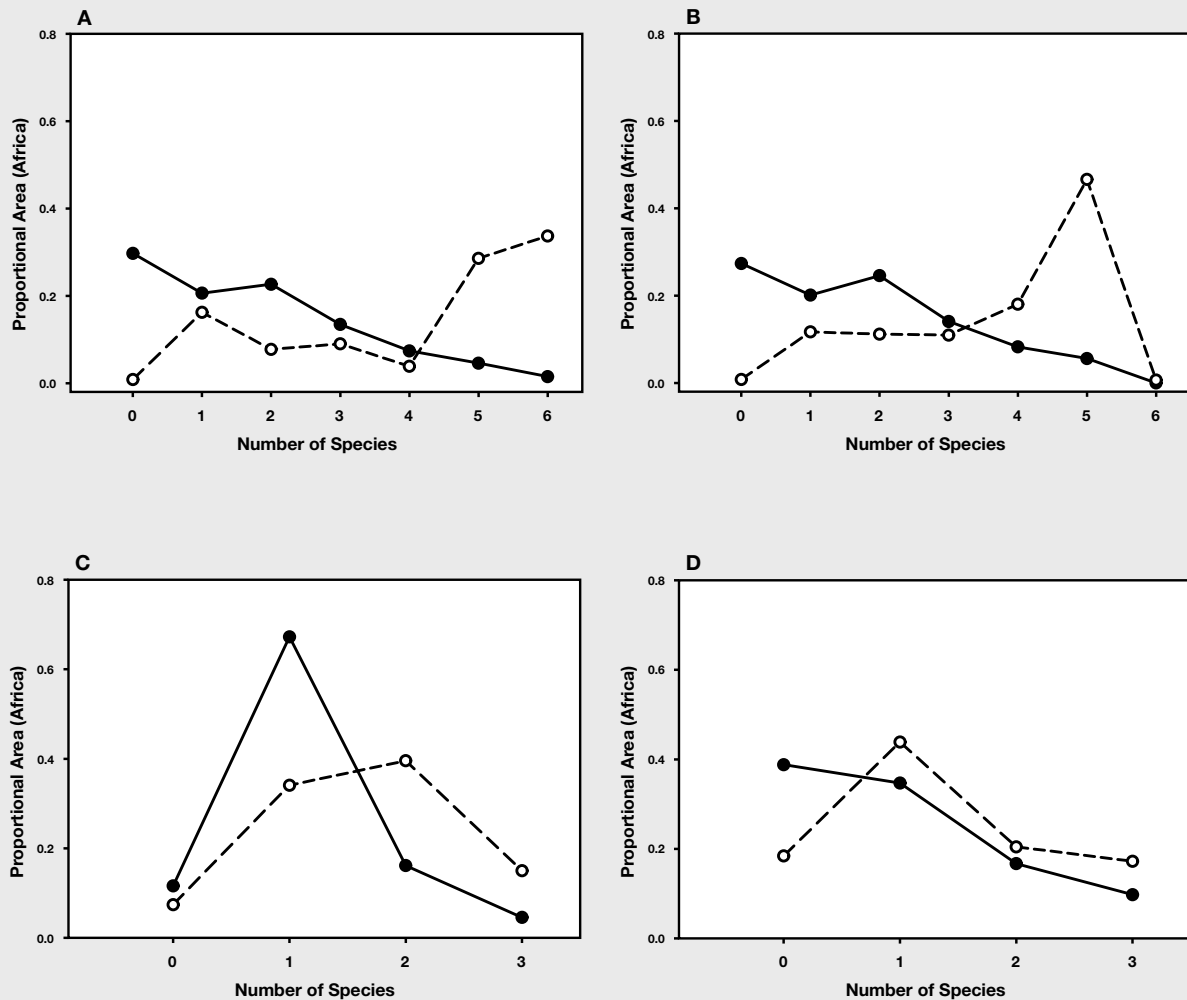
When we analyzed the subset of seven larger carnivores (lion, leopard, cheetah, African wild dog, striped hyena, spotted hyena, and brown hyena) separately, as many as six species were once sympatric throughout a large portion of the continent. Again, this continuous block is considerably more fragmented today, with most species loss having occurred in the southern tip and in western Africa. Historical small carnivore distribution patterns were similar, but only modest losses (not more than 4 species) have occurred in scattered patches. Historically, as many as six felid species were once sympatric over large portions of the continent, with pronounced species loss characteristic of much of the northern, western, and southern portions of the continent. Canid and hyenid distribution hotspots were similar to those for all carnivores, with most species loss having occurred in eastern Africa for canids, and in southern Africa for hyenids.
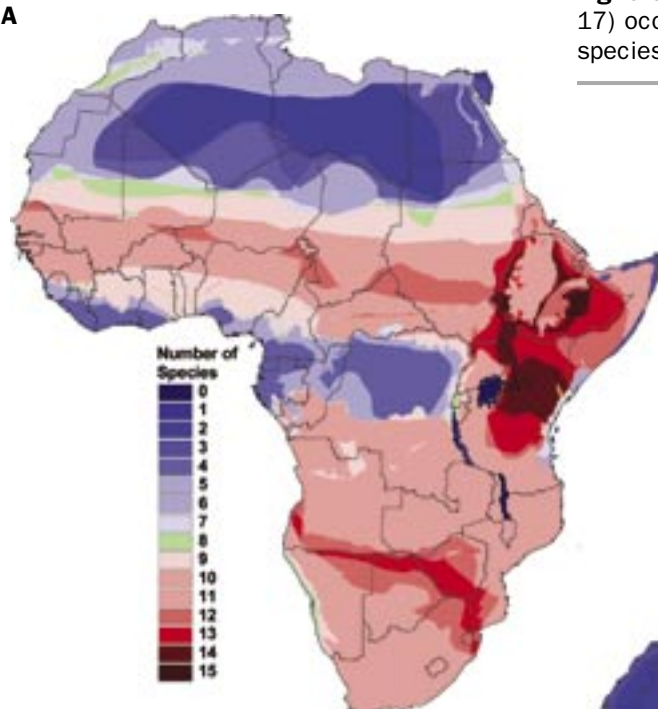
Fig. 3.3 Number of sympatric carnivore species (maximum 17) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.
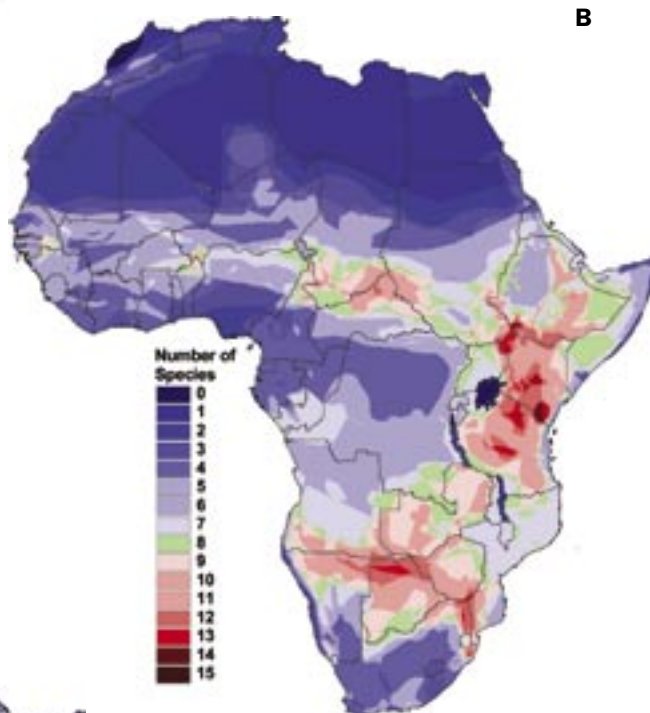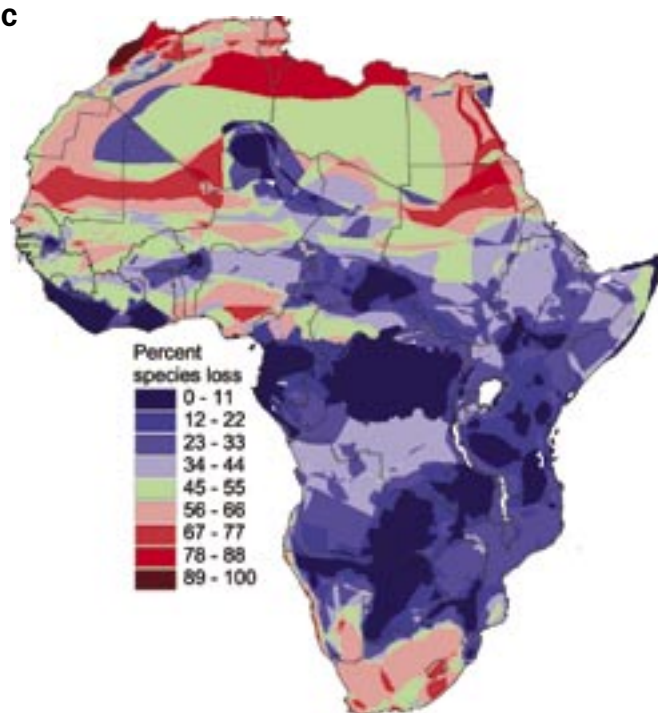
A
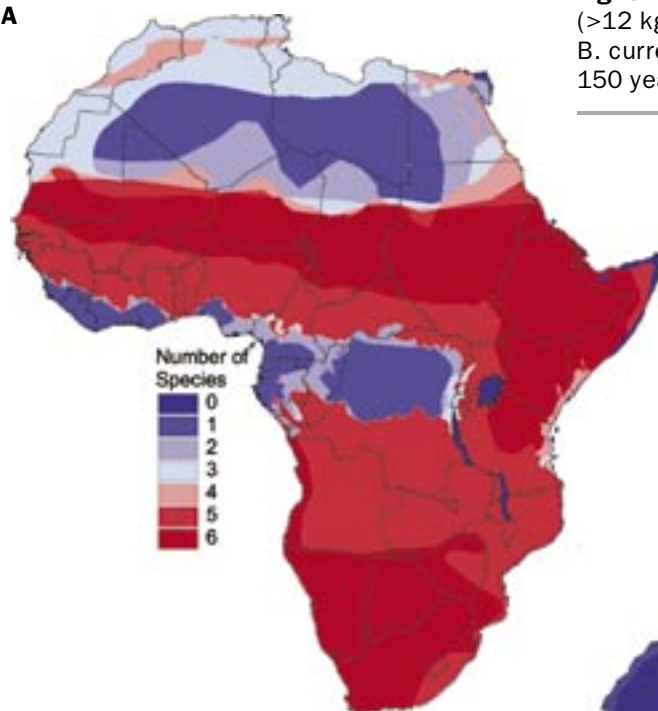
Fig. 3.4 Number of sympatric large carnivore species (>12 kg; 7 species) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.

Number of Species
0
1
2
3
4
5
6

B

Number of Species
0
1
2
3
4
5
6

C

Number of Species
0
1
2
3
4
5
6
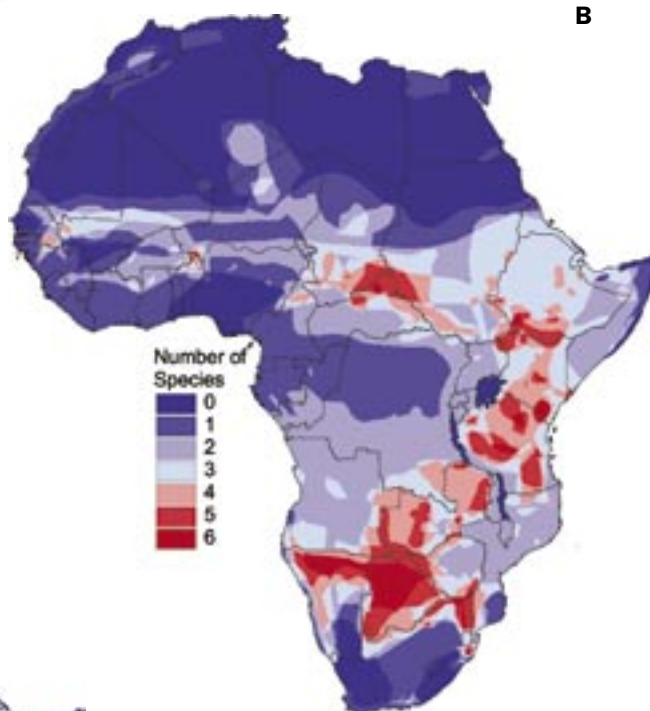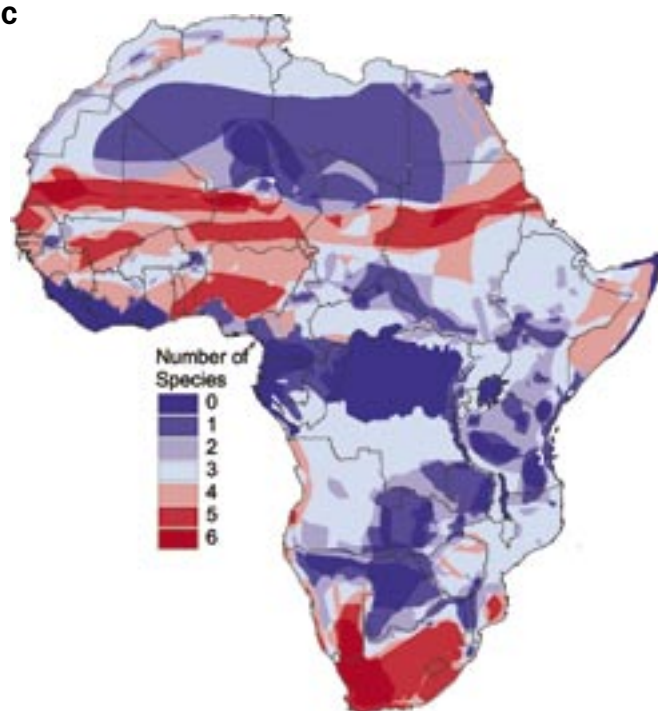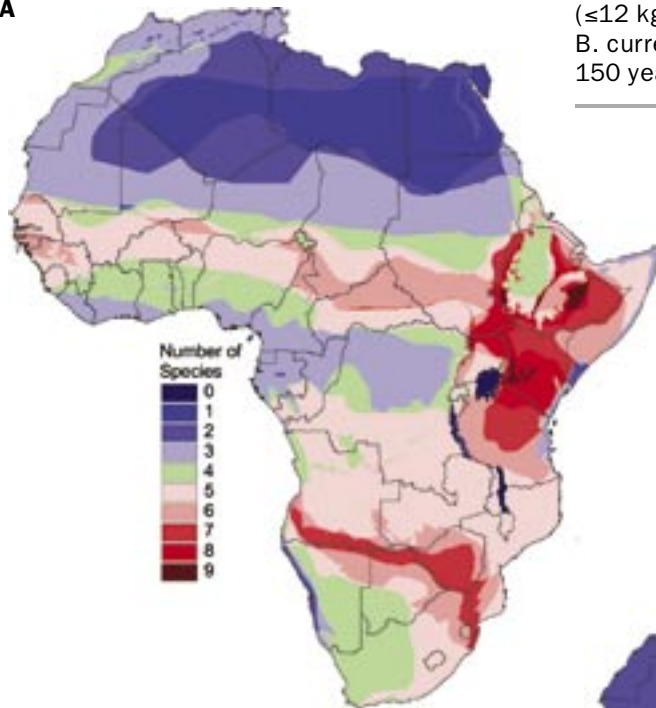
Fig. 3.5 Number of sympatric smaller carnivore species (≤12 kg; 10 species) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.
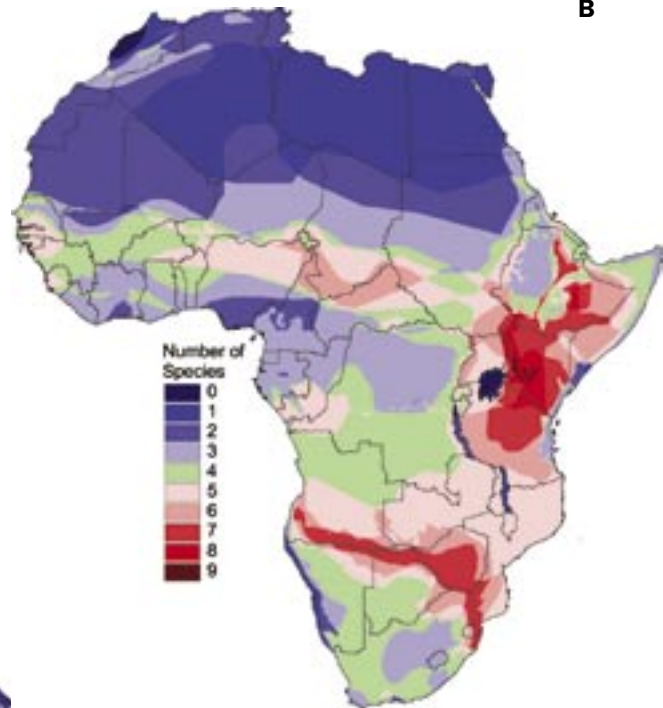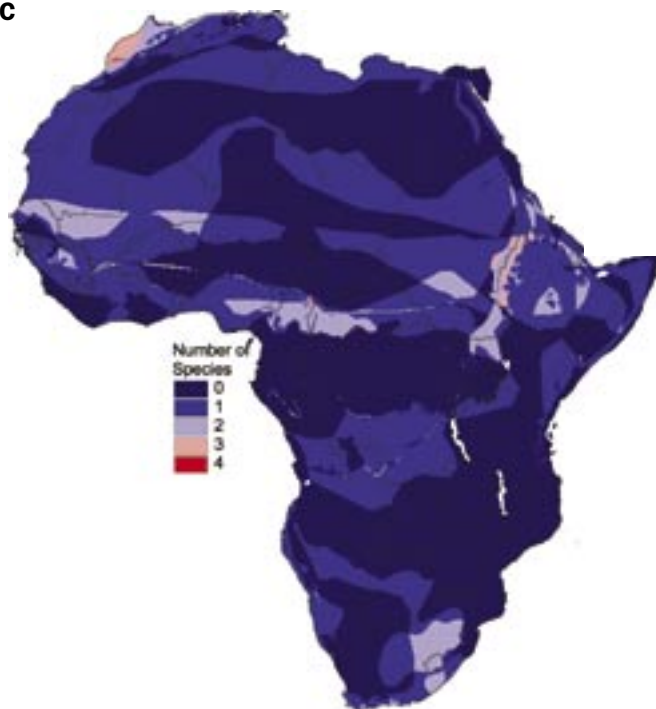
Fig. 3.6 Number of sympatric Felidae (6 species) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.
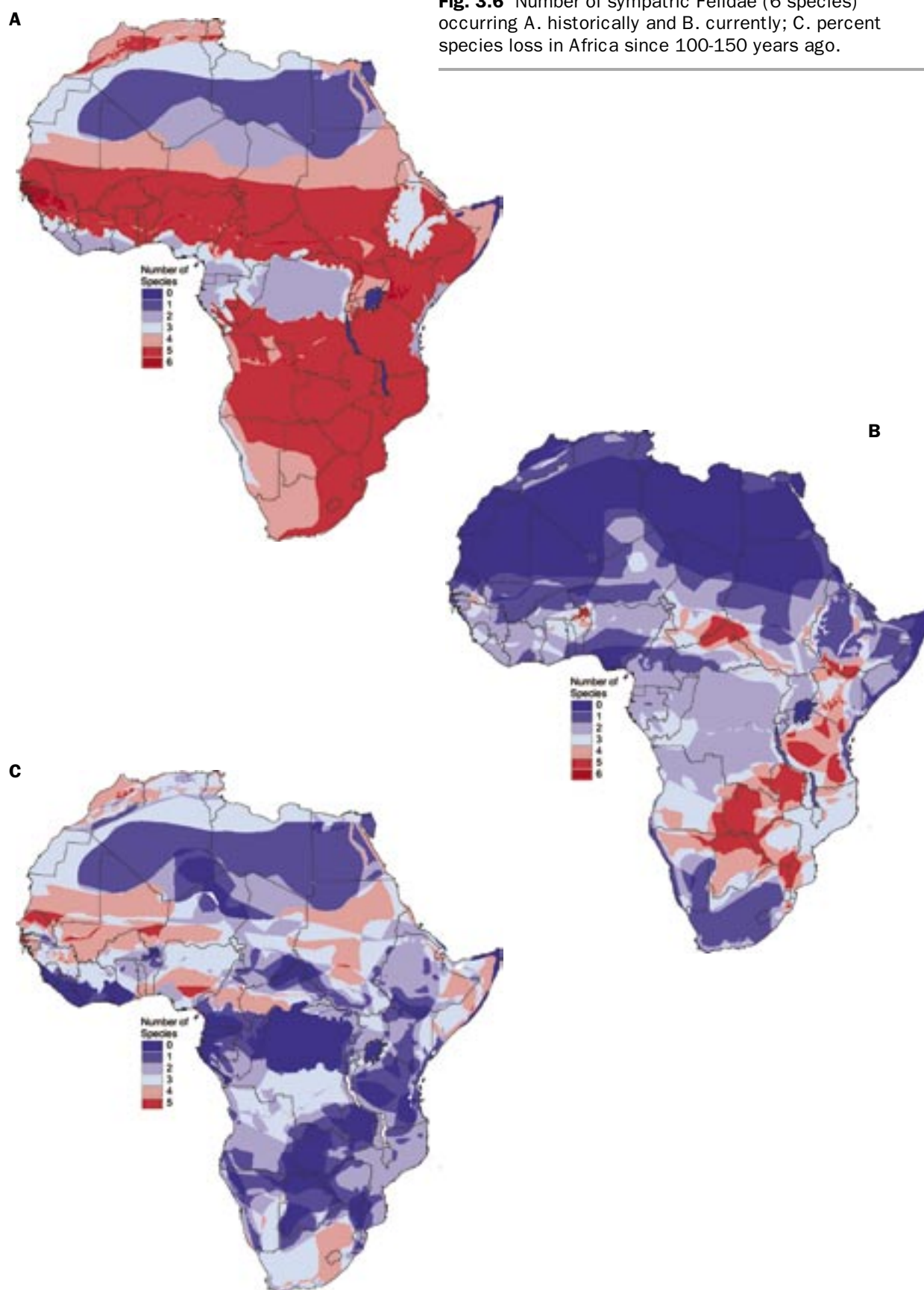
Fig. 3.7 Number of sympatric Canidae (5 species) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.
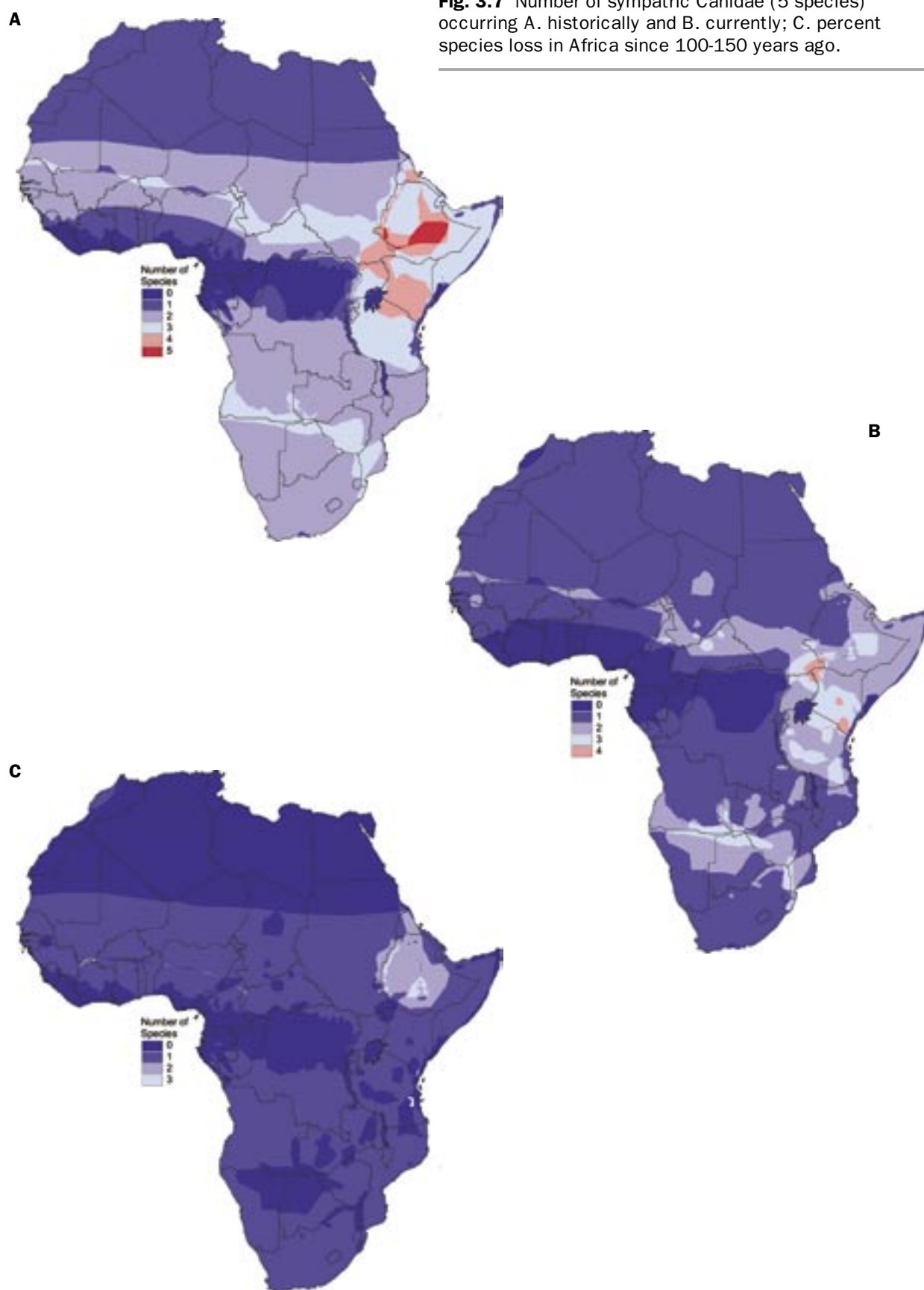
Fig. 3.8 Number of sympatric Hyaenidae (4 species) occurring A. historically and B. currently; C. percent species loss in Africa since 100-150 years ago.
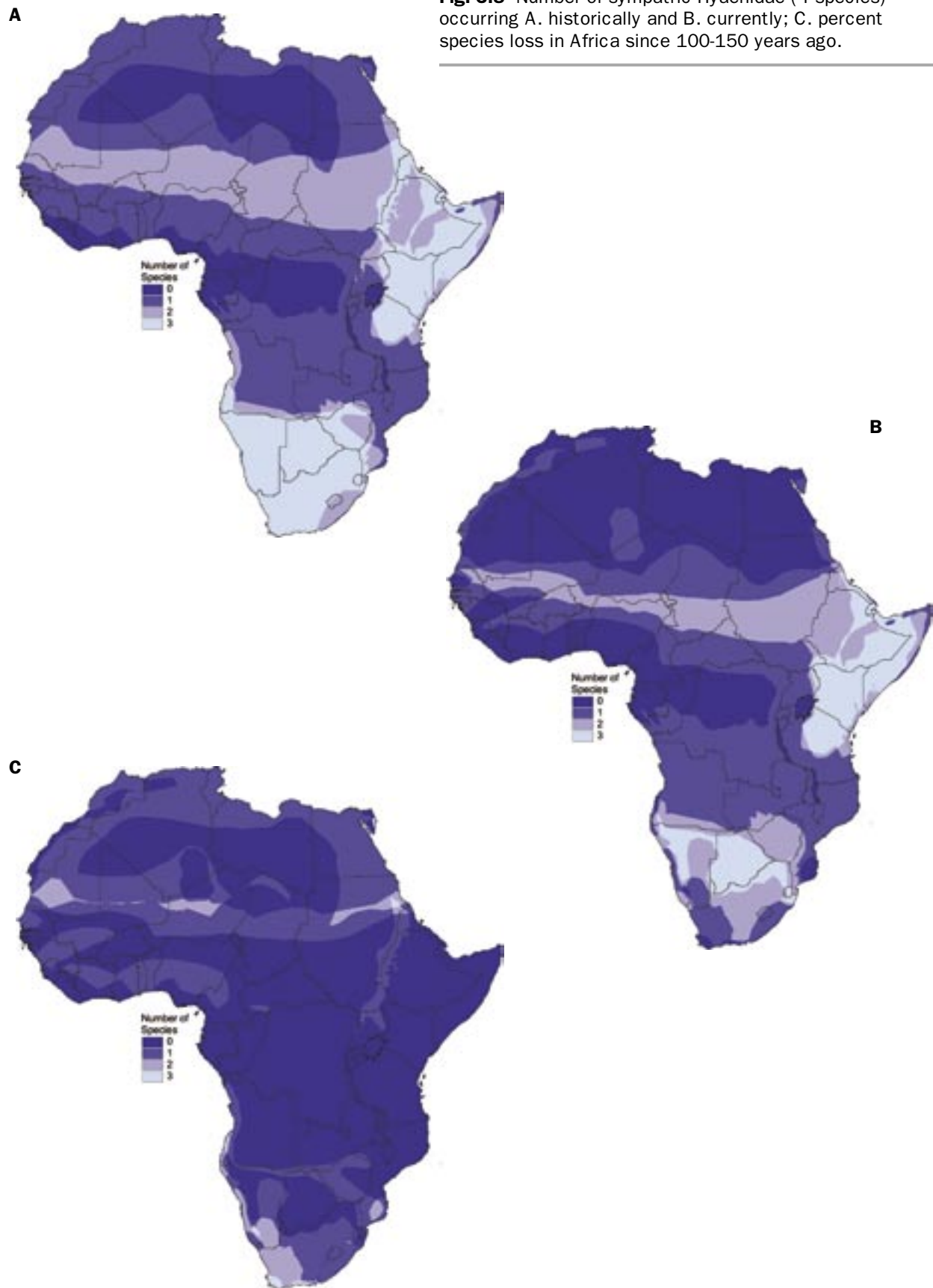
Mediterranean and montane biomes have suffered the greatest species loss across all groups, while the forest biome has experienced the least species loss (Fig. 3.9a,b). The most species loss has occurred in the west georegion, and the least in the central part of the continent (Fig. 3.9c,d). Felids experienced the greatest species loss across all biomes and all georegions. Countries in the forest belt predominated among those that have experienced the least carnivore species loss (Table 3.4). Southern, northern and western countries have experienced the most profound degree of carnivore species loss (Table 3.4 and 3.5).

Fig. 3.9 Percent species loss for A. Large (> 12 kg) vs. smaller (≤12 kg) carnivores across biomes; B. Felidae, Canidae, and Hyaenidae across biomes; C. Large (> 12 kg) vs. smaller (≤12 kg) carnivores across georegions; and D. Felidae, Canidae, and Hyaenidae across georegions. Percent species loss calculated by dividing mean species loss with maximum number of species present historically in that biome or georegion (see Appendix 6).
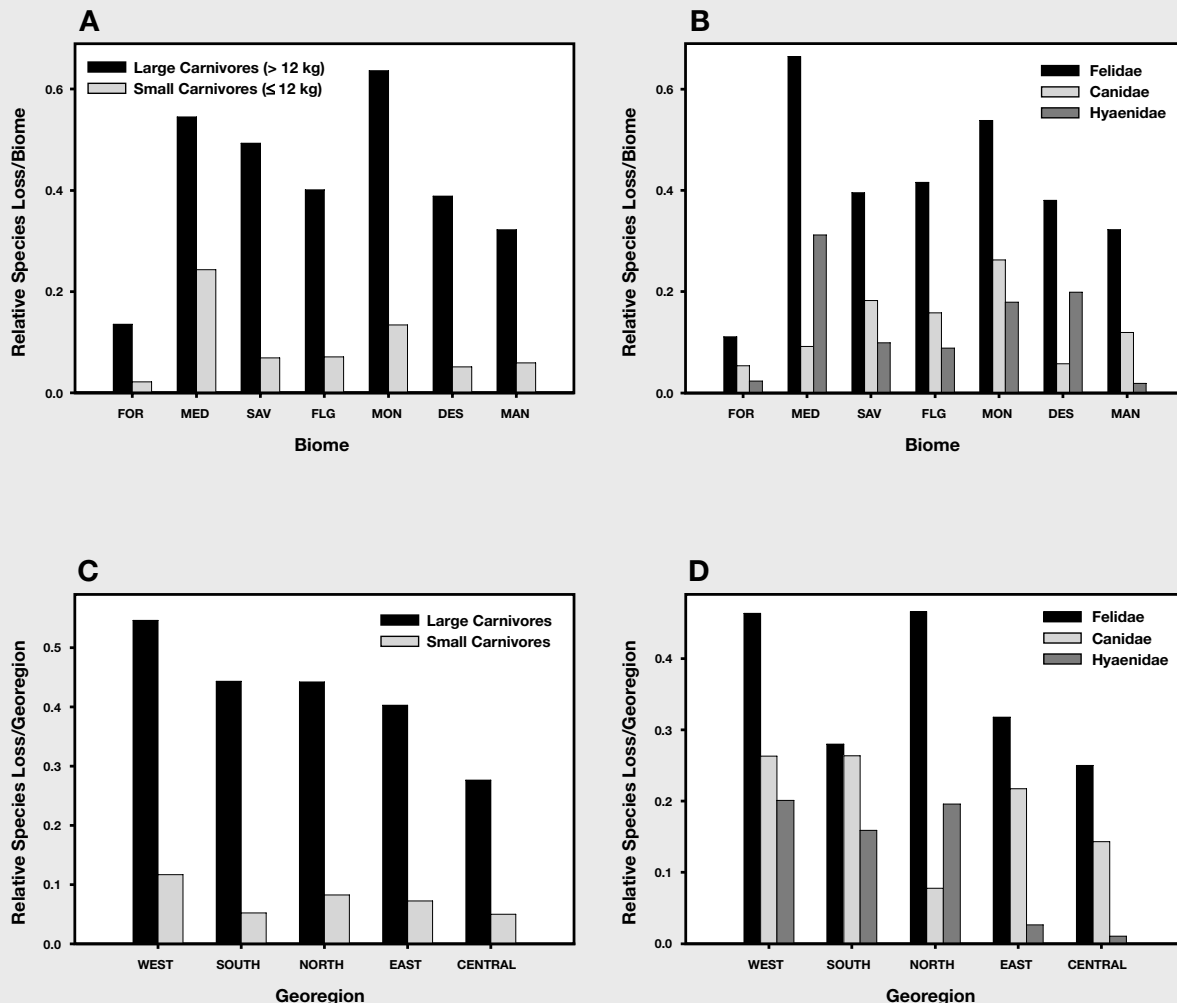
Table 3.3 Countries with highest and lowest proportional area of intact carnivore communities.

Species Group	Countries with highest proportion of zero species loss	Countries (>50,000 km²) with <0.01 proportion of zero species loss
All Carnivores	Equatorial Guinea (1.0); Liberia (0.92); Gabon (0.57); Sierra Leone (0.53); Congo-K (0.46); Congo (0.30); Ghana (0.29); Ivory Coast (0.27); Zambia (0.26)	Guinea, Uganda, Tunisia, Malawi, Libya, Mozambique, Benin, Togo, Ethiopia, Senegal, Western Sahara, Mauritania, Morocco, Nigeria, Sudan, Chad, Mali, Burkina Faso
Large Carnivores	Equatorial Guinea (1.0); Liberia (0.99); Sierra Leone (0.66); Gabon (0.56); Congo-K (0.46); Botswana (0.40); Ivory Coast (0.37)	Ethiopia, Libya, Uganda, Tunisia, Mozambique, Benin, Togo, Senegal, Western Sahara, Mauritania, Morocco, Sudan, Nigeria, Chad, Mali, Burkina Faso
Felids	Equatorial Guinea (1.0); Liberia (0.92); Zambia (0.69); Sierra Leone (0.58); Gabon (0.57); Congo-K (0.47); Botswana (0.46)	Malawi, Uganda, Tunisia, Libya, Togo, Western Sahara, Senegal, Mauritania, Morocco, Nigeria, Mali
Canids	Algeria (1.0); Tunisia (1.0); Libya (1.0); Western Sahara (1.0); Egypt (1.0); Equatorial Guinea (1.0); Liberia (0.99); Morocco (0.84); Gabon (0.83)	Ethiopia
Hyenids	Gambia, Djibouti, Somalia, Guinea-Bissau, Liberia, Equatorial Guinea, Congo, Gabon, Rwanda, Kenya, Burundi, Tanzania, Malawi (all 1.0)	Tunisia

Table 3.4 Top-ranking countries with highest proportional loss of carnivore species.

Species Group	Maximum Loss (# of Species)	Top-ranking countries with highest proportional loss
All Carnivores	7	Lesotho (0.89); South Africa (0.23); Senegal (0.14); Mauritania (0.13); Nigeria (0.06); Eritrea (0.05); Mali (0.04) Niger (0.02); Sudan (0.02).
Large Carnivores	6	South Africa (0.21); Namibia (0.12); Mauritania (0.12); Niger (0.05); Sudan (0.02); Mali (0.01); Lesotho (0.01)
Felids	5	Senegal (0.33); Nigeria (0.06); Guinea-Bissau (0.06); Gambia (0.05); Morocco (0.04); Mauritania (0.03); Mali (0.03)
Canids	3	Ethiopia (0.07)
	2	Ethiopia (0.60); Eritrea (0.44); Sudan (0.03)
Hyenids	3	South Africa (0.03); Namibia (0.01); Sudan (0.01); Angola (0.01)

DISCUSSION

The geographic analyses of species loss and location of intact and eroded carnivore communities elucidate patterns regarding both threats and opportunities facing African carnivore conservation. Under the premise that carnivore species loss can help signal landscapes under threat, the northern, southern and some of the western regions of the continent stand out as the most impacted. Similarly, biomes that are rare in Africa, namely montane and Mediterranean areas, have experienced the highest degree of relative species loss among the seven biomes considered here, with forested regions remaining the most intact for carnivores.

In some of the most adversely affected regions and biomes, the prospects for conservation of large carnivores are bleak. The Sahara is now almost surrounded by a band of high species loss (see Figs. 3.3-3.8) and conservation efforts must consider a rapidly rising human population and scarcity of resources for wildlife management compared to the eastern and southern parts of the continent. In this context, the scattering of refugia available for carnivore guilds remaining around the Sahara as identified by our maps stand out as urgent priorities for that region. Similarly, the pockets of extant carnivore guilds in the Sahel, and West African dry savanna and coastal forest highlight the few remaining prospects for conserving intact carnivore guilds in those very heavily impacted landscapes.

Interestingly, while carnivore species loss in the extreme southern part of Africa has been just as profound, the conservation outlook is somewhat different. South Africa and Namibia are among the top-ranked countries for the highest proportional loss of carnivores (Table 3.4), yet both countries boast large, well-managed protected areas with intact carnivore guilds, and a vigorous private sector pursuing conservation initiatives (Wells 1996; Hunter 1998; Scriven & Eloff 2003; Spenceley 2003). The economic opportunity represented by wildlife (via tourism or the sale of wildlife products) is encouraging a process of restoring large carnivores (and wildlife in general) to areas of their former range (Hunter 1998; van Dyk & Slotow 2003; but see Cilliers 2003). While this has already resulted in some range reclamation by large carnivores in South Africa and Namibia, it remains to be seen whether these trends result in meaningful range expansion for large carnivores (Hunter *et al*. 2004).

At the other extreme, intact regions of eastern, central, south-central and north-central regions may represent some of the best carnivore conservation opportunities, a result that concurs with the carnivore diversity hotspot analysis conducted by Mills *et al*. (2001). Many of these sites reflect the location of large protected areas where a great deal of research and conservation effort has been devoted to carnivores. Clearly such places will remain crucial to the conservation of large carnivores. Areas where little attention has been devoted to carnivores, yet guilds remain intact, present some intriguing possibilities for conservation. This is particularly true where the distribution of intact carnivore guilds bridges international boundaries, for example northern C.A.R/southern Chad/south-west Sudan, northern Benin/western Burkina Faso/south-west Niger, and northern Kenya/southern Ethiopia/southern Sudan. Other areas of

interest include northern Mozambique, southern Angola and the great swathe of equatorial forest in central Africa. In all of these cases, incomplete knowledge of carnivore status (which, in most cases, is limited to simple occurrence information), combined with increasing human pressures and threats, heighten the urgency of action.

Analyses of family groupings revealed some unexpected patterns. Felids have experienced the most pronounced relative species loss, with a much smaller proportion of the continent containing intact felid assemblages than historically observed. In part, this is due to the extensive range loss undergone by two of the larger species, lion and cheetah. These species are among the most challenging to conserve in Africa, owing chiefly to persecution leveled at them in retribution for real and perceived livestock depredation. Lions are now restricted largely to protected areas and surrounding wildlife management areas (Bauer & van der Merwe 2004). In comparison, cheetahs have demonstrated an ability to persist more widely outside protected areas in Namibia (Marker 2003) though their prospects are poor outside East and southern Africa where marginal habitat and low prey density make the species especially vulnerable to threats (Nowell & Jackson 1996). Both species would benefit from the development of a dedicated geographic priority-setting conservation strategy such as has been undertaken for jaguars (Sanderson *et al*. 2002) and tigers (Wikramanayake *et al*. 1998). Hyenids and canids have both fared better than felids, although such group level generalizations obscure the critical status of some individual species and should not be interpreted as reason for complacency. Hyenids have experienced the least relative species loss, but because canids comprise some of the most (African wild dog, Ethiopian wolf) and least (jackals) imperiled species, it is impossible to generalize about the group. Both families have retained relatively intact distributions for most of their respective species with the exception of extreme range loss for two canids (Ethiopian wolf and African wild dog) and considerable range loss for spotted hyena and brown hyaena.

It is worth noting again that the distribution maps, which form the basis of the analyses presented here, are subject to their own set of problems that may influence results. Even after a year of consultation in an effort to create accurate maps, they contain numerous deficiencies and biases, especially for local areas. In particular, a lack of refined knowledge on distribution of many of the smaller, data-deficient species considered here may obscure the extent of range collapse they have actually experienced. Indeed, the same can be said of virtually every species considered here for some parts of their range. By way of example, the distributions for most large carnivores in certain countries (e.g. Angola, Equatorial Guinea and Sudan) is largely assumed based on the availability of suitable habitat, presence of large protected areas and relatively recent reports of presence. Accordingly, the results presented here might present a best-case scenario for some regions and countries; they should therefore be interpreted conservatively and groundtruthed for the countries and species noted above. Again, we reiterate the call for enhanced distributional data for all species and hope the publication of this report promotes the collection and collation of ever more refined data.

PART IV.
SPECIES CONSERVATION PROFILES

INTRODUCTION

This section provides profiles of the 20 focal species in this report, summarizing information pertinent to their conservation status in Africa. For each species, we first provide a summary of their habitat associations, degree of ecological specialization, and distribution trends. We then explore the extent to which it is affected by ten key threats by reviewing the available literature on threats, and presenting an overview for each to accompany the scores provided in Part 1 (see Table 2.12). For some species, we provide a brief summary on controversial threats that we considered invalid and therefore excluded from the threat scoring process; these appear at the end of the relevant species profile under the heading 'Other.' Species are presented in family groups (Felidae, Canidae, Hyaenidae and Mustelidae/Viverridae).

Accompanying each species description are maps depicting current and historical distribution as well as locations where field studies have been conducted. Range maps were produced through a process described in Part III. For the three otters, we were not confident in coming up with historical maps; therefore, only current distribution maps appear here. The study localities are not exhaustive. They are derived from a combined search of Web of Science® and the World Wide Web, so as not to have an institutional bias (see Part II). Records outside of the current range can be explained either because they derive from regional studies (where a central point is used) or the range has since retracted.

FELIDAE

LION (PANTHERA LEO)

Habitat associations
Although lions reach their highest densities in savanna woodlands-plains mosaics of eastern and southern Africa, the species has a wide habitat tolerance which excluded them historically only from rainforest and the hyper-arid interior of the Sahara. Provided that cover and prey are available, lions can successfully inhabit all arid habitats including the Kalahari Desert and the Kunene region of northwest Namibia (Stander & Hannsen 2001); they formerly occurred around desert massifs in the Sahara (Rosevear 1974). Lions (most likely transients) have been recorded at altitudes of up to 4,240 m in montane habitat in East Africa (Nowell & Jackson 1996). They are intolerant of anthropogenic habitat conversion.

Degree of ecological specialization
Lions are generalists and have been recorded to consume virtually every mammal species larger than 1 kg in their range, as well as a wide variety of larger reptiles and birds (Nowell & Jackson 1996; Sunquist & Sunquist 2002). The constraints

of large physical size and extended social groups, however, bind them to large-bodied prey and their diet is dominated by medium-large ungulates. In fact, typically fewer than five species of large ungulates comprise a majority of their diet wherever they occur (Schaller 1972; Stander 1992; Packer *et al*. 1995), and they are unable to persist in areas without large-bodied prey. The threshold of this requirement is perhaps represented at Etosha National Park, Namibia, where Stander (1992) showed that lions hunting in pairs met their minimum requirements hunting springboks which, at < 50 kg, is the smallest preferred prey species recorded.

Distribution trends

Lions formerly occupied most of the African continent except for equatorial forest and the inner Sahara. Today, they are extinct in North Africa and

Current (dark gray) and historical (light gray) distribution of **Lion** *(Panthera leo)*.

have undergone dramatic range retraction at the limits of their historical distribution. Currently, lions are restricted mainly to protected areas and surrounding conservancies or 'game management areas,' with the largest populations in East and southern Africa. Where protection is poor, particularly outside protected areas, range loss or population decreases can be significant. Declines have been most severe in West and Central Africa, with only small, isolated populations scattered chiefly through the Sahel. Lions in the region are declining in some protected areas and, with the exception of southern Chad and northern Central African Republic, are virtually absent from unprotected areas (Bauer 2003).

Most lion populations in the protected areas of East and southern Africa have been essentially stable over the last three decades. The recovery within three years of the Serengeti population following a canine distemper epidemic (see Disease section) is illustrative of the species' resilience when adequate protection occurs (Bauer & Van der Merwe 2004). More than 350 lions have been reintroduced to more than 21 reserves comprising over 4500 km^2 in southern Africa (chiefly South Africa). However, all these reintroduced populations are small, isolated, and restricted to small areas with very limited potential to expand or connect to other populations (Hunter *et al*. 2004).

Human conflict

Throughout its range, conflict with pastoralists is one of the primary threats to lions (Macdonald & Sillero-Zubiri 2002; Frank 2004; Patterson *et al*. 2004). Resolving lion-pastoralist conflicts is particularly challenging because of their incompatibility with free-ranging livestock and the substantial loss they incur.
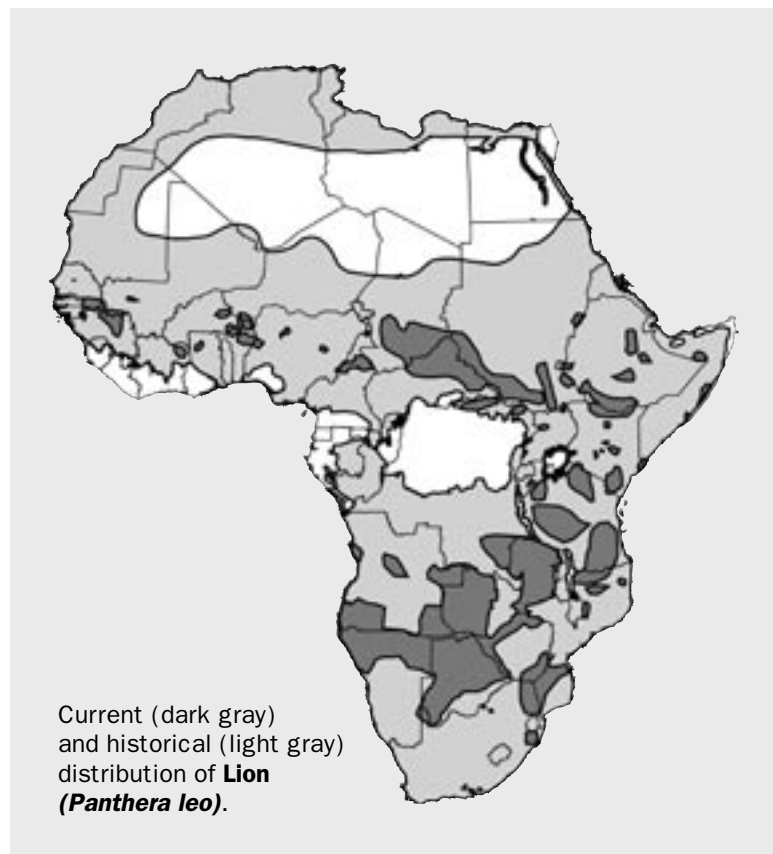
This is particularly true of cattle; most cattle kills are made by lions and cattle are usually the most valuable domestic species to herders. For example, annual losses of cattle to lions in areas adjacent to Waza National Park, Cameroon comprised only about 3.1% of all livestock losses to all factors, but represented >22% of financial losses amounting to approximately US$112,000 or US$370 per owner (Bauer 2003). Similarly, in communal lands bordering the Sengwa Wildlife Research Area, Zimbabwe, lions were responsible for 34% of recorded kills which represented 58% of financial losses (Butler 2000).

Lions are persecuted intensely in livestock areas throughout Africa. The species is easily killed by various methods including shooting over baits, gin traps, and particularly by poisoning carcases to which they are especially vulnerable given their predilection to scavenging (Hoare & Williamson 2001; Ogutu & Dublin 2002; Baldus 2004). Removals from areas adjacent to protected areas can represent a significant percentage of the population. For example, between 1982 and 1986, an annual average of 37 lions was killed on commercial cattle farms bordering Etosha National Park, Namibia which represented as much as 10% of the population (Stander 1990). An estimated 3% (n = 93) of the lion population in the Kgalagadi Transfrontier Park, Botswana, was killed on adjacent farms between 1997 and 2001 (Castley *et al*. 2002). Overall, this population has marginally declined in the last 20 years, with the ratio of females to males doubling in the same period, potentially influencing future population viability (Castley *et al*. 2002). Frank (2004) estimates that shooting annually removes 20% of a lion population inhabiting commercial livestock ranches in northern Kenya, though there is no evidence of a decline in overall numbers.

Recent studies have demonstrated that intensive monitoring of livestock and improved husbandry can reduce losses to lions (Ogada *et al*. 2003; Patterson *et al*. 2004; Frank 2004). Frank (2004) stresses that such efforts often fail when it is less costly to simply lay poison and and/or when lions remain valueless to landowners. Stander (1990) demonstrated some success with translocating occasional cattle killers. When occasional raiders were moved back into Etosha National Park, Namibia, only one eventually moved out of the park again and was destroyed, while the rest did not kill cattle for at least 12 months after translocation (Stander 1989/1990; 1990). Problem lions – habitual stock killers that repeatedly entered farms – were typically small groups of subadult or adult males displaced by incoming males or driven from their natal pride moving onto surrounding farmlands. This cohort was not successfully translocated and was destroyed (Stander 1990).

Lions also kill people occasionally. Baldus (2004) estimated that as many as 66 people are killed annually by lions in Tanzania, most of them in isolated (but sometimes prolonged) episodes involving a small number of habitual human killers.

Decline in habitat and/or prey availability

Loss of habitat and prey is another chief threat to lions in Africa. Although the species has a wide tolerance for various habitats, they are sensitive to loss of cover or prey, and are largely incompatible with human populations and activities. Anthropogenic habitat conversion, especially to pastoralism with its associated persecution (previous section), has encroached heavily upon lion habitat throughout the species' range. This has resulted in widespread extirpation,

fragmentation and reduced densities (Nowell & Jackson 1996; Bauer & Van der Merwe 2004). Severe lion population declines in western and central Africa have been attributed mainly to the spread of human settlements and agriculture into lion habitats (Bauer & Van der Merwe 2004). Habitat and prey loss from human encroachment along the edges of protected areas causes greatly reduced densities and 'hard edges' for protected lion populations, (e.g., Etosha: Stander 1990; Serengeti: Packer 1990; Hluhluwe-Umfolozi: Maddock *et al.* 1996; Kalahari: Castley *et al.* 2002).

Interspecific conflict

Healthy adult lions are essentially invulnerable to predation, except by other lions. Spotted hyenas, African wild dogs and leopards occasionally kill juvenile or sickly individuals but too infrequently to comprise a threat to populations. Lions compete strenuously with spotted hyenas over carcases, but there is little evidence that lions are significantly affected by competition from hyenas. Hyenas are able to usurp lions from kills when they greatly outnumber lions, and when adult male lions are absent (Cooper 1991; Höner *et al.* 2002; Kissui & Packer 2002). In the Serengeti and Ngorongoro Crater, lions probably balance losses to hyenas or derive a net benefit by scavenging hyena kills (Packer 1990; Kissui & Packer 2002). Small prides lacking adult males are most heavily impacted. Mills (1990) concluded that hyenas had moderate negative impacts on lions in the Kalahari, and Cooper (1991) estimated that prides in Chobe National Park, Botswana comprised solely of adult females and sub-adults lost an estimated 20% of the edible portion of their kills to mobbing hyenas.

Lions and spotted hyenas hunt similar prey species but Kissui & Packer (2002) demonstrated some niche separation with each species specializing on different age–sex classes.

Disease

The highly social behavior of lions and their ability to live at high densities creates significant potential for disease epidemics. The most severe and well documented case was the 1993-94 outbreak of canine distemper virus (CDV) in the Serengeti-Mara lion population, which killed at least 35% of the population ($\geq$1000 lions) within six months (Packer *et al.* 1999). The likely reservoir for the disease was the large semi-feral domestic dog population inhabiting local villages adjacent to the National Park (Roelke-Parker *et al.* 1996; Packer *et al.* 1999). Rapid recovery of the Serengeti population occurred following the epidemic, resulting in the recovery of its former size by 1997 (Packer *et al.* 1999).

The Ngorongoro Crater lion population crashed in 1962 apparently due to an exceptional plague of blood-sucking stable flies *Stomoxys calcitrans*. Massive secondary infection arising from *Stomoxys* bites led to widespread mortality, with lion numbers reduced from 75-100 to 12 in 12 months (Packer *et al.* 1991). They subsequently climbed rapidly to 100 animals by 1975, followed by a persistent decline after 1983 possibly associated with the deleterious effects of inbreeding (see Genetics section). A combination of tick-borne disease and CDV in the Ngorongoro Crater in 2001 killed an estimated 34% of this lion population, and similar population declines were associated with likely disease events in 1994 and 1997 (Kissui & Packer 2002).

Field locations
for **Lion** studies.
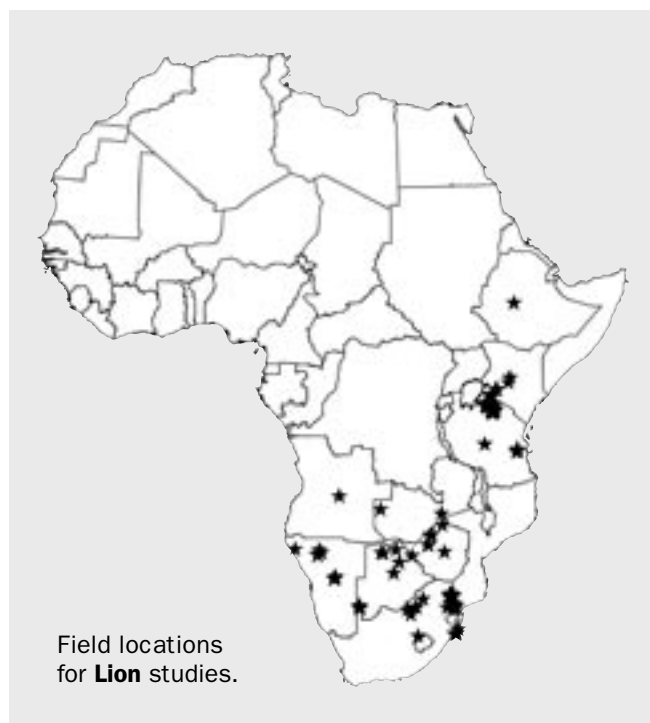
Lions in numerous populations exhibit high seroprevalence for various other viral diseases, but epidemics rarely result. For example, feline immunodeficiency virus (FIV) and feline herpes virus show consistently high prevalence in some East and southern African lion populations while incurring little or no mortality (Brown *et al*. 1993; Packer *et al*. 1999). No apparent signs of immunodeficiency or clinical pathology have been observed in FIV-postive individuals nor is there any evidence that FIV status influences mortality (Packer *et al*. 1999). Similarly, 99% (n = 374) of tested individuals from the Serengeti and Ngorongoro Crater were seropositive for feline herpes virus but showed no pathology or mortality (Packer *et al*. 1999). Feline calicivirus, feline parvovirus, and feline coronavirus in Serengeti lions demonstrated a pattern of seroprevalence suggesting discrete disease epidemics but with no demonstrable effects on birth and death rates in lions (Packer *et al*. 1999).

Bovine tuberculosis (BTB) is an emerging disease that may emerge as a significant threat for lions in the Kruger National Park (KNP) system, South Africa. BTB is a recent (+/- 1960) arrival to this system, crossing from infected domestic cattle herds along the southern river boundary into the African buffalo population. Infection in buffalo is currently spreading north at an annual rate of 6 km, with the entire KNP buffalo population predicted to be infected in less than 30 years if the present rate is maintained (De Vos *et al*. 2001). Of 125 lions sampled across districts, 78.2%, 46.2% and 0% tested positive for tuberculosis in the high (n = 64), medium (n = 39) and low (n = 22) prevalence regions, respectively (Keet *et al*. 2000). Lions are probably infected by scavenging on infected carcases or killing buffalo in advanced stages of BTB (Keet *et al*. 2000). The long-term effects on the KNP lion population remain to be seen.

Human hunting and commercial trade

Legal trade in lions is restricted largely to sport hunting trophies, skins for tourist souvenirs (usually from control operations) and, minimally, live animals for zoos. Trophy hunting is permitted in 13 countries, comprising 40% of range states. Exports from South Africa, Tanzania and Zimbabwe are the highest, exceeding 100 annually for each between 1993-2002 (Bauer & Nowell 2004). Nowell (*in litt.*; Bauer & Nowell 2004) estimated that an annual average of 919 skulls, skins and trophies were exported from African range states between 1999 and 2002. Based on incomplete population estimates by region, the percentage offtake represented by trophy hunting ranges from 1.25% (West Africa) to 3.33% (southern Africa).

The effect of trophy hunting on populations is controversial. Creel & Creel (1997) found little evidence that offtake by hunting altered the density of lions in Selous Game Reserve, Tanzania. Had allowed quotas been filled, however,

hunting mortality would have exceeded natural mortality rates of males and likely been unsustainable. The same study found possible demographic effects from hunting: while the sex ratio of adults did not differ from that in unhunted population, juvenile males were significantly over-represented, perhaps to compensate for the high turnover rates of pride males from hunting (Creel & Creel 1997). Similarly, male biased litters were observed after culling and following turnovers in male pride ownership in Kruger National Park (Smuts 1976; Starfield et al. 1981) and Serengeti National Park (Packer & Pusey 1987).

Using models based on 40 years of demographic data from Tanzania, Whitman et al. (2004) demonstrated that the age of hunted males was a critical factor in population persistence. Shooting too many young males (≥3 years old) led to population declines and extinctions, due to elevated rates of male takeovers and infanticide of cubs. Restricting hunting to a minimum safe age eliminated the risk of over-harvest; by shooting only ≥5 or ≥6 year old males, younger males would be able to remain resident long enough to provide security for lionesses to raise a cohort of cubs. Aging potential trophies in the field presents a significant practical challenge to this method, though Tanzania is now developing a system for quotas based on age (Baldus 2004).

Unintentional killing of lions by snaring also contributes to mortality. Typically, snares are set mainly for game meat (i.e., ungulates) but lions are vulnerable due to their tendency to scavenge the carcases of snared animals and become caught themselves (Hunter 1998; Ogutu & Dublin 2002). Where snaring pressure is intense, it may constitute a significant localized threat; the primary cause of death for lions around the shores of Lake Kariba, Zimbabwe, was strangulation by wire snares set by game meat poachers (Hoare & Williamson 2001).

Genetic issues

The potential for inbreeding depression exists in isolated populations with few founders. For example, the population in Hluhluwe-Infolozi GR, South Africa grew to 120 from three founders before steadily declining due to a host of health and reproductive effects, thought to be due to reduced heterogeneity (Maddock et al. 1996). A recent experimental attempt to address the declining population involved the introduction of new founders (R. Slotow pers. comm.). A similar solution is proposed for the homogenous Ngorongoro Crater lion population which underwent a population crash in 1962 (C. Packer pers. comm.). Compared to lions from the Serengeti National Park, Crater lions had significantly lower levels of heterozygosity and males had significantly higher proportions of abnormal sperm (Packer et al. 1991). Even with a consistently high biomass of resident prey and relatively low cub mortality (Packer et al. 1998), the Ngorongoro population has consistently declined or remained below carrying capacity. This is likely due to repeated disease incidents resulting from low genetic heterogeneity (Kissui & Packer 2002). Bjorklund (2003) modeled the effects of inbreeding in isolated populations as a result of habitat fragmentation. He concluded that to sustain a large outbred population of lions, a continuous population of at least 50 prides with no limits to male dispersal was required.

No data

Road kill, Climate change, Insect control, Tourism

Current (dark gray) and historical (light gray) distribution of **Cheetah (Acinonyx jubatus)**.

CHEETAH
(ACINONYX JUBATUS)

Habitat associations

Cheetahs are generally associated with open habitats but are known to readily occupy various woodland habitats. Indeed, extensive, very open habitats such as the Serengeti short grass plains may be sub-optimal due to high vulnerability of cubs. A mosaic of open and semi-closed habitat appears optimal (Nowell & Jackson 1996; Hunter 1998; Mills *et al*. 2004). They are relatively well adapted to arid environments and occur in the Kalahari, Namib and Sahara deserts (albeit at very low densities in the latter two). Cheetahs are sparsely distributed in more humid miombo woodland of central southern Africa and are absent from equatorial forest in central and coastal West Africa (Nowell & Jackon 1996).
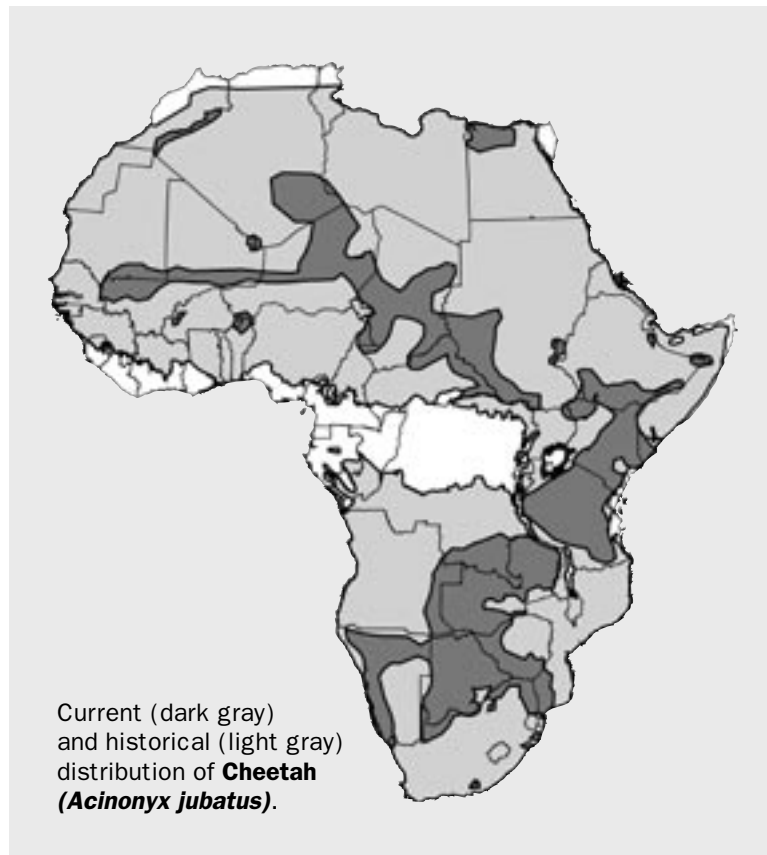
Degree of ecological specialization

The cheetah is the only extant felid specialized for a prolonged, high-speed pursuit of its prey and its diet is heavily dominated by medium-sized ungulates weighing 20-60 kg. Although the species is able to exploit a wider variety of habitats and prey than often depicted (see Hunter & Hamman 2003), its specialization excludes it from a most closed and montane habitats where the terrain, vegetation density and/or prey type are unsuitable.

Distribution trends

Cheetahs have undergone significant declines in distribution over much of their range. Large, contiguous populations are now restricted to the woodland savannas of southern Africa (Namibia, Botswana, Zimbabwe, Zambia and South Africa) and East Africa (Kenya and Tanzania). Cheetahs are chiefly though not exclusively associated with large protected areas. The species is now scarce and restricted to mostly fragmented populations everywhere north of the Equator, with the exception of parts of Kenya and perhaps Ethiopia. Cheetahs have become extinct in at least 13 countries in the past 50 years (Marker 2003).

Human conflict

Cheetahs are often killed by pastoralists and game-farmers, despite the fact that the species generally causes relatively minor damage. Marker (2003) demonstrated that Namibian cheetahs preferred wild prey rather than domestic

livestock even when the latter was abundant. For example, cheetahs were only responsible for 3% of the livestock losses to predators (Marker 2003). On a 200 km² Kenyan ranch, cheetah predation comprised 11 sheep per year, likely due to the presence of a largely intact wild ungulate assemblage (Mizutani 1993). Cheetahs were ranked below lion, spotted hyenas and leopards in the amount of livestock loss caused (Mizutani 1993).

The best data on cheetah removals come from Namibia which has the largest remaining free-ranging population of the species, estimated at 2,000-3,000 animals (Marker 2003). 90%-95% of this population occurs on farmland (producing domestic stock and wild 'game') outside protected reserves, where cheetahs are widely persecuted for depredation. Between 1980 and 1991, Namibian farmers reported killing 5,870 animals; Marker-Kraus *et al.* (1996) suggest the actual number removed during this period was at least 10,000 given that under-reporting was widespread. Morsbach (1986) suggested reports represented approximately 50% of actual levels of removals. Elsewhere, information is less complete but the species is killed in retribution for depredation throughout its range. Low density populations are probably especially vulnerable; in the Sahara where cheetahs are extremely scarce, Toureg herders conduct intensive punitive campaigns when cheetahs are blamed for occasional losses of young camels or goats (Dragesco-Joffe 1993).

Cheetahs are easily removed, especially by cage-trapping but also by shooting, gin-trapping and pursuing with dogs (Dragesco-Joffe 1993; Marker-Kraus *et al.* 1996; Marker 2003). Continuous indiscriminate trapping apparently results in high turnovers of resident individuals, creating sinks that draw in more cheetahs than would normally occur and increasing the potential problems for farmers (Marker-Kraus *et al.* 1996; Marker 2003).

Decline in habitat and/or prey availability

Loss of habitat and prey is one of the chief threats to the species (Nowell & Jackson 1996; Marker-Kraus *et al.* 1996). In East and southern Africa, widespread agricultural habitat conversion has been paralleled by local intensification of savanna-degrading activities such as wood gathering, charcoal making and meat poaching (Monela *et al.* 1993; Gros 2002). Tanzania provides a typical example where habitat conversion driven by the replacement of traditional pastoral cultures with agro-pastoral ones has been further exacerbated by economic liberalization promoting large-scale farming (Meertens *et al.* 1995; Leader-Williams *et al.* 1995; Gros 2002). In Namibia, bush encroachment – the thickening and multiplication of endemic bush driven by the removal of native ungulates, altered fire regimes and heavy cattle stocking rates – appears to reduce both cheetah hunting efficiency and the population densities of its preferred antelope prey (Jeo & Marker 2001; Marker 2003). Cheetah populations in the Sahelian and Sudanian dry savannas have declined from the combined pressures of desertification and human population growth driving the degradation of savanna habitat (Le Houérou & Gillet 1986; Newby 1990).

The eradication of cheetah prey has particular significance in North Africa and the Sahel where recreational hunting of desert ungulates is popular and where cheetahs naturally occur in low densities (Newby 1992; Saleh *et al.* 2001). The small surviving Egyptian cheetah population appears to be restricted

to marginal habitats in inaccessible areas as a result of gazelle eradication from more favorable areas of the coastal desert and larger oases. Saleh *et al.* (2001) suggest that cheetahs will not survive in Egypt unless hunting of their prey species is curtailed.

Interspecific conflict

Both adult and juvenile cheetahs are vulnerable to predation from other large carnivores as well as (for cubs) jackals and raptors. On the Serengeti short-grass plains, juvenile mortality is extremely high, with fewer than 5% of cubs reaching independence, most of which are killed by predators (Laurenson *et al.* 1992; Laurenson 1994). Serengeti cheetah cubs have a 27.7% chance of survival to eight weeks of age, with an 8.8% and 4.8% chance of reaching four months and independence, respectively (Laurenson 1994). Predation primarily by lions and less so by spotted hyenas accounted for 73-78% of cheetah cub deaths (Laurenson 1995b). It is important to note that such losses to predation are the highest documented and probably reflect elevated vulnerability of cubs due to the very open habitat. In more closed habitats where cubs more easily find refuge from predators, mortality is reduced; for example, 68% of cubs survive in South African woodlands where high densities of resident prey and relatively lower densities of lions and hyenas also favored cub survival (Hunter 1998). In areas where lions and hyenas have been extirpated, cheetahs exhibit signs of predator release (Kelly *et al.* 1998) e.g., on Namibian ranches where average cheetah litter size at 10 months was double that observed in the Serengeti (McVittie 1979).

Serengeti cheetah reproductive success is significantly negatively correlated to lion presence, with cheetahs actively avoiding high lion density areas (Durant 1998; Kelly *et al.* 1998). In one study, female cheetahs with higher reproductive success (number of surviving cubs per year) reacted more strongly to playbacks of lion calls, compared to individuals with poor reproductive success, suggesting that females diligent in predator avoidance raise more offspring (Durant 2000).

A recent increase in lion density in the Serengeti National Park (likely due to increases in wildebeest populations following rinderpest control operations) appears to have lowered female cheetah reproductive success (Nowell & Jackson 1996; Kelly *et al.* 1998). Litter size at emergence from the lair (four months) significantly decreased from an average of 2.9 cubs in the 1970s to 2.1 cubs in 1980-1994. Litter size at independence also declined over the same period, to 2.0 from 2.5 cubs (Kelly *et al.* 1998). Average lifetime reproductive success of females declined from 2.1 cubs raised to independence in the 1970s to 1.6 in 1980-1994. While it is unclear if the decrease in lifetime reproductive success also resulted in an overall population decrease of cheetahs on the Serengeti Plains (Kelly *et al.* 1998), half the total Serengeti cheetah population was produced by only 8% of female lineages between 1970 and 1994. Over this period, cheetahs lost 16.1% matrilines per generation, and a total of 76% of matrilines in comparison to 3-40% in other large mammals (Kelly 2001).

Two attempts at population viability analyses of the Serengeti cheetahs suggested that adult survival is more important than cub survival in influencing both population growth and extinction risk (Crooks *et al.* 1998; Kelly & Durant 2000). Crooks *et al.* (1998) suggested that the compensatory effect of rapid

reproduction in the face of increased neonatal mortality buffered cheetah populations against high cub losses. Nonetheless, very low cub survival clearly has a major effect on population growth rates (Laurenson *et al.* 1992; Crooks *et al.* 1998).

Cheetahs are easily driven off their kills by lions, leopards, hyenas and African wild dogs; jackals, baboons and vultures are also recorded as occasional klepto-parasites (Nowell & Jackson, 1996). O'Brien *et al.* (1986) suggested that cheetahs lose about 50% of their kills to competitors, although this was brought into question following intensive monitoring in Serengeti National Park by Caro (1994). This study suggested the loss to be less severe than assumed, with spotted hyenas taking only about 9% of meat procured by male cheetahs. Similarly, of 325 kills recorded by Hunter (1998), cheetahs abandoned only five to other predators.

Field locations for **Cheetah** studies.
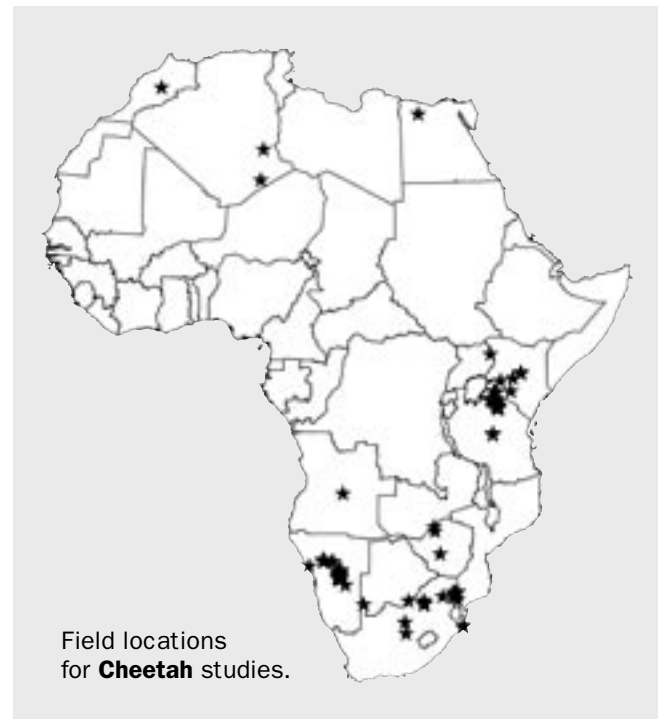
Disease

In light of its high genetic homogeneity (see Genetic Issues), the cheetah is potentially highly vulnerable to disease. Indeed, occasional outbreaks in captive populations have been devastating (O'Brien *et al.* 1985). Evidence of epidemics in wild populations, however, is limited to one incident in Etosha National Park, Namibia in which anthrax killed six of seven radio-collared cheetahs (Lindeque *et al.* 1998).

Cheetahs often test seropositive for various viruses but demonstrate little evidence of disease or increased mortality (Caro 1994). For example, although 20% of sampled cheetahs (n = 60) from southern and East African were seropositive for FIV, no immunological or pathological consequences associated with FIV infection in the species has been documented anywhere (Brown *et al.* 1993). Similarly, wild cheetahs show a high prevalence of feline herpesvirus, (43.6%) and feline coronavirus, (61.5%) with few apparent deleterious effects (Evermann *et al.* 1993). Brown *et al.* (1993) found that feline infectious peritonitis virus (FIPV) antibody titers of cheetahs were negligible or very low.

Caro (1994) suggests that the various aspects of cheetah ecology may reduce their vulnerability to disease, including living in low densities, partial asociality, an aversion to scavenging, and a distribution mostly limited to dry climates.

Human hunting and commercial trade

Legal commercial trade in the species is driven by the demand for live animals and for hunting trophies. Annual quotas for live animals and trophies from countries permitted such exports (Botswana, Namibia and Zimbabwe) in 2005 totaled 205. Additionally, Ethiopia permits the export of up to 34 cheetah skins annually from sources other than trophy hunting (usually confiscations), though actual exports are typically fewer than the quota. The *ex-situ* cheetah population

in the world's zoos is not self-sustaining due to poor reproduction in captivity and is maintained through the continuous importation of wild caught individuals, mainly from Namibia (Marker-Kraus 1990; Marker 2003). 30% (408 animals) of the 2001 captive cheetah population registered in the International Studbook were wild-caught animals (Marker, 2003).

Trophy hunting is permitted in Namibia, Zimbabwe, and Botswana. South Africa also has a current proposal to CITES to open trophy hunting of the species. Although trophy hunting is intended to foster tolerance for the species among private landowners by creating opportunities for revenue generation, there is limited evidence that persecution of cheetahs has been reduced as a result (Conniff 1999).

Cheetahs are occasionally killed for their skins with the illegal trade centered mainly in north-east Africa where Djibouti is an important conduit (Edroma 1984; Dollinger 1982). Live animals are also exported from this region (especially Somalia) to feed a demand among wealthy Arab men in Saudi Arabia, the UAE and Oman (Hunter & Hamman 2003). Cheetahs inhabiting woodlands are somewhat vulnerable to being killed in snares, chiefly as by-catch (Hunter 1998).

Genetic issues

Both captive and wild cheetahs exhibit high levels of genetic homogeneity believed to have resulted from at least one population bottleneck 8,000-20,000 years ago (O'Brien *et al*. 1983; 1985; 1986; 1987a). Lack of genetic diversity is thought to be associated with a variety of deleterious effects such as increased susceptibility to pathogens, reduced reproductive success, and poor ability to respond to environmental perturbations (O'Brien & Evermann, 1988). Although some possible effects of genetic homogeneity such as poor sperm quality in males (O'Brien *et al*. 1983; 1985) have been demonstrated, there is scant evidence that it has impacted wild populations (Caughley 1994). For example, Laurenson *et al*. (1995b) found little evidence in the Serengeti population for the presumed effects on reproduction, such as stillbirths, litter re-absorption during gestation and postnatal defects, and only 1.6% of Serengeti cubs examined (n = 125) were non-viable (Laurenson *et al*. 1995b). Although breeding in captivity is problematic, the reasons behind this appear to be unrelated to genetic effects (Laurenson *et al*. 1995b).

Tourism

With their mostly diurnal behavior and relative shyness, cheetahs are vulnerable to disturbance by tourists. Burney (1980; 1982) showed that the response of cheetahs in the Masai Mara Game Reserve to disturbance depended on the individual; those not habituated to vehicles fled at large distances and did not hunt when vehicles were present. Cheetahs were also likely to move if vehicles drove directly towards them rather than make a circling approach. Human interference may also contribute to cub mortality. Disturbance by tourists caused a Kenyan female to become severely agitated and move her cubs, dropping one in the open, where it was killed by a secretary bird (D. Richards, in Laurenson 1993). S. Durant (pers comm.) saw a litter in the Serengeti separated by tourist vehicles, with one cub disappearing as a result. Laurenson (1993) suggested that human interference may also account for high rates of females moving lair sites.

Caro (1994) emphasized that tourism pressure in many reserves has grown since Burney's study, warranting a re-examination of the issue.

No data
Road kill, Climate change, Insect control.

LEOPARD (PANTHERA PARDUS)

Habitat associations

The leopard has the widest habitat tolerance of any African felid and is the only species occupying both rainforest and desert habitats. Leopards are most abundant in woodland, grassland savanna and all forest types but also occur widely in montane habitats, coastal scrub, shrubland, semi-desert and desert. They are relatively tolerant of habitat conversion and may persist close to large human populations provided cover and prey is present, and persecution is absent (Hunter *et al. in press*). Reliable records come from Mt Kilimanjaro's Kibo Crater at 5,638 m (Tilman 1937) and mountain ridges up to 4600 m on Mt Kenya (Rödel *et al.* 2004).

Degree of ecological specialization

Like all felids, leopards are obligate carnivores but among large cats, they are highly opportunistic generalists with at least 92 prey species ranging from arthropods to adult male elands recorded in Sub-Saharan Africa (Bailey 1993). Even so, their diet is dominated by medium-sized ungulates weighing 20-80 kg and densities are correlated with prey availability (Stander *et al.* 1997a). Leopards are widely celebrated for their ability to persist in human-modified habitats where other large felids cannot; however, their presence in many sub-optimal areas is unlikely to be viable without nearby protected source populations or large tracts of relatively undisturbed habitat (Balme & Hunter *in press*).

Distribution trends

The leopard is still widely distributed within its historical range but has experienced marked range loss from Africa north of the Sahara, West Africa, north-east Africa and South Africa (Nowell & Jackson 1996; Kingdon 1997; Hunter *et al. in press*). Locally,

Current (dark gray) and historical (light gray) distribution of **Leopard (Panthera pardus)**.
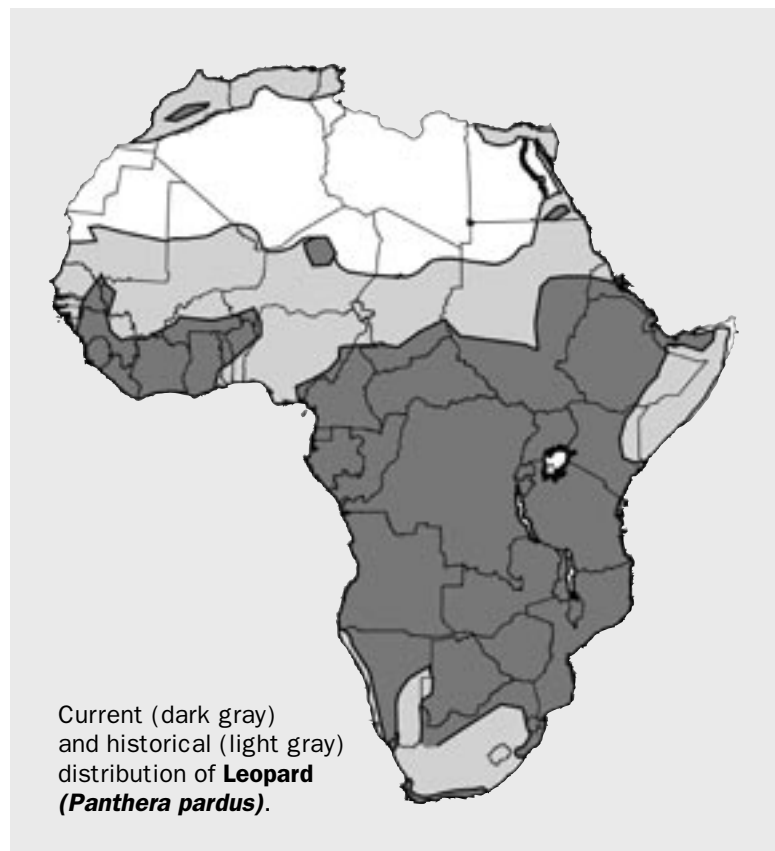
leopards persist in very reduced densities in, or have been extirpated from areas characterized by dense human populations or extreme habitat conversion (Martin & De Meulenaar 1988). Leopards recolonize former range when threats are reduced; for example they have naturally recolonized some areas in South Africa (Anderson, in Hunter *et al*. *in press*; Friedman & Daly 2004) and have reportedly increased in Eritrea since the cessation of human fighting in 1991 (Zinner *et al*. 2001).

Human conflict

Leopards come into conflict with people throughout their range (particularly outside protected areas) for their role as predators of livestock, game species and occasionally people. For example, an average of 4.7 people were killed and 7 injured by leopards annually in Tanzania between 1993-1999 (Games & Severre 2002). Leopards killed 37 Ugandans between 1923-1994 compared to 206 deaths to lions for the same period (Treves & Naughton-Treves 1999). The proportion of attacks that are unprovoked versus those occurring when leopards are hunted or harassed is rarely reported.

The frequency and severity of livestock depredation varies widely. In general, the greatest losses occur where wild prey density is low and/or husbandry practices increase vulnerability of stock. For example, between 1996-1999, leopards did not contribute to any of 433 losses to carnivores from a commercial cattle ranch in southern Kenya where wild prey was abundant and herders always accompanied stock (Patterson *et al*. 2004). On a similar ranch in northern Kenya with less intensive husbandry, leopards killed an average of 4.3 cattle and 10.5 sheep per annum, comprising 16.4% of all depredation costs, representing a cost to landowners of US$0.25/ha/year compared US$0.72/ha/year for lions (Mizutani 1993; 1999). In communal land in Zimbabwe, leopard predation accounted for only 12% of livestock killed (n = 241) between 1993 and 1996; 93% of losses occurred during the dry season when natural prey was scarce (Butler 2000). In contrast, leopards caused the majority (38.2%; n = 976) of depredations in arid central Botswana (Scheiss, in Hunter *et al*. *in press*), and were the second most costly predator after lions to Ju/Hoan San communities in arid north-eastern Namibia, accounting for 100% of dog losses, 97% of chicken losses and 42% of cattle losses (Stander *et al*. 1997b). Rainforest leopards seldom kill livestock, probably because intensive pastoralism is rare in central Africa and domestic stock is usually corralled in villages overnight (Hunter *et al*. *in press*).

Leopards are intensely persecuted for real and perceived damage on livestock land throughout Africa. Indeed, leopards were treated as vermin even inside parks until relatively recently. Up to the early 1960s, leopards were 'controlled' in numerous East African national parks because of their assumed deleterious effects on herbivore populations (Cobb 1981). Similarly, leopards were classified as vermin in the Cape Province, South Africa until 1957 and in fact farmers were legally required to kill the species on their land or face fines. Today, leopards are legally protected in most African countries but are widely removed by government control officers in response to complaints or are legally killed by complainants themselves with 'destruction' permits; for example, permits issued by the former Cape Department of Nature and Environmental Conservation resulted

in 110 leopards legally culled in the Cape Province between 1977 and 1980 (Stuart *et al*. 1985). Finally, illegal killing of leopards is widespread though accurate figures are unknown. Leopards are relatively easy to hunt, by gin-traps, cage-traps, poison or shooting over baits.

Decline in habitat and/or prey availability

Of the three large African felids, leopards have suffered the least range loss, most likely due to their wide habitat tolerance combined with their ability to adapt to settled environments and altered natural habitat (provided persecution is absent or minimal). Nonetheless, loss of habitat and prey does remain one of the chief threats to the species. Leopards have been extirpated from large areas of intensive pastoralism in East and southern Africa, and persist in greatly reduced densities near human population centers in many areas (Martin & De Meulenaar 1988). At

Field locations
for **Leopard** studies.

the edges of their range and in large regions throughout, they currently occur in small, fragmented populations; for example, populations in south-western South Africa are almost exclusively restricted to inaccessible mountainous areas and wooded valleys unsuitable to farming (Norton 1986b). Increasing habitat loss is associated with elevated conflict between leopards and the interests of local people (Cobb 1981). This drives direct persecution which serves to eliminate isolated populations.

In forested Africa, deforestation combined with human hunting for bushmeat represent significant threats (Henschel & Ray 2003). Leopards were extirpated from much of the West African coastal forest belt by 1945 (Bailey 1993). In south-eastern Nigeria, intensive forest exploitation due to urbanization and oil extraction activities continues to be a principal threat for leopards today (Angelici *et al*. 1998). Even in intact forest, competition between humans and felids for shared prey items may potentially limit large cat populations (Redford 1992). Intensive human hunting in African forests may alter densities and population structure of leopard prey, particularly of medium sized duikers and monkeys (Hart & Petrides 1986; Koster & Hart 1988) and leopards are now extinct or nearly so in various forest patches where bushmeat harvests are very high, e.g., Cameroon's Banyang-Mbo Wildlife Sanctuary (Bennett 2001).

Interspecific conflict

Leopards are occasionally killed by various larger or communal predators which may also appropriate their kills (see Hunter *et al*. *in press* for review). The leopard's ability to conceal itself and its food, however, means adults generally suffer little from inter-specific predation and competition (Stander *et al*. 1997a). Predation of cubs is the main mortality factor for that cohort but is unlikely to limit the species except perhaps in sub-optimal habitat or in concert with aggravating
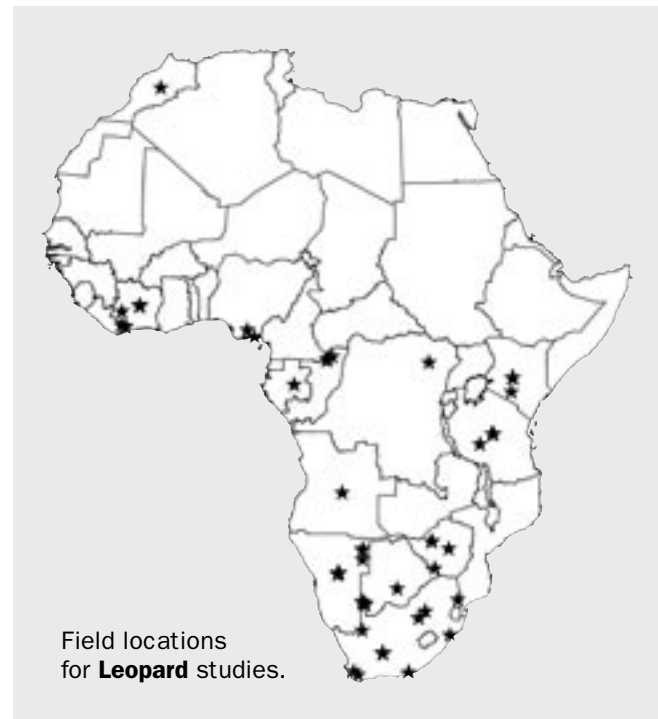
factors such as drought and reduced prey availability (Bothma & LeRiche 1986; Bothma 1998). Caching kills, particularly in trees, reduces the frequency of visits by competitors and loss of carcasses due to scavenging (Stander *et al.* 1997a) and is more common where competing carnivores are abundant (Schaller 1972; Bothma & Le Riche, 1984). Throughout the African forest biome, leopards persist as the sole large carnivore in this ecosystem. Although prey overlap with African golden cats is evident (Ray 2000; Ray & Sunquist 2001), the degree to which this results in interspecific conflict is unknown.

Disease

Disease-related mortalities in leopards occur at low frequencies; large epidemics are unknown (Spong *et al.* 2000). As with other wild carnivores, exotic disease from large populations of dogs or domestic livestock adjacent to protected areas has some potential to impact leopards. Rabies and canine distemper in leopards has been confirmed from numerous populations at low incidences (van Vuuren *et al.* 1997) and bovine tuberculosis infection in African buffaloes has spilled over into Kruger National Park leopards (Keet *et al.* 1996). Nonetheless, few deaths are known for any of these diseases. The leopard's solitary lifestyle, ability to avoid other carnivores and reliance more upon hunting than scavenging probably limits the species' vulnerability to infectious diseases (Spong *et al.* 2000).

Leopards carry the feline ear mite *Notoedres cati* which gives rise to mange, e.g. 53% of Kruger National Park individuals (n = 16; Bailey 1993). Leopards often recover naturally but stressed individuals or those already in poor condition may die from secondary infection (Bailey 1993).

Human hunting and commercial trade

There is no legal international trade for leopard skins except as hunting trophies or tourist souvenirs. Eleven African countries allow sport hunting of leopards, and The Democratic Republic of Congo and Gabon each has permission to export five skins from other sources (such as problem animal control). The 2005 CITES export quota combined for all African states is 2590. The impact of trophy hunting on populations is unclear but the potential for over-exploitation exists where regulations are abused. For example, females comprised 28.6% of 77 trophies shot between 1995-1998 in Tanzania, even though only males are legally hunted there (Spong *et al.* 2000). The unregulated removal of females may constitute additive rather than compensatory mortality, and has the potential to adversely impact population dynamics (Spong *et al.* 2000). Similarly, over-exploitation of adult males potentially lowers recruitment since incoming male leopards tend to kill cubs fathered by other males (Packer & Pusey 1984; Greene *et al.* 1998; Balme & Hunter *in press*). Finally, Caro *et al.* (1998) emphasized that off-take calculations rarely consider legal hunting by resident communities or illegal poaching, which reaches high levels around some protected areas in Tanzania. They concluded that leopards are probably being hunted unsustainably, and recommended a reduction in hunting quotas to permit some populations to recover (Caro *et al.* 1998). In spite of this finding, Tanzania doubled its leopard trophy-hunting quota to 500 in 2002.

There is widespread illegal trade in leopard parts, most of it domestic though many of the same markets provide skins for illegal international trafficking. For

example, leopard skins bought mainly by French military personnel in Djibouti are smuggled to Europe; Künzel *et al.* (2000) counted 44 skins in tourist shops on one day in 1999. Similarly, Shipp (2002) counted 17 skins in a two-hour period in one Marrakech market and was offered a further 20, including courier delivery to the United Kingdom. The skins of at least 58 individuals intended for export were seized in 2004 in KwaZulu-Natal, South Africa (Gunter, in Hunter *et al. in press*). Domestically, skins and canines are widely traded in some central and West African countries where leopard parts are valued for traditional rituals (Henschel & Ray 2003). In northern Congo (Brazzaville), 15 skins were seized over a two-week period in 2000 (P. Elkan, in Ray & Quigley 2001) and skins are common in the large markets of Côte D'Ivoire (Gross 1998).

Genetic issues
Based on limited sampling of African populations, all leopards in Africa belong to the same sub-species *P. pardus pardus* and are distinct from Eurasian populations (Miththapala *et al.* 1996; Uphyrkina *et al.* 2001). Among leopard subspecies, African leopards are considered the most genetically variable in both mtDNA sequences and microsatellites (Uphyrkina *et al.* 2001). Spong *et al.* (2000) reported that Tanzanian leopards had high heterozygosity (0.77 ± 0.03), and a low heterozygote deficiency (0.06 ± 0.03). They demonstrated that gene flow was not restricted to within protected areas, suggesting that loss of genetic variation is not an imminent threat, at least in Tanzania (Spong *et al.* 2000).

No data
Road kill, Climate change, Insect control, Tourism.

AFRICAN GOLDEN CAT (PROFELIS AURATA)

Habitat associations
Golden cats are strongly associated with moist forests, favoring primary equatorial forest with little human disturbance (Nowell & Jackson 1996). The intact forests of Central and West Africa are prime habitat but golden cats are apparently also known to occur in wooded savanna, gallery forest and coastal forest habitats (Boy 2003). They occur patchily in East Africa where they are recorded mainly from moist montane forests, bamboo forest and humid, lowland forest. Golden cats inhabit abandoned logged areas, perhaps favored by dense secondary undergrowth and elevated rodent densities (Kingdon 1977; Delany 1986; Anstey 1991; S. Lahm *in litt.;* Nowell & Jackson 1996). They are occasionally reported from savanna habitat but there are no reliable records.

Degree of ecological specialization
This species is poorly studied with few detailed ecological data available. Dietary analyses from scats suggests that golden cats in Dzangha-Sangha Reserve, Central African Republic and the Ituri forest, Democratic Republic of Congo take a wide variety of mostly mammalian prey with rodents and small antelopes being most important (Hart *et al.* 1996; Ray & Sunquist 2001). Hart *et al.* (1996)

Current (dark gray) and historical (light gray) distribution of **African Golden Cat** *(Profelis aurata)*.
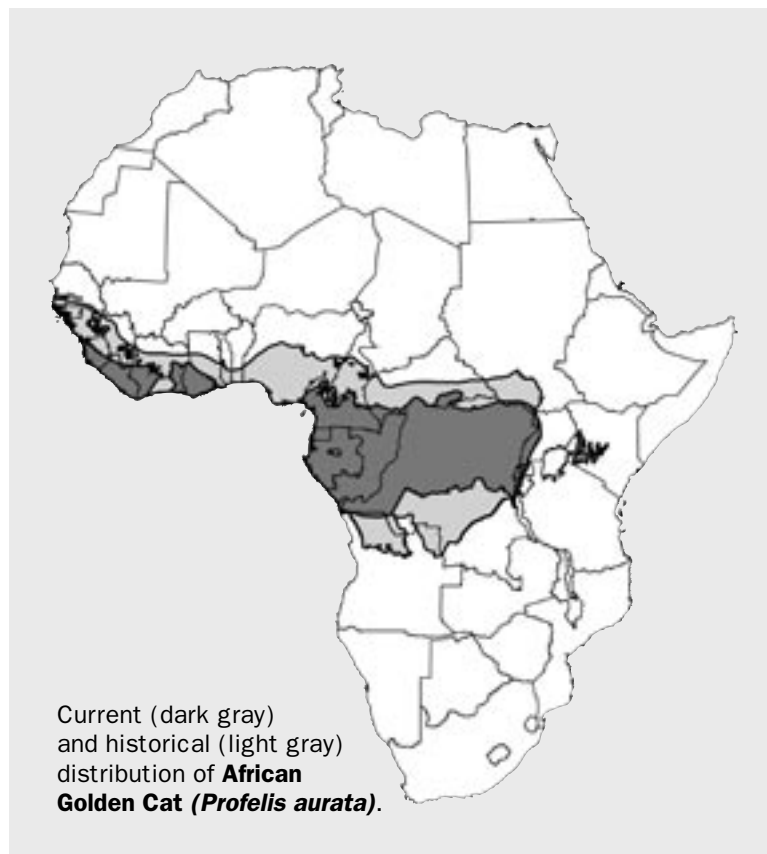
suggested that golden cats scavenge from the remains of eagle kills that have fallen to the forest floor. Rather than any trophic specialization, their dependence on tropical forested habitats is the chief factor elevating their vulnerability.

Distribution trends

The golden cat has the most restricted distribution of the felids considered here. The species is thought to be still widely distributed in the contiguous forests of the Congo Basin. In the remaining West African coastal forest belt golden cats occur in fragmented populations. They have been extirpated from large patches throughout their range where deforestation has occurred, and have experienced marked range loss at the edges of forested equatorial Africa. In East Africa, their distribution is poorly known but they appear restricted to forest remnants largely associated with highlands. There is no evidence that they have ever occurred in the eastern coastal forest belt (T. Davenport, *pers. comm.*).

Human conflict

There are conflicting reports regarding the degree of conflict between humans and African golden cats. Kingdon (1977) suggested that golden cats are commonly caught raiding poultry coops, and killing goats and sheep in the face of human colonization of secondary forest in Ugandan lowlands and valleys. (Kingdon 1977). Davenport (1996) agreed, stating that Bakiga communities on the boundaries of Bwindi complained of regular depredation by the species on chickens, sheep and goats; they were additionally blamed for occasional losses of domestic cats and one hunter's dog. However, Butynski (cited in Boy 2003) found little evidence for widespread depredation by golden cats and suggested many reports were probably due to misidentification for servals. Numerous authorities consulted by Nowell & Jackson (1996) considered depredation by golden cats to be rare. Whether it is actual or perceived, killing golden cats in retribution likely occurs wherever there are human settlements in its range.

Decline in habitat and/or prey availability

Loss of habitat is the greatest threat to this species. Deforestation has destroyed suitable habitat and driven declines of prey species in large areas of golden cat range, particularly in West and East Africa (Nowell & Jackson 1996; Ray & Butynski *in press*). West African moist forests have been heavily degraded with remaining undisturbed stands patchily distributed, and large areas of former

golden cat habitat converted to savanna (Myers 1989; Collins 1990; Sayer *et al*. 1992).

In otherwise suitable habitat, human hunting for bushmeat has the potential to impact the species. Two of the four chief game species hunted in Dzanga-Sangha, were also principal prey items of the golden cat (Ray 2001). Similarly, 47% of the Lobeké Forest, SE Cameroon bushmeat off-take was comprised of golden cat prey species (Davenport *et al*. unpubl. data). Human hunting of forest ungulates, particularly medium sized species, has been demonstrated to alter densities and population structure (Hart & Petrides 1986; Koster & Hart 1988), potentially affecting the densities of their felid predators (Henschel & Ray 2003).

Interspecific conflict

Competition and predation by leopards may impact the species. Where it has been assessed, food niche overlap between leopards and golden cats is high. This is particularly so where large prey is unavailable or scarce, and leopards concentrate on the same small species preferred by golden cats. In Dzanga-Sangha, overlap was 0.92 (where complete overlap is 1.0), with the most frequently occurring species in scat analysis for both species being the 4.5 kg blue duiker (Ray & Sunquist 2001). Similarly, Ososky (1998) attributed a high niche overlap between golden cats and leopards in Ndoki Park, Republic of Congo to the large proportion (68.5%) of prey under 5 kg in the leopard diet. Hart *et al*. (1996) suggested that the availability of small antelopes to golden cats in the Ituri forest, Democratic Republic of Congo may be limited by selective predation on these species by leopards.

Golden cats are occasionally eaten by leopards. Five leopard scats from a sample of 197 collected in Lopé, Gabon contained golden cat remains (Henschel 2001) and Hart *et al*. (1996) found one leopard-killed golden cat in Ituri, Congo.

Disease

Three emaciated individuals were found in Lopé Reserve, Gabon over a 15-year period, with cause of death remaining unknown (C. Tutin *unpubl. data*). Three species of ecto-parasites (*Dirofilaria granulossa, Taenia taenieformis, Ligula* sp.) were collected by Gaillard (1969) from one adult male in Senegal. There is no evidence of disease impacting African golden cat populations.

Road kills

Few data are available except for occasional anecdotes but the proliferation of logging roads into forested central and West Africa represents a growing threat.

Field locations for **African Golden Cat** studies.
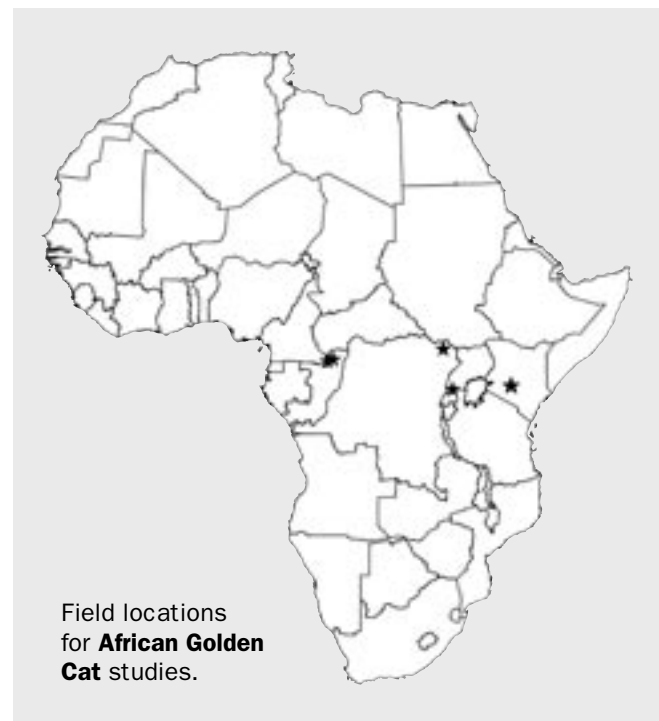
Human hunting and commercial trade

Golden cats are caught in wire-snare traps generally at low frequencies, for example 0.8% (n = 2) of 254 kills by hunters in NE Gabon (S. Lahm *pers. comm.*), and 0.4% (n = 4) of carnivore carcasses in eastern Congo markets surveyed by Colyn *et al.* (1987). Nonetheless, while golden cats are rarely the primary target and typically constitute a small proportion of the catch, intensive trapping can remove substantial numbers. For example, during a three-month period of wire snare trapping at four sites in Lobeké, SE Cameroon, 13 African golden cats were captured, representing 0.4% of total captures (n = 3,197: Davenport *et al.* unpubl. data).

The golden cat is valued in local religious beliefs in much of Central and West Africa. Cameroon pygmy tribesmen value the tail as a protective talisman for hunting elephants (Guggisberg 1975) and sections of golden cat skin have totemic value, being used to wrap valuable objects or for circumcision rites (Van Mensch & Van Bree 1969; E. Gadsby *in litt.*; Nowell and Jackson 1996). Markets within African golden cat range regularly display skins (Kingdon 1997) with furs being frequently sold alongside medicinal herbs and fetishes in Yaoundé and Kampala (T. Davenport *pers. comm.*). Occasional hunting of golden cats for food may also occur (Van Mensch & Van Bree 1969). Based on the relative numbers of skins of different west African felids in collections, Rosevear (1975) thought that golden cats were easily hunted.

No data

Genetic poverty, Climate change, Insect control, Tourism.

SERVAL (LEPTAILURUS SERVAL)

Habitat associations

The serval is strongly associated with permanent water sources and requires cover such as tall grass, reeds and brush for refuges and for rodent prey (Hunter & Bowland *in press*). It reaches highest densities in savanna woodlands, grasslands and dry forest where it is associated with wetlands, rivers and floodplains. This species is also found in alpine grasslands (to altitudes of 3800 m in Kenya), moorland (to at least 3850 m near Mt Kilimanjaro; Grimshaw *et al.* 1995) and high-altitude bamboo forests (Andama 2000). Servals tolerate agricultural areas as long as cover and water is available.

Degree of ecological specialization

Servals specialize on small mammals, particularly murids. Rodents and shrews accounted for over 80% of serval diet in Bwindi Impenetrable National Park, Uganda (Andama 2000) and 93.5% on farmland in the Drakensberg Mountains, South Africa (Bowland 1993). Small mammals comprised 89% of observed kills in the Ngorongoro Crater, Tanzania (Geertsema 1985). A wide variety of additional prey is taken, especially birds but servals appear to attain high densities only where rodents are abundant.

Distribution trends

Servals are still widely distributed within historical limits but the species has suffered marked range loss at the north, west and extreme south of their range. Elsewhere it has been extirpated from areas densely populated with people or where habitat conversion is extreme (Smithers 1978; Nowell & Jackson 1996). Servals have expanded their range in a few regions; for example, they are gradually re-colonising the eastern Free State, South Africa in association with agricultural development (C. Stuart *in litt.*; Hunter & Bowland *in press*). Moreover, servals possibly benefit from forest clearance and resulting encroachment of savanna habitats at the edges of the equatorial forest belt in central Africa (Nowell & Jackson 1996; Ray 2001).

Current (dark gray) and historical (light gray) distribution of **Serval (*Leptailurus serval*)**.
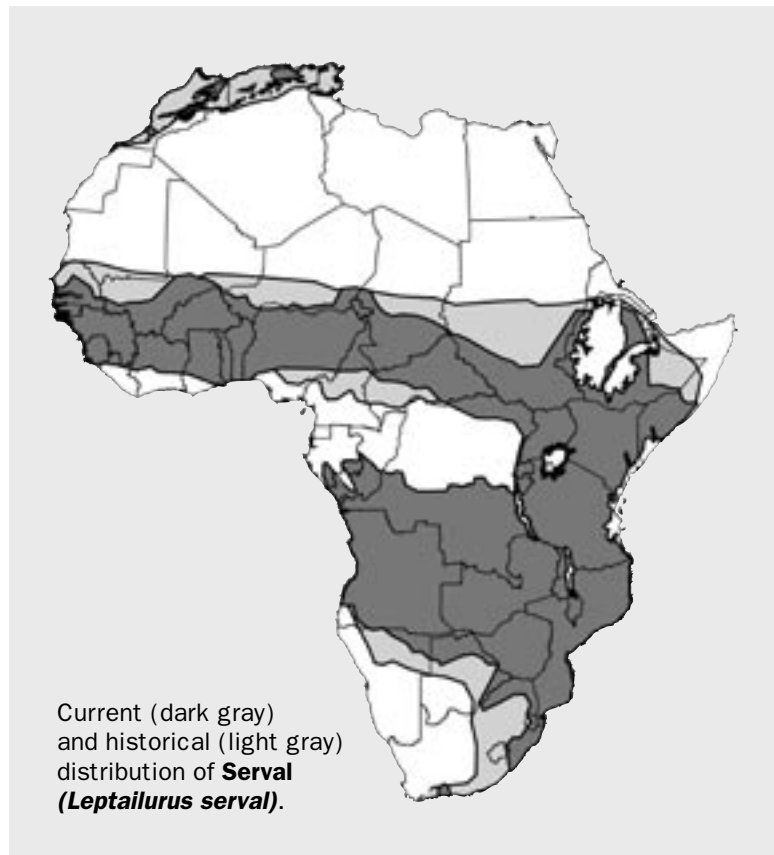
Human conflict

Servals rarely prey upon livestock. Analysis of serval diet inhabiting farming areas in Zimbabwe (Smithers 1978) and South Africa (Lawson 1987; Bowland 1990) found little evidence of predation on stock. Further, wild-caught servals were reluctant to kill small lambs in captive trials, only doing so when alternative food was unavailable (Bowland 1993). Domestic poultry and juvenile small stock (rarely) is vulnerable, particularly if left unpenned over-night (Nowell & Jackson 1986). Based on interviews with locals, Atickem (2003) describes an unusually high incidence of small stock predation apparently by servals in the Web Valley of Bale, Ethiopia.

Servals are actually beneficial to crop farmers due to their preference for rodents. Geertsema (1985) calculated that a single adult serval killed about 4000 rodents per annum. Under enlightened management, farmlands (agriculture and livestock) can be beneficial to servals. Of Namibian farmers reporting servals on their land, only 15% considered them predators of livestock, and none employed any of the legally permissible control measures (Joubert *et al*. 1982).

Despite all this, servals are often killed by farmers, either because they are mistakenly believed to kill stock, they are mis-identified as leopards or caracals, or they are killed by indiscriminate methods such as gin traps and poison (Lawson 1987; Bowland & Perrin 1993). Non-selective predator control programs in southern Africa significantly impacts the species in some areas (Bowland & Perrin 1993); serval skins arising from these operations are very common in rural taxidermists in South Africa (L. Hunter, *pers. obs.*).

Field locations for **Serval** studies.
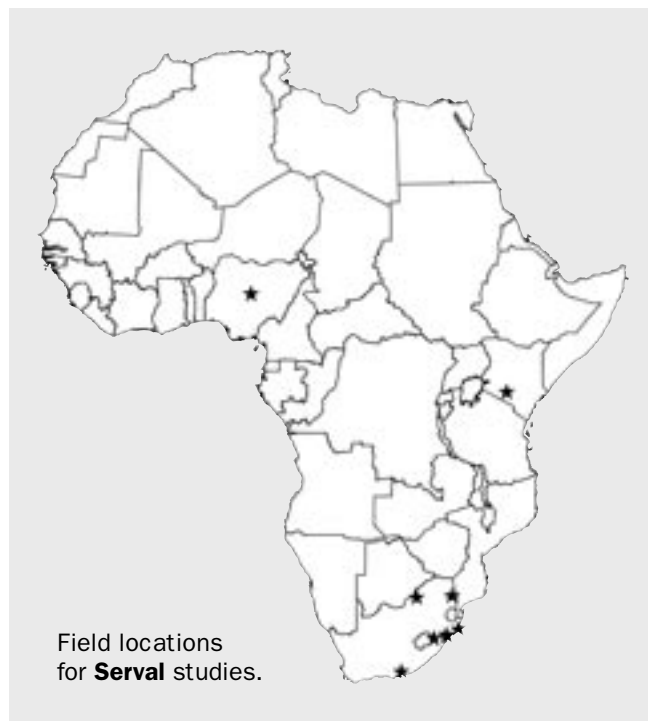
Decline in habitat and/or prey availability

Habitat loss is a significant threat to servals. Wetlands, marshes and riparian habitat harbor high rodent densities and are preferred habitat (Geertsema 1985; Bowland 1990) but are under extreme pressure in much of Africa. The degradation of grasslands through artificial burning regimes and over-grazing by livestock is a further threat as it leads to lowered densities of small mammal prey which likely drives local extirpations (Rowe-Rowe 1982; 1992).

These losses are balanced to some extent by the species' tolerance of agriculture, where it benefits from increased rodent densities provided that sufficient provided cover and water are available (Nowell & Jackson 1996; Bowland 1990). Kingdon (1977) suggests that it has adapted well to the cultivation-fallow mosaic widespread characteristic of much of mesic East Africa.

Interspecific conflict

Servals are occasionally killed by various large predators, mainly large cats and spotted hyenas. Domestic dogs may be a significant threat near human settlements (Hunter & Bowland *in press*). Sympatric similarly-sized carnivores such as caracals and various jackal species represent minor sources of competition. The serval's specialization on rodents reduces direct competition with these species for prey and, being quickly consumed, also means they rarely lose kills to competitively dominant scavengers. Radio tracking of two caracals concurrently with servals showed a 20% overlap in area utilization with caracals preferring higher rocky, dry ground (Bowland 1993). Additionally, caracal diet is typically far more diverse with a greater reliance on larger mammals.

Disease

Wild servals have tested positive for leptospirosis (Sebek *et al*. 1989) and babesiosis (Penzhorn *in litt*.; Hunter & Bowland *in press*). *Hookworms Ancylostoma paradoudenale* were found in servals from Somalia (Macchioni 1995). There is no evidence that disease is a significant threat in any population.

Road kills

Servals appear drawn to road edges, perhaps because of hunting opportunities (Stott 1980) and they tend to freeze in oncoming headlights, increasing their vulnerability (L. Hunter *pers. obs.*). In northern KwaZulu-Natal, South Africa they are killed on roads fairly frequently (Hoffman 1987; L. Hunter *pers. obs.*). There is no information on the impact on populations but areas with relatively high densities of roads may be sub-optimal for the species.

WILDLIFE CONSERVATION SOCIETY

Human hunting and commercial trade

The serval is a popular species in the local fur trade, particularly in north-east Africa and countries of the west African Sahel belt (Yalden *et al*. 1980; Sayer & Green 1984; Myers 1986; Gadsby 1991; Rowe-Rowe 1992). The demand is apparently mainly for domestic ceremonial/medicinal purposes or for tourists, rather than for international commercial export. Nonetheless, skins are traded in large quantities in some countries e.g., Senegal, Gambia and Benin (O. Burnham, Di Silvestre *in litt*.; Hunter & Bowland *in press*), and Mali, Nigeria, and Sudan are significant exporters of serval skins (Dollinger 1982). Skins are frequently marked as cheetah or leopard, which command higher prices and are sought after by tourists (Nowell & Jackson 1996).

Servals are easy to hunt. They are readily bayed by dogs and their localized distribution near permanent water sources may increase their vulnerability (Stuart 1985). Recreational hunting of servals with dogs is popular in the eastern Free State, South Africa (L. Hunter *pers*. *obs*.) but the effects on populations are unknown.

No data

Genetic poverty, Climate change, Insect control, Tourism.

CARACAL (CARACAL CARACAL)

Habitat associations

The caracal has a broad habitat tolerance, being present in all African habitat types except for equatorial forest and the Sahara interior. Members of the species display a marked preference for dry lowland habitats including savanna, coastal scrub and semi-arid woodlands, although they have been also recorded from evergreen and montane forest (Stuart 1984; Nowell & Jackson 1996) and altitudes up to 2500 m (exceptionally 3300 m) in Ethiopia (Yalden *et al*. 1980). It is most numerous in the dry savannas of southern Africa (Davies 1997).

Degree of ecological specialization

Weighing up to 18 kg (Stuart 1981), caracals are the largest of Africa's smaller cats and occupy a broad unspecialized niche which bridges the small-large felid gap. They are versatile hunters, preying upon a wide variety of mainly vertebrate prey, ranging from rodents to medium-sized ungulates the size of a female impala (mean mass approximately 41 kg; Skinner & Smithers 1991). Caracals occupy a broad selection of habitats provided some cover is available (Rowe-Rowe 1992).

Distribution trends

Caracals are still widely distributed through their historical range but have experienced substantial loss at the peripheries, particularly in North and West Africa. They have been locally extirpated from areas with high human pressure or extreme habitat change but are known to adapt well to livestock areas. They are still common on livestock lands in southern and East Africa where

Current (dark gray) and historical (light gray) distribution of **Caracal** *(Caracal caracal)*.
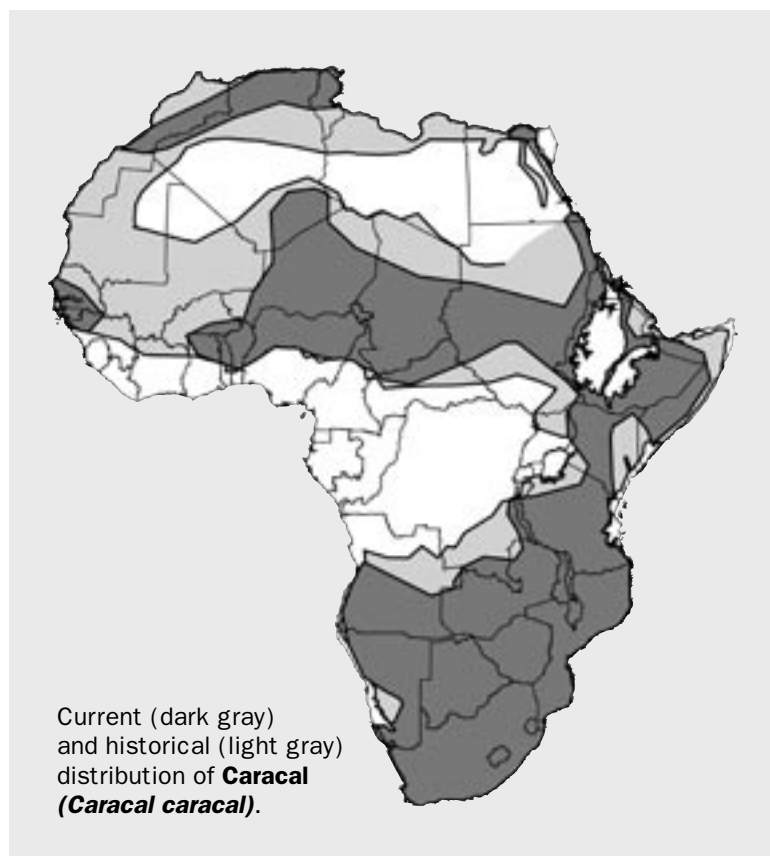
they are difficult to extirpate. They usually recolonize such areas when local extinction occurs (Visser 1978; Stuart 1981). For example, they have expanded their range in farming areas in South Africa and Namibia (Stuart & Wilson 1988; Rowe-Rowe 1992).

Human conflict

Caracals are capable of killing ungulates much larger than themselves and will prey upon small livestock and poultry. Depredation is considered most problematic in the semi-arid regions of southern Africa (Nowell & Jackson 1996). Scat and stomach content analyses from various unprotected areas in South Africa estimated that between 17-55% of the caracal's diet comprised domestic stock (Pringle & Pringle 1979; Stuart 1982; Moolman 1986). Reported small stock losses attributed to caracals in South Africa's former Cape province ranged up to 5.3 animals per 10 km² (Brand 1989) and 82% of Cape farmers considered the caracal to be the principal predator of domestic wild stock (Stuart 1984).

Occasional surplus killing by caracals fuels the perception among small stock farmers that the species is particularly damaging (Skinner 1979; Stuart 1981). Most surplus killing incidents occur in holding pens or against fence lines. Although rare, such incidents can be devastating to individual farmers. Seventeen of 79 stock raiding cases blamed on caracals involved the killing of two or more small stock animals, with 21 young goats being killed in a single event (Stuart 1981). Davies (1997) suggests that such problems are attributable to repeat offenders which can be selectively removed.

Severity of depredation is affected by husbandry techniques and availability of wild prey. Avenant and Nel (2002) found that predation on small stock and introduced springbok was seasonal when alternative prey was scarce; such losses can be reduced by intensive husbandry during vulnerable periods. Where wild prey species are abundant, depredation is less. For example, no remains of domestic livestock were found in 200 caracal scats collected in the Mountain Zebra National Park, South Africa including scats from boundary areas with farms (Grobler 1981). The most common prey item was the rock hyrax (dassie). Indeed, caracals have the potential to benefit crop farmers by limiting pest populations of this species (Davies 1997).

The caracal is legally classified as a problem animal in South Africa and Namibia, permitting aggrieved landowners to kill it without restriction. An average of 2,219 animals were killed annually between 1931-1952 in South Africa's

Karoo region (Stuart 1982). Similarly, Namibian farmers responding to a government questionnaire reported killing up to 2,800 caracals in 1981 (Joubert *et al*. 1982). Although control measures in South Africa and Namibia are intense, caracals have demonstrated resilience and remain widespread. Nonetheless, the effects on populations have not been quantified. Intensive persecution where they naturally occur at low densities, for example in Niger where Tuareg pastoralists hunt them assiduously with dogs (Dragesco-Joffé 1993) is likely a significant threat.

Decline in habitat and/or prey availability

Habitat destruction is a significant threat in Central, West, North and north-east Africa where caracals are naturally sparsely distributed (Kingdon 1977). A combination of burning, cultivation and pesticide use in dry savanna threatens

Field locations for **Caracal** studies.

a number of protected areas in Cameroon, Niger, Nigeria and Senegal (IUCN/ UNEP 1987) where caracals occur patchily (Kingdon 1977). This is likely exacerbated by increasing desertification of the Sahel savanna band (IUCN/ UNEP 1987). Local extinction occurs in mesic areas where intensive agricultural practices remove all cover.

Interspecific conflict

Although records are few, caracals are occasionally killed by larger carnivores, with unattended kittens possibly also vulnerable to jackals and large raptors. Packs of feral domestic dogs infrequently kill them in rural areas (L. Hunter *pers. obs.*). Jackals occasionally harass caracals but at their own risk; in one account, a caracal treed by two black-backed jackals leapt on one and killed it (Davies 1997). Range expansion in Southern Africa is speculatively linked to the extirpation of black-backed jackals (Pringle and Pringle 1979; Stuart 1982; Stuart and Wilson 1988), implying release from competitive pressure, although this remains untested.

Road kills

Little information but their ability to persist in rural and peri-urban areas with relatively high densities of roads makes them vulnerable to vehicles such that they are killed on major roads even where sparsely distributed (Kunzel *et al*. 2000). Significant impacts are likely to be limited to low density populations.

Human hunting and commercial trade

The caracal is not protected over most of its range and is widely hunted opportunistically. The species is resilient to hunting pressure but is threatened where it is naturally sparsely distributed or where it has been reduced to fragmented
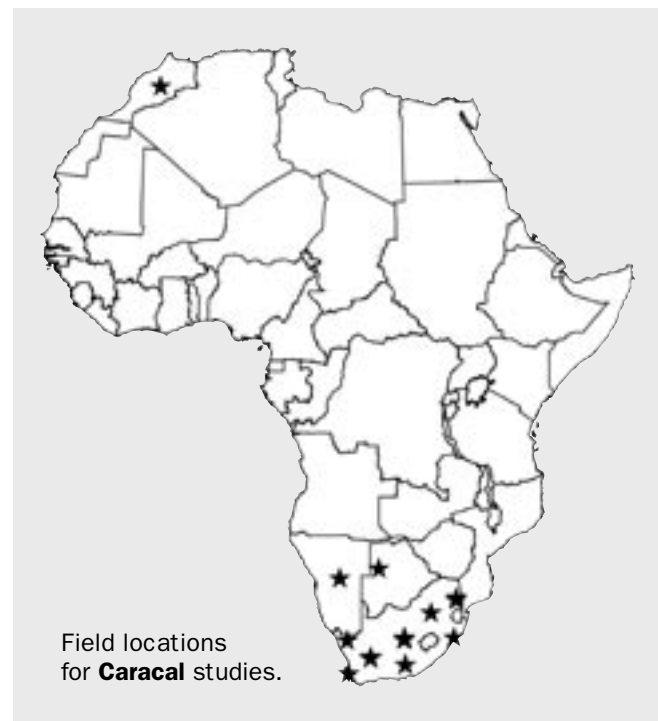
pockets of occurrence. The threat is greatest in West and Central Africa where low density populations are exploited for skins and "luxury bushmeat" (F. Hurst *in litt*.; Nowell & Jackson 1996). There is little commercial trade in the species.

Recreational hunting of caracals with dogs and by spotlighting is widespread in parts of southern Africa but the effects on populations are unknown. Predator hunting clubs in the former Cape Province, South Africa, reported between 0.02 and 1.6 caracals killed annually per 10 km^2 (Brand 1989).

No data
Disease, Genetic poverty, Climate change, Insect control, Tourism

CANIDAE

ETHIOPIAN WOLF (CANIS SIMENSIS)

Habitat associations
Ethiopian wolves are restricted to afroalpine grasslands and ericaceous heathlands at altitudes of 3000-4400 m. Afroalpine habitats (approximately 3700-4400 m asl) are preferred while subalpine habitats (3000-3700 m) are considered marginal for wolves (Sillero-Zubiri & Macdonald 1997).

Degree of ecological specialization
Perhaps the most specialized carnivore discussed here, the Ethiopian wolf is endemic to the high montane ecosystem of Ethiopia. Members of this species are dependent on high altitude afroalpine rodents which account for up to 96% of prey occurrence in faeces from Bale Mountains (Sillero-Zubiri & Macdonald 1997). The abundance of rodent prey is closely correlated with that of wolves (Sillero-Zubiri *et al*. 1995a; 1995b).

Distribution trends
The global range of the Ethiopian wolf is broken up into to eleven small fragments, totaling less than 12,000 km^2 (Sillero-Zubiri & Marino 2004). Ethiopian wolves have always been restricted to afroalpine grassland, a habitat that has never been widespread although it probably covered a greater area in the past. During the gradual warming that took place in the late Pleistocene, this habitat retreated to higher altitudes, and the wolves were forced into ever smaller, isolated pockets. For approximately the last three centuries, this isolation has been aggravated by increasing human utilization of their habitat (Marino 2003). Nine of eleven populations occur outside protected areas. Density estimates are highest for Bale Mountains National Park (BMNP) (0.5/km^2) compared to Simen Mountains National Park (protected) and Guassa region (unprotected) at 0.2 km^2 (Marino 2003; Ashenafi *et al*. 2005)

Human conflict

Attitudes towards the Ethiopian wolf by local people relate directly to their farming and grazing needs (Sillero-Zubiri & Macdonald 1997). Although some populations are tolerated and evidence of stock-killing is scarce, wolves have been hunted as pests in the some of the northern parts of their range where pressure for land is severe (Ginsberg & Macdonald 1990; Sillero-Zubiri & Macdonald 1997; Marino 2003). Gottelli & Sillero-Zubiri (1992) observed only two cases of livestock predation in Bale, but found that 66% of heads of families interviewed (n = 40; Oromo pastoralists) in regions of high wolf density had declared at least one lamb loss to wolves in the preceding three years. Losses blamed on wolves in the southern highlands were dismissed as unimportant compared to losses to other carnivores, particularly spotted

Current (dark gray) and historical (light gray) distribution of **Ethiopian wolf (Canis simensis)**.

hyena (Gottelli & Sillero-Zubiri 1990). Marino (2003) surveyed villagers at five sites where wolves occurred; 90% of respondents from one (North Wollo) were negative towards wolves but no data are provided on persecution. In the unprotected Guassa region where cattle are the most common livestock, Ethiopian wolves were largely ignored by cattle herders, and their presence had little or no influence on wolf behavior (Ashenafi *et al*. 2005). In contrast, although sheep herding is rare in this region, sheep herders chased wolves though no data are provided on persecution (Ashenafi *et al*. 2005).

Ethiopian wolves in the Bale region were used as shooting targets by the Oromo people in the period of unrest following the overthrow of the Mengistu government in 1991 (Gottelli and Sillero-Zubiri 1992; IUCN/SSC, 1997b). This appears to have been fueled by grudges towards Park administration in which wolves were killed as scapegoats for broader political problems (Gottelli & Sillero-Zubiri 1992; Sillero-Zubiri & Gottelli 1993). At least six adult wolves were shot in late 1991, with the shooting of a breeding female resulting in the death of her 3 week old litter. Two other pups died when their den was blocked with the corpse of a shot wolf (Gottelli & Sillero-Zubiri 1992).

Decline in habitat and/or prey availability

Rapid and continuing habitat loss due to subsistence agriculture in the Ethiopian highlands represents the major threat faced by Ethiopian wolves (Sillero & Marino 2004). The Ethiopian highlands are among Africa's most densely populated agricultural areas, where rural population densities of 47 people/km^2 are typical (Gottelli & Sillero-Zubiri 1992; Gottelli *et al*. 1994). The associated

Field locations for **Ethiopian wolf** studies.
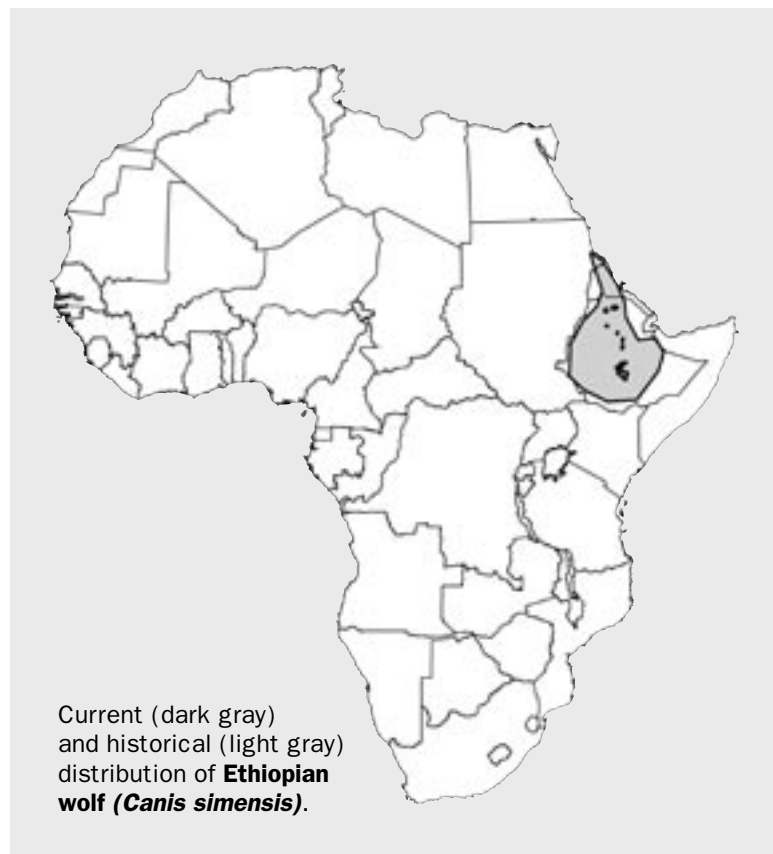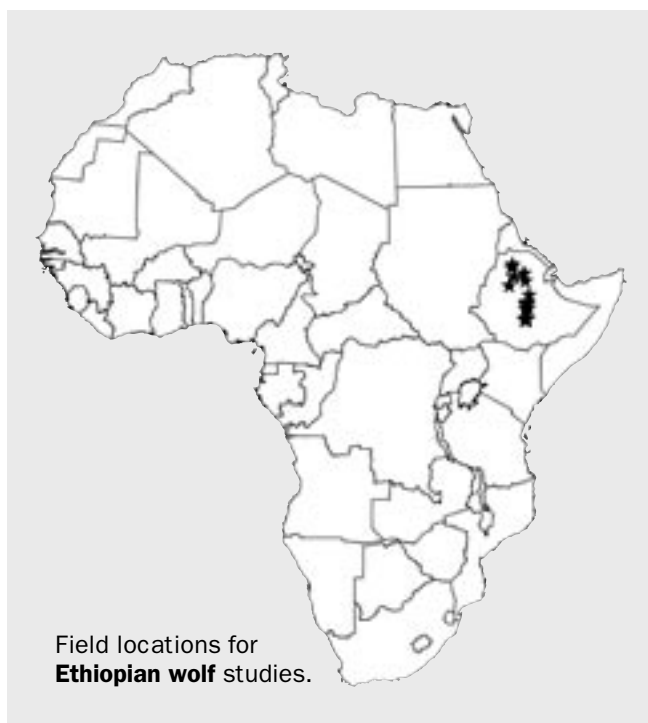
intensification of high-altitude agriculture, shifting cultivation, heather fires, fuelwood collection, and livestock overgrazing results in increased conflict with human activities and diminished mole-rat prey populations (Gottelli & Sillero-Zubiri 1992; IUCN/SSC 1997b). Wolves living in the unprotected Guassa area where grazing pressure is high survive by eating chiefly small murids; however, wolf densities are lower, possibly due to lower overall prey biomass (Ashenafi *et al*. 2005).

Interspecific conflict

The most immediate threat faced by Ethiopian wolves, at least in BMNP, is the domestic dog (Gottelli & Sillero-Zubiri 1992; Laurenson *et al*. 1997). Domestic dogs kept by sheepherders are effectively independent, living on offal and carrion, and roaming widely in wolf habitat (Gottelli & Sillero-Zubiri 1992; IUCN/SSC 1997b). Contact between the two species is greatest along the lower limits of the Ethiopian wolf's altitudinal range (Gottelli & Sillero-Zubiri 1992; Sillero-Zubiri *et al*. 1996). Domestic dogs affect Ethiopian wolf populations primarily by disease transmission (below) as well as through direct competition and aggression (dogs generally chased wolves in observed encounters) and hybridization/genetic introgression (Ginsberg & Macdonald 1990; Gottelli & Sillero-Zubiri 1992; Gottelli *et al*. 1994; Sillero-Zubiri 1994).

No known natural enemies, but leopards, spotted hyenas, domestic dogs, golden jackals, servals and large eagles are all potential predators (mainly of pups) or competitors for prey (Sillero-Zubiri & Gotteli 1994). Dogs and spotted hyenas exclude wolves from large carcasses and honey badgers might compete with wolves for prey and burrows (Sillero-Zubiri & Marino 2004).

Disease

Ethiopian wolves have suffered repeated disease outbreaks, which has resulted in significant declines to an already small population. Domestic dogs are strongly implicated as the reservoir of disease in all cases. In the early 1990s, rabies reduced wolf numbers in BMNP to an estimated 205-270 from 440-470 during 1990 (Gottelli & Sillero-Zubiri 1992; Sillero-Zuburi *et al*. 1996). Since this outbreak, the Bale population further declined to 120-160 adults. Interviews with Web Valley, BMNP inhabitants revealed the occurrence of another disease outbreak between 1993 and 1994, suspected to be canine distemper virus infection following a CDV outbreak in the surrounding domestic dog population (Malcolm & Sillero-Zubiri 1997; Laurenson *et al*. 1998). Thirty percent of wolves sampled (n=30) in the Web Valley of BMNP between 1989 and 1992 indicated past incidences of exposure to a variety of canine viruses, including CDV, canine adenovirus (CAV-1), and canine parvovirus (CPV-2) (Laurenson *et al*. 1998).

Between March-September 2003, another rabies outbreak killed 70-80% of the Web Valley population (Williams 2004).

Road kills

At least six wolves were killed on the Sanetti road traversing the BMNP between 1984 and 1991 (Hillman 1986; Gottelli & Sillero-Zubiri 1992). Another two Ethiopian wolves have become permanently lame from vehicle collisions, with two more being shot from the road (Hillman 1986; Gottelli & Sillero-Zubiri 1992). Again, such effects exacerbate the overall threat to this highly endangered population.

Human hunting and commercial trade

IUCN/SSC (1997a) found no indication of hunting for the fur industry or trading of live animals. No commercial uses are known (Ginsberg & Macdonald, 1990). Local use occurs opportunistically, for example, wolf skin is sometimes used as saddle pads (Sillero-Zubiri & Marino 2004).

Genetics

Ethiopian wolves hybridize with domestic dogs though to date, this has only been confirmed for the Bale region, where wolves are at their highest densities (Sillero-Zubiri & Marino 2004). Dispersing non-resident females from such areas may have a greater opportunity of encountering a dog instead of another wolf, and hybrids are thought to arise from male domestic dogs mating with female wolves (Gottelli & Sillero-Zubiri 1992; Laurenson *et al.* 1997). Hybrids may be active members of their packs, with at least one individual producing offspring (Gottelli *et al.* 1994). About 17% of the sampled population (wolves from both Sanetti Plateau and Web Valley) is represented by phenotypically abnormal individuals, suggesting substantial effects on the genetic integrity of Ethiopian wolves due to hybridization (Gottelli *et al.* 1994). The presence of dog alleles in wolves from the Sanetti region, an area mostly lacking domestic dogs, implies that gene flow from Web Valley may have caused the introgression of dog alleles into the Sanetti population (Gottelli *et al.* 1994).

Higher resistance to rabies epizootics in dog-wolf hybrids than phenotypically normal *C. simensis* suggests that diseases like rabies exacerbate genetic introgression. Subsequent to demographic bottlenecks, the establishment of hybrid wolves with greater rabies resistance would accelerate genetic drift (Sillero-Zubiri *et al.* 1996).

Climate change

Receding lower boundaries of the afroalpine grasslands due to gradual warming of the African continent has contributed to the decrease of Ethiopian wolf habitat (IUCN/SSC 1997b). Although it remains largely unquantified, significant future loss of afroalpine habitat as a result of global warming is highly likely.

No data

Insect control, Tourism

AFRICAN WILD DOG (LYCAON PICTUS)

Current (dark gray) and historical (light gray) distribution of **African wild dog** *(Lycaon pictus)*.

Habitat associations

Wild dogs historically occupied all habitats except for rainforest and desert interiors. They are presently found from semi-desert to relatively high rainfall regions, open plains, light to moderately closed woodland and dense upland forest (Woodroffe *et al*. 1997). They reach their highest densities in savanna woodlands (Woodroffe *et al*. 2004). Their current distribution is probably limited chiefly by human activities and availability of prey rather than loss of a specific habitat type (Woodroffe *et al*. 2004).

Degree of ecological specialization

African wild dogs are generalists with wide dietary and habitat tolerances. However, they require extremely large areas disproportionate to their body size and naturally exist at very low densities (Woodroffe *et al*. 2004).

Distribution trends

The African wild dog has undergone the second most extreme range retraction of all large carnivores considered here (after Ethiopian wolves). The species formerly occurred in 39 countries but is now extirpated from 25 of these. It is extinct or greatly reduced in West Africa, central Africa and north-east Africa. Large populations are restricted to southern Africa (Botswana, eastern Namibia, South Africa, Zambia and Zimbabwe) and Tanzania-northern Mozambique. Its status in Angola is unknown (Woodroffe *et al*. 2004).

Human conflict

Human persecution during the 20th Century is probably the single most important factor driving declines of African wild dogs throughout Africa (Woodroffe & Ginsberg 1997). A widespread perception of African wild dogs as vermin led to government-sanctioned control programs which destroyed thousands of individuals in the 1940s and 1950s, including inside protected areas (Childes 1988; Davies 1992; Woodroffe & Ginsberg 1999a). Although wild dogs are now protected throughout their range, intolerance and associated persecution persists on livestock areas, game farms and hunting concessions where wild dogs are widely perceived as wasteful killers of domestic and wild ungulates. Due to
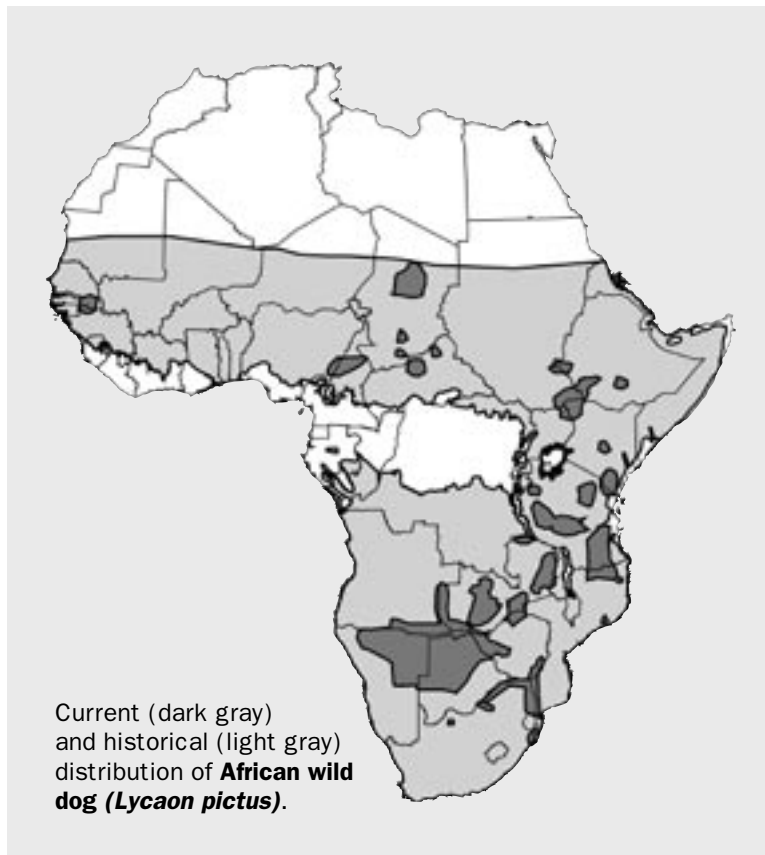
their wide-ranging movements which often take them beyond park boundaries, human persecution is also the most important cause of adult mortality in protected areas (Woodroffe & Ginsberg 1999a). Shooting and poisoning accounted for 21%, 19%, 25%, and 47% of known adult mortality for free-ranging African wild dog populations in Kruger National Park (van Heerden *et al*. 1995), Hwange National Park (Ginsberg *et al*. 1995a), Selous Game Reserve (Ginsberg *et al*. 1995a), and various Zambian protected areas (K. Buk, in Woodroffe & Ginsberg 1997) respectively.

The common portrayal of the wild dog as a rapacious stock-killer is rarely justified. Wild dogs generally ignore livestock when wild prey is available (Fuller & Kat 1990; Woodroffe *et al*. 2005b). In unprotected areas in northern Kenya, depredation was extremely uncommon (approximately one attack per 1000 km^2 annually) even though livestock was abundant (Woodroffe *et al*. 2005b). Herders who accompany their livestock by day, and use enclosures by night or kraals close to habitation rarely suffer losses to wild dogs (Fuller & Kat 1990; Rasmussen 1999; Woodroffe *et al*. 2005b). Unprotected or infrequently manned cattle ranches in Zimbabwe reported occasional wild dog predation on calves; for example, a two-year study in the Nyamandhlovu region recorded only 26 wild dog predations from a herd of 3,142 cattle accounting for 1.8% of the cost of total livestock losses (Rasmussen 1996; Woodroffe & Ginsberg 1997). Losses of small stock are occasionally severe, particularly where natural prey has been depleted. In northern Kenya, the cost of wild dog losses rose from US$3.40/wild dog/year in areas where both wild prey and livestock was abundant to US$389/wild dog/year where wild prey was seriously depleted.

Indirect anthropogenic mortality is significant in some areas, particularly along or just outside reserve borders. Snares intended chiefly for ungulates accounted for 21% and 25% of adult mortality for free-ranging wild dogs in Kruger (van Heerden *et al*, 1995) and Selous (Ginsberg *et al*. 1995a) respectively, and 5% for free ranging pups in Kruger (van Heerden *et al*. 1995). Snaring impacts can be locally severe. Over a third of monitored wild dogs in the Lower Zambezi National Park, Zambia carried snares and snare-related mortality was as high as 30% (Woodroffe *et al*. 2005).

Decline in habitat and/or prey availability

The wild dog's extensive land requirements and wide ranging behavior renders them particularly vulnerable to habitat loss (Woodroffe *et al*. 2005). Only extremely large wild areas offer protection from their chief threats, conflict with people and disease from domestic dogs. Land conversion to farming has driven eradication of wild dogs through wild prey depletion and direct persecution while fragmentation further drives wild dog declines by increasing contact with people and domestic dogs (Woodroffe & Ginsberg 1999a).

Interspecific conflict

Lions and spotted hyenas have major impacts on wild dogs. Lion predation is the single most important cause of natural mortality in free-ranging populations (Woodroffe & Ginsberg 1999a). Predation by lions comprised up to 47% (n = 7) of known adult *L. pictus* deaths from five sites, averaging 10% across all sites (Woodroffe *et al*. 2004). Pup mortality attributed to lion predation

Field locations for **African wild dog** studies.
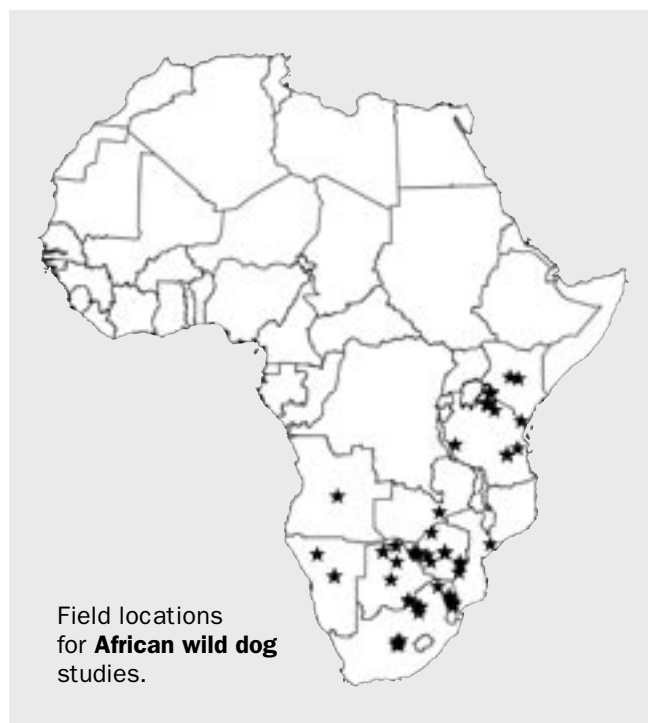
was highest in Kruger (37%; n = 14) and averaged 20% of total pup mortalities across sites (Woodroffe *et al*. 2004). Predation by spotted hyenas is less frequent. Across the same five sites, hyenas were responsible for 2% (n = 3) of adult and 6% (n = 6) of pup mortality (Woodroffe *et al*. 2004).

Kleptoparasitism, particularly from hyenas, may limit wild dog densities especially in open habitat with good visibility and high hyena densities (Woodroffe *et al*. 2004). The loss of kills to hyenas is particularly severe for small wild dog packs or when the ratio of hyenas to dogs is high (Fanshawe & Fitzgibbon 1993). Gorman *et al*. (1998) predicted that a 25% loss of kills would force Kruger National Park wild dogs to increase their foraging time to a physiologically unsustainable 12 hours a day. Predator avoidance can force wild dogs to occupy areas of low prey densities, requiring greater travel time when hunting. This inflates home range size and increases exposure to human activity, particularly at the borders of protected areas (Woodroffe *et al*. 2004).

Disease

Wild dogs seem particularly vulnerable to disease. Effects are likely to be most severe in small populations (Woodroffe *et al*. 2004) and may be additive, driving populations to extinction where other factors such as intense interspecific competition serves to keep densities low (Creel & Creel 1996; Carbone *et al*. 1997; Mills 2001).

Rabies is perhaps the most prevalent viral infection associated with disease-based mortalities in free-ranging populations. Indeed, this disease contributed to the extinction of wild dogs in the Serengeti ecosystem in 1990-1991(Woodroffe & Ginsberg 1997; Hofmeyr *et al*. 2000). Rabies mortalities are also confirmed from South Africa (Hofmeyer *et al*. 2004), Namibia (Scheepers and Venzke 1995) and the Central African Republic (A.K. Turkalo *in litt*.; Woodroffe & Ginsberg 1997); and is implicated in wild dog deaths in Zimbabwe (C. M. Foggin *in litt*.; Kat *et al*. 1995) and Zambia (K. Buk *in litt*.; Woodroffe & Ginsberg 1997). Rabies outbreaks contributed to the failure of attempted reintroductions into the Madikwe Game Reserve, South Africa (Hofmeyer *et al*. 2004) and Etosha National Park, Namibia (Scheepers & Venzke 1995)

Canine Distemper Virus (CDV) resulted in the loss of an entire pack in Chobe National Park, Botswana, (Alexander *et al*. 1996) and was implicated in wild dog deaths in the Serengeti ecosystem (Malcolm 1979; Macdonald *et al*. 1992; Alexander & Appel 1994), Kruger (Reich 1981) and Moremi Game Reserve, Botswana (J. W. McNutt *in litt*.; Woodroffe & Ginsberg 1999a).

Anthrax (*Bacillus anthracis*) related deaths of wild dogs have been recorded from Kruger NP (van Heerden *et al*. 1995), Selous (Creel *et al*. 1995), South

Luangwa National Park, Zambia (Turnbull *et al*. 1991) and central Kenya (Woodroffe *et al*. 2005). Resistance to anthrax by *L. pictus* appears to vary among populations (Woodroffe & Ginsberg 1997). Creel *et al*. (1995) suggest that *L. pictus* and *B. anthracis* may have co-existed long enough to reduce disease pathogenicity but mortality may increase when exposure becomes constant and heavy (Turnbull *et al*. 1991).

Serology studies implicates adenovirus, coronavirus and *Toxoplasma sp* in wild dog deaths (particularly of pups), though the impacts of these pathogens remains unclear (van Heerden *et al*. 1995; Woodroffe & Ginsberg 1997).

Road kills

The number of African wild dog mortalities attributed to vehicle collisions varies between populations and is correlated with road density and quality (Woodroffe & Ginsberg 1997). Road and rail mortality comprised 11% of all mortalities recorded from eight studies (Woodroffe *et al*. 2005). In Hwange National Park, Zimbabwe, more than half of recorded adult mortalities resulted from road accidents occurring along the high-speed Bulawayo-Victoria Falls highway bordering the northern edge of park (Ginsberg *et al*. 1995a). Three wild dog deaths were recorded in a 15-month period along a 20 km stretch of the Tanzania-Zambia highway, where it passes through Mikumi National Park, Tanzania (Drews 1995). Highways passing through Kafue National Park, Zambia, accounted for eight vehicle related mortalities (K. Buk *pers. comm*., in Woodroffe & Ginsberg 1997).

Human hunting and commercial trade

No commercial uses aside from non-consumptive ecotourism (Woodroffe *et al*. 2004).

Genetic issues

Wild dog populations may be susceptible to low levels of genetic heterozygosity (R. Wayne *in litt*.; Ginsberg & Macdonald 1990), potentially increasing vulnerability to diseases and pathogens.

Other: Handling

Handling by researchers was controversially implicated in the decline and eventual extinction of wild dogs in the Serengeti ecosystem. Burrows *et al*. (1994) first suggested that stress from handling increased the susceptibility of wild dogs to diseases like rabies due to increased adrenocorticosteroid production resulting in immune suppression, and possible reactivation of latent rabies virus in handled carriers. This suggestion was later discredited by detailed studies and reviews (Creel 1992; Ginsberg *et al*. 1995a) and current consensus suggests handling constitutes a negligible threat or none at all (Ginsberg & Woodroffe 1990; Woodroffe *et al*. 2004; Woodroffe *et al*. 2005).

No data

Climate change, Insect control, Tourism

Current (dark gray) and historical (light gray) distribution of **Black-backed jackal** *(Canis mesomelas)*.

BLACK-BACKED JACKAL (CANIS MESOMELAS)

Habitat associations

Black-backed jackals prefer open habitats and avoid densely vegetated areas but they occupy virtually all habitats within their distribution including arid coastal desert, fynbos, montane grassland, woodlands, savannas and farmlands.

Degree of ecological specialization

Black-backed jackals are generalist feeders subsisting on a very catholic diet dominated by small-medium sized vertebrate prey, invertebrates, carrion and human refuse. They are opportunistic and aggressive competitors, able to displace other jackal species and smaller predators from food resources (Loveridge & Nel 2004).
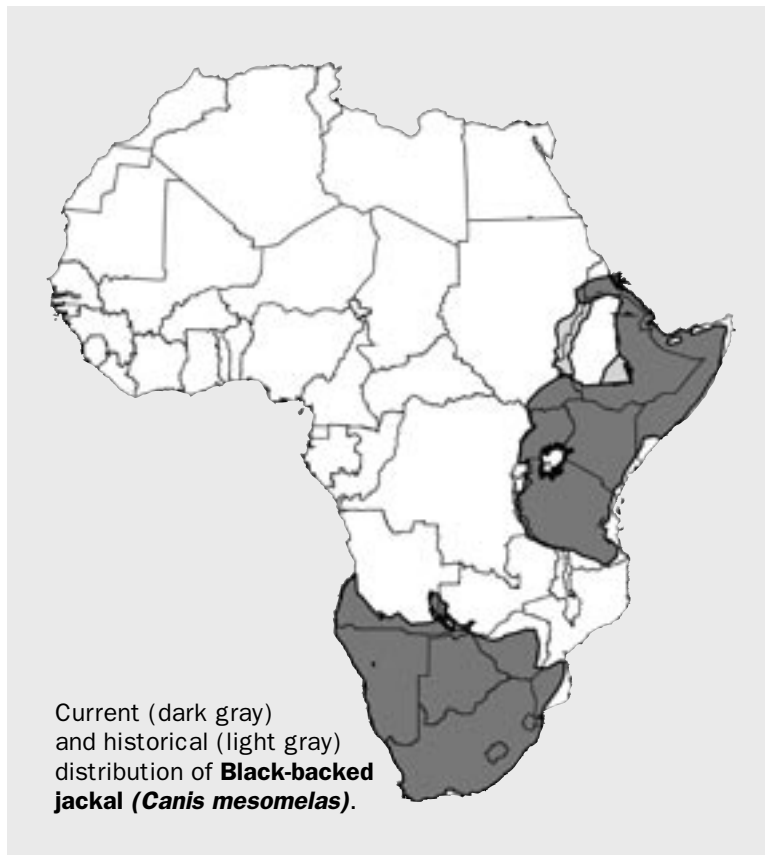
Distribution trends

Even in historical times, black backed jackals appear to have always existed in two disjunct populations in East and southern Africa. There is little evidence of change in distribution except locally in metropolitan areas with very high human densities.

Human conflict

This species has the reputation of being a voracious predator of small stock and calves, and is also blamed for mauling cows during birth (Rowe-Rowe 1986). Although black-backed jackals do take livestock, depredation usually is localized and comprises a relatively small percentage of losses (Rowe-Rowe 1975; Lawson 1989). Sheep predation is seasonal, with frequencies increasing during the lambing season, with severe potential impacts on individual farmers (Rowe-Rowe 1986; Brand 1993). With controlled husbandry particularly during the lambing season, losses are reduced dramatically (Brown 1988).

Based on this perception, black-backed jackals are intensely persecuted by trapping, poisoning, shooting and hunting with dogs (Rowe-Rowe 1986; Bingham & Purchase 2002). In most countries within their range, jackals are afforded no legal protection outside protected areas and are shot as vermin by landowners and recreational shooters when encountered. As is common for mesocanids, despite the enormous effort and expense involved in population control efforts, extirpation is largely ineffective. Hunting, trapping or poisoning of

C. mesomelas in agricultural areas forms population gaps that are filled by either neighboring territory expansion or dispersing sub-adults from other areas (McKenzie 1993). Local reductions in density are temporary (Loveridge & Nel 2004) and control efforts are probably best directed towards specific individuals causing damage (Rowe-Rowe 1986).

Decline in habitat and/or prey availability

Despite the widespread conversion of natural habitat to farmland in East and southern African, black-backed jackals appear little affected. They likely benefit from predator release in livestock farming areas where they remain relatively abundant despite intense human persecution. Because jackals are rarely censused, population trends in relation to landscape and/or prey changes are unknown. Densities are probably lower in intensive crop farming areas but they persist provided healthy rodent populations occur.

Field locations for **Black-backed jackal** studies.
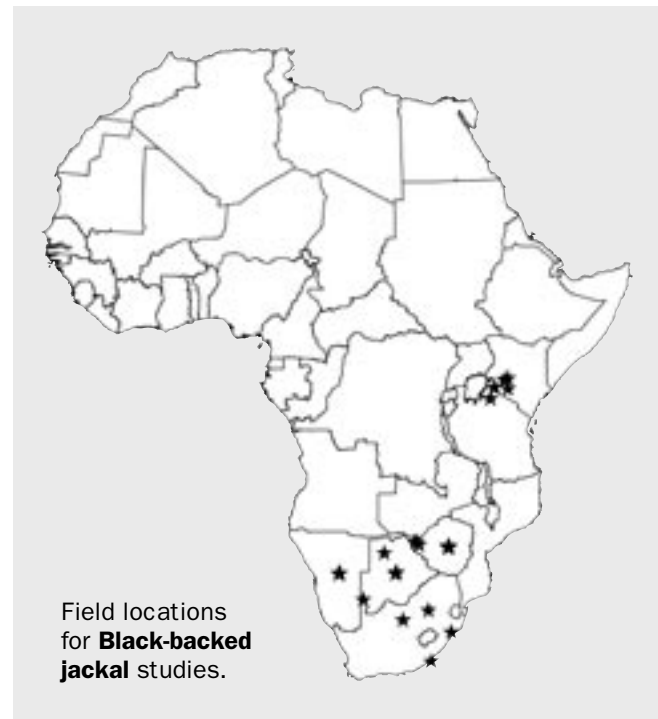
Interspecific conflict

Black-backed jackals are killed by large felids, hyenas, African wild dogs, and in the case of pups or sub-adults, other jackal species and large raptors (Loveridge & Nel 2004). Leopards appear to occasionally specialize on jackals (Estes 1967; Kingdon 1977). Black-backed jackals compete with other scavengers for carrion but generally displace similarly-sized species (such as other jackals) or benefit overall from remains left by larger species. Large domestic dog populations in rural areas appear to be correlated with low jackal densities, perhaps as a result of competitive exclusion or predation (Brooks 1990; Bingham *et al*. 1999a; Butler & Du Toit 2002).

Disease

Black-backed jackals are vulnerable to domestic dog diseases and test positive to most transmissible canid diseases wherever the two species overlap. They are considered significant vectors of rabies in southern Africa. Most of Namibia's reported rabies cases involving wildlife between 1986 and 1996 were in black-blacked jackals, 1.3 cases/month compared to 0.5 cases/month for domestic dogs (Courtin *et al*. 2000). However, stable populations, particularly those in conservation areas, have low to non-existent rabies prevalence. The highest prevalence is associated with high levels of persecution where rapid population turnover gives rise to increased movement of individuals; this may facilitate increased transmission of rabies by increasing contact rates between strange individuals. In Zimbabwe, of 397 *C. mesomelas* rabies cases between 1950 and 1996, 78.8% occurred on commercial farmlands, 11.3% in the communal sector, 9.6% in urban areas, and 0.3% in protected areas (Bingham *et al*. 1999a).

In the Serengeti-Mara ecosystem of East Africa, canine distemper virus (CDV) is thought to have been the cause of several fatal epidemics affecting black-backed jackal populations in 1978 (Moehlman, 1983). During the 1994-1995 Serengeti ecosystem CDV epidemic, however, neurological disease was observed in only two individuals suggesting resistance was conferred from previous exposures (Roelke-Parker *et al*. 1996). Serology studies show exposure to various other diseases including canine parvovirus, and canine adenovirus type-1 but mortalities and effects on populations remain unknown (Spencer *et al*. 1999).

Road kills
Road kills claim many jackals and, together with snaring, may be the commonest cause of mortality in areas of high human density (Loveridge & Nel 2004). The extent to which this mortality agent impacts population levels, however, remains unknown.

Human hunting and commercial trade
This species is hunted for the local fur trade, especially in South Africa and Namibia where karosses (rugs) made of multiple skins are locally popular and sold to tourists. However, the industry is not widespread (Loveridge & Nel 2004).

Genetic issues
C. mesomelas occasionally interbreeds with domestic dogs (Van der Merwe 1953a). The degree of occurrence and associated impacts has not yet been fully investigated but hybridization is unlikely to constitute a significant threat.

No data
Climate change, Insect control, Tourism.

SIDE-STRIPED JACKAL (CANIS ADUSTUS)

Habitat associations
Side-striped jackals occupy most habitats in African broad-leaved savanna zones, including various woodlands, open grasslands, marshlands and montane habitats, and human-modified habitats including livestock farms, abandoned cultivation, rural and peri-urban areas (Atkinson & Loveridge 2004). Side-striped jackals invade the edges of equatorial forest in association with human settlements (Kingdon 1997) and appear more tolerant of dense habitats than other jackal species (Loveridge 1999).

Degree of ecological specialization
Omnivorous and highly opportunistic, with a celebrated ability to persist in areas where food resources are scarce (Atkinson 1997b). Atkinson & Loveridge (2004) suggest that the species dietary flexibility and ability to live close to humans renders populations vulnerable only to extreme habitat modification or severe disease epidemics.

Distribution trends

There is no evidence for any negative change in distribution, except locally where large cities and dense human populations occur. They are considered common, stable and widespread throughout their distribution (Atkinson & Loveridge 2004).

Human conflict

The side-striped jackal is considered the least predatory jackal species and very rarely takes mammals larger than baby antelopes (Atkinson & Loveridge 2004). There is very little evidence for predation upon domestic stock though it is often mistakenly blamed for losses and killed in indiscriminate predator control efforts, particularly in southern Africa where persecution may be intense (Atkinson & Loveridge 2004). Similarly, as for other jackal species, it is widely trapped and poisoned during rabies outbreaks in attempts to control the disease (Ginsberg & Macdonald, 1990). Control efforts probably reduce densities in some areas, although Bingham & Purchase (2002) demonstrated that culling has to be very intense to produce significant long-term declines in jackal populations.

Current distribution of **Side-striped jackal *(Canis adustus)***. No significant change from historical distribution.
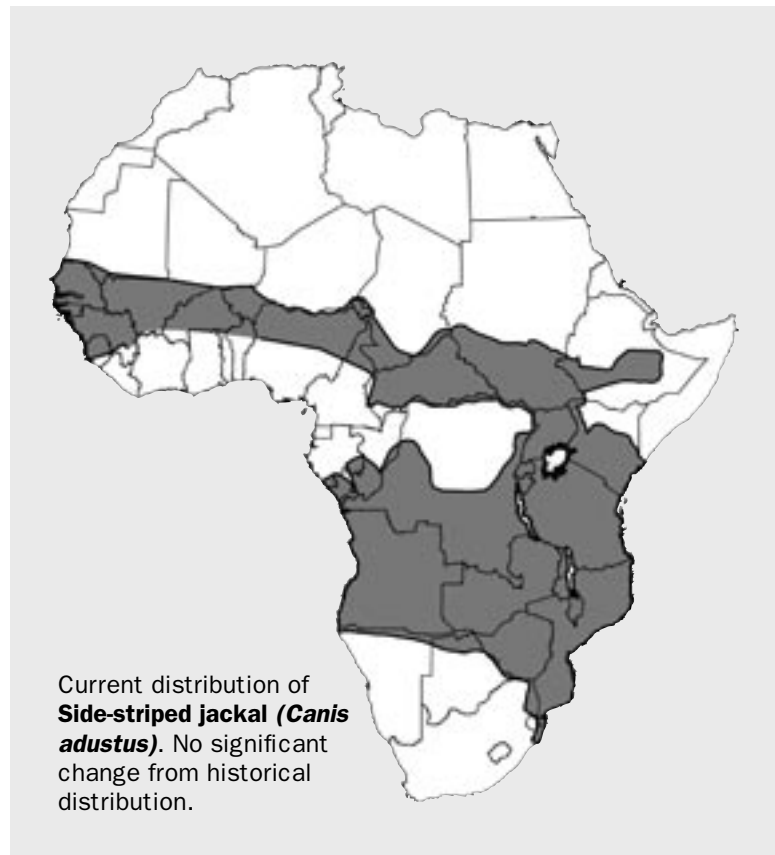
Decline in habitat and/or prey availability

Side-striped jackals are capable of exploiting rural, urban and suburban habitats (Atkinson & Loveridge 2004) and appear little affected by anthropogenic habitat change. They exploit temporal and spatial fluctuations in a wide variety of food resources, including fruit, invertebrates, rodents, carrion and human refuse. The species may benefit from anthropogenic forest clearing and encroachment of savanna habitats at the edges of the equatorial forest belt in central Africa (Kingdon 1997).

Interspecific conflict

Despite its larger size, this species is dominated by other jackals, especially by the black-backed jackal which always displaces *C. adustus* during interspecific encounters (Loveridge & Macdonald 2002). In areas of sympatry, competitive exclusion by black-backed jackals limits their access to carrion, and they are displaced from prime open habitats where *C. mesomelas* reaches high densities (Loveridge 1999; Loveridge & Macdonald 2003). Likewise, in rural areas, high densities of domestic dogs possibly limit their access to carrion (Butler & Du Toit 2002).

Leopards are considered the species' chief natural predator (Atkinson & Loveridge

Field locations for **Side-striped jackal** studies.
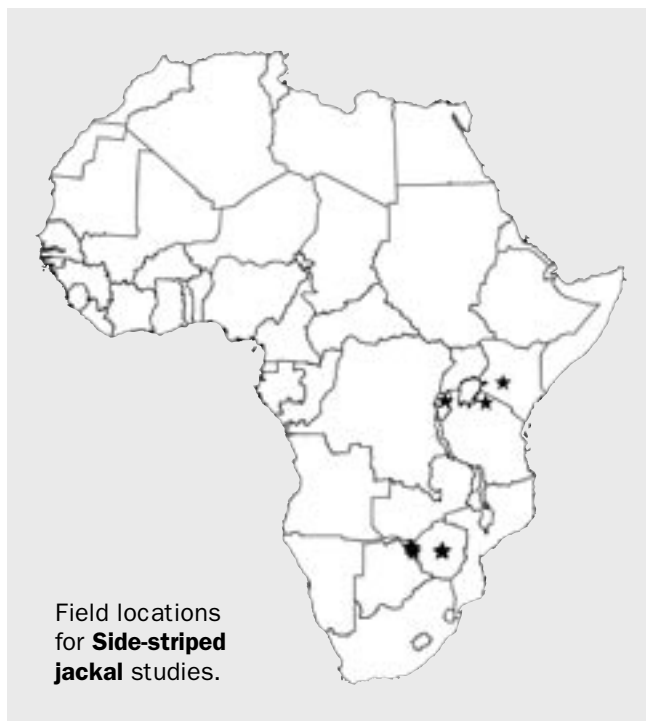
2004) though it is vulnerable to the same suite of predators as the black-backed jackal. Individuals in urban and rural populations are sometimes killed by domestic dogs.

Disease

Vulnerable to canid diseases, as for *C. mesomelas*. In Zimbabwe, *C. adustus* is considered to be a maintenance host for rabies (Bingham *et al*. 1999a; Bingham *et al*. 1999b; Bingham & Purchase 2002). As for the black-backed jackal, it appears that rabies is most prevalent in disturbed populations. Between 1950 and 1996, 88.5% (n = 2,050) of *C. adustus* rabies cases were reported from commercial farmlands, 4.9% from the communal sector, 6.3% from urban areas, and 0.2% from protected areas (Bingham *et al*. 1999a). Interactions with domestic dogs at the boundaries of communal lands and commercial farmland continually expose *C. adustus* to disease infection. This is believed to be the primary entrance point of rabies infection into jackal populations in Zimbabwe (Rhodes *et al*. 1998).

During the early part of the 20th century (1900s), large numbers of side-striped jackals were believed to have died from distemper (Ginsberg & Macdonald 1990). Sera collected from 22 free-ranging *C. adustus* in Zimbabwe between 1990 and 1993 revealed that 8, 2, and 6 individuals were seropositive for canine distemper virus, canine parvovirus, and canine adenovirus type-1, respectively. Although results indicate that the side-striped jackals can be infected by these viruses and potentially act as reservoirs for them, the degree of susceptibility by *C. mesomelas* remains unknown (Spencer *et al*. 1999). Tick fever and sarcoptic mange have been recorded (Kingdon 1977; Atkinson & Loveridge 2004). As with other jackal species, side-striped jackals are seldom monitored enough to detect population impacts from disease or other agents of disturbance.

Road kills

Side-striped jackals are hit by vehicles around towns and suburbs (Kingdon 1977). The impact on populations remains unknown, but their ability to reach high densities around towns suggests it does not constitute a significant threat.

Human hunting and commercial trade

No commercial uses are known. Parts are used locally for traditional medicinal purposes (Ginsberg & Macdonald 1990). Snaring by-catch accounts for as much as a third of adult deaths in areas of high human populations, though areas around towns often harbor very high densities of the species (Atkinson 1997a; Atkinson & Loveridge 2004).

No data

Genetic, Climate change, Insect control, Tourism.

WILDLIFE CONSERVATION SOCIETY

GOLDEN JACKAL (CANIS AUREUS)

Habitat associations

Golden jackals display a wide tolerance for different habitats. They occur in all natural habitats within their range, are absent only from hyper-arid regions of the Sahara (Le Berre 1990), and are common in semi-desert, open grasslands, woodland savannas, montane forest and mangroves. They are tolerant of human-modified habitats.

Degree of ecological specialization

Like other jackals, the golden jackal is an opportunistic generalist with an omnivorous diet and ability to occupy a wide variety of natural and human-modified habitats. It is the most widespread jackal species (the

Current (dark gray) and historical (light gray) distribution of **Golden jackal** *(Canis aureus)*.

only one occurring outside Africa) and in much of its range, it is the only jackal species present.

Distribution trends

There is little evidence for distribution declines except locally in areas of intensive agriculture and industrialization. Extra-limitally, they have undergone range expansion in parts of Europe (see Giannatos 2004 for review) though there are no data from Africa.

Human conflict

Golden jackals sometimes kill small and vulnerable stock as well as poultry (Kingdon 1977; Jhala & Moehlman 2004), but appear to create considerably fewer problems than other jackal species. They also cause damage to various cash crops; most reports come from Asia (see Jhala & Moehlman 2004 for references). Golden jackals are killed in indiscriminate predator control operations, particularly by poison-laced carcasses (Frank 2004) but the lack of large-scale statutory control programs for small carnivores (as widely practiced in South Africa and Namibia) in most of golden jackal range probably indicates that effects on the species are localized.

Decline in habitat and/or prey availability

Similar to other jackals, this species is tolerant of anthropogenic habitat change. Extralimitally (India), land-use conversion from traditional farming to intensive agriculture and industrialization is thought to be reducing golden jackal

Field locations for **Golden jackal** studies.
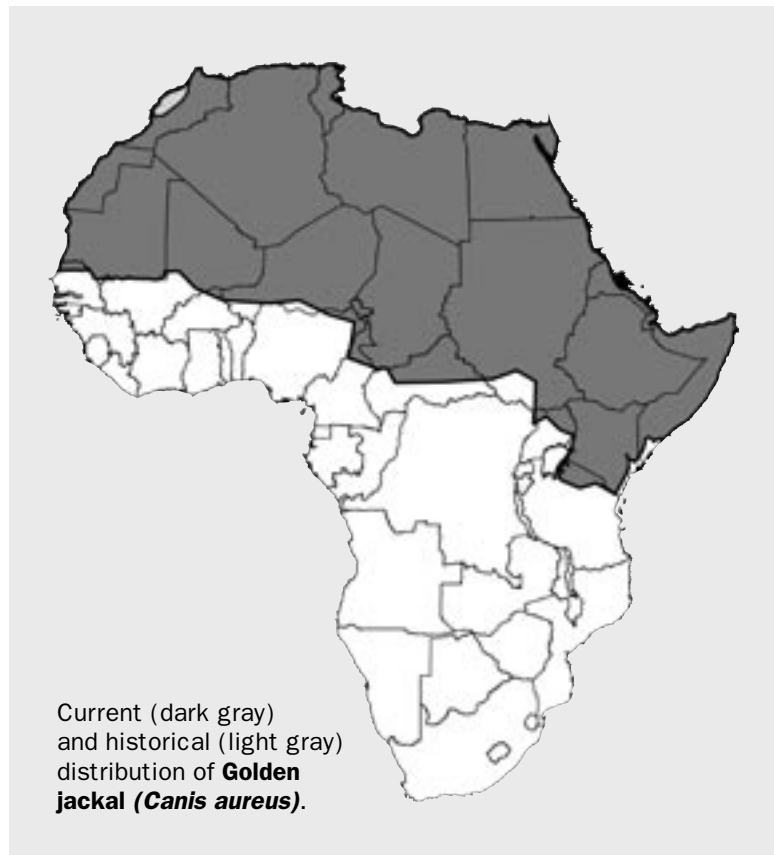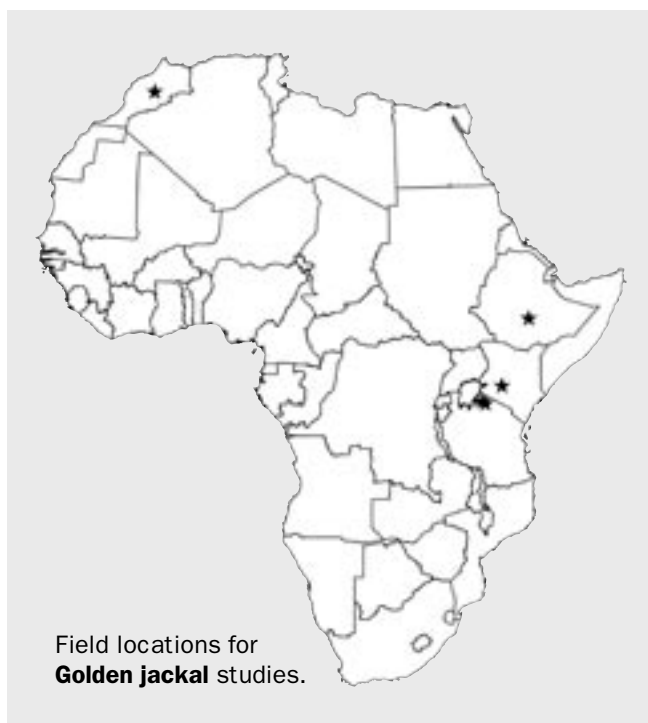
populations (Jhala & Moehlman 2004), though there are no data from Africa.

Interspecific conflict

Black-backed jackals apparently displace golden jackals from carrion; the latter were less common than the former at large carnivore kills in Ngorongoro Crater despite being more abundant in the area (Wyman 1967). Additionally, they are generally less bold than *C. mesomelas* in scavenging from kills when larger carnivores are present, and probably less than 20% of their diet comes from scavenging kill remains (Estes 1991).

Golden jackals are vulnerable to the same predators as other jackals. Spotted and striped hyenas feature prominently as predators in the few available reports (Kruuk 1972; Kingdon 1977; Jhala & Moehlman 2004) though probably no more so than for any jackal species. They are sometimes killed by feral dogs around towns and villages (Jhala & Moehlman 2004).

Disease

Vulnerable to canid diseases as for other jackals. Rabies and CDV are likely the most important. They are commonly reported from populations in India (Jhala & Moehlman 2004), though prevalence of both in Africa appears less frequent and less widespread than in *C. mesomelas* and *adustus*. During the 1994-1995 Serengeti ecosystem distemper epidemic, CDV-like neurological disease was observed in a single golden jackal (Roelke-Parker *et al.* 1996). In Tanzania, serological tests have returned positive for canine parvovirus, canine herpesvirus, canine coronavirus and canine adenovirus (W. Karesh, in Jhala & Moehlman 2004). In Nakuru, Kenya, nine of sixteen *C. aureus* tested positive for CPV-2, with none testing positive for CDV antibodies. Sarcoptic mange is apparently common in high density populations (Jhala & Moehlman 2004). The impacts on individuals and populations of viral diseases remain unknown.

Road kills

Few reports from Africa. In India where this species reaches high densities in rural areas, it is the most common species after domestic dogs killed on roads (Jhala & Moehlman 2004). African populations appear less affected perhaps because the majority of its African distribution is characterized by a relatively low density of roads. Golden jackals are invariably hit by vehicles in and adjacent to protected areas (Mills & Harvey 2003) but this appears to be an insignificant threat.

Human hunting and commercial trade

There is no significant commercial use of *C. aureus* in Africa (Ginsberg & Macdonald 1990; Jhala & Moehlman 2004).

Genetic issues

Hybridization with domestic dogs occurs (Kingdon 1977) but there are few reports. It is unlikely to constitute a significant threat for most populations.

No data

Climate change, Insect control, Tourism.

HYAENIDAE

AARDWOLF (PROTELES CRISTATUS)

Habitat associations

Aardwolves inhabit primarily open-country in eastern and southern Africa, particularly open, grassy plains. They display a marked preference for areas with a mean annual rainfall between 100 mm and 800 mm (Mills & Hofer 1998). They are absent from forests and true deserts. Under optimum conditions, densities can reach 1 adult/km^2 (Richardson 1984; 1985; Skinner and Van Aarde 1985).

Degree of ecological specialization

Aardwolves have highly specialized feeding habits, being apparently unable to feed efficiently on any prey other than social insects (Anderson *et al*. 1992). Throughout their range, they rely almost exclusively on nasute harvester termites of the genus *Trinervitermes* (Smithers 1971; Kruuk & Sands 1972; Richardson 1987). In winter or high rainfall periods when *Trinervitermes* is less active, aardwolf diet is supplemented by other termites such as *Hodotermes mossambicus* in southern Africa (Richardson 1987) and *Odontotermes* and *Macrotermes* in East Africa (Kruuk & Sands 1972).

Current (dark gray) and historical (light gray) distribution of **Aardwolf (Proteles cristatus)**.
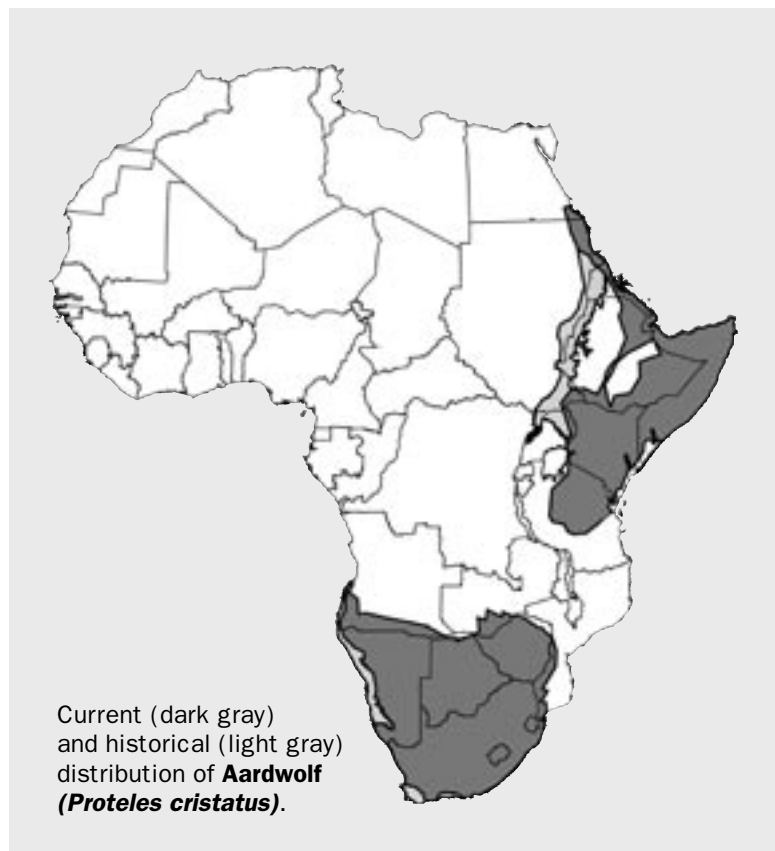
Distribution trends

Aardwolves occur presently and historically in two distinct populations in eastern and southern Africa, separated by a 1,500 km gap of relatively unsuitable wetter woodland habitat. They have never occurred in the arid grassland habitats in western Africa, perhaps because harvester termites there are less abundant and occur in bushier habitats than in southern and eastern Africa (Skinner 1977). There is no significant difference between the current and historical distribution of aardwolves (Mills & Hofer 1998). While some distribution records are not recent, for example, from Zimbabwe and southwestern Angola (Mills & Hofer 1998), there is no evidence that aardwolves have been extirpated from these areas.

Decline in habitat and/or prey availability

Although prime aardwolf habitat is commonly used for livestock grazing, this land use rarely results in sufficient enough habitat conversion to seriously affect aardwolves (Mills & Hofer 1998). Intensive agriculture, which affects a much smaller proportion of aardwolf range, has probably resulted in minor loss of habitat and prey.

Human conflict

Aardwolves are almost exclusively insectivorous and unlikely to be responsible for domestic stock losses (Kok 1996). Nonetheless, the majority of aardwolves in southern Africa occur on farmlands outside conservation areas where they are widely perceived as lamb predators and often shot opportunistically (Von Ketelhodt 1966; Richardson 1984; Anderson 1988; Mills & Hofer 1998). Misidentification of aardwolves as hyenas or jackals contributes to this persecution (Kruuk and Stands 1972; Gingerich 1975).

Human hunting and commercial trade

Both the extent of cultural use and its impact on aardwolf populations remain undetermined but are probably minor (Anderson 1988; Richardson 1984). Aardwolves are opportunistically hunted in some regions for body parts used in medicinal applications and are occasionally sought for pelts and meat (Estes 1991). There is no international market for aardwolf pelts.

Disease

Although rabies and rabies-related viruses have been confirmed in 43 specimens from southern Africa (Swanepoel *et al*. 1993), disease appears to be a minor contributor to aardwolf mortality (Mills & Hofer 1998).

Interspecific conflict

Together with severe drought, black-backed jackal predation is the most important cause of aardwolf cub mortality in well-studied populations (Mills & Hofer, 1998). Brown hyenas have been recorded attempting to dig out aardwolf cubs but aardwolves are very rarely recorded in hyena diet (Mills 1990), suggesting the threat is minor.

Although there are few observations, large carnivores would have little trouble over-powering adult aardwolves despite *Hyaena* mimicry by the much

weaker and poorly matched *Proteles* as a preda- tor defense tactic (Gingerich 1975). Aardwolves are indiscriminately killed by dog packs hunting jackals and foxes (Von Ketelhodt 1966; Rich- ardson 1984; Anderson 1988; Mills & Hofer 1998).

Direct foraging competition between aard- wolves and other ant/termite-feeders is generally avoided due to most other species' intolerance of terpene secretions of *Trinervitermes* (Bothma *et al*, 1984; Richardson 1987c; Smithers 1983). Aardvarks eat *Trinervitermes* but their excava- tion of termite nests is probably a net benefit to aardwolves, particularly during times of food stress (Taylor & Skinner 2000). Opening *Tri- nervitermes* nests by aardvarks may also al- leviate competition from bat-eared foxes for *Hodotermes* during winter months (Richardson & Levitan 1994; Mills & Hofer 1998).

Field locations for **Aardwolf** studies.
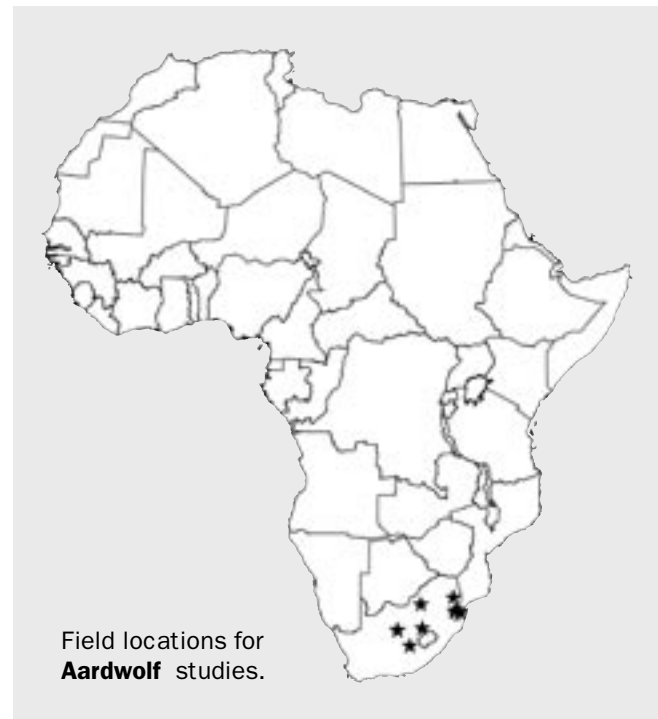
Road kills

Collisions with motor vehicles at night contribute to aardwolf mortality. In southern Africa, road kills are most prevalent during summer months during the time when yearlings are emigrating from their natal territories (Mills & Hofer, 1998).

Climate change

Global warming has the potential to affect aardwolf distribution given their acute niche specialization. Changing precipitation levels and temperatures will influence the seasonal availability of aardwolf food resources and hence the distribution of the species (Richardson 1987).

Aardwolves undergo severe food stress during winter in southern Africa when *Trinervitermes* become inactive. Aardwolves compensate by shifting peak activity to the early afternoon to feed on *Hodotermes sp.* but not sufficiently to balance the deficit (Hewitt *et al*. 1972; Richardson 1987a). During winter, only one-fifth the usual quantity of termites is consumed per month by aardwolves, and individuals lose up to 25% of body weight (Anderson 1994). Adults appear unaffected by drought but cub survival can decline from 70% to 45% (Mills & Hofer 1998).

Insect control

The principal threat faced by aardwolves is indirect poisoning directed at periodic locust plague outbursts. Poisoning events can kill up to 50% of adult aardwolves in a population with young adult individuals being particularly vulnerable. Higher male *P. cristatus* susceptibility to poisoning due to wide- ranging movements can impact reproductive success of females who rely on their mates for paternal care, particularly in guarding dens against predators. Females without mates are three times less successful than females with mates at

raising cubs (Richardson 1985; 1987a). Recovery of local populations following insect control efforts can be slow; a Northern Cape population took four years to recover to pre-poisoning levels (Richardson, cited in Mills & Hofer 1998).

No data
Genetic poverty, Tourism.

BROWN HYENA (HYAENA BRUNNEA)

Habitat associations
Brown hyenas are generally associated with arid to semi-arid habitat. They occur in true desert areas with annual rainfall less than 100 mm, semi-desert, open scrub and open woodland savannas, with a maximum rainfall up to about 650 mm. Their distribution in Africa is centered in the Kalahari and Namib deserts. Occurrence of brown hyenas is largely independent of drinking water but is associated with the presence of day-time cover.

Degree of ecological specialization
Brown hyenas are primarily scavengers of mammal (especially ungulate) remains and benefit from carrion left by other carnivores, particularly large felids (Mills 1997). They are rare where large mammal biomass is low, even in otherwise suitable habitat.

Current (dark gray) and historical (light gray) distribution of **Brown hyena** *(Hyaena brunnea)*.
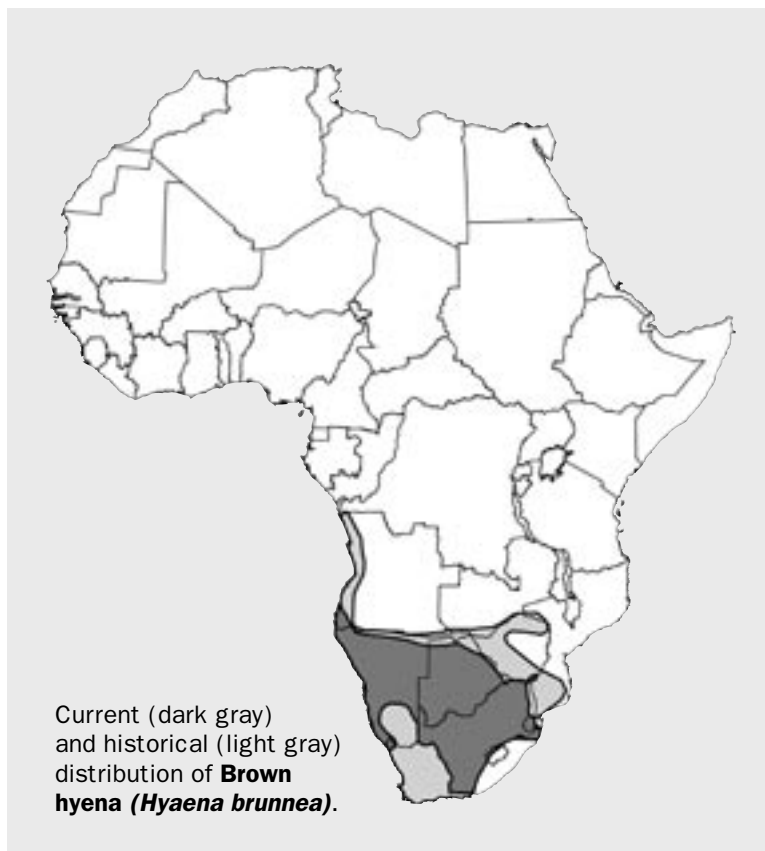
Distribution trends
The brown hyena has always been confined to the arid zones of southern Africa. Its range has shrunk significantly since the end of the 18th century with only the central part of historical distribution remaining intact (Smithers 1983).

Decline in habitat and/or prey availability
Adequate habitat for brown hyenas outside protected areas is present on agricultural lands, particularly in areas that are unsuitable for small stock production. Decreasing natural sources of carrion due to declines in populations of other large carnivores likely results in reduced brown hyena densities (Mills 1997; Mills & Hofer 1998).

Human conflict

Outside protected areas, persecution of brown hyenas is common (Mills & Hofer 1998). Although brown hyenas are inefficient hunters of ungulates (a very small proportion of observed hunting attempts result in success; Mills 1987b), they are widely blamed for livestock depredation. Respondents of the Hyena Action Plan questionnaire asserted that brown hyenas commonly killed sheep and goats and, at times, took bovid calves, poultry, domestic dogs and cats. However, careful monitoring of livestock depredation reveals that brown hyenas are rarely the culprits. For example, during 15 years following the first observance of hyenas at Tweeputkoppies, there were no reports of bovid calf predation by brown hyenas despite the frequent presence of new born calves in paddocks containing *H. brunnea* dens (Skinner 1976). Commercial ranchers in Namibia considered brown hyenas the least damaging carnivore present after black-backed jackals, leopards and cheetahs (Stein 2005). Farmers reported that brown hyenas were not powerful enough to kill cattle but conflict arose because they inflicted bite wounds on legs, hindquarters and tails which often became septic, requiring slaughter.

Verified incidents involving domestic stock raiding are usually attributed to single individuals; removal of the problem animal almost always alleviates the problem, even while *H. brunnea* continues to occupy the area (Skinner 1976; Mills & Hofer 1998). Identification of problem individuals is problematic given that brown hyenas are habitual scavengers, including of cattle carrion (Skinner 1976). Accordingly, their presence at a carcass is not the 'smoking gun' but their scavenging behavior makes them particularly vulnerable. They are often killed by non-selective measures such as the use of gin traps, poison and coyote-getters located around carcasses (Skinner & van Aarde 1987; Mills & Hofer 1998). Additionally brown hyenas are often killed in predator eradication or control programs aimed at other species; for example, brown hyenas from four Northern Cape farms were killed during predator control programs targeting black-backed jackals (Stuart *et al.* 1985).

Such control measures may largely negate any benefits associated with ranching practices (i.e., increased availability of bovid carcases and removal of competitors or predators), resulting in overall population declines for *H. brunnea*. Furthermore, the large home ranges and wide ranging habits of brown hyenas may result in increased mortality rates for populations inhabiting conservation areas since individuals frequently travel outside protected area boundaries (Eaton 1976).

Human hunting and commercial trade

There is limited use of the brown hyena in traditional medicines and rituals (Mills & Hofer 1998). Commercial trade is not a significant mortality factor; there is very low demand for *H. brunnea* as a trophy species and no international demand for its skin (Mills & Hofer 1998).

Disease

Although data are minimal (Mills & Hofer 1998), there is little evidence implicating disease as a significant cause of *H. brunnea* mortality. Rabies occurs at low frequencies (Swanepoel *et al.* 1993). Ectoparasites on Kalahari brown

Field locations for **Brown hyena** studies.
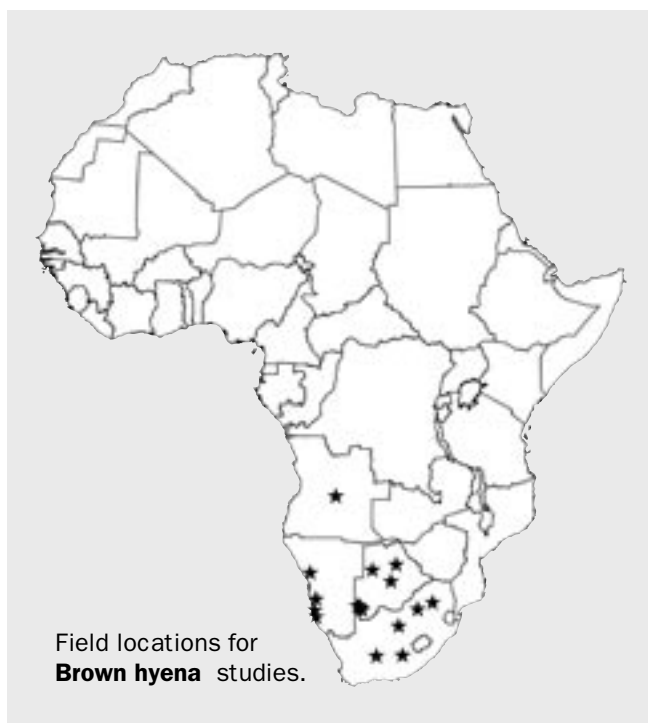
hyenas included fleas, *Hippoboscidae* biting flies, and rarely *Acarina* ticks but none was associated with disease episodes (Mills 1981). Observations of sarcoptic mange are few and not associated with mortality (Mills 1981).

Interspecific conflict

Spotted hyenas represent the greatest source of interspecific strife. They occasionally kill *H. brunnea* but more importantly, exclude them from carcasses, which can result in significant food deprivation in some areas (Mills 1981; 1990; 2000). Areas frequented by spotted hyenas are avoided by brown hyenas irrespective of food availability and even where spotted hyena density is low (Mills & Mills 1982; Mills 1990). High spotted hyena densities appear to directly negatively impact the number of brown hyenas, although brown hyenas will even avoid areas where spotted hyena density is low (Mills 1990; 2000; Mills & Gorman 1997). Lions occasionally kill brown hyenas but the remains of lion kills likely yield a net benefit for hyenas (Mills & Hofer 1998; Mills 1990; 2000).

In Kruger National Park, the artificial provisioning of water for wildlife from the 1930s onwards may have driven the competition-mediated extirpation of brown hyenas as a breeding species (Mills 2003). Increased water availability resulted in elevated densities of resident prey species and ultimately of lions and spotted hyenas, particularly in more xeric areas (Mills & Gorman 1997).

Brown hyena diet overlaps strongly with other scavenging carnivores. Competition between black-backed jackals and brown hyenas over food resources is occasionally severe (Mills 1977; 1978b; Owens & Owens 1978); even large numbers of vultures sometimes exclude *H. brunnea* from carcasses (Mills 1977; Mills & Hofer 1998). However, brown hyenas usually dominate cheetahs, caracals, jackals and, occasionally, leopards (Mills & Hofer 1998; Mills 2000).

Road kills

In South Africa, *H. brunnea* is occasionally killed by vehicles (Mills & Hofer 1998). This is unlikely to comprise a significant threat but may limit dispersal from some populations; for example brown hyenas reintroduced into the Greater St Lucia Wetland Reserve, South Africa are killed on nearby roads, apparently limiting their ability to recolonize suitable habitat to the immediate west (Hunter 1998).

No data

Genetic poverty, Climate change, Insect control, Tourism.

STRIPED HYENA
(HYAENA HYAENA)

Habitat associations

Throughout most of its range, the striped hyena occurs in open dry habitat or light thorn bush country (Mills & Hofer 1998). In North Africa this species apparently prefers open woodlands and bushy mountainous regions, with the Sahara desert considered as sub-optimal habitat (Rieger 1979a). In West Africa, the striped hyena occurs in the Sahel and Sudan savannas.

Degree of ecological specialization

Probably the East African ecological analogue of the brown hyena, this species scavenges carrion, particularly the remains of large mammals. It also

Current (dark gray) and historical (light gray) distribution of **Striped hyena** *(Hyaena hyaena)*.

consumes a variety of small vertebrates, invertebrates, plant matter and human refuse. The relative proportion of various foods in their diet is not known (Mills & Hofer 1998) but as for brown hyenas, they possibly suffer reduced densities where the extirpation of other large carnivores reduces the availability of carrion (Mills & Hofer 1998).

Distribution trends

Historically and presently, the striped hyena has always been confined to the northern part of the continent, never having occurred south of Tanzania. This is the only hyena species whose distribution extends beyond continental limits into the Middle East, southern Europe and central Asia. Historical distribution was probably continuous throughout this entire range, however current distribution is patchy. In Africa, they have undergone the greatest range loss in West African countries where there is evidence of local extirpation, especially outside protected areas.

Decline in habitat and/or prey availability

Population declines are in part attributed to habitat loss. Furthermore, large home ranges and low densities are presumed to increase the probability of population fragmentation into small, non-viable units (Mills & Hofer 1998). Decreasing natural sources of carrion due to declines in populations of other large carnivores is also a significant threat (Mills & Hofer 1998)

Field locations for
Striped hyena studies.
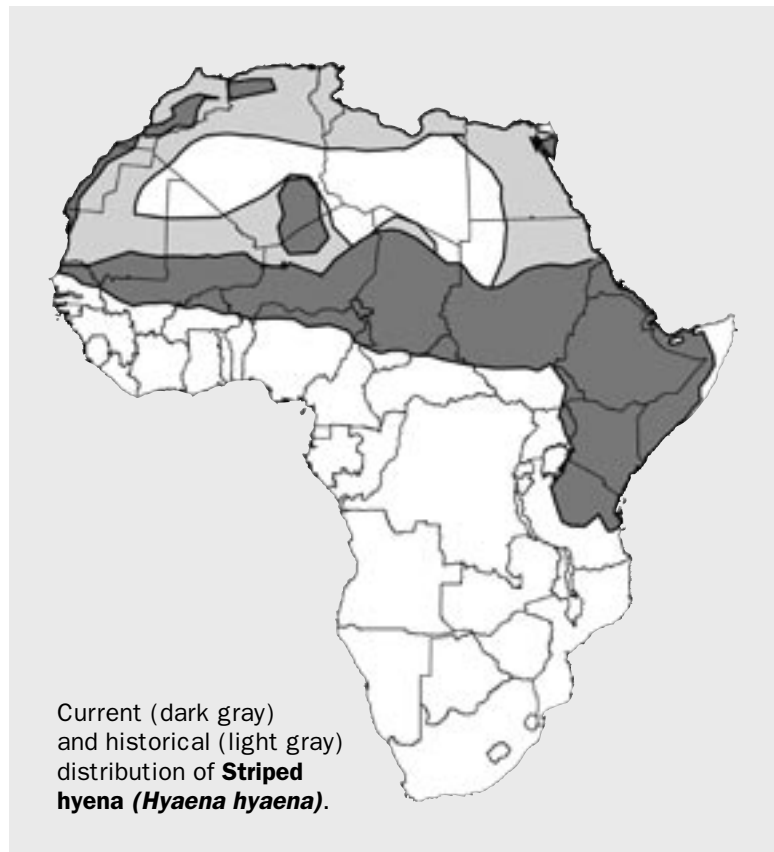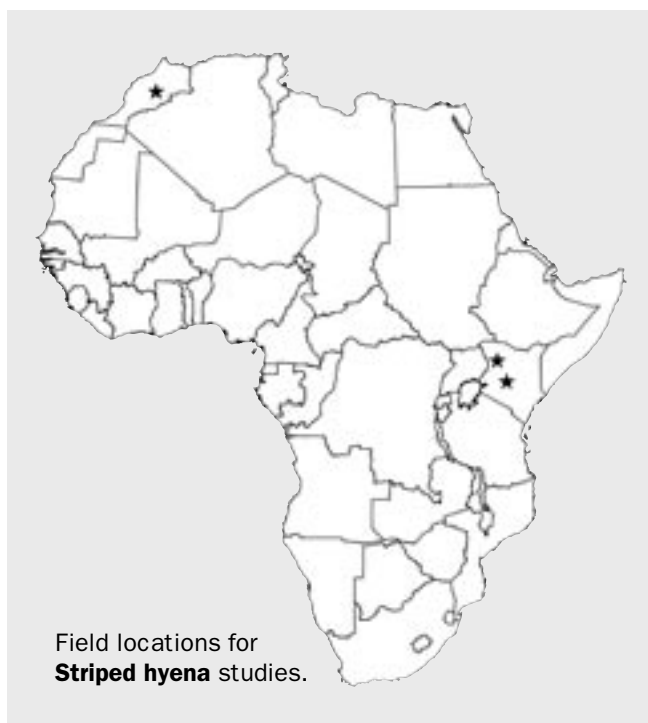
Human conflict

Throughout Africa, human persecution is the most significant factor affecting striped hyena mortality. Striped hyenas are killed mainly in retribution for perceived and occasional actual predation on domestic livestock. In North Africa, they are persecuted intensely for assumed and actual grave robbing (Mills and Hofer 1998). Poisoning constitutes a particular threat as they readily accept baits. In Niger, for example, large-scale population reductions associated with the widespread use of strychnine poisoning has been threatening striped hyena populations (Millington & Tiega 1990; 1991).

In general, actual predation of livestock probably occurs at low frequencies and reports of larger animals taken by striped hyenas should be treated with caution since cases of scavenging are easily misidentified as kills (Mills & Hofer 1998). Overall, the most commonly taken livestock by striped hyenas are goats, sheep, dogs, chickens and in some cases donkeys (Ronnefeld 1969; Roberts 1977; Rieger 1979a; Mills & Hofer 1998). A recent analysis of skeletal remains in and around striped hyena dens in Lothagam, northern Kenya revealed high proportions of caprines, canids, donkey, camel, cattle and humans (Leakey *et al*. 1999). All interviewed Turkana reported regular striped hyena kills of goats and sheep, mainly of straying individuals outside enclosures.

Cattle are too large for hyena predation and striped hyenas can reach high densities on cattle ranches provided ranchers correctly view the species as innocuous (A. Wagner *pers. comm.*).

Human hunting and commercial Trade

Historically, striped hyena parts have been valued as aphrodisiacs and for traditional healing (Mills & Hofer 1998). In Egypt, the whiskers and eyeballs were used for protection against the 'evil eye' (Prater 1948; Osborn & Helmy 1980), while the heart is believed to increase courage (Prater 1948). Until very recent times and possibly ongoing, North African tuaregs tamed striped hyenas, and fattened them for consumption (Lhote 1946). The extent to which traditional use of striped hyenas constitutes a threat (past or present) to striped hyena populations is unknown.

Interspecific conflict

One of the primary factors contributing to striped hyena population declines are decreasing natural and domestic sources of carrion due to reductions in other large carnivore populations (cheetah, leopard, lion), their prey and changes in livestock practices (Mills & Hofer 1998). East African striped hyenas are dominated by the spotted hyena and to some extent by leopards (Kruuk 1976). Lions would easily kill or dominate striped hyenas though observations are lacking.

Skinner & Ilani (1979) report that an adult caracal may be able to kleptoparasitize subadult hyenas. However, it is just as likely that striped hyenas experience a net benefit from the presence of other carnivores.

Road kills

Road accidents constitute the chief mortality factor in Israel where hyenas are attracted to roads to scavenge animals hit by cars (Mills & Hofer 1998). The frequency of road kills in Israel is sufficient to prevent females raising cubs and has driven a downward shift in age distribution in the population (Mills & Hofer 1998). There are few data for Africa indicating as drastic a situation but road kills have the potential to constitute a threat for isolated and fragmented populations.

No data

Disease, Genetic poverty, Climate change, Insect control, Tourism.

SPOTTED HYENA (CROCUTA CROCUTA)

Habitat associations

The spotted hyena inhabits a variety of habitat types, ranging from semi-desert and savanna to open woodland, dense dry woodland, and mountainous forest up to 4,000 m (Kruuk 1972a). It is largely absent from or occurs in very low densities in tropical rainforests and along coasts, although it has been documented infiltrating dense forest habitats in central Africa via logging roads (Henschel & Ray 2003). Spotted hyenas have always been absent from extreme desert conditions. In optimum habitat, densities of the spotted hyena may exceed those of any other large African carnivore including lions. However, in desert and semi-desert regions, both brown and striped hyenas tend to occur at higher densities than the spotted hyena (Mills 1990).

Degree of ecological specialization

Spotted hyenas are extremely successful predators and scavengers, able to live on a very catholic diet and in a wide variety of habitat types. Africa-wide, this species is among the most successful of large carnivores. The increasing conservation concerns surrounding this species are due to intense anthropogenic persecution rather than any ecological specialization.

Distribution trends

Historically, spotted hyenas were common and widespread over all the more open habitats across sub-Saharan Africa but today, outside of protected areas, most populations have suffered a decline. Distribution is now patchy in many places especially in West Africa, where there are few populations outside protected areas and adjacent land areas. Continuous distribution over large areas is now restricted to Ethiopia, Kenya, Tanzania, Botswana, Namibia and eastern South Africa.

If tolerated by people, the spotted hyena adapts to surviving on human-

associated carrion and organic refuse in semi-urban areas. This has allowed the species to maintain a presence close to many major African cities, albeit rarely at high densities.
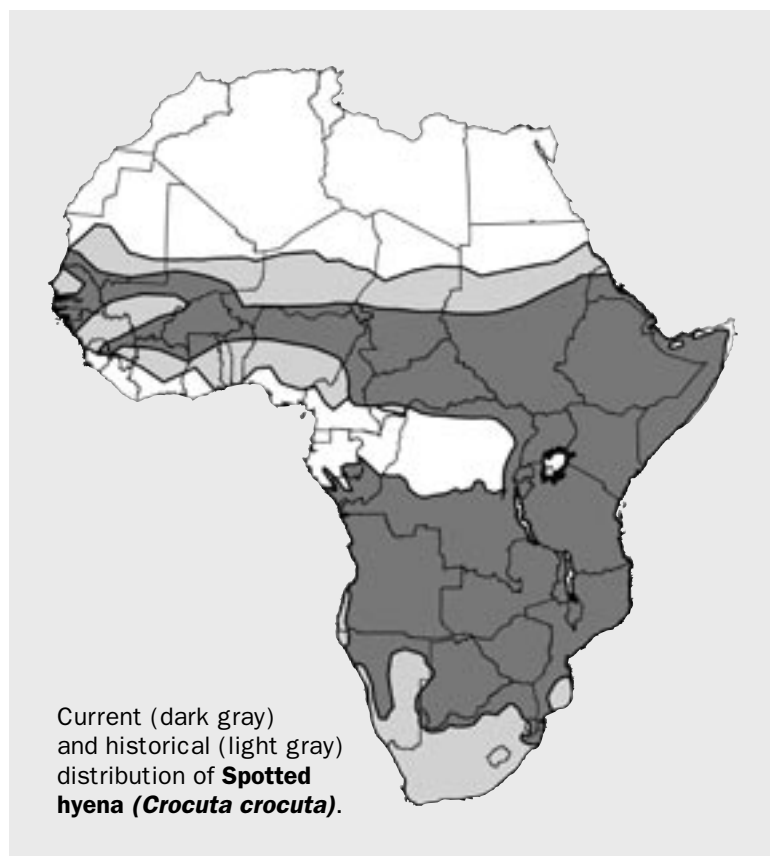
Decline in habitat and/or prey availability

Habitat loss, degradation and reduced suitability for both spotted hyenas and their prey has resulted from over-grazing of domestic livestock (Mills & Hofer 1998). Where wild prey is significantly reduced as a result of human hunting pressures, there may be an increase in siblicide. Thus spotted hyena populations may face increased stress from low prey densities and increased cub mortality.

Recent records of spotted hyenas in forested habitats in Equatorial Guinea and Gabon could be evidence of forest degradation or deforestation along the Congo forest edge (Juste & Castroviejo 1992; Henschel & Ray 2003), and may represent range expansion.

Current (dark gray) and historical (light gray) distribution of **Spotted hyena *(Crocuta crocuta)***.

Human conflict

Human persecution by shooting, trapping and poisoning is the most important source of mortality for the spotted hyena outside protected areas and is often the source of population declines (Henschel 1986; Mills & Hofer 1998). Persecution may be intense in farming areas following confirmed or perceived livestock damage, or as a preventative measure for livestock protection. Spotted hyenas are also killed for 'target practice' (e.g., Namibia and Kenya), or due to superstitions associated with the animal (Mills & Hofer 1998). Although southern African spotted hyena populations in protected areas appear to be stable, eastern and western African spotted hyena populations both inside and outside protected areas are declining due to human-mediated mortality (Mills & Hofer 1998).

The spotted hyena is known for killing and scavenging domestic stock, and has been observed preying on cattle, sheep and goats, and to a lesser extent poultry, cats, dogs, horses, donkeys and camels. The degree to which domestic stock is utilized as prey by spotted hyenas depends on accessibility, availability of alternative prey, and availability of human rubbish and waste (Mills & Hofer 1998). Several studies undertaken in communal lands have found spotted hyenas to be the most common livestock predators where they are residents (e.g., Hawke 1991; Madzudzo 1994). When natural prey species are abundant in areas surrounding ranches, total losses to hyena predation are relatively minimal in relation to overall losses incurred by a given ranch. In such cases, spotted hyenas are not dependent on domestic stock predation as their primary source

of food (e.g., Mizutani 1993). Spotted hyenas are considered to be problem animals in regions where their natural prey species have been exterminated and replaced by livestock ranching (Kruuk 1972a; Moss 1976; Henschel, 1986). As with other hyenas, scavenging individuals at carcasses are widely blamed as the killers themselves. Spotted hyenas display low recolonization rates of vacant or underpopulated areas even when resources are plentiful. Recovery of hyena numbers following intensive persecution may require decades (Henschel 1986).

Husbandry methods strongly influence livestock vulnerability to spotted hyenas. For example, hyena attacks on livestock are reduced when domestic dogs are present and thorn bushes are used to corral livestock (Mills & Hofer 1998). Kruuk (1980) reported that 90% of spotted hyena livestock kills occurred outside the protection of thorn fences. In one study investigating spotted hyena depredataion in Kenya's Laikipia District (Frank 2000), hyena predation on cattle occurred mainly when animals were forgotten overnight outside their fenced enclosures (bomas). Similarly, there was a 71% chance that a sheep forgotten outside at night would be killed by spotted hyenas. Sheep killed inside bomas are generally attributed to a combination of poor boma maintenance, careless night guarding, or the learned ability of individual hyenas to break into bomas. Annual spotted hyena predation per head of sheep is estimated at US$0.33, or 23% of overall incremental predation costs. Annual spotted hyena predation per head of cattle was estimated at US$1.24, or 26% of overall predation costs (Frank 2000). Overall, spotted hyenas are the least expensive large predator to maintain, costing approximately US$35 per individual large-scale rancher in Laikipia (Frank 2000).

Predation of humans by spotted hyenas occurs exceptionally, for example, four records from Uganda between 1923-1994 compared to 243 deaths to large cats for the same period (Treves & Naughton-Treves 1999). Six recent deaths attributed to spotted hyenas in Malawi resulted in killing of hyenas by the Department of Parks and Wildlife (Xinhus News Agency 2002); given hyenas rarely prey upon people, such retaliatory hunting is unlikely to constitute a threat to the species.

Human hunting and commercial trade

The legal classification of spotted hyenas ranges from vermin in Ethiopia to fully protected in the conservation areas of many countries. (Mills & Hofer 1998). Outside protected areas, many countries allow private landowners to kill spotted hyenas at their discretion.

In Tanzania, game meat hunting by snares seriously impacts spotted hyena populations in protected areas through widespread incidental killing. Snares kill around 400 adult hyenas each year and are responsible for more than half of all adult mortality (Hofer et al. 1996). Demographic effects include a significant downward change in the distribution of ages at time of death since 1966-1969, a time when the impact of game meat hunters was low (Kruuk 1972a; Mills & Hofer 1998). Furthermore, an annual population decline of 2.4% between 1987 and 1991 as compared to an excess of 4% population growth in previous years indicates that game meat hunting has reduced the annual rate of population increase by 7% (Hofer et al. 1993; Hofer & East 1995a).

Field locations for
Spotted hyena studies.
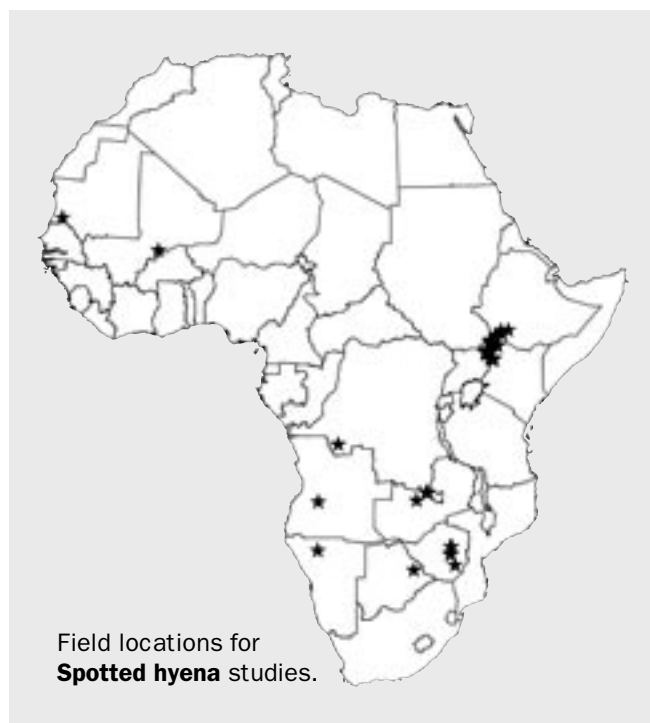
Several countries permit spotted hyena sport hunting on a quota basis but only a small number are taken by hunters since it is not considered an attractive trophy species (Mills & Hofer 1998). The spotted hyena is hunted for traditional medicinal purposes throughout its range. Less commonly, they are harvested as a food resource e.g., in the Ivory Coast, Cameroon and Senegal (Mills & Hofer 1998).

Disease

Antibodies of numerous diseases have been found in spotted hyena populations when investigated (e.g., Hofer & East 1995), but there is little evidence that disease is a major mortality factor. An outbreak of CDV among spotted hyenas in Masai Mara, Kenya did not affect mortality (Alexander *et al*. 1995). On the other hand, several cubs were killed during an outbreak in the Serengeti in 1993-1994 (Haas *et al*. 1996), and seven additional spotted hyena deaths were confirmed to have resulted from CDV infection (Roelke-Parker *et al*. 1996).

Spotted hyena deaths due to rabies have been reported from eastern and southern Africa (Mills & Hofer 1998). The rare occurrence of rabid spotted hyenas in other regions of Africa indicates that challenge can be fatal and typically results in furious rabies (Thomson & Meredith 1993; Mills 1990). The source of rabies infection remains unknown, and may be domestic (dogs) or wildlife-based (Mills & Hofer 1998). The effect on populations appears to differ regionally. Rabies epizootics in Kalahari spotted hyenas may contribute to a bias in the age class structure towards older individuals (Mills 1990; East *et al*. 2001). In contrast, although Serengeti spotted hyenas revealed a high frequency of exposure (37%, n = 100) to rabies, none displayed symptoms, and survival of seropositive individuals was common (East *et al*. 2001).

Spotted hyenas are exposed to a variety of pathogens carried by their ungulate prey, although there is no evidence of negative impacts at the population level. Feeding by spotted hyenas on carrion where animals had succumbed to anthrax and foot-and-mouth disease did not result in contraction of these diseases (Pienaar 1969b). All hyenas sampled for rinderpest virus between 1990 and 1992, were negative for antibodies (Alexander *et al*. 1995). Individuals sampled from Serengeti National Park and surrounding area showed a high prevalence of trichinellosis (Pozio *et al*. 1997), with findings being comparable to infection rates previous reported from East Africa (85%; Nelson *et al*. 1963), South Africa (85%; Young & Kruger 1967), and Tanzania (75%; Sachs 1970).

Spotted hyenas carry numerous endo- and ecto parasites but there is no evidence of deleterious impacts at the population level (see Mills & Hofer 1998).

Interspecific conflict

In most regions where hyenas and lions coexist, lion predation accounts for up to 50% of hyena mortalities (Kruuk 1972a; Schaller 1972a; Moss 1976; Henschel 1986; Mills 1990). Violent encounters between conspecifics at kills and during clan wars (Kruuk 1972a; Henschel & Skinner 1991) are important sources of natural mortality for spotted hyenas. Leopards occasionally kill individual hyenas (Bailey 1993). Cub predation by other hyena species may occur, but is considered rare based on circumstantial evidence (Mills 1990).

In Kruger National Park, one clan failed to raise a single litter for a minimum of eight detected pregnancies, with only one litter surviving more that two weeks. Lion predation was the underlining factor in litter failure, and eventually resulted in the clan's demise though this was probably exceptional (Henschel 1986). Female spotted hyenas from East Africa were vulnerable to lion predation as a consequence of having to travel long distances to follow migrating game and having to stay away up to five days from their dens (East *et al*. 1989).

Lions are also the most frequent competitor of spotted hyenas for food resources (Kruuk 1972a; Schaller 1972a; Bearder 1977; Eaton 1979). Although lions usually displace hyenas at kills, the reverse applies where hyena group size is large, and male lions are absent (Cooper 1991; Höner *et al*. 2002). There is a wide variation in the proportion of food obtained from scavenging and lost to other scavengers (Mills & Hofer 1998). Where the densities of hyenas and lions are similar, both species scavenge approximately the same proportion of their diet from each other's kills (Kruuk 1972a; Schaller 1972a). In Kruger National Park, spotted hyenas scavenge far more from lions than vice versa (Mills & Biggs 1993). In general, within protected areas, high lion densities are associated with high spotted hyena densities (Creel 1996; Purchase 2004) suggesting interspecific conflict does not significantly impact most hyena populations (Höner *et al*. 2002; 2005). Hyenas successfully compete with lions by numerical superiority and are better able to exploit migratory herbivores than are lions (Purchase 2004; Höner *et al*. 2005).

Climate

During El Niño in 1997/1998, the Serengeti ecosystem had an unusually early and prolonged rainy season resulting in increased vegetation density. During this period, lion predation on spotted hyena cubs had a higher success rate than previous study years due primarily to changes in vegetation structure hindering hyena cub attempts to escape (Hofer 2000). Spotted hyena cub mortality in the Kalahari Gemsbok National Park increased to 46.5% at the height of the 1985-1986 drought period, up from 10.5% during the years preceding the major drought event (Knight *et al*. 1992).

No data

Genetic poverty, Climate change, Insect control, Tourism.

MUSTELIDAE AND VIVERRIDAE

SPOTTED NECKED OTTER (LUTRA MACULICOLLIS)

Habitat associations

Believed to be more of a fish specialist than the other otters considered here, the spotted necked otter is dependent on clear, unstilted and unpolluted permanent freshwater. It favors deeper, open water than other species and is less suited to coastal habitats than the Cape clawless otter (Somers *et al*. 2003) or smaller streams occupied by Congo clawless otter. As for other otters, it requires cover such as dense riparian vegetation for refuges.

Degree of ecological specialization

The spotted necked otter lives almost entirely on fish in the large inland water bodies of central and East Africa where small freshwater fish are abundant (Lejeune 1990). Where the resident fish fauna is depauperate, such as occurs naturally in South African systems this species is known to exploit freshwater crustaceans in addition to fish, supplemented by smaller proportions of frogs and insects (Rowe-Rowe 1997). The relative percentage of purely aquatic prey from four locations was 97-100% (Rowe-Rowe & Somers 1998)

Distribution trends

The distributional range of the spotted necked otter is thought to be declining, particularly in southern Africa where intensive agriculture in catchments and along rivers is widespread. Accurate data are mostly lacking but it is now thought to be absent from various silted rivers (e.g., Lower Buffalo River, South Africa) where the Cape clawless otter persists (Stuart 1985). Rowe-Rowe (1997) reported the species extirpated from Lesotho though it is unclear if it ever occurred there (Lynch 1994).

Decline in habitat and/or prey availability

The spotted necked otter is heavily dependant on sight when foraging, requiring clear water for hunting and making the species particularly vulnerable to degraded water quality (Stuart 1985; IUCN 2002b). Accu-

Current distribution of **Spotted Necked Otter (Lutra maculicollis)**. Extent of historical distribution unknown.
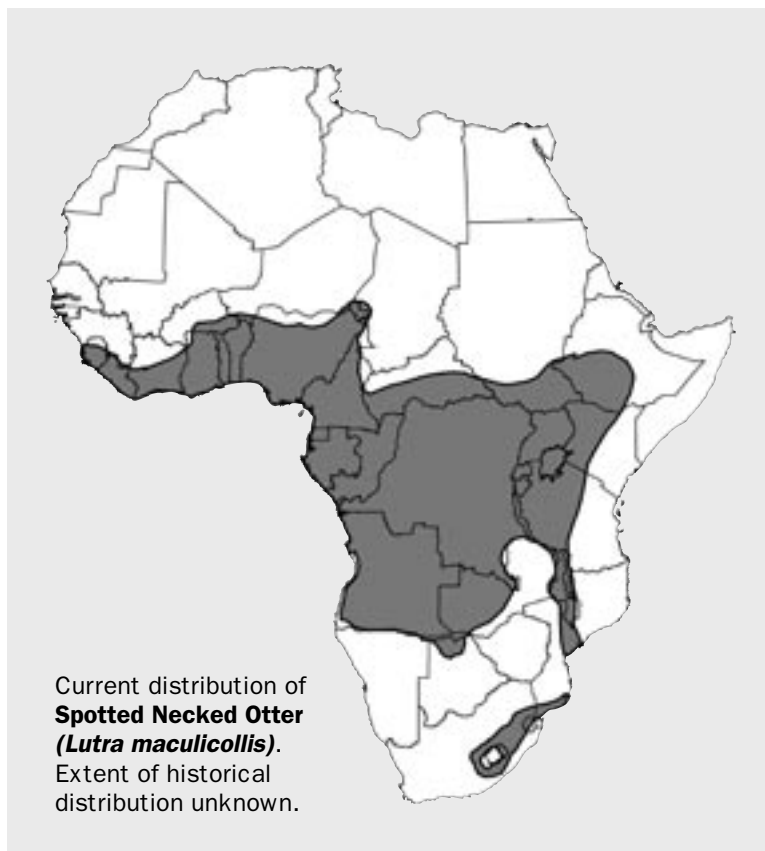
rate data quantifying the extent of habitat loss are few, but degradation clearly results from agriculture, livestock grazing, and the extraction of wood and groundwater, resulting in increased silt loads (turbidity) in many African rivers (IUCN 2002b). Increased silt loads may be further compounded by the regulation of water flow through impoundment projects, ensuring permanently high levels of silt (Stuart 1985). Heavy agricultural and industrial utilization along the lower Buffalo River of the former Cape Province, South Africa, appears to have extirpated this species prior to *Aonyx capensis*, which still occurs.

Loss of suitable prey appears to have driven a decline in this species in Lake Victoria, Tanzania. Once very common there, the population has declined since the introduction of the large Nile perch (*Lates niloticus*) which has contributed to catastrophic declines or extinctions of most endemic fish species (Barel *et al*. 1985; Kruuk & Goudswaard 1990). Although spotted necked otters are capable of adapting to a diet of larger fish (e.g., introduced tilapia, *Oreochromis niloticus*), the effects of introduced species combined with intensive fishing pressure has resulted in a fish community less suited to the otter's preferences (Kruuk & Goudswaard 1990).

Interspecific conflict

Temporal, spatial and dietary partitioning seems to limit competition with the sympatric Cape clawless otter and water mongoose (*Atilax paludinosus*; Purves *et al*. 1994). The spotted necked otter prefers deeper water than the Cape clawless otter and is primarily diurnal compared to the crepuscular/semi-nocturnal Cape clawless otter (Mason 1990). In Bushmans River, South Africa, spotted necked otters preyed upon fish more often, and consumed larger specimens than Cape clawless otters and water mongooses (Somers & Purves 1996). When fish densities are too low to sustain spotted necked otters, crabs comprise an important component of their diet, increasing the potential for competition (Somers & Purves 1996). Being less suited for foraging on crabs than Cape clawless otters may place the spotted necked otter at a disadvantage, though crabs taken by spotted necked otters in Bushmans River were significantly larger than those fed upon by Cape clawless otters suggesting selection for different crab species (Somers and Purves 1996). The effect of reduced crab densities on competition between otters is unknown but is likely to favor the Cape clawless otter.

Procter (1963) suggested that spotted necked otters may be absent in the presence of the Nile crocodile, though Kruuk & Goudswaard (1990) documented otters in areas of high crocodile density in Lake Victoria, Tanzania. Potential predators of juvenile spotted necked otters in their study included African fish eagles (*Haliaetus vocifer*), which were regularly distributed along the coast at a density of one pair per kilometer (Kruuk & Goudswaard 1990).

Human conflict

Deliberate persecution of spotted necked otters seems to be rare (Kruuk & Goudswaard 1990), though deliberate and indiscriminate persecution still occurs widely where humans compete with otters for fish resources. The introduction of nylon fishing nets which entangle otters is thought to be a serious threat in many African lakes (The World Conservation Union 1992; IOSF undated; Kruuk & Goudswaard 1990). Nets are typically placed in the same vegetation

Field locations for **Spotted Necked Otter** studies.
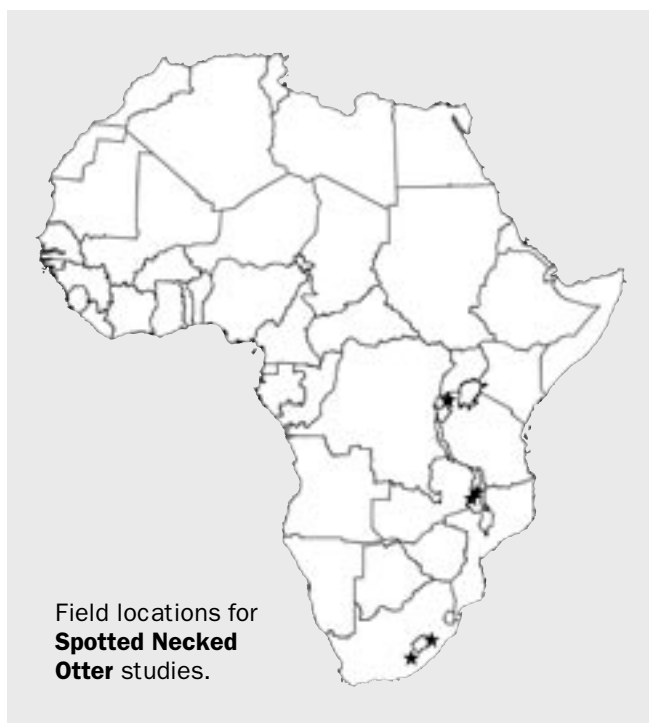
used by otters when foraging, and due to this species' sociality, a single entwined otter struggling in a net often attracts conspecifics which may face a similar fate (The World Conservation Union 1992; Kruuk & Goudswaard 1990).

Up to 1964, gill nets set for fish in dams of the Buffalo River system, South Africa captured spotted necked otters; there have been no records of the species since then. Since these dams had clear water with suitable fish resources, Stuart (1985) attributed the extirpation of the spotted necked otters in the area to hunting and drowning in gill nets.

As for the Cape clawless otters, this species is persecuted by trout farmers and fisherman. Damage by this species is potentially greater than the Cape clawless given its preference for fish. The majority of fish taken by spotted necked otters in KwaZulu-Natal were under 20 cm in length, less than the legal minimum size allowable for anglers to capture (Rowe-Rowe 1978b), indicating that otter impact on fisheries is negligible.

Spotted necked otters are sometimes killed by domestic dogs in rural areas, e.g., the Drakensberg Mountains, South Africa (L. Hunter *pers. obs.*).

Human hunting and commercial trade

Many lakeshore-dwelling communities highly prize the fur of spotted necked otters, wearing it in the form of a wristlet. They also use skins to wipe their eyes and nose, believing that it cures infections (The World Conservation Union 1992).

No data

Disease, Road kills, Genetic issues, Climate change, Insect control, Tourism.

CAPE CLAWLESS OTTER (AONYX CAPENSIS)

Habitat associations

This species is reliant upon permanent unpolluted, freshwater with suitable cover for refuges such as dense riparian vegetation, rocks or overhanging banks (Rowe-Rowe 1992). Because hunting is mostly by touch, they are relatively tolerant of still and turbid water (Ogada 2003; Somers *et al.* 2003). They readily inhabit coastal shores, estuarine waters and saline lagoons, provided freshwater is available, apparently to wash salt from the fur (Somers 1997). Where these requirements are met, they also occur in anthropogenic water sources, including artificial ponds, aquaculture ponds, water storage areas, canals and wastewater treatment areas (Somers *et al.* 2003).

Degree of ecological specialization

In freshwater habitats, Cape clawless otters are generally regarded as crab specialists, supplementing their diet with fish, frogs and aquatic insects (Rowe-Rowe 1977c). Coastal populations take mainly marine crustaceans and molluscs (Rowe-Rowe 1992). Occasional dietary records exist of birds, reptiles, small mammals, and poultry (Somers 1997; Rowe-Rowe & Somers 1998). The relative percentage of purely aquatic prey from five locations was 87-97% (Rowe-Rowe & Somers 1998).

Distribution trends

There are few accurate data for this species. Rowe-Rowe (1991) assumed that the species was present wherever there are permanent bodies of water but former suitable habitat in intensive agricultural areas is likely too degraded to sustain the species. Somers (1997) thought the species is still widely distributed throughout its historical range but is no-where common; it is unclear whether that is due to natural rarity or anthropogenic decline.

Current distribution of **Cape Clawless Otter (Aonyx capensis)**. Extent of historical distribution unknown.
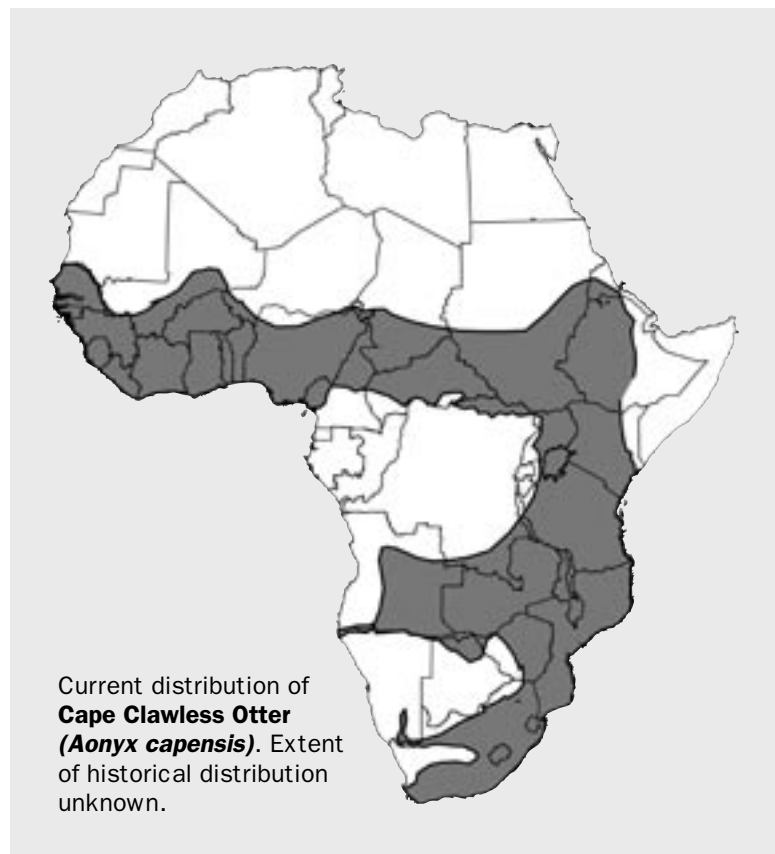
Decline in habitat and/or prey availability

The greatest threat for all otter species is habitat degradation. This comes primarily from increased urbanization, agricultural and industrial activity, combined with human demands for water resources. Overgrazing, bush clearance and deforestation contributes to catchment degradation, soil erosion and river siltation, reducing the availability of otter prey. Otters are further impacted by water extraction operations and the denudation of riparian vegetation (Rowe-Rowe 1990; IUCN 2002b). The draining of swamps and wetlands to provide agricultural land, and subsequent increases in pesticide use may also affect otter densities (Mason & Macdonald 1986).

Cape clawless otters inhabiting mangroves in the Gulf of Guinea, West Africa are threatened by habitat loss due to urbanization, industrialization, agriculture, and impacts from timber and petroleum exploration. Additional threats include oil spills, deploying dynamite and poison for fishing, canalization, sewage discharge, siltation, sand mining, erosion, and embankment construction (WWF Global 2000 undated b).

Human disturbance and heavy beach utilization at Betty's Bay, South Africa, may be responsible for low densities compared to undisturbed areas like Tsitsikamma (Verwoerd 1987). In addition, artificial burning has resulted in inadequate vegetation close to the sea, apparently reducing the availability of suitable

Field locations for **Cape Clawless Otter** studies.
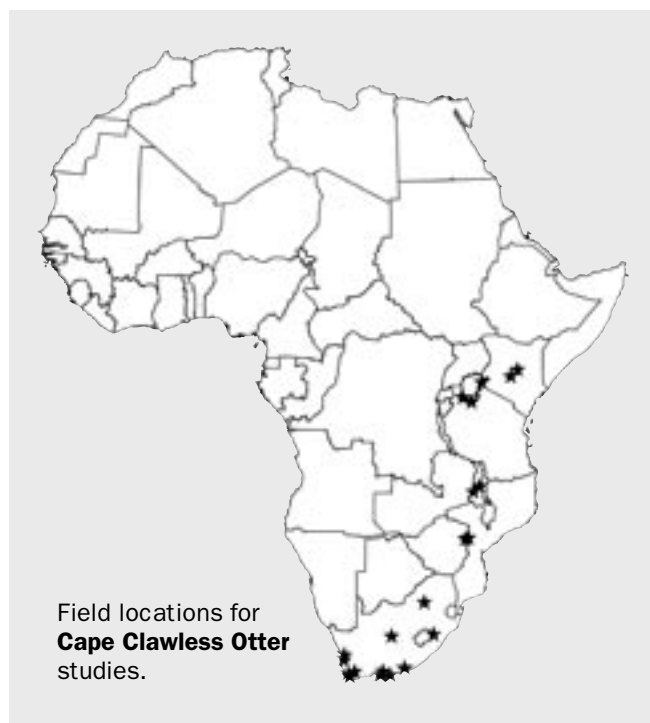
holt sites along the coast (Verwoerd 1987).

Dam construction in commercial farming areas may provide Cape clawless otters with suitable habitat conditions provided enlightened agricultural activities occur (Rowe-Rowe 1991).

The introduction of the Nile perch into Lake Victoria and subsequent declines in native fish species appears to have affected the Cape clawless otter minimally (cf. spotted necked otter) due to its preference for crabs over fish. Kruuk & Goudswaard (1990) conclude that variations in fish populations are unlikely to affect Cape clawless otter densities, unless aquatic faunal changes result in as yet unseen reduced crab availability.

Interspecific conflict

Over much its range, the Cape clawless otter coexists with both the spotted necked otter and water mongoose (Skinner & Smithers 1990; Purves *et al*. 1994). A number of studies demonstrate dietary and spatial separation, reducing competition for resources. Compared to the spotted necked otter, Cape clawless otters take crabs rather than fish (Purves *et al*. 1994). The potential for competition may increase where the resident fish fauna become impoverished and spotted necked otters turn to foraging on crabs, though the latter is more likely to be negatively affected (Rowe-Rowe 1977c). In KwaZulu-Natal where reduced fish abundance led to an increased representation of crabs in spotted necked otter diet, crab population estimates ranged between 7,500 to 13,000 per hectare, which was sufficient to support populations of all three species (Rowe-Rowe 1977c).

Fish taken by Cape clawless otters are similar in size to those eaten by the water mongoose with up to 65% dietary overlap for these two species occupying freshwater habitats (Rowe-Rowe 1977c; Purves *et al*. 1994). However, *Atilax* is restricted to shallow water and edge habitats where terrestrial prey assumes a higher importance in the diet and reduces the potential for significant competition (Rautenbach & Nel 1978; Purves *et al*. 1994). There was virtually no dietary overlap between Cape clawless otters and *Atilax* in marine habitats, where *Aonyx* foraged on benthic prey, while *Atilax* focused on shore crabs and other terrestrial species (Louw & Nel 1986).

Cape clawless otters and large mottled eels showed a 69% overlap in diet in Kairezi River Protected Area (KRPA), Zimbabwe. Both otters and eels fed on medium sized crabs, the most abundant cohort (Butler & Marshall 1996). Despite the overlap, spatial partitioning appears to occur with clawless otters hunting by feel in shallower water and large eels feeding mainly in deep pools (Butler & Marshall 1996). Predation on eels by otters probably further reduces intraguild competition (Butler& Marshall 1996).

Potential predators of clawless otters include Nile crocodiles and possibly larger terrestrial predators though there are few reliable records.

Road kill

Where otters occur in peri-urban areas, road kills might constitute a significant local threat. Verwoerd (1987) suggested that road kills were a major mortality factor for a coastal population of otters at Betty's Bay, South Africa. He found a male otter cub killed and stated that otters are occasionally found dead alongside the main paved road of Betty's Bay. Local residents confirmed the occurrence of occasional otter road kills (Verwoerd 1987). The extent to which this has led or has the potential to lead to negative population impacts is unknown.

Human conflict

Otters are sometimes blamed for reduced fish stocks in commercial and subsistence fisheries. For example, fisheries managers of the Kairezi River Protected Area, Zimbabwe blamed trout declines on otter predation and competition with trout for food despite evidence to the contrary (Butler, 1994). Scat analysis revealed that only 1% of otter feces (n = 255) contained trout remains, while diets of otters and trout overlapped only by 17% (Butler 1994).

Despite mostly minor impacts, clawless otters are killed by people in commercial trout farms, aquaculture projects and especially by rural communities that reply upon fishing or where the species is held responsible for significant poultry losses (IUCN 2002b). In the Kairezi River Protected Area, between three to eight Cape clawless otters were killed at a single trout farm for pond raiding and fish killing between 1988 and 1994 (Butler 1994). Additional complaints came from households near the river's edge, who blamed otters for losses of domestic poultry at night; respondents reported not persecuting otters because they were considered too difficult to capture with dogs and dangerous if held at bay (Butler 1994).

Human hunting and commercial trade

Cape clawless otter meat is generally not considered to have any value but parts are used widely for traditional medicinal practices. Based on interviews, De Luca & Mpunga (2005) concluded the Cape clawless otter was the carnivore species most sought after by villagers in the Udzungwa Mountains, Tanzania. The most valued parts were the skin, penis, fur, head and vocal cords which were used to treat a variety of ailments including sexual problems, convulsions, burns, neck pain, tuberculosis and earache. Body parts were also used for spiritual purposes for example, for protection from evil spirits, and to increase boys' strength and aggression. Otter parts were occasionally also used in burial ceremonies, to stop children crying and for decorative purposes in belts and hats. Otters were hunted by snares laid in the rainy season. De Luca & Mpunga (2005) presented preliminary data suggesting that such hunting may locally extirpate the species. In Zimbabwe, otter pelts are considered luxury items (Butler 1994).

No data

Disease, Genetic issues, Climate change, Insect control, Tourism.

CONGO CLAWLESS OTTER (AONYX CONGICUS)

Current distribution of **Congo Clawless Otter (Aonyx congicus)**. Extent of historical distribution unknown.
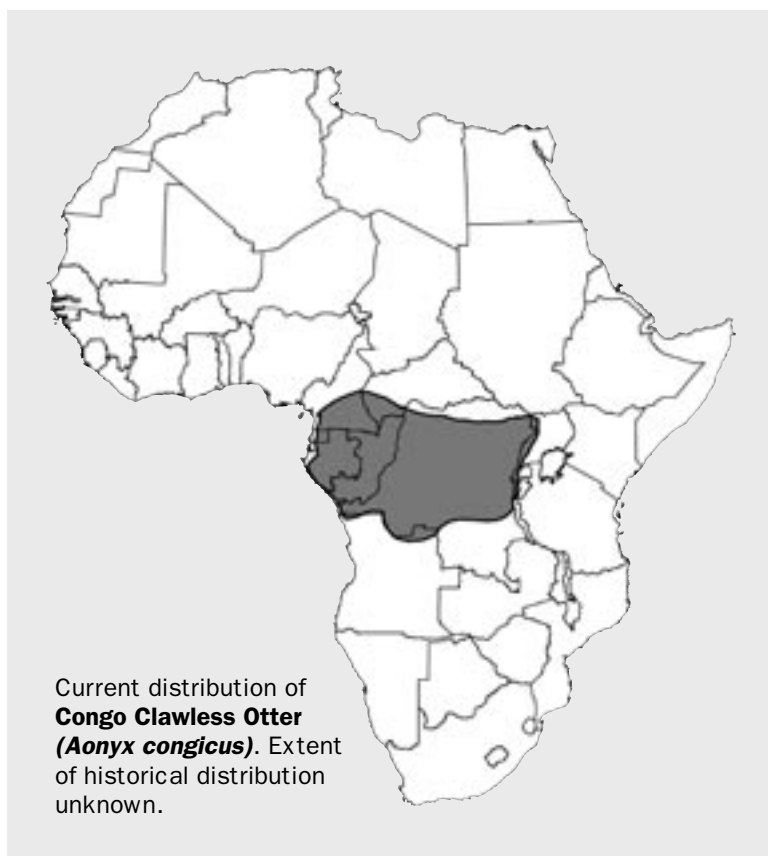
Note: The distinction between Aonyx congicus and A. capensis has not been resolved satisfactorily. The present understanding is that the two are allopatric.

Habitat associations

Restricted to forested regions of central Africa.

Degree of ecological specialization

One of the least known carnivores considered in this report, Congo clawless otters are considered to be forest specialists. They are restricted to wetland habitats.

Distribution trends

The extent to which current distribution has changed from that of a century ago is unknown. Since the recent push to further baseline knowledge of African otters, new records are by and large considered to be improvements in knowledge, rather than reflective of changes in distribution.

Human conflict

In the Dja River area, there is conflict between the Congo clawless otter and fishermen, due to the destruction of nets, stolen fish and disturbance (Alary *et al*. 2002). In Gabon, *A. congicus* is persecuted and killed only in areas where it is considered a competitor with fish (S. Etouk *pers. comm.*, as cited in Jacques *et al*. 2002), with *A. congicus* avoiding such areas (S. Lahm, *pers. comm.*, in Jacques *et al*. 2002). There are also few reports that consist of otters drowning in fish traps, with *A. congicus* seeming to be a lesser concern in comparison to *L. macullicollis* (Jacques *et al*. 2002).

Decline in habitat and/or prey availability

Congo clawless otter habitat has either been dramatically altered or lost due to bush clearing, deforestation, agriculture, overgrazing, siltation, wetland drainage, water extraction or denudation of riparian vegetation (Rowe-Rowe 1995; Nel and Somers 1998; IUCN 2002a).

Habitat destruction in the Dja River area is a serious problem for otter populations (Alary *et al*. 2002). In comparison, habitat destruction in Gabon does not appear to be a present threat (Jacques *et al*. 2002). Eighty-five of present day Gabon is covered with evergreen lowland rainforest (Guineo-Congolian rainforest), with annual deforestation rates being 0.5% (WRI, 2000) and nearly

half the forest has never been exploited (Jacques *et al.* 2002). Since the population density is very low (ca. 1 million people who are mainly concentrated in towns), human disturbance or overfishing are problems only in a few locations (Jacques *et al.* 2002).

Additionally, food harvesting and gathering of materials also threaten Congo clawless otters (IUCN 2002a).

Human hunting and commercial trade

Bushmeat hunting is a present threat in the Dja River (Delvingt *et al.* 1994), and also occurs on the other side of the border in Northeastern Gabon (Lahm 2001). Various regions of the body are used as witchcraft material and as aphrodisiacs, with the skin being used to make drums (Alary *et al.* 2002). Along roads or in villages (four sites in the region between 1992 and 2002: Somalomo (Franck Alary), Abong-Mbang (Mark van der Wal), north of Dja (Hubert Planton), Doumé (Jean-François Noblet)), Congo clawless otter carcasses were for sale in markets (Alary *et al.* 2002).

Field locations for **Congo Clawless Otter** studies.

There have also been occasional cases of cubs being caught in order to be sold to Europeans with cubs not surviving in either case (Jacques *et al.* 2002).

No data

Interspecific conflict, Disease, Road kills, Genetic issues, Climate change, Insect control, Tourism.
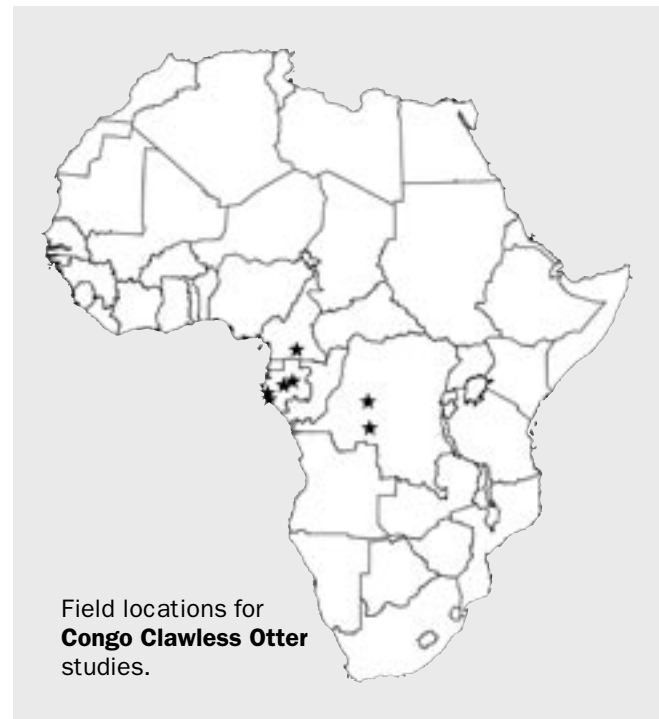
HONEY BADGER (MELLIVORA CAPENSIS)

Habitat associations

The honey badger has a very wide habitat tolerance and, in Africa is absent only from open dune desert (Skinner & Smithers 1990). The species occurs in rainforest, woodland savannas, grasslands, marshes, afro-alpine steppes up to 4,050 m, scrub, coastal sandveld, and deserts (Marlow 1983; Smithers 1971; Stuart 1981; Sillero-Zubiri 1996).

Degree of ecological specialization

The honey badger is a generalist with a board omnivorous diet. In the southern Kalahari, diet comprised 59 species and was dominated by vertebrates (83%) including mammals up to the size of springhare (2 kg), reptiles and birds, followed by invertebrates (11%, mainly bee larvae) and tsama melons (Begg *et al.* 2003). Honey badgers also consume birds eggs, berries, fruit, honey and carrion (Kingdon 1977). They are notable for low reproductive rates and extensive home

Current (dark gray) and historical (light gray) distribution of **Honey badger** *(Mellivora capensis)*.
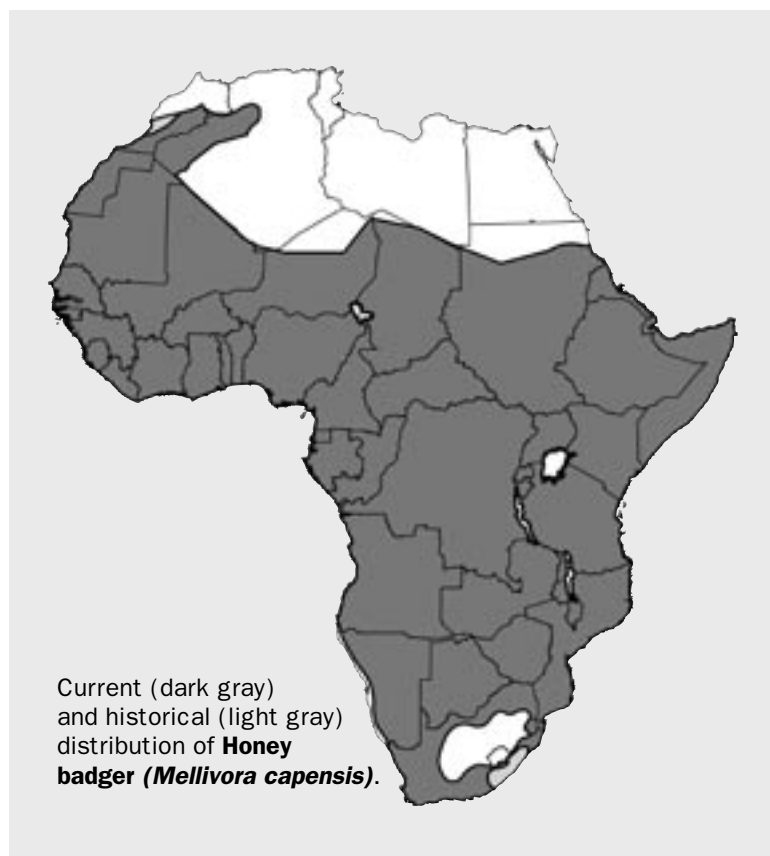
ranges, both greatly disproportionate to their size (female home range size in the southern Kalahari was five times larger than predicted from body size; Begg 2005a; b).

Distribution trends

The species still occurs widely throughout its historical range but appears to naturally occur at relatively low densities and is nowhere abundant (Stuart 1981; Skinner & Smithers 1990). High natural mortality rates, low reproductive output and large range requirements (at least for semi-arid habitat) may reduce the natural resilience of populations and increase the likelihood of local extinctions (Begg *et al.* 2005b). Distribution trends are poorly known for this species, but they have been extirpated from much of their former range in South Africa.

Human conflict

Honey badgers come into conflict with subsistence and commercial bee-keepers throughout their range. Raids on apiaries by honey badgers have been reported from Angola, Botswana, Ethiopia, Kenya, Malawi, Mozambique, Nigeria, Senegal, Somalia, South Africa, Tanzania, Togo-Benin, Uganda, Zaire, and Zimbabwe (Hepburn & Radloff 1998). Damage inflicted by badgers can be significant; for example 2,700 hives from a total of 24,000 (more than 10%, n=56, of apiaries) were damaged by badgers in Tanzania (Kingdon 1977), while annual losses in the Western Cape, South Africa estimated by beekeeping authorities exceeded ZAR500 000 (Begg 2001). The decline of wild honeybees as a result of human activities (see next section) has been suggested as a factor increasing raids by honey badgers.

Honey badgers are persecuted widely in retribution for such damage. Begg (2001) estimated that surveyed beekeepers in the Western Cape destroyed a minimum of 248 badgers, with 231 removals occurring within the previous 15 years. A quarter of the interviewees admitted to actively trapping badgers, with 15% estimating their individual kills to total between 30 to 90 badgers. The rest admitted to having killed fewer than 10 badgers each. One beekeeper declared that 22 honey badgers were captured in a year at a solitary apiary site (Begg 2001). Honey badgers are also often taken in the widely-held but mistaken belief that they create significant damage to livestock. They do occasionally kill juvenile goats and sheep and raid chicken coops but as a result of their formidable reputation are wrongly blamed for the deaths of much larger stock (Smithers 1971; Kingdon 1977).

WILDLIFE CONSERVATION SOCIETY

Badgers are killed chiefly in steel-jawed traps with as many as 20 traps placed permanently at apiaries. The species is susceptible to poisoned and baited traps (e.g., coyote getters), and is routinely killed during non-selective control operations targeting caracals and black-backed jackals (Stuart 1981; Comrie-Gregg 1985; Smithers 1986). They are sometimes killed by recreational hunting clubs using dogs.

Honey badgers occasionally become problem animals at national park rest camps. During the 1980's, 40 badgers were killed or removed after raiding fridges and dustbins in the Satara rest camp, Kruger National Park (Begg & Begg 2005c).

Most conflict situations are easily resolved. Hives are easily protected by raising above the ground, suspending them from trees by wire or placing on a sturdy stand which badgers cannot overturn (Begg & Begg 2005c). Nonetheless persecution remains common, from farmers refusing to implement hive protection, implementing only partial measures or lacking confidence that their intervention will resolve their problems (Begg 2001). Additionally, honey badgers are sometimes killed by farmers lacking problems in support of beekeepers (Begg 2001).

Field locations for **Honey badger** studies.
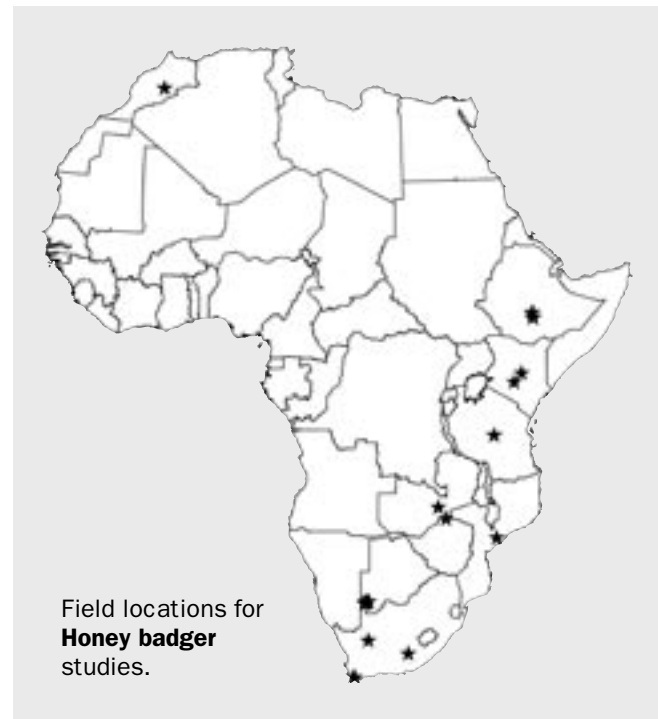
Decline in habitat and/or prey availability

Provided persecution is absent, honey badgers are relatively tolerant of habitat conversion to agriculture because it can lead to enhanced prey densities (i.e., rodents and arthropods). In South Africa, a reduction in the availability of wild bee hives may explain their increased reliance on domestic beehives for honey (and concomitant elevated persecution and risk of extirpation) (Begg 2001). Monoculture agriculture, the widespread application of chemicals, and associated habitat transformation may drive declines in wild honeybee densities, though this is yet to be rigorously demonstrated (Begg 2001). Artificial fire regimes combined with drought is thought to reduce the abundance of rodents in some regions, probably contributing to increased occurrence of raids on domestic hives and perhaps local extinctions (Begg 2001).

Interspecific conflict

Honey badgers are occasionally killed by large cats but adults are very well equipped to defend themselves. They have extremely powerful jaws, pungent anal gland secretions and loose, rubbery skin which is resistant to bites and also permits them to twist around and deliver bites even when held by the neck (Skinner & Smithers 1990). Juveniles are vulnerable to large predators and other adult badgers (Begg *et al*. 2005c).

Disease

The natural asociality and low densities of this species probably limits its vulnerability to disease epidemics. Honey badgers are susceptible to rabies infection and although there are few data, none has brought forth evidence evidence of epidemics. Isolated cases are reported occasionally from southern Africa (Hayles *et al*. 1977; Begg & Begg 2005c). Parvovirus and canine distemper virus infection has been documented, both associated with poor health and possible deaths (Kingdon 1977; Steinel *et al*. 2000).

Road kills

Although there are few data, the species' very wide-ranging movements (Begg *et al*. 2005a) probably increase their vulnerability to vehicles. Their apparent fearlessness of vehicles may aggravate this; L. Hunter (pers. obs.) saw an individual stand its ground against an oncoming vehicle in Phinda Game Reserve, South Africa.

Human hunting and commercial trade

There is no international trade in the species except for occasional legal take by sports hunters. They are occasionally hunted for bushmeat, either opportunistically or when other more favored species are no longer available (Begg & Begg 2005c; Colyn *et al*. 2004). In Zambia, the species is considered poor eating due to the sweet taste of its meat, but is hunted particularly in the north-western region were there is little wildlife remaining (Begg & Begg 2005c). It is also valued for traditional medicine applications. In Zambia, the heart, tail and nose are combined with tree roots, believed to provide protection against stab wounds and other injuries (Begg & Begg 2005c) and parts are valued in KwaZulu-Natal as charms for hunting dogs (Rowe-Rowe 1992)

No data

Genetic issues, Insect control, Tourism, Climate change

AFRICAN CIVET (CIVETTICTIS CIVETTA)

Habitat associations

African civets have a relatively wide habitat tolerance within the more mesic areas of the continent where they are usually associated with cover for daytime refuges. They inhabit forests, woodland savannas, tall grasslands, floodplains and thickets (Ewer & Wemmer 1974; Abebe 2000; Skinner & Smithers 1990). They do not occur in most of arid south-west Africa and north of 15°N but are found in the dry northern savannas and in riparian habitat in the Sahel (Rosevear 1974; Ray 1995). They occur at altitudes up to 5,000 m probably as transients (Grimshaw *et al*. 1995). They are tolerant of agriculture and other human modified habitat provided cover is available (Skinner & Smithers 1990; Ray 1995). They adapt well to degraded secondary forest (Grubb *et al*. 1998)

Degree of ecological specialization

Omnivorous with a catholic diet dominated by insects, myriapods, wild fruit,

murids, reptiles, birds, and amphibians. The African civet is able to utilize noxious prey items such as millipedes, *Strychnos* fruit and highly decayed carrion (Kingdon 1977; Schliemann 1990; Richardson & Levitan 1994). It is thought to subsist for extended periods exclusively on fruit in forested regions (Kingdon 1977; Pendje 1994) and takes aquatic species (crabs and snails) in riparian habitat (Rosevear 1974; Kingdon 1977). Civets raid plantations (particularly papaya and maize) and poultry houses, and have are occasionally blamed for taking lambs (Rosevear 1974; Kingdon 1977).

Distribution trends

Civets are able to persist in human-modified habitats provided cover is available and remain widely distributed within historical limits. Rowe-Rowe (1992) reported that numbers

Current distribution of **African Civet (*Civettictis civetta)*.** No significant change from historical distribution.

were declining in the former northern Transvaal Province, South Africa though there are no data to corroborate this impression.
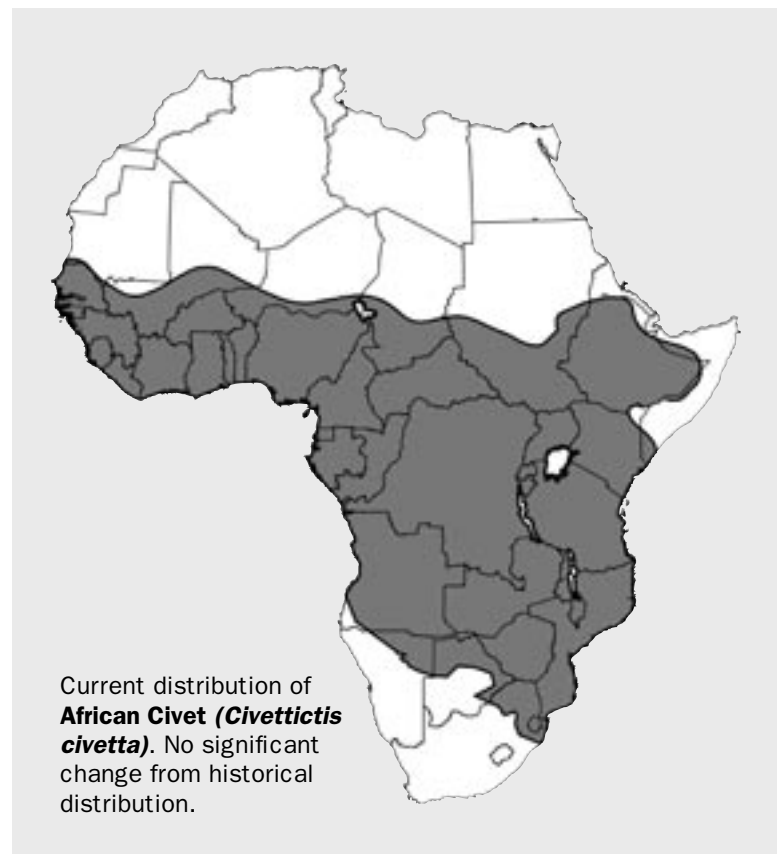
Human conflict

Civets are killed widely in retribution for damage to domestic animals and crops (though motivation is confounded by hunting for meat in many areas). Farmers view the civet as a pest due to its raiding of cultivated gardens and poultry coops (Rosevear 1974; Kingdon 1977; Carpaneto & Germi 1989). A survey of households surrounding Bénoué Wildlife Conservation Area in northern Cameroon, revealed that 24% of respondents experienced loss of livestock (presumably poultry) to civets, the highest for any predator (Weladji & Tchamba 2003). Civets were not considered to damage to any crops. Civets are easily hunted, by dogs, snares, gin traps or shooting by spotlight. They are killed during control operations intended for other species, for example by coyote-getters, poison baits or night shooting for jackals (Rowe-Rowe 1992). Rowe-Rowe (1992) estimates that indiscriminate methods kill six civets for each jackal in the former northern Transvaal, South Africa.

Decline in habitat and/or prey availability

Civets benefit from numerous types of human habitat conversion for example, to degraded forest or agriculture which often favors rodents and arthropods or provides alternate food source such as fruit crops.

Field locations for
African Civet
studies.
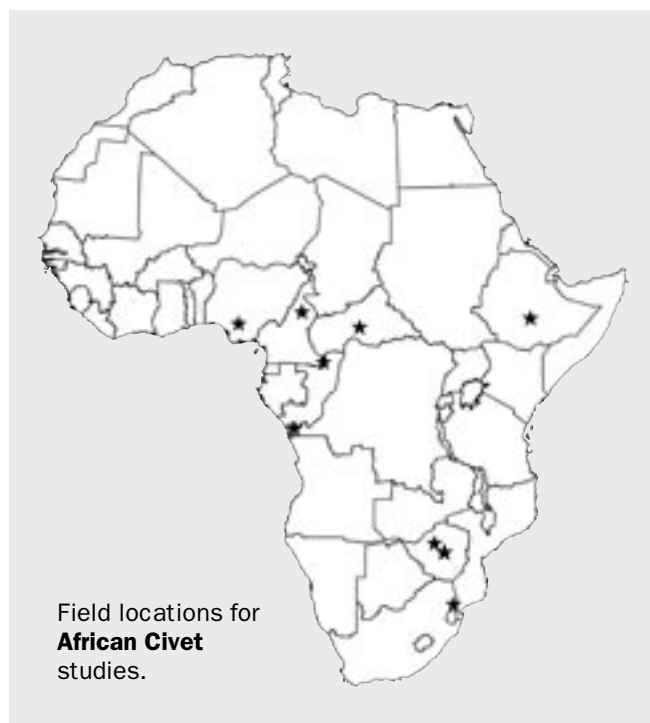
Interspecific conflict

African civets are occasionally preyed upon by all the larger carnivores (Kingdon 1977). In Niolokolo Koba National Park, Senegal, civet remains were recorded in 2 of 117 spotted hyena scats (Di Silvestre *et al*. 2000). Populations in close proximity to human settlements are vulnerable to predation by domestic dogs (Kingdon 1977; Carpaneto & Germi 1989), though it is unknown if this comprises a significant threat.

Disease

There is no evidence for disease epidemics in this species. They are believed to be vectors and potential reservoirs of rabies, with cases sporadically reported mainly from West Africa (Enurah *et al*. 1988; Bingham *et al*. 1994). It is unknown if rabies leads to increased mortality or to population declines.

Road kills

Civets are relatively slow-moving and often killed on roads, though this possibly reflects their ability to persist in numbers close to human populations. Kingdon (1977) states that most of the road kills (n>20) he encountered were sub-adults, with only two incidences of adults. The majority of road kills occurred on roads with high cut banks (Kingdon 1977). This suggests that road kills may limit the ability of dispersing animals to colonize new areas or disperse between populations. The effects on the species at the population level have not been assessed.

Human hunting and commercial trade

Where available, the African civet is readily exploited by human hunters mainly for meat (Ray & Stein 2003). In south-eastern Nigeria, it is one the most common mammals in the bushmeat trade (Angelici *et al*. 1999b). Hunters in Sierra Leone (Grubb *et al*. 1998), the eastern Congo (Carpaneto & Germi 1989), and the savannas of northern region of Central African Republic (R. Ruggerio in Ray & Stein 2003), frequently trap civets for human consumption. African civet meat is highly prized in the northern Congo, such that hunters opt to consume it themselves rather than sell it (R. Ruggerio in Ray & Stein 2003). During a 1.5 year study in the surrounding villages of Banyang-Mbo Wildlife Sanctuary, Cameroon, 1% of the total offtake and biomass from 96 hunters comprised African civets (Nzouango & Willcox 2000). Civet represented 7% and 18% of the overall carnivore offtake and biomass, respectively (Nzouango & Willcox 2000). Colyn *et al*. (1987) found that the African civet represented only 2.3% of small carnivores captured as bushmeat in the Kisangagi region, Congo (Kinshasa), probably reflecting its relative scarcity, rather than extent of human demand (Colyn *et al*. 1987). Consumption of African civets by some ethnic groups in eastern Zaire is dominated by food taboos, for instance an expecting couple will not consume the flesh of an African civet for fear that their child will

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be born with abnormalities (Carpaneto and Germi 1989). Despite the species' protected status in Zanzibar, it is regularly hunted for meat by local hunting associations (Goldman & Winther-Hansen 2003).

African civets have been kept in captivity for centuries for the extraction of musk secretions from their perineal glands to produce perfume (Dannenfeldt 1985; Ray 1995). Despite synthetic alternatives, civiculture persists, primarily in Ethiopia which accounts for 90% of the global trade in civet musk. Niger and Senegal also export musk (Jemal 1999). In 1997, Ethiopia had a minimum estimate of 2,617 African civets in 174 farms, compared to 3,037 civets in 203 farms in 1998 (Fikadu *et al*. 1997; Pugh 1998; WSPA 1999). All civets on farms were wild-caught, with a reported mortality rate approaching 40% within the first three weeks of captivity (WSPA 1999). Male civets are preferentially harvested due to their larger perineal glands which are thought to produce a more potent and higher quality secretion (Vandenput 1937; Abebe 2000). There is no quota system in place for civet harvests. Abebe (2000) suggest that civet populations may undergo local declines due to harvest for civiculture and further concluded that the destruction of woodlands and forests for ease of hunting was encouraged by civiculture.

Not applicable
Genetic issues, Climate change, Tourism, Insect control.

PART V:
CONCLUSIONS AND RECOMMENDATIONS

Both the species-specific and geographic analyses of carnivore conservation on the African continent reveal uneven conservation portraits for the 20 species considered in this report. A subset of species – lion, African wild dog, cheetah, and Ethiopian wolf – rises to the top in priority with regard to both intrinsic vulnerability and exposure to extrinsic threats. Reassuringly, these species have also benefited from some of the greatest conservation and research attention. Nevertheless, research (on all species) is heavily weighted towards subject matter with limited relevance to conservation or management. Further, the geographic focus of research on carnivores has been overwhelmingly centered in East and southern Africa, primarily in protected areas. However, these are not necessarily areas where carnivore communities have been the most adversely affected (taking species loss as a measure) nor where there is the greatest conservation potential.

The analyses presented here have brought increased attention to several species that display unexpected vulnerability, but for which the state of knowledge is insufficient to monitor the effects of increasing threats. Notable among these are medium-sized felids (African golden cat, serval, caracal), canids (jackals), and striped hyenas. In many localities, such species are emerging as the apex carnivores in impacted ecosystems which have lost larger carnivore species. The persistence of these new top carnivores is not necessarily assured, particularly against the backdrop of low levels of baseline knowledge regarding their status, distribution, and ecology against which to monitor changes. The opportunity exists in human-transformed landscapes to prevent the further loss of carnivore species but this will require greater effort directed towards species which have received low levels of conservation attention to date (see # 9 below).

Felidae stood out as the only family group with consistently higher component species priority scores and species loss statistics. All six felids covered here have experienced range losses of at least 20%; within-family variability in this and other variables was more pronounced for canids and hyenids. Beyond this, most natural groupings were either defined by size (large vs. small), or other characteristics (see Table 2.13).

This report does not add significantly to the discussion of predictors or correlates of extinction risk – a subject that has received ample attention, including studies devoted specifically to carnivores (Purvis *et al*. 2000; 2001; Cardillo *et al*. 2004). Rather, our combined approach of evaluation of extrinsic and intrinsic factors together with a knowledge profile for each have added additional information for establishing species priorities on a continental scale. This was further informed by the geographic analyses which highlighted regions that have suffered greatest impacts, and identified areas that may hold maximum conservation promise.

From this exercise, we bring forward several key recommendations for carnivore conservation on the African continent, not in any order of priority:

1. Improve range-wide knowledge on key species

Five well-studied large carnivores – cheetah, lion, African wild dog, leopard, and spotted hyena – are highlighted in this report as species of concern. We recommend that this attention be sustained but consolidated such that local research and conservation is pursued with a regional, if not continental context. Due to their risk status, and that 1) their ranges formerly spanned most of the continent

and 2) they currently receive a high relative amount of research and monitoring attention, these five species are ideal candidates for range-wide priority setting exercises. Sanderson *et al.* (2002) and Rabinowitz (2005) have demonstrated significant benefits to such an approach, including:

  (i) The development of a synthetic, spatially explicit summary of the status and distribution of the species across its historical range (and see #2 below);

 (ii) The establishment of biological conservation priorities for the species in all the major, ecologically distinct settings where the species occurs; and

(iii) Increased coordination of resources and actions by arriving at those priorities through a consensual process involving all major data holders, practitioners and active conservation groups working on the species.

2. Improve overall distributional knowledge

There is a clear need to improve the ability of researchers and practitioners in Africa to collect and integrate distributional information on carnivores, particularly in western and northern Africa. We recommend that practitioners *in situ* focus effort on survey techniques that cover a lot of ground, are cost-efficient, and are easily transferable to non-specialists. Valuable ongoing or proposed initiatives addressing this need include:

  (i) Conducting country-wide mapping exercises refining carnivore distributions relying on observer reports, for example, for Tanzania (Durant *et al.* 2003), Namibia (Stander & Hannsen 2004) and South Africa (Friedman & Daly 2004);

 (ii) Disseminating techniques for surveying carnivores. Recent field manuals (Loveridge *et al.* 2001, Henschel & Ray 2003, Durant *et al.* in prep.) provide models intended for use by non-specialist field workers conducting biological surveys who might otherwise exclude carnivores from their efforts. At the same time, they cover specialized techniques for dedicated carnivore survey activities;

(iii) Providing training in survey techniques to practitioners at all levels;

(iv) Increasing survey effort outside protected areas. Even for the well-studied species, distributional information is clearly biased towards protected areas, yielding distributional maps that are more fragmented than reality by essentially dismissing intervening areas that may offer secure habitat. Addressing this recommendation may necessitate a different set of survey protocols better suited to areas with human populations, for example, respondent interviews and track surveys. We recommend increased effort devoted towards the refinement of such methods and, in particular, verification and calibration against established protocols; and

(v) Assigning responsibility to individual(s) or institution(s) to be the repository of distributional information for species or species groups. They would collate and maintain the "latest" distributional maps, adding new information when appropriate. The IUCN SSC Specialist Groups have initiated this process for some carnivore taxa, e.g felids (Breitenmoser, pers comm.). The African Mammal Databank (IEA 1999) is another promising venue, although its extensive scope (i.e. in numbers of species) may impede regular updates and accuracy.

3. Focus conservation action and research on addressing threats

Conflict with people is clearly the chief threat facing large carnivores in Africa. While there are enormous efforts underway to address the issue, the great majority are localized in scope. There is a clear need for consolidation, coordination, and dissemination of knowledge about threats impacts and solutions across species and regions. While we are not suggesting an abandonment of a single-species focus where appropriate (see #1), we stress the importance of dissolving barriers that prevent cross-cutting lessons to be disseminated and applied to other species. Human hunting, disease, and possibly habitat decline constitute other important threats that would benefit from a similarly coordinated approach. Further, an integrated approach that seeks to unravel the extent to which threats interact with one another (e.g. conflict and disease; interspecific competition and habitat decline) is preferable to one that focuses on a threat in isolation.

4. Refine tools for conservation planning outside protected areas

The dearth of knowledge on biodiversity status outside protected areas (see #6i), combined with a lack of existing processes for cross-jurisdictional conservation-based land use planning, hampers conservation action on the scale required to ensure the continued persistence of large carnivore species and intact carnivore guilds (Mills 2005; Woodroffe & Ginsberg 2005). Range-wide priority-setting for selected focal carnivore species (see #1) can guide the selection of the appropriate scale and connectivity of areas with conservation potential, regardless of their protected status (Groves 2003). In addition, the maps of carnivore species loss featured in Part 3 (Figs. 3.3-3.8) can provide further spatially-specific information at the community level to identify areas of conservation potential in a variety of categories:

(i) Areas with intact carnivore communities, i.e., where no species loss has occurred;
(ii) Areas where the most highly endangered species occur;
(iii) Areas where carnivore species diversity is the highest (also see Mills *et al.* 2001); and/or
(iv) Areas that connect carnivore strongholds to focus efforts on maintaining or restoring connectivity between communities.

5. Develop models and methodologies for connecting carnivore populations

Addressing the increasing isolation and fragmentation of carnivore populations in the face of growing human pressure is a critical need. The 'Peace Parks' (Wolmer, 2003) model represents one extremely exciting possibility with some obvious potential benefits for large carnivores. Nonetheless, clear strategies to effect connectivity of carnivore populations where intervening human communities represent the main obstacle are still in their infancy.

6. Work towards redressing the geographical bias towards carnivore research and conservation.

The heavy bias towards research and conservation activities in East and southern Africa reflects a combination of opportunity, political stability and conservation potential. There is undeniable value in retaining efforts in these regions and we would counsel against withdrawing resources or conservation action from them. However, there is a clear need to increase conservation activities beyond the traditional focus. Accordingly we make two recommendations:

(i) Focus conservation-based research and activities in unprotected areas where the threats are greatest, and which will be critical for retaining or restoring connectivity between populations of carnivores. This is especially salient for East and southern Africa where most carnivore research occurs in large protected areas, but this recommendation is generally applicable across Africa; and

(ii) Initiate more research and conservation action on carnivores in neglected regions, primarily North, West and Central Africa. The two recommendations which follow expand upon this point.

7. Groundtruth carnivore "hotspots"

Several promising areas for carnivore conservation, where little or no species loss has occurred, stand out in this report and in Mills *et al.* (2001). In several of these localities, there is a lack of past or present research and conservation attention. We recommend ground-truthing a number of areas for their overall biodiversity potential. These include (but are not limited to):

(i) southern Senegal/northern Guinea
(ii) northern Niger/Southern Algeria
(iii) northern Benin/western Burkina Faso/south-west Niger,
(iv) northern Central African Republic/southern Chad/south-west Sudan,
(v) northern DR Congo /southern Sudan/ southern Central African Republic
(vi) southern DR Congo
(vii) northern Kenya/southern Ethiopia/southern Sudan.
(viii) northern and southern Mozambique
(ix) southern and eastern Angola

8. Focus carnivore conservation and monitoring efforts on practical "indicator" species

Leopards and spotted hyenas are two species that, by virtue of their ability to persist in areas heavily populated by humans (Bailey 1993; Mills & Hofer 1998), tend to receive less conservation attention than other sympatric large carnivores, such as lion, African wild dog, and cheetah. While this exercise confirmed this lower priority status to some extent, their vulnerability and threat scores were still high on the overall spectrum, indicating complacency is unwarranted. Further, both species merit attention as members of a "second tier" of large carnivores, ably fulfilling large predator roles even when others are absent. As relatively visible members of carnivore communities when present, we recommend focusing conservation attention and monitoring efforts on spotted hyenas and/or leopards where: a) lions, cheetahs, wild dogs, and/or brown hyenas are present but critically endangered (although not in expense of

attention to those species) or b) following their extirpation (e.g., North Africa and extensive areas in West Africa). A noticeable negative change in status for either leopards or spotted hyenas can indicate further degradation, while continued persistence may bring renewed hope for recovery of the carnivore community at large. The fact, for example, that both persist in higher densities than other named species even when exposed to persecution and are both individually recognizable makes accurate long-term monitoring (e.g., by camera-traps) a useful possibility. In forested biomes where leopards have always been the sole large predator, focusing conservation attention on this species is important for similar reasons (Henschel & Ray 2003).

Although some species – jackals and African civets, in particular – will thrive in landscapes that have been intensively modified by humans, they can signal overhunting, since such species tend to be selected only once preferred game meat (e.g., ungulates) becomes scarce. While these species did not register as priorities for attention in any of our analyses, they could be useful for biodiversity conservation at large by flagging areas that require targeted hunting management.

9. Improve knowledge on mesocarnivores

Considering their potential ecological importance, we know remarkably little about the ecology of mesocarnivores, even in places where they have assumed top predator roles following the eradication of large carnivores (Andama, 2000). While we recognize that the level of baseline knowledge may never equal that of larger and conspicuous well-studied species, several species warrant targeted studies of their basic ecology. This is especially true of species that have some demonstrated vulnerability, but for which there is a marked lack of data on deleterious impacts such as African golden cats, Congo clawless otters and striped hyenas. The first comprehensive study of the striped hyena in Africa is presently nearing completion (Wagner pers. comm.) while the other species remain almost entirely unstudied.

10. Coordinate research and conservation efforts to focus on carnivore guilds rather than single species

Africa presents extraordinary opportunities for conducting multi-species research and conservation efforts on carnivores, yet the majority of projects remain focused on single species. Funding, manpower, and logistical restrictions remain constraints for any individual researcher, team or project yet significant benefits can accrue simply from greater coordination between researchers in a region. Even with the large number of research papers devoted to carnivores, there remain very few that evaluate and address the impacts of threats to multiple species in a region. Recent examples of data-sharing and coordinated analysis from North America (e.g. Ruth *et al*. 2003) represent a valuable model.

The present exercise has served to illuminate conservation priorities focused on African carnivores at the level of species, communities, and geographic regions. Similarly, while the recommendations furnished here are neither exhaustive nor even a guarantee of conservation success if implemented, they highlight important and achievable actions at the same three levels; species, communities and

regions. It will require such an inclusive conservation effort, at all these levels, to secure the future of many species of large carnivores in Africa. We hope the recommendations provided here inform ongoing efforts to conserve these species, and stimulate and guide the development of new initiatives.

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APPENDIX 1:

SCORING DETAILS: VULNERABILITY CATEGORY

The Vulnerability category comprised 6 variables (see Part II for descriptions):
1) Current distribution
2) Percent range loss
3) Fecundity
4) Ecological specialization
5) Body size
6) Home range size

Methods and references for current distribution and percent range loss can be found in Part III and Appendix 4. Body sizes were taken from Mills *et al.* (2001), Appendix 21.1. Scoring methodologies for the remaining variables are described in turn below:

Fecundity

Fecundity (F) of each species as a measure of reproductive potential was calculated as:

$$F=MAR + IBI + (LIT \times PBF)$$

Where MAR=minimum age of first reproduction, IBI=average interval between births, LIT=average litter size, and PBF=proportion of breeding females. Tables A1.1 and A1.2 contain raw data and sources for all four fecundity parameters and Table A1.3 displays the final fecundity scores for each of the 20 species.

Ecological Specialization

Ecological specialization for each species was assessed by occurrence in different habitats using the habitat-specialization index (HSI) devised by Brashares (2003), calculated as the total number of distinct habitat types (maximum 10) in which a carnivore species is known to occur. The highest score (i.e. most specialized) represented those species present in the least number of habitats. Table A1.4 provides scoring details for each of the 20 species.

Home Range Size

Data from the published literature were used to estimate the average female home range sizes for each of the 20 species, with each species assigned to one of five home range classes (Table A1.5). Those species for which home range data was not available (African golden cat, Congo clawless otter) were assigned to the same class as similar-sized species within their taxonomic group.

Total Vulnerability Scores

The total vulnerability scores and those of the six vulnerability variables are found in Table A1.6.

Table A1.1 Raw data and sources for minimum age of reproduction and mean litter size for 20 African carnivores.

Species	Minimum age of reproduction (months)	References and notes	Range in number young/ female/yr. used to derive mean litter size values	References
Ethiopian Wolf	24	Sillero-Zubiri & Gottelli 1994; Sillero-Zubiri *et al.* 2004	2-7	Sillero-Zubiri 1994; Sillero-Zubiri *et al.* 2004
African Wild Dog	24	Creel *et al.* 1997	7-11	Fuller *et al.* 1992; McNutt in Sillero-Zubiri 2004; Woodroffe *et al.* 1997
Black-backed Jackal	11	Moehlman 1979; 1983; Ferguson *et al.* 1983	4	Moehlman 1979; 1983
Side-striped Jackal	6-8	Smithers & Wilson 1979	4-6	Smithers & Wilson 1979; Skinner & Smithers 1990
Golden Jackal	11	Ginsberg & Macdonald 1990	5-6	Ginsberg & Macdonald 1990
Cheetah	24-36	Schaller 1972; Laurenson *et al.* 1992; Kelly & Durant 2000; Kelly *et al.* 1998	2-5	McVittie 1979; Kelly & Durant 2000; Laurenson *et al.* 1992; Frame 1977; Marker & O'Brien 1989
Lion	48-60	Pusey & Packer 1987	1-4	Bertram 1975; Smuts *et al.* 1978; Pusey & Packer 1987
Serval	18-24	P. Andrews 1993 in Nowell & Jackson 1996	1-4	Smithers 1978; Skinner & Smithers 1990; Mellen 1989
African Golden Cat	18-24	Information not available; used information from serval, a felid of the same weight	1	Carpaneto & Germi, 1989; Hart *et al.* 1996;
Leopard	33-35	Martin & de Meulenaer 1988	1-3	Martin & de Meulenaer 1988; Eaton 1977; Le Roux & Skinner 1989; Scott 2003
Caracal	14-16	Bernard & Stuart 1987; P. Andrews 1993 in Nowell & Jackson 1996	1-3	Bernard & Stuart 1987; Avenant 1993
Aardwolf	22	Van Jaarsveld 1993	1-4	Anderson in Mills & Hofer 1998; Richardson 1985; Koehler & Richardson 1990
Spotted Hyena	24-60	Frank *et al.* 1995; Hofer & East 1996	2	Frank *et al.* 1991

Species	Minimum age of reproduction (months)	References and notes	Range in number young/ female/yr. used to derive mean litter size values	References
Brown Hyena	33	Mills 1982	1-5	Mills 1982
Striped Hyena	15	Mendelssohn 1985	1-4	Pocock 1941; Ronnefeld 1969; Heptner & Sludski, 1980; Rieger 1979
Cape clawless otter	12	Skinner & Smithers 1990	1-3	Ewer 1973; Skinner & Smithers 1990
Congo-clawless otter	12	Information not available; used information from cape clawless otter, an otter of the same weight	1-3	Jacques *et al. in press*
Spotted-necked Otter	24	Nowak 1999	1-2	Rowe-Rowe 1978; d'Inzillo Carranza 1997
Honey Badger	12	Johnstone-Scott 1981; Skinner & Smithers 1990; Rosevear 1974; Begg & Begg 2005	1-2	Johnstone-Scott 1981; Skinner & Smithers 1990; Rosevear 1974; Begg & Begg 2005
African Civet	12	Ewer & Wemmer 1974; Mallinson 1973; 1974; Rosevear 1974	2-3	Ewer & Wemmer 1974; Mallinson 1973; 1974; Rosevear 1974

Table A1.2 Raw data and sources for proportion of breeding females and inter-birth interval for 20 African carnivores. Species codes as in Table 1.1.

	Proportion breeding females	Inter-birth interval (mos.)	References and Notes
ETW	0.5	12	Sillero-Zubiri & MacDonald 1997
AWD	0.32	12	Creel & Creel 2002
BBJ	1	12	Loveridge & Nel 2004
SSJ	1	12	Atkinson & Loveridge 2004
GOJ	1	12	Jhala & Moehlman 2004
CHE	1	15-20	Nowell & Jackson 1996; Kelly *et al.* 1998
LIO	1	20	Nowell & Jackson 1996
SER	1	12 – 15	Geertsema 1985
AGC	1	12	Sunquist & Sunquist 2002
CAR	1	12	Bernard & Stuart 1987
LEO	1	15; 16.6	Nowell & Jackson 1996; Hunter *et al. in press*
AAR	1	12	Koehler & Richardson 1990
SPH	1	18-24	Mills & Hofer 1998
BRH	1	12-41, mean = 24	Mills 1982
STH	1	12 – 18	Rieger 1981; Mills & Hofer 1998
CCO	1	12	No data[1]
CGO	1	12	No data[1]
SNO	1	12	Rowe-Rowe 1997
HOB	1	18	Begg *et al.* 2005
AFC	1	4 – 6	Ray 1995

1. In the absence of empirical data, inter-birth interval was assumed to be similar to spotted-necked otter.

Table A1.3 Fecundity scores for 20 carnivore species.

SPECIES	FAMILY	SIZE	MAR[1]	LIT$_{adj}$[2]	IBI[3]	F[4]
Aardwolf	Hyaenidae	S	0.4444	0.6667	0.50	0.6197
African civet	Viverridae	S	0.2222	0.6667	0.25	0.4380
African golden cat	Felidae	S	0.3333	1.0000	0.50	0.7051
African wild dog	Canidae	L	0.3333	0.5822	0.50	0.5444
Black-backed jackal	Canidae	S	0.2037	0.1111	0.50	0.3134
Brown hyena	Hyaenidae	L	0.5556	0.6667	1.00	0.8547
Caracal	Felidae	S	0.2593	0.7111	0.50	0.5655
Cape clawless otter	Mustelidae	S	0.2222	0.6667	0.50	0.5342
Congo clawless otter	Mustelidae	S	0.2222	0.6667	0.50	0.5342
Cheetah	Felidae	L	0.4444	0.4222	1.00	0.7179
Ethiopian wolf	Canidae	S	0.4444	0.7778	0.50	0.6624
Golden jackal	Canidae	S	0.2037	0.0001	0.50	0.2707
Honey badger	Mustelidae	S	0.2593	1.0000	1.00	0.8689
Leopard	Felidae	L	0.6111	0.8000	0.75	0.8312
Lion	Felidae	L	1.0000	0.6000	1.00	1.0000
Serval	Felidae	S	0.3333	0.7111	0.75	0.6902
Spotted-necked otter	Mustelidae	S	0.4444	0.8889	0.50	0.7051
Spotted hyena	Hyaenidae	L	0.4444	0.7778	1.00	0.8547
Side-striped jackal	Canidae	S	0.1111	0.0222	0.50	0.2436
Striped hyena	Hyaenidae	L	0.2778	0.6222	0.75	0.6346

1. Final scores for minimum age of first reproduction was calculated by dividing mean value for each species by the highest in that category to generate scores scaled from 0-1.
2. Final scores for litter size adjusted for number of breeding females was calculated by multiplying mean litter size by proportion of breeding females and then dividing this by the highest value in that category to generate scores scaled from 0-1.
3. Final scores for interbirth-interval were assigned as follows: 0.25=<12; 0.5=12; 0.75=12-18; 1.0=18-24.
4. Total fecundity score for each species (F)=MAR+LIT$_{adj}$+IBI.

Table A1.4 Ecological specialization scores as derived from Habitat Specialization Index (HSI; Brashares 2003) for each of twenty carnivores. Species codes as in Table 1.1.

	Desert	Semi-desert	Dry bush/scrub	Dry savanna	Wet savanna	Moist-mixed woodland	Forest mosaic	Lowland forest	Afro-montane	Riparian/lakeshore	HSI	10-HSI	SCORE[1]
AAR	0	1	1	1	1	0	0	0	0	0	4	6	0.6667
AFC	0	0	1	1	1	1	1	1	1	1	8	2	0.2222
AGC	0	0	0	0	0	0	1	1	0	1	3	7	0.7778
AWD	0	1	1	1	1	1	1	0	0	0	6	4	0.4444
BBJ	1	1	1	1	1	1	1	0	1	0	8	2	0.2222
BRH	1	1	1	1	0	0	0	0	0	0	4	6	0.6667
CAR	1	1	1	1	1	1	0	0	1	0	7	3	0.3333
CCO	0	0	0	0	1	1	1	0	0	1	4	6	0.6667
CGO	0	0	0	0	0	0	1	1	0	1	3	7	0.7778
CHE	1	1	1	1	1	1	0	0	0	0	6	4	0.4444
ETW	0	0	0	0	0	0	0	0	1	0	1	9	1.0000
GOJ	1	1	1	1	1	1	0	0	1	0	7	3	0.3333
HOB	1	1	1	1	1	1	1	1	1	1	10	0	0.0000
LEO	1	1	1	1	1	1	1	1	1	1	10	0	0.0000
LIO	1	1	1	1	1	1	1	0	0	0	7	3	0.3333
SER	0	0	1	1	1	1	1	0	1	1	7	3	0.3333
SNO	0	0	0	0	1	1	1	1	0	1	5	5	0.5556
SPH	1	1	1	1	1	1	1	1	1	0	9	1	0.1111
SSJ	1	1	1	1	1	1	0	0	1	1	8	2	0.2222
STH	1	1	1	1	0	1	0	0	0	0	5	5	0.5556

1. Final ecological specialization score was calculated by dividing (10-HSI) by the highest value in that category (9) to generate scores scaled from 0-1.

Table A1.5 Mean home ranges and sources for 20 African carnivores.

Species	Home Range information	Location	Source	Score[1]
Ethiopian Wolf	2-15 km²; Optimal habitat, mean 6.0 km²; Marginal habitat, mean 13.4 km²	Ethiopian highlands	Sillero-Zubiri & Gotteli 1995	0.4
	5.5–9.2 km²	Guassa (unprotected), Ethiopia	Ashenafi *et al.* 2005	
African Wild Dog	659 km²	Aitong, Kenya	Fuller & Kat 1990	1
	423 km² (range 260 - 633 km²)	Hwange NP, Zimbabwe	Fuller *et al.* 1992	
	553 km² (range 150 - 1,110 km²)	Kruger NP, South Africa	Fuller *et al.* 1992	
	617 km² (range 375 - 1,050 km²)	Moremi GR, Botswana	Fuller *et al.* 1992	
	438 km² (range 620 - 2,460 km²)	Selous GR, Tanzania	Creel & Creel 1995	
	1,318 km² (range 620 - 2,460 km²)	Serengeti NP, Tanzania	Fuller *et al.* 1992	
	50 - 260 km² denning, 1,500 - 2,000 km² otherwise	Serengeti NP, Tanzania	Burrows 1995	
	80 km² denning, 885 km² post-denning	Kruger NP, South Africa	Gorman *et al.* 1992	
Black Backed Jackal	mated adults 19 km²; unmated adults 33 km²; young (< 1 year) 9 km²	Giants Castle GR, South Africa	Rowe-Rowe 1982	0.4
	2.1 km² ± 0.85 km²	adjacent to Hwange NP, Zimbabwe	Loveridge & Macdonald 2003	
	adults, 2.6 - 5.2 km², (mean 4.3 km²); subadults, 4.0-8.8 km² (mean 6.3 km²)	Kalahari, South Africa	Ferguson *et al.* 1983	
	0.7 - 3.5 km², mean 1.8 km²	Rift Valley, Kenya	Fuller *et al.* 1989	
	7.1 - 24.9 km²	Cape Cross Seal Reserve, Namibia	Hiscocks & Perrin 1988	
Side Striped Jackal	1.6 ± 1.3 km²	adjacent to Hwange NP, Zimbabwe	Loveridge & Macdonald 2003	0.2
	0.2 - 1.2 km²	western Zimbabwe game areas	Atkinson & Loveridge 2004	
	4.0 - 12.0 km²	Zimbabwe farmland	Atkinson & Loveridge 2004	

Species	Home Range information	Location	Source	Score[1]
Golden Jackal	adults: 7.9 to 48.2 km²; subadults: 24.2 to 64.8 km²	Ethiopian Highlands	Admasu *et al.* 2004	0.4
	1.1 - 20 km²		Jhala & Moehlman 2004	
Cheetah	females and non-territorial males: 800 - 1,500 km²	Serengeti NP, Tanzania	Frame 1980; Morsbach 1987; Caro 1994	1
	territorial male coalitions; mean 37 km²; maximum 150 km²	Serengeti NP, Tanzania	Bertram 1978; Frame 1980; Caro & Coffins 1986	
	three-male cheetah coalition, 126 km²; solitary male, 195 km²; females, 150 km² and 171 km²	Kruger NP, South Africa	Broomhall *et al.* 2003	
	Single males mean 1483.8 km² (range 119.6 - 3938.1 km²); Coalition males mean 1344.3 km² (range 544.5 - 4347.6 km²); Females mean 2160.7 km² (range 553.9 - 7063.3 km²)	north-central Namibian farms	Marker 2003	
Lion	26 to 226 km²		van Orsdol *et al.* 1985; Viljoen 1993	0.8
	2,075 km²	Etosha NP, Namibia	Stander 1991	
	52.4 ± 26.3 km²	Selous GR, Tanzania	Spong 2002	
	mean = 65 km² (woodlands) to 184 km² (grasslands);	Serengeti NP, Tanzania	Hanby *et al.* 1995	
	626 - 3438 km2	Kunene, north-west Namibia	Stander & Hannsen 2003	
Serval	adult male, 11.6 km² (minimum); adult female 9.5 km² (minimum)	Ngorongoro (monitored over 4yrs), Tanzania	Geertsema 1985	0.4
	adult male, 31.5 km²; adult females, 16 - 20 km²	South Africa (monitored for 4-5 months, spring/ summer)	Bowland 1990	
African golden cat	No data			0.4

Table A1.5 *continued*

Species	Home Range information	Location	Source	Score[1]
Leopard	males, 30 to 78 km²; females, 15 to 16 km²	mesic protected areas	Tsavo NP - Hamilton 1981; Kruger NP - Bailey 1993; Serengeti NP - Bertram 1982	0.6
	females, 23 - 33 km²	long term study in protected area	Le Roux & Skinner 1989	
	females, 37 - 38 km²	long term study in protected area	Cavallo 1993	
	males, 338 km²; females, 487 km²	Cape Province, South Africa	Norton & Lawson 1985	
	male, 55 km²; female, 8 km²	Kenya (cattle ranch)	Mizutani 1993	
	male, 86 km²; female, 22-29 km²	Tai rain forest, Ivory Coast	Jenny 1996	
	males, 210 - 1164 km²; females, 183 - 194 km²	north eastern Namibia	Stander *et al.* 1997	
	males, 1982.9 - 2750.1 km²; females, 199.8 - 908.4 km²	southern Kalahari, South Africa	Bothma *et al.* 1997	
Caracal	males, 31 to 65 km²; females, 4 to 31 km²	Cape Province, South Africa	Stuart 1982; Norton & Lawson 1985; Moolman 1986; Avenant 1993	0.4
	males, 26.9 ± 0.75 km²; females, 7.39 ± 1.68 km²	South Africa	Avenant and Nel 1998	
	males, 308.2 - 456.6 km²	north central Namibian farms	Marker & Dickman 2005	
Aardwolf	1 - 4 km²		Mills & Hofer 1990	0.2
Spotted Hyena	<40 km²	Ngorongoro Crater, Tanzania	Kruuk 1972a	0.6
	>1000 km²	Kalahari, South Africa	Mills 1990	
	55.5 km² (clan territory)	Serengeti NP, Tanzania	Hofer & East 1993	
Side Striped Hyena	male, 72 km² ; female, 44 km²	Serengeti NP, Tanzania	Kruuk 1976	0.6

Species	Home Range information	Location	Source	Score[1]
Brown Hyena	235 to 481 km² (clan territory)	southern Kalahari, South Africa	Mill 1982; Mills 1990	0.8
	220 km² (clan territory)	Namib desert, Namibia	Goss 1986	
	31.9 to 220 km² (individuals)	Namib desert, Namibia	Skinner *et al.* 1995	
Cape Clawless Otter	male, min. total area: 19.5 km² (core 12.0 km²); female, min. total area: 14.3 km² (core 7.5 km²)	Cape Province, South Africa	Arden-Clarke 1986	0.4
	total length: 4.9 - 54.1 km (core length: 0.2 - 9.8 km); total area: 0.05 - 10.6 km² (core area: 0.01 - 1.4 km² ha)	Western Cape, South Africa	Somers & Nel 2004	
Spotted Necked Otter	males mean 16.2 ± 1.2 km² ; females mean 5.8 ± 4.2 km²	KwaZulu-Natal Drakensberg, South Africa	Perrin *et al.* 2000	0.4
Congo Otter	No data			0.4
Honey Badger	females: 126 ± 13 km²; males 541 ± 93 km²; young males 151 ± 45 km²	southern Kalahari, South Africa	Begg *et al.* 2005	0.8
African Civet	subadult male 11.1 km² (core area: 0.4 km²)	Bale Mountain NP, Ethiopia	Admasu *et al.* 2004	0.4

1. Home range class: ≤5 km² = 0.2; 5 - 30 km² = 0.4; 30 - 100 km² = 0.6; 100 - 500 km² = 0.8; >500 km² = 1.0

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Table A1.6 Vulnerability category scores.

	Body size	Fecundity	Specialization	Current Distribution	Range Loss	Home Range	TOTAL
Lion	1	1.0000	0.3333	0.8706	0.8288	0.80	4.833
African Wild Dog	1	0.5444	0.4444	0.9346	0.8953	1.00	4.819
Ethiopian Wolf	0.75	0.6624	1.0000	0.9995	0.9829	0.40	4.795
Brown Hyena	1	0.8547	0.6667	0.9348	0.3808	0.80	4.637
Cheetah	1	0.5342	0.7778	0.7913	0.7650	0.40	4.268
African Golden Cat	0.75	0.7051	0.7778	0.9060	0.4421	0.40	3.981
Striped Hyena	1	0.6346	0.5556	0.7399	0.3827	0.60	3.913
Congo Clawless Otter	0.75	0.7179	0.4444	0.9108	0.0000	1.00	3.823
Spotted Hyena	1	0.8547	0.1111	0.5338	0.2662	0.60	3.366
Leopard	1	0.8312	0.0000	0.5139	0.3659	0.60	3.311
Caracal	0.75	0.5342	0.6667	0.5809	0.3768	0.40	3.309
Aardwolf	0.75	0.6197	0.6667	0.8165	0.1004	0.20	3.153
Side-striped Jackal	0.75	0.7051	0.5556	0.6508	0.0000	0.40	3.061
Serval	0.75	0.6902	0.3333	0.6090	0.2392	0.40	3.022
Honey badger	0.75	0.8689	0.0000	0.2193	0.0047	0.80	2.643
Cape Clawless Otter	0.75	0.5655	0.3333	0.5440	0.0000	0.40	2.593
Black-backed Jackal	0.75	0.3134	0.2222	0.7852	0.0314	0.40	2.502
African civet	0.75	0.4380	0.2222	0.4732	0.0000	0.40	2.283
Golden Jackal	0.75	0.2707	0.3333	0.4794	0.0041	0.40	2.238
Spotted Necked Otter	0.5	0.2436	0.2222	0.6101	0.0000	0.20	1.776

APPENDIX 2:
SCORING DETAILS: KNOWLEDGE CATEGORY

The Knowledge category comprised 5 variables (see Part II for descriptions):

1) Knowledge of distribution in Africa
2) Knowledge base of ecology, requirements and population limitations
3) Knowledge of population trend
4) Number of studies
5) Geographic scope of knowledge

Scoring methodology for the first four variables is presented in Table 2.2.

Geographic Scope of Knowledge

Geographic scope of knowledge (GSK) for each species was calculated as:

$$\sum (S \times PRG^1)/G$$

Where S=number of studies in georegion, PRG=proportion of species' range in georegion, and G=georegion. Only georegions (maximum five) that comprised at least 5% of a species' range were included in the calculation (Table A2.1).

Research Subjects

As described in Part II, we used Web of Science®, an academic search engine that searches the titles and abstracts of approximately 8,700 research journals as far back as the 1940s, to tabulate a score for number of studies on each species. For further analysis unrelated to the scoring process, each record for each species was assigned a subject category (Table A1.2).

Total Knowledge Score

The total knowledge scores and those of the five knowledge variables are found in Table A2.3.

Table A2.1 Scoring details for geographic scope of knowledge

	SOUTH			NORTH			EAST			CENTRAL			WEST			ALL REGIONS COMBINED			
	S¹	PRG²	SxPRG³	S¹	PRG²	SxPRG³	S¹	PRG²	SxPRG³	S¹	PRG²	SxPRG³	S¹	PRG²	SxPRG³	ΣSxPRG	#geo>0.05	Σ/#geo	Score⁴
AAR	10	0.597	5.973	0	0.022		1	0.381	0.381	0	0.000		0	0.000		6.3534	2	3.1767	0.20
AFC	4	0.259	1.035	1	0.057	0.057	4	0.192	0.192	1	0.192	0.192	1	0.192	0.192	2.6764	5	0.5353	0.10
AGC	0	0.001		0	0.000		3	0.843	2.528	1	0.140	0.140	1	0.140	0.140	2.6684	2	1.3342	0.10
AWD	47	0.645	30.309	1	0.050	0.050	23	0.231	5.305	1	0.053	0.053	0	0.022		35.717	4	8.9293	0.60
BBJ	17	0.002		0	0.014		5	0.958	4.789	1	0.027		0	0.000		4.7885	1	4.7885	0.40
BRH	18	1.000	18.000	0	0.000		0	0.000		0	0.000		0	0.000		18	1	18	1.00
CAR	17	0.427	7.257	1	0.285	0.285	1	0.168	0.168	1	0.042		2	0.078	0.078	7.7877	4	1.9469	0.10
CCO	18	0.341	6.134	0	0.069		5	0.219	1.097	1	0.133	0.133	1	0.238	0.238	7.602	4	1.9005	0.10
CGO	0	0.010		0	0.000		0	0.002		2	0.988	1.975	0	0.000		1.9751	1	1.9751	0.10
CHE	56	0.392	21.950	4	0.290	1.162	35	0.217	7.597	0	0.076		0	0.025		30.784	4	7.6961	0.60
ETW	0	0.000		0	0.000		19	1.000	19.000	0	0.000		0	0.000		19	1	19	1.00
GOJ	0	0.000		1	0.768	0.768	4	0.170	0.679	1	0.059	0.059	0	0.002		1.507	3	0.5023	0.10
HOB	13	0.239	3.103	1	0.269	0.269	8	0.157	1.255	1	0.203	0.203	1	0.132	0.132	4.9628	5	0.9926	0.10
LEO	29	0.341	9.891	1	0.042		7	0.198	1.388	4	0.321	1.285	11	0.098	1.073	13.637	4	3.4093	0.20
LIO	61	0.585	35.666	1	0.030		56	0.178	9.983	1	0.162	0.162	0	0.045		45.811	3	15.27	0.80
SER	7	0.332	2.327	0	0.043		1	0.203	0.203	1	0.222	0.222	1	0.199	0.199	2.9517	4	0.7379	0.10
SNO	1	0.236	0.236	8	0.008		2	0.160	0.320	1	0.417	0.417	1	0.180	0.180	1.1525	4	0.2881	0.10
SPH	12	0.325	3.900	1	0.104	0.104	44	0.262	11.532	1	0.217	0.217	2	0.092	0.185	15.938	5	3.1876	0.20
SSJ	8	0.351	2.809	0	0.042		3	0.182	0.547	1	0.271	0.271	1	0.153	0.153	3.7807	4	0.9452	0.10
STH	0	0.000		1	0.467	0.467	2	0.391	0.782	1	0.067	0.067	1	0.076	0.076	1.3909	4	0.3477	0.10

1. Number of studies in georegion
2. Proportion of species' range in georegion
3. Calculations only for georegions comprising at least 5% of species' range
4. Final score was calculated first by dividing Σ/#geo for each species by the highest value in that category to generate scores scaled from 0-1, and then by assigning final scores as follows: 1.0=.81-1; 0.80=.61-.80; 0.60=.41-.60; 0.40=.21-.40; 0.20=.11-.20; 0.10=0-.10.

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Table A2.2 Subject categories for Web of Science® publication records.

Category	Subject	Description
Anatomy/ Morphology/ Physiology	Anatomy/Morphology	Body measurements; morphology; dentition
	Physiology	metabolic rate; histology; endocrinology; nutrition; biochemistry; physiology
Ecology	Diet/Predation	prey/food preferences; predation; predator/prey interactions; prey behavior
	Community Ecology	general community ecology; resource partitioning (diet, habitat, activity); competition; kleptoparasitism
	Reproductive Ecology	seasonality; reproductive endocrinology; pregnancy; postnatal/fetal growth rate/development; parturition; contraception/vasectomy; spermatozoa (numbers/motility/defects/inbreeding depression effects on spermatozoa); lactation effort; fetal androgens and sex mimicry
	Population Dynamics	survivorship; abundance; population estimate; growth rate; density; sex ratio; population decline; age profile; emigration/immigration-dispersal (excluding behavior); population viability modeling; general population dynamics
	Habitat	habitat structure/preferences/use; habitat degradation; spraint sites; den locations/structure
	Activity Patterns	Activity
	Home range and Movements	home range analyses; distances traveled; spatial organization
	Other	other ecological factors
Conservation/ Management	Distribution and Status	presence/surveys/censuses; species range expansion/contraction; status
	Trophy Hunting	effects of trophy hunting; targeted gender/age groups; hunting returns
	Human-Wildlife Conflict	livestock predation; carnivore mortality due to poisoning/direct killing; crossing park borders; attacks on humans (injury/death); crop damage; economic costs/compensation; road effects; road kills; conflict reduction methods (i.e., changing crop patterns, control efforts); tourism
	Captive Breeding	semen cryopreservation/effects; genome banking; husbandry regime/food preparation; food storage and level of nutrition; stress/status of captive animals
	Reintroduction/ Relocation	failure/success of attempt(s)
	General cons/mgmt	conservation and management efforts/suggestions/recommendations
Methods	Techniques and Methods	new approaches, technical applications (i.e., disease determination, monitoring methods for endocrine status, population estimates); reliability of methods
	Capture and Handling	physiological effects of methods/techniques/ radiocollaring; stress and recovery; anesthetic effectiveness/effects; survivorship of handled animals

Behavior	Ethology/Behavior	predator avoidance; dispersal; response to odors; adaptations; group patterns; multiple behaviors (i.e., reproduction/feeding/social); response to/effects of temperature/weather; cannibalism; familial relationships; siblicide
	Reproductive Behavior	breeding/reproductive/nursing behaviors; inbreeding avoidance; extra pair copulations and parentage; adoption; den attendance; allosuckling; egalitarianism; infanticide/avoiding infanticidal males; female vigilance; antipredator response/actions (i.e., den switching); choice of lair/moving lairs; mate desertion; breeding synchrony; communal denning behavior; breeding synchrony; function of birth dens
	Foraging Behavior	tolerance of prey defenses; time spent foraging; discrimination between food items/species; food caching; volume consumed; hunting tactics (i.e., approach methods/number involved; prey choice in terms of age/gender of prey; bone accumulations/collecting; surplus killing (usually with livestock); feeding behavior
	Social Behavior	social-interaction with conspecifics (i.e., greetings, play); social organization-hierarchies/rank, pack formation/fission; roaring/vocal communication; infanticide; vocalizations/vocal recognition; territory behavior; vocalization structure
Genetics	Genetics	phylogenetics/cytogenetics; DNA; lineage; MHC; hemoglobin primary structure/amino acid sequence; hybridization
Paleontology and Evolution	Paleontology and Evolution	Anatomy of archeological specimens; paleoenvironment; taphonomics; evolution;
Disease and Contaminants	Environmental Contaminants	Pollutants in air/water/food (i.e., pesticides, other agricultural run-off, heavy metals)
	Clinical	disease/parasites; cancer/viruses/antibody surveys; viral-genetics/composition; vaccine administration; immunology/immunopathology; antibody reactions; disease/illness symptoms; effects on individuals/populations; timing of epidemics; medical ailments and treatment/surgery
Other	Other	Not in above categories

Table A2.3 Knowledge category scores

	Knowledge of distribution (surveys)	Knowledge of population trend	Knowledge of baseline ecology	Total number of studies	Geographic scope of knowledge	Total Score
Lion	1	0.75	0.75	1	0.80	4.3
Ethiopian wolf	1	1	1	0.25	1.00	4.25
Cheetah	1	0.75	0.75	1	0.60	4.1
African wild dog	1	0.75	0.75	0.75	0.60	3.85
Brown hyena	1	0.5	0.75	0.5	1.00	3.75
Leopard	0.75	0.5	0.75	1	0.20	3.2
Spotted hyena	0.75	0.5	0.75	1	0.20	3.2
Black-backed jackal	0.5	0.5	0.5	0.5	0.40	2.4
African civet	0.75	0.25	0.5	0.5	0.10	2.1
Honey badger	0.75	0.5	0.5	0.25	0.10	2.1
Aardwolf	0.5	0.25	0.5	0.5	0.20	1.95
Caracal	0.5	0.25	0.5	0.5	0.10	1.85
Congo clawless otter	0.5	0.5	0.5	0.25	0.10	1.85
Serval	0.5	0.25	0.5	0.5	0.10	1.85
Side-striped jackal	0.5	0.5	0.5	0.25	0.10	1.85
Golden jackal	0.25	0.25	0.5	0.5	0.10	1.6
Spotted-necked otter	0.5	0.25	0.5	0.25	0.10	1.6
Striped hyena	0.5	0.25	0.25	0.5	0.10	1.6
African golden cat	0.25	0.25	0.25	0	0.10	0.85
Congo clawless otter	0.25	0.25	0.25	0	0.10	0.85

APPENDIX 3:
SCORING DETAILS: THREAT CATEGORY

The Threat category assessed how each species is differentially impacted by a set of ten external threats commonly encountered by African carnivores (see Part II). Each species was subjected to a scoring process for each threat that assessed the relative severity (its effect on the species), urgency (timescale over which it is most likely to occur), probability (likelihood of occurrence), and geographical extent of the threat through the species' range in Africa (modified from Coppolillo *et al.* 2004). All the scores are presented in Table A3.1. Please refer to the narratives in the species profiles (Part IV) for detailed information on the significance of each threat to all species.

Table A3.1 Threat category scores.

SPECIES	CRITERIA	CLIMATE	HABITAT DECLINE	DISEASES	HUMAN CONFLICT	INSECT CONTROL	ROAD KILLS	HUMAN HUNTING	INTERSPECIFIC	GENETIC POVERTY	TOURISM	TOTAL SCORE
AARDWOLF	SEVERITY	1	0	0	1	3	1	1	1	0	0	46
	URGENCY	1	0	1	3	3	3	3	3	0	0	
	PROPORTION	2	0	1	2	3	1	1	2	0	0	
	PROBABILITY	0.5	0	0.3	1	1	1	1	1	0	0	
	(UxSxPaxPo)	1	0	0	6	27	3	3	6	0	0	
BROWN HYENA	SEVERITY	0	2	0	3	0	1	0	3	0	0	63
	URGENCY	0	3	1	3	0	3	0	3	0	0	
	PROPORTION	0	2	0	3	0	2	0	2	0	0	
	PROBABILITY	0	1	0	1	0	1	0	1	0	0	
	(UxSxPaxPo)	0	12	0	27	0	6	0	18	0	0	
STRIPED HYENA	SEVERITY	0	3	0	3	0	1	1	0	0	0	57.5
	URGENCY	0	3	1	3	0	1	1	0	0	0	
	PROPORTION	0	3	2	3	0	2	2	0	0	0	
	PROBABILITY	0	1	0.8	1	0	1	0.75	0	0	0	
	(UxSxPaxPo)	0	27	0	27	0	2	1.5	0	0	0	
SPOTTED HYENA	SEVERITY	1	2	1	2	0	1	2	1	0	0	45.6
	URGENCY	1	3	1	3	0	1	2	1	0	0	
	PROPORTION	2	3	2	3	0	2	1	2	0	0	
	PROBABILITY	0.5	1	0.8	1	0	1	1	0.5	0	0	
	(UxSxPaxPo)	1	18	1.6	18	0	2	4	1	0	0	

ETHIOPIAN WOLF	SEVERITY	1	3	3	3	0	2	0	1	2	0	159.05
	URGENCY	1	3	3	3	0	3	0	1	3	0	
	PROPORTION	1	4	4	4	0	4	0	3	4	0	
	PROBABILITY	0.8	1	1	1	0	1	0	0.75	1	0	
	(UxSxPaxPo)	0.8	36	36	36	0	24	0	2.25	24	0	
AFRICAN WILD DOG	SEVERITY	0	2	3	3	0	2	1	3	2	0	171
	URGENCY	0	3	3	3	0	3	2	3	3	0	
	PROPORTION	0	4	3	4	0	3	3	4	4	0	
	PROBABILITY	0	1	1	1	0	1	1	1	1	0	
	(UxSxPaxPo)	0	24	27	36	0	18	6	36	24	0	
BLACK-BACKED JACKAL	SEVERITY	0	0	2	2	0	1	1	1	0	0	34
	URGENCY	0	0	3	3	0	1	3	2	0	0	
	PROPORTION	0	0	2	2	0	2	2	2	0	0	
	PROBABILITY	0	0	1	1	0	1	1	0.5	0	0	
	(UxSxPaxPo)	0	0	12	12	0	2	6	2	0	0	
SIDE-STRIPED JACKAL	SEVERITY	0	0	2	2	0	1	1	2	0	0	38.5
	URGENCY	0	0	3	3	0	1	1	3	0	0	
	PROPORTION	0	0	2	2	0	2	1	2	0	0	
	PROBABILITY	0	0	1	1	0	1	0.5	1	0	0	
	(UxSxPaxPo)	0	0	12	12	0	2	0.5	12	0	0	
GOLDEN JACKAL	SEVERITY	0	0	1	1	0	0	0	2	0	0	6.6
	URGENCY	0	0	1	1	0	0	0	1	0	0	
	PROPORTION	0	0	2	2	0	0	0	2	0	0	
	PROBABILITY	0	0	0.8	0.5	0	0	0	1	0	0	
	(UxSxPaxPo)	0	0	1.6	1	0	0	0	4	0	0	
LION	SEVERITY	0	3	3	3	0	0	1	0	2	0	87
	URGENCY	0	3	3	3	0	0	2	0	1	0	
	PROPORTION	0	3	2	4	0	0	2	0	2	0	
	PROBABILITY	0	1	1	1	0	0	1	0	0.5	0	
	(UxSxPaxPo)	0	27	18	36	0	0	4	0	2	0	

SPECIES	CRITERIA	CLIMATE	HABITAT DECLINE	DISEASES	HUMAN CONFLICT	INSECT CONTROL	ROAD KILLS	HUMAN HUNTING	INTERSPECIFIC	GENETIC POVERTY	TOURISM	TOTAL SCORE
CHEETAH	SEVERITY	0	3	2	3	0	1	1	3	1	2	155.2
	URGENCY	0	3	3	3	0	1	2	3	1	3	
	PROPORTION	0	4	4	4	0	2	3	4	4	2	
	PROBABILITY	0	1	1	1	0	1	1	1	0.8	1	
	(UxSxPaxPo)	0	36	24	36	0	2	6	36	3.2	12	
LEOPARD	SEVERITY	0	3	1	3	0	1	2	1	0	0	75
	URGENCY	0	3	1	3	0	1	2	1	0	0	
	PROPORTION	0	3	2	4	0	2	2	2	0	0	
	PROBABILITY	0	1	0.5	1	0	1	1	0.5	0	0	
	(UxSxPaxPo)	0	27	1	36	0	2	8	1	0	0	
AFRICAN GOLDEN CAT	SEVERITY	0	3	0	1	0	1	2	1	0	0	44.5
	URGENCY	0	3	0	1	0	1	1	1	0	0	
	PROPORTION	0	4	0	3	0	1	2	1	0	0	
	PROBABILITY	0	1	0	1	0	0.5	1	1	0	0	
	(UxSxPaxPo)	0	36	0	3	0	0.5	4	1	0	0	
SERVAL	SEVERITY	0	3	0	3	0	1	1	0	0	0	67
	URGENCY	0	3	0	3	0	1	1	0	0	0	
	PROPORTION	0	4	0	3	0	2	2	0	0	0	
	PROBABILITY	0	1	0	1	0	1	1	0	0	0	
	(UxSxPaxPo)	0	36	0	27	0	2	2	0	0	0	
CARACAL	SEVERITY	0	3	0	3	0	1	1	0	0	0	58
	URGENCY	0	3	0	3	0	1	1	0	0	0	
	PROPORTION	0	3	0	3	0	2	2	0	0	0	
	PROBABILITY	0	1	0	1	0	1	1	0	0	0	
	(UxSxPaxPo)	0	27	0	27	0	2	2	0	0	0	

SPOTTED-NECKED OTTER	SEVERITY	0	3	0	2	0	1	1	3	0	0	
	URGENCY	0	3	0	3	0	1	1	3	0	0	
	PROPORTION	0	4	0	2	0	2	2	2	0	0	69
	PROBABILITY	0	1	0	1	0	0.5	1	1	0	0	
	(UxSxPaxPo)	0	36	0	12	0	1	2	18	0	0	
CAPE CLAWLESS OTTER	SEVERITY	3	3	0	2	0	1	1	3	0	0	
	URGENCY	1	2	0	3	0	1	1	3	0	0	
	PROPORTION	3	3	0	2	0	2	2	2	0	0	68.5
	PROBABILITY	0.5	1	0	2	0	1	1	1	0	0	
	(UxSxPaxPo)	4.5	18	0	24	0	2	2	18	0	0	
CONGO CLAWLESS OTTER	SEVERITY	0	3	0	2	0	0	1	0	0	0	
	URGENCY	0	3	0	3	0	0	1	0	0	0	
	PROPORTION	0	3	0	2	0	0	2	0	0	0	67
	PROBABILITY	0	1	0	3	0	0	2	0	0	0	
	(UxSxPaxPo)	0	27	0	36	0	0	4	0	0	0	
AFRICAN CIVET	SEVERITY	0	0	0	0	0	0	0	0	0	0	
	URGENCY	0	0	0	0	0	0	0	0	0	0	
	PROPORTION	0	0	0	0	0	0	0	0	0	0	0
	PROBABILITY	0	0	0	0	0	0	0	0	0	0	
	(UxSxPaxPo)	0	0	0	0	0	0	0	0	0	0	
HONEY BADGER	SEVERITY	0	2	0	2	0	2	1	0	0	0	
	URGENCY	0	1	0	3	0	1	3	0	0	0	
	PROPORTION	0	2	0	2	0	2	2	0	0	0	26
	PROBABILITY	0	1	0	1	0	1	1	0	0	0	
	(UxSxPaxPo)	0	4	0	12	0	4	6	0	0	0	

APPENDIX 4:
REFERENCES FOR AFRICAN CARNIVORE DISTRIBUTION MAPS

Species	Baseline source	Baseline source—historical[1]	Local modifications
African wild dog	Sillero-Zubiri *et al*. 2004	Woodroffe *et al*. 1997	Peter Lindsay (Zimbabwe, South Africa); Peter Coppolillo (Tanzania, Zimbabwe); Gus Mills (South Africa); Luke Hunter (South Africa); Tim Davenport (East Africa); Megan Parker (southern Africa); Greg Rasmussen (Zimbabwe)
Ethiopian wolf	Sillero-Zubiri *et al*. 2004	Sillero-Zubiri *et al*. 2004	
Black-backed jackal	Sillero-Zubiri *et al*. 2004	Sillero-Zubiri *et al*. 2004	
Side-striped jackal	Sillero-Zubiri *et al*. 2004	Sillero-Zubiri *et al*. 2004	
Golden jackal	Sillero-Zubiri *et al*. 2004	Sillero-Zubiri *et al*. 2004	Fabrice Cuzin (North Africa)
Cheetah	Hunter & Hamman 2003	Nowell & Jackson 1996	Fabrice Cuzin (North Africa); Paula White (Zambia); Netty Purchase (Zimbabwe); Tim Davenport (Tanzania); Hanssen & Stander 2004 (Namibia); Hans Bauer (West Africa); Luke Hunter (South Africa); Peter Lindsay (South Africa)
Lion	Bauer & Van Der Merwe 2004; Chardonnet 2002;	Nowell & Jackson 1996	Paula White (Zambia); Hanssen & Stander 2004 (Namibia); Luke Hunter (southern Africa); Peter Lindsay (Botswana, Zimbabwe, South Africa)
Serval	Nowell & Jackson 1996	Kingdon 1977	Fabrice Cuzin (North Africa); IUCN Cat Specialist Group (Christine Breitenmoser; multiple locales)
African golden cat	Nowell & Jackson 1996; Ray & Butynski *in press*	Nowell & Jackson 1996	Tim Davenport and Daniela De Luca (Tanzania); IUCN Cat Specialist Group (Christine Breitenmoser; multiple locales); Justina Ray (Central Africa); Brugière 2003 (Guinea)
Leopard	Kingdon 1997; IUCN Cat Specialist Group (Christine Breitenmoser)	Guggisberg 1975; Nowell & Jackson 1996	Fabrice Cuzin (North Africa); Justina Ray (West/Central Africa); Hanssen & Stander 2004 (Namibia); Luke Hunter (South Africa); Ilaria Di Silvestre (West Africa)
Caracal	IUCN Cat Specialist Group (Christine Breitenmoser)	Stuart 1984	Luke Hunter (southern Africa)
Aardwolf	Koehler & Richardson 1990; Mills & Hofer 1998	Mills & Hofer 1998	Daniela De Luca (Tanzania)

Spotted hyena	Mills & Hofer 1998	Mills & Hofer 1998	Hanssen & Stander 2004 (Namibia); Peter Lindsay (South Africa)
Brown hyena	Mills & Hofer 1998	Mills & Hofer 1998	Megan Parker (southern Africa); Hanssen & Stander 2004 (Namibia)
Striped hyena	Mills & Hofer 1998	Mills & Hofer 1998	Fabrice Cuzin (entire range)
Cape clawless otter	Somers & Nel *in press*	N.A.	
Congo clawless otter	Jacques *et al. in press*	N.A.	
Spotted-necked otter	Carranza & Rowe-Rowe *in press*	N.A.	
Honey badger	Begg & Begg 2005	Begg & Begg 2005	Fabrice Cuzin (North Africa)
African civet	Ray 1995; Skinner & Smithers 1990	assumed to not have changed significantly	

1. Approx 150 years ago, i.e., before the advent of the colonial era when firearms and pervasive human-induced land-used changes became increasingly prevalent.

APPENDIX 5:
BIOME CLASSIFICATION

Biomes used as units of analysis in this report were modified from biomes of the World Wildlife Fund ecoregional classification scheme (Olson *et al.* 2000) as described in Table A5.1. See Fig 1.2 for biome map.

Table A5.1 WWF biome reclassification

BIOME[1]	NEW BIOME CLASSIFICATION	BIOME CODE
Tropical and subtropical moist broadleaf forests	Tropical and subtropical broadleaf forests	FOR
Tropical and subtropical dry broadleaf forests	Tropical and subtropical broadleaf forests	FOR
Temperate coniferous forests	Mediterranean scrub and forests	MED
Tropical and subtropical grasslands, savannas, and shrublands	Tropical, subtropical & temperate grasslands, savannas, and shrublands	SAV
Temperate grasslands, savannas, and shrublands	Tropical, subtropical & temperate grasslands, savannas, and shrublands	SAV
Flooded grasslands	Flooded grasslands	FLG
Montane grasslands	Montane grasslands	MON
Mediterranean scrub	Mediterranean scrub and forests	MED
Deserts and xeric shrublands	Deserts and xeric shrublands	DES
Mangroves	Mangroves	MAN
Lake	Lake	LAK

1. After Olson *et al.* 2000

APPENDIX 6:
AFRICAN CARNIVORE SPECIES LOSS

Table A6.1 and A6.2 contain details on carnivore species loss for various groupings in all of Africa, biomes, and georegions.

Group	Number Species Lost	All Africa	GEOREGION (proportion of area)				
			WEST	SOUTH	NORTH	EAST	CENT
All Carnivores (17 spp.)	0	0.10	0.09	0.07	0.02	0.08	0.32
	1	0.18	0.06	0.16	0.26	0.10	0.11
	2	0.12	0.05	0.17	0.12	0.14	0.08
	3	0.15	0.09	0.27	0.09	0.19	0.20
	4	0.22	0.24	0.11	0.24	0.31	0.21
	5	0.12	0.26	0.05	0.14	0.16	0.06
	6	0.09	0.18	0.11	0.11	0.01	0.01
	7	0.02	0.03	0.05	0.02	0.00	0.00
	8	0.00	0.00	0.00	0.00	0.00	0.00
Large Carnivores (7 spp.)	0	0.11	0.12	0.10	0.03	0.09	0.32
	1	0.20	0.07	0.18	0.29	0.12	0.15
	2	0.13	0.05	0.17	0.13	0.20	0.09
	3	0.30	0.16	0.30	0.26	0.43	0.41
	4	0.13	0.39	0.07	0.15	0.15	0.02
	5	0.10	0.21	0.12	0.12	0.00	0.00
	6	0.02	0.00	0.06	0.02	0.00	0.00
Small Carnivores (10 spp.)	0	0.54	0.40	0.68	0.47	0.47	0.63
	1	0.40	0.50	0.27	0.48	0.41	0.29
	2	0.06	0.10	0.05	0.04	0.09	0.08
	3	0.00	0.00	0.00	0.01	0.02	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00
Felids (6 spp.)	0	0.14	0.11	0.20	0.04	0.13	0.35
	1	0.24	0.06	0.24	0.33	0.22	0.16
	2	0.21	0.13	0.31	0.13	0.34	0.21
	3	0.25	0.36	0.18	0.28	0.20	0.21
	4	0.15	0.30	0.06	0.21	0.09	0.07
	5	0.01	0.03	0.00	0.01	0.00	0.00
Canids (5 spp.)	0	0.44	0.22	0.21	0.69	0.16	0.43
	1	0.53	0.78	0.79	0.30	0.61	0.57
	2	0.03	0.00	0.00	0.00	0.20	0.00
	3	0.00	0.00	0.00	0.00	0.02	0.00
Hyenids (4 spp.)	0	0.65	0.60	0.63	0.45	0.92	0.97
	1	0.32	0.40	0.27	0.51	0.08	0.03
	2	0.03	0.00	0.09	0.04	0.00	0.00
	3	0.00	0.00	0.01	0.00	0.00	0.00

Table A6.1 Proportional area of: 1) Africa, 2) each of five georegions, and 3) seven biomes that have experienced carnivore species loss. Biome codes as in Appendix 4.

Table A6.1 *continued*

Group	Number Species Lost	BIOME (proportion of area)						
		FOR	MED	SAV	FLG	MON	DES	MAN
All Carnivores (17 spp.)	0	0.55	0.00	0.04	0.07	0.01	0.03	0.24
	1	0.20	0.00	0.09	0.18	0.01	0.34	0.10
	2	0.06	0.02	0.12	0.13	0.03	0.16	0.03
	3	0.08	0.13	0.21	0.16	0.15	0.10	0.30
	4	0.07	0.40	0.24	0.24	0.33	0.21	0.17
	5	0.02	0.25	0.17	0.18	0.08	0.07	0.07
	6	0.01	0.16	0.11	0.03	0.12	0.09	0.01
	7	0.00	0.03	0.02	0.00	0.28	0.01	0.00
	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Large Carnivores (7 spp.)	0	0.57	0.00	0.05	0.13	0.01	0.04	0.24
	1	0.21	0.01	0.11	0.14	0.02	0.37	0.12
	2	0.06	0.10	0.13	0.18	0.07	0.16	0.24
	3	0.11	0.63	0.38	0.35	0.39	0.22	0.12
	4	0.02	0.15	0.19	0.17	0.10	0.09	0.20
	5	0.01	0.06	0.12	0.04	0.41	0.07	0.01
	6	0.00	0.04	0.01	0.00	0.00	0.05	0.00
Small Carnivores (10 spp.)	0	0.82	0.12	0.47	0.53	0.25	0.59	0.54
	1	0.16	0.62	0.44	0.36	0.43	0.40	0.36
	2	0.01	0.17	0.08	0.10	0.32	0.00	0.01
	3	0.00	0.08	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Felids (6 spp.)	0	0.58	0.00	0.11	0.18	0.01	0.06	0.24
	1	0.21	0.00	0.15	0.19	0.09	0.43	0.11
	2	0.17	0.10	0.25	0.18	0.45	0.14	0.12
	3	0.03	0.47	0.28	0.25	0.10	0.27	0.37
	4	0.01	0.39	0.20	0.19	0.35	0.09	0.07
	5	0.00	0.02	0.02	0.00	0.00	0.00	0.00
Canids (5 spp.)	0	0.80	0.81	0.12	0.37	0.02	0.77	0.59
	1	0.12	0.18	0.85	0.63	0.67	0.23	0.33
	2	0.07	0.00	0.03	0.00	0.27	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Hyenids (4 spp.)	0	0.93	0.20	0.73	0.75	0.46	0.47	0.86
	1	0.06	0.70	0.25	0.24	0.53	0.46	0.05
	2	0.00	0.05	0.02	0.01	0.00	0.07	0.00
	3	0.00	0.04	0.00	0.00	0.00	0.00	0.00

Table A6.2 Mean[1] and percent[2] species loss for carnivore groups in biomes and georegions.

BIOME	All carnivores (17 spp.)		Large Carnivores (≥12 kg) (7 spp.)		Small Carnivores (< 12 kg) (10 spp.)	
	Mean (± SD) species loss[1]	Percent Loss[2]	Mean (± SD) species loss[1]	Percent Loss[2]	Mean (± SD) species loss[1]	Percent Loss[2]
Forest	1.01±1.46	0.0671	0.81±1.19	0.1355	0.19±0.44	0.0215
Mediterranean	4.47± 1.09	0.4070	3.27±0.91	0.5448	1.22±0.77	0.2433
Savanna	3.58± 1.64	0.2387	2.96±1.34	0.4932	0.62±0.66	0.0693
Flooded Grassl.	2.97± 1.66	0.2125	2.41±1.36	0.4010	0.57±0.67	0.0711
Montane	4.89±1.65	0.3492	3.82±1.14	0.6365	1.07±0.75	0.1344
Desert	2.74±1.78	0.1960	2.33±1.54	0.3887	0.41±0.50	0.0515
Mangrove	2.35±1.72	0.1810	1.93±1.49	0.3223	0.42±0.51	0.0594
GEOREGION						
West	3.97±1.87	0.3309	3.28±1.59	0.5463	0.70±0.64	0.1168
South	3.04±1.89	0.2336	2.66±1.66	0.4431	0.37±0.57	0.0523
North	3.23±1.85	0.2484	2.65±1.50	0.4421	0.58±0.60	0.0823
East	3.08±1.53	0.2055	2.42±1.16	0.4029	0.65±0.71	0.0724
Central	2.11±1.80	0.1506	1.66±1.35	0.2764	0.45±0.64	0.0498

BIOME	Felids (6 spp.)		Canids (5 spp.)		Hyenids (4 spp.)	
	Mean (± SD) species loss[1]	Percent Loss[2]	Mean (± SD) species loss[1]	Percent Loss[2]	Mean (± SD) species loss[1]	Percent Loss[2]
Forest	0.66±0.90	0.1108	0.267±0.60	0.0535	0.07±0.27	0.0234
Mediterranean	3.32±0.70	0.6640	0.18±0.39	0.0916	0.94±0.64	0.3120
Savanna	2.37±1.28	0.3951	0.91±0.38	0.1826	0.30±0.50	0.0987
Flooded Grassl.	2.08±1.39	0.4156	0.63±0.48	0.1580	0.26±0.47	0.0882
Montane	2.69±1.07	0.5380	1.31±0.57	0.2626	0.54±0.50	0.1792
Desert	1.90±1.14	0.3799	0.23±0.42	0.0576	0.60±0.62	0.1989
Mangrove	1.93±1.38	0.3223	0.36±0.48	0.1193	0.06±0.24	0.0190
GEOREGION						
West	2.78±1.33	0.4633	0.79±0.42	0.2629	0.40±0.49	0.2011
South	1.68±1.17	0.2800	0.80±0.41	0.2636	0.48±0.69	0.1588
North	2.33±1.26	0.4656	0.31±0.47	0.0779	0.59±0.57	0.1958
East	1.91±1.16	0.3176	1.09±0.66	0.2172	0.08±0.27	0.0265
Central	1.50±1.35	0.2502	0.57±0.50	0.1433	0.03±0.18	0.0107

1. Species loss averaged across 10 km2 pixels in each biome or georegion
2. Mean species loss divided by historical maximum number of species in each biome or georegion (Table A6.3)

Table A6.3 Historical maximum number of species in each biome or georegion.

BIOME	All Carnivores	Large Carnivores	Small Carnivores	Felids	Canids	Hyenids
Forest	15	6	9	6	5	3
Mediterranean	11	6	5	5	2	3
Savanna	15	6	9	6	5	3
Flooded Grassl.	14	6	8	5	4	3
Montane	14	6	8	5	5	3
Desert	14	6	8	5	4	3
Mangrove	13	6	7	6	3	3
GEOREGION						
West	12	6	6	6	3	2
South	13	6	7	6	3	3
North	13	6	7	5	4	3
East	15	6	9	6	5	3
Central	14	6	9	6	4	3

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