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WG 5 – Mammals
CASE STUDY 4
Panthera pardus
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LEOPARD (*PANTHERA PARDUS*) CASE STUDY

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I. Background information on the taxa

1. BIOLOGICAL DATA

1.1 Scientific and common names: Leopard (*Panthera pardus*)

CLASS: Mammalia
ORDER: Carnivora
FAMILY: Felidae
GENERA: *Panthera*
SPECIES: *pardus* (Linnaeus, 1758)
SUB SPECIES: *pardus*

While the question of subspecies is controversial, it is generally accepted that there are seven subspecies of Leopard which are separated on variations in coat colour and spot size (Hes, 1991).

I. Amur Leopard (*P. p. orientalis*): Siberia, Korea and north-eastern China. *Endangered*.
II. Barbary Leopard (*P. p. panthera*): Atlas mountains of Morocco and Algeria in North Africa. *Endangered*.
III. Sinai Leopard (*P. p. jarvis*): found on the Sinai peninsula and in Israel. *Endangered*.
IV. South Arabian Leopard (*P.p. nimr*): mountainous regions along the Saudi Arabian Red Sea coast and the coasts of South Yemen and Oman. *Endangered*.
V. Zanzibar Leopard (*P. p. adersi*): Island of Zanzibar off the East African coast, this subspecies is now thought to be *extinct*.
VI. North African Leopard (*P. p. pardus*): widespread over nearly all of Africa south of the Sahara and over the greater part of southern Asia including the Malayan pensinsula and Java. *Not threatened*.
VII. Anatolian Leopard (*P. p. tulliana*): the Caucasus and in Turkey. *Endangered*. (Hes ,1991).

1.2 Distribution

The Leopard has the greatest geographic distribution of any felid, occurring from the southern parts of the African continent through the Middle East to the far East, north-wards to Siberia and south to Sri Lanka and Malaysia.

Countries to which the Leopard is native include: Afghanistan; Algeria; Angola; Armenia; Azerbaijan; Bangladesh; Benin; Bhutan; Botswana; Burkina Faso; Burundi; Cambodia; Cameroon; Central African Republic; Chad; China; Congo; Congo, The Democratic Republic of the; Côte d'Ivoire; Djibouti; Equatorial Guinea; Eritrea; Ethiopia; Gabon; Gambia; Georgia; Ghana; Guinea; Guinea-Bissau; India; Indonesia (Jawa); Iran, Islamic Republic of; Iraq; Israel; Jordan; Kenya; Korea, Democratic People's Republic of; Lao People's Democratic Republic; Lesotho; Liberia; Malawi; Malaysia; Mali; Mozambique; Myanmar; Namibia; Nepal; Niger; Nigeria; Oman; Pakistan; Russian Federation; Rwanda; Saudi Arabia; Senegal; Sierra Leone; Somalia; South Africa; Sri Lanka; Sudan; Tajikistan; Tanzania, United Republic of; Thailand; Togo; Turkey; Turkmenistan; Uganda; Uzbekistan; Viet Nam; Yemen; Zambia; Zimbabwe

Regionally extinct: Hong Kong; Kuwait; Libyan Arab Jamahiriya; Singapore; Syrian Arab Republic; Tunisia

Possibly extinct regionally: Egypt; Korea, Republic of; Lebanon; Morocco; United Arab Emirates

Uncertain presence and origin: Mauritania; Swaziland
(Cat Specialist Group 2002. Panthera pardus. In: IUCN 2007. 2007 IUCN Red List of Threatened Species.)

In the PHVA workshop, only the South African population of Leopards was assessed. The distribution of Leopards in South Africa is widespread across a variety of geographic locations, habitats and management units. Leopard distribution information was provided by Gus Mills at the PHVA based upon the Red Data Book of the Mammals of South Africa (Friedmann and Daly, 2004) (Figure 1). Subsequent group discussion among the participants identified ten core areas, which were modelled as separate populations with varying levels of connectivity among these populations and with Leopard populations in adjacent countries (Figure 2). In South Africa, the Leopard range has been substantially reduced by agricultural development, hunting and human population encroachment in the interior, and today it is found only in the remote mountainous regions of the Western Cape, the bushveld wildlife areas of the North West Province, Limpopo Province, Mpumalanga and KwaZulu-Natal, and the semi-desert areas of the Northern Cape bordering on Botswana. There are possibly still small, isolated populations of Leopard in the KwaZulu-Natal Drakensberg and the forest of the Eastern Cape (Mills and Hes, 1997). The Leopard

population size in South Africa is unknown, but it has however, become apparent that Leopard populations are smaller and more fragmented than previously appreciated.

Figura 1: Distribution of the Leopard in South Africa. From Friedmann, Y. and Daly, B. (eds) 2004. Red Data Book of the Mammals of South Africa.

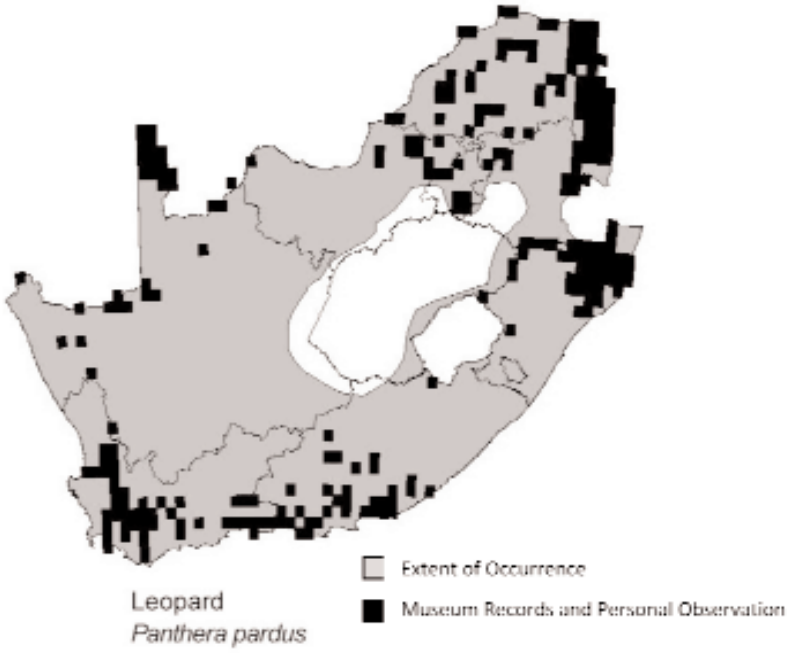
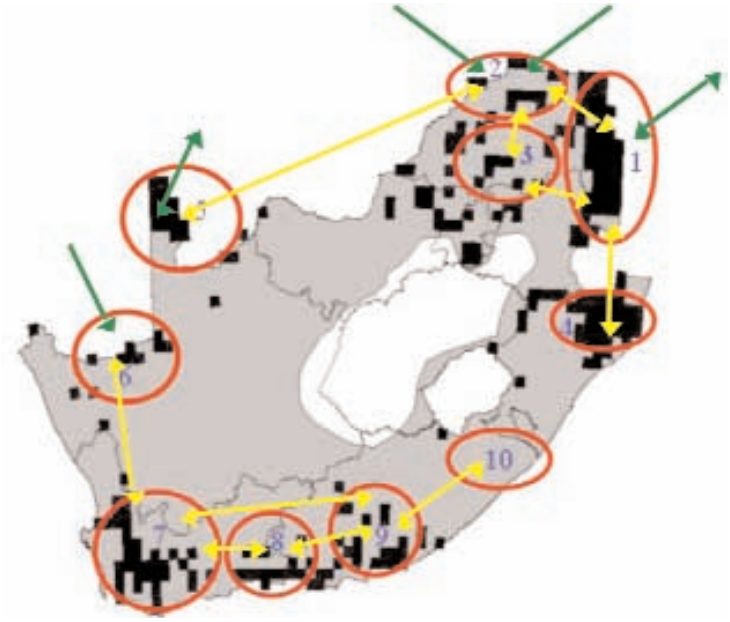


Figura 2: Ten Leopard populations in South Africa that were used in the PHVA Vortex model. Arrows indicate dispersal pathways incorporated in the baseline model (yellow = dispersal within South Africa; green = movement across international boundaries).



1. *Great Kruger Area*: Kruger Park and surrounding private reserves, Lowveld of the Limpopo and Mpumalanga provinces.
2. *Northern Limpopo Area*: Includes the north-western regions of the Limpopo valley in the Limpopo province.
3. *Waterberg and Mpumalanga Area*: Includes widespread central areas of the Limpopo province, eastern regions of the North West Province (such as Pilanesberg and Magaliesberg) and the Mpumalanga Escarpment up to the Lydenburg area. Soutpansberg is in the northern extremity of this defined area.
4. *Northern KwaZulu-Natal*: Includes Hluhluwe-Imfolozi Park, Greater St Lucia, Mkuzi, Phinda, Ndumu, and Itala and numerous other private reserves.
5. *Kalahari Area*: Kgalagadi Transfrontier Park, Molopo, and the North West Province (this population may be a sink for the neighbouring Botswana population).
6. *Orange River*: Includes the northern area of the Northern Cape, within the riverine vegetation of that river system e.g. Orange River.
7. *Western Cape*: Population widely distributed within the Cape Fold Mountains in the Western Cape.
8. *Eastern Cape Mountain*: Includes the cluster in the mountains and forest areas in the Eastern Cape.
9. *Eastern Cape Valley*: The valley Bushveld areas of the Eastern Cape appear to contain another population.
10. *Wild Coast*: Northern part of the Eastern Cape including the Transkei area.

1.3 Biological characteristics

1.3.1 *Provide a summary of general biological and life history characteristics of the species***.**

The information provided below outlines the primary biological input parameters used in the Leopard Vortex model. These input values were developed based on consensus by the workshop participants using all available published biological information for Leopards as well as expert opinion. These values result in a deterministic annual growth rate of about 10% (potential growth in the absence of demographic and environmental variation, inbreeding depression, migration, and harvest (both legal and illegal), a generation time of about 7 years (7.2 for males, 6.7 for females), and an adult sex ratio of 1.6 females per adult male. These population characteristics were accepted by workshop participants as realistic and a reasonable representation of wild Leopard populations.

A baseline model was developed to project the best possible estimate of Leopard population viability in South Africa. Model input values were then modified to explore: 1) the sensitivity of the model to demographic rates, population estimates, and population structure; 2) the effect of alternative futures and management options; and 3) the impact of various harvest rates and strategies on Leopard popula-

tion viability. All model scenarios were run with 500 iterations for 100 years (about 14 Leopard generations). Model output included the probability of extinction, mean stochastic growth rate, and mean population size over time.

Age of first reproduction for each sex:
Female Leopards become sexually mature at 2.5 to 3 years old (Bailey 1993, Nowell and Jackson 1996, Hunter and Balme 2004), and males at about two and a half to four years old (Skinner and Smithers 1990, Bathma and Walker 1999). Leopards are non-seasonal breeders and likely breed soon after reaching sexual maturity; young are born at any time of the year after a gestation of 100 days (Mills and Hes 1997). The input values of 3 years (for females) and 4 years (for males) were used as the average age of first reproduction in the Vortex model.

Litter Size:
Born in lairs among rocks, in brush piles and in termite mound holes, leopards give birth to 1 to 4 cubs per litter. Mean litter size was calculated as 1.92 (SD = 0.38), taken as an average across estimates by Hemmer (1976) as cited by Nowell and Jackson (1996), Martin and de Meulenaer (1988), Skinner (1989), and Mills and Hes (1997). Sex ratio at birth was assumed to be 50:50.

Breeding Success:
Mating usually takes place over a period of two to three days (Mills & Hes 1997). If the female has not mated, oestrus occurs again every 20 to 50 days (Bothma & Walker 1999). In the Kruger National Park the mating success rate appears to be low, and in one study only two of 13 suspected matings (15%) resulted in the birth of cubs. This low success rate is much like that of the lions (20%) in the same park.

Cub development:
Cubs are fully weaned at four months, and from the age of eight months start making their own kills. When cubs are about 12 months old, the mother Leopard becomes less and less tolerant of her offspring, striking out at them aggressively when they approach. She comes into oestrus at this time and sets off on patrols of her territory. Female cubs are more likely to settle on the borders of their mother's territory while males disperse well away from their natal area (Mills & Hes 1997). They attain independence at about 12.5 months, with siblings remaining together for a further 2-3 months (Skinner & Smithers 1990).

Adult sex ratio:
A sex ratio of 1 male: 1.8 females for resident adults (Nowell & Jackson 1996).

Mortality rates and longevity:
First-year mortality was estimated to be 41% by Martin and de Meulenaer (1988) and to be at least 50% by Bailey (1993). Bothma and Walker (1999) estimate that in Kruger National Park only 50% of all cubs survive to become adults. Bailey (1993) observed high annual sub-adult mortality (32%) in Kruger and a mean annual adult mortality of 19%. Mortality rates were observed to be higher in males than in females and higher in older individuals vs. prime age adults. These data were based on relatively small sample sizes and appear to be high as compared with other large cats; when combined with reproductive values used in the model, these mortality rates resulted in a negative deterministic growth rate. After much consultation and discussion among workshop participants, the mortality rates in *Table 1* were selected for the leopard Vortex model. Maximum age was set at 12 years in the baseline model.

Table 1: Mean annual mortality rates for male and female leopards by age class. EV = SD in mean due to annual environmental variation.

	Females			Males		
Life stage	**Age class**	**Mean annual mortality**	**EV**	**Age class**	**Mean annual mortality**	**EV**
Juvenile	0 – 1	40%	8%	0 – 1	40%	8%
Sub-adult	1 – 3	10%	2%	1 – 4	14%	3%
Adult	3 – 10	5%	1%	4 – 10	7%	1.5%
Geriatric	10+	15%	1%	10+	20%	1.5%

Social structure with regards to breeding:
Solitary and territorial, males and females associate only briefly to mate. Males hold large territories encompassing the territories of 2 or 3 females. Females defend their territories against other females, males against other males (Mills & Hes 1997). Male territories encompass up to 4 or 5 females in the Cederberg, Western Cape. Reproduction was modeled as short-term polgyny (promiscuous breeding system with no pair bonds).

The size of a male Leopard range is determined mainly by the number of females present, but a female's range depends mainly on suita-

ble available prey. Therefore the size of a Leopard's range varies extensively between regions. In the Kruger National Park the ranges of adult male Leopards vary from 16.4 to 96.1 km^2, and those of adult females from 5.6 to 29.9 km^2. In the Sabie-Sand Game Reserve the range of one female Leopard studied was 23 km^2 (Bothma & Walker 1999). There are few reliable observations of infanticide in Leopards (see: Ilani, 1986; 1990; Scott & Scott, 2003) but new males entering the population are likely to kill existing cubs (Balme & Hunter 2004). Balm and Hunter 2004 studies in Phinda showed that few cubs were produced during the study may be a further consequence of high male turnover. Rapid turnover of male Leopard might drive females into a reproductive dead-end in which cubs are killed at high rates and subsequent conception is delayed.

Proportion of adult females breeding:
Of eleven adult females captured during the Bailey (1993) study, ten (91%) apparently had young prior to or gave birth during the study. During some years no females gave birth to cubs in the study areas, during others up to one-half of the females produced young. The average proportion of adult females producing young each year was 27.7%. In Wilpattu National Park five females produced seven litters in two years (Muckenhirn & Eisenberg 1973). In Serengeti National Park two of four females had young one year, and two years later both females had young again (Schaller 1972).

The known interval between successive litters in the same female varies from 16 to 17 months in the South African bushveld savanna where it is less than the interval of 24 – 25 months recorded in Serengeti (Bothma & Walker 1999). Interbirth interval averages at 15 months (Martin & de Meulenaer 1988; these data include some shorter periods after litters did not survive) to over 2 years (Schaller 1972, Bailey 1993) (Nowell & Jackson 1996). The percent of adult females breeding each year was modeled as 50% (interbirth interval = 2 years), with an environmental variation SD = 10%. Reproduction was assumed to be independent of population density.

1.3.2 *Habitat types*
Leopards are found in all habitats with annual rainfall above 50mm (Monod 1965), and can penetrate areas with less than this amount of rainfall along river courses: e.g. Leopards are found along the Orange River in the Richtersveld National Park, which lies at the southernmost extension of the Namib Desert (Stuart and Stuart 1989) (Nowell & Jackson 1996).

Leopards occur in all habitats except the most arid desert interior and reaches highest densities in the woodland savannah (Hunter & Balme). Limitations in food, cover and water are usually the major factors affecting an animal's distribution, but for a Leopard the definition of these basic requisites is extremely board. Food can be anything from beetles to ungulates the size of eland and sambar. Cover can be as rudimentary as a few scattered shrubs and trees or as dense as moist tropical evergreen forests. In the Kalahari Desert Leopards have been known to drink only once in ten days (Sunquist & Sunquist 2002). Leopards are commonly associated with 1-Forest; 1.5.-Subtropical/Tropical Dry; 1.6.-Subtropical/Tropical Moist; 2-Savanna; 2.1.-All Latitudes; 3-Shrubland; 3.5.-Subtropical/Tropical Dry; 4-Grassland; 4.5.-Subtropical/Tropical Dry; 8-Desert; 8.1.-Hot (Friedmann et al. 2004).

Leopards are tolerant of a wide range of habitats and climatic conditions, including mountains, rocks, bushveld, woodlands, desert and semi-desert, forest, from sea-level to 2000m above sea-level, in areas of less than 100mm of rain to areas receiving above 1200mm of rain. Usually requires some form of cover in the form of rocks or patches of thick bush. They also occur in the Namib Desert where vegetation on banks of watercourses provides cover (Mills & Hes 1997). The two major factors that appear to limit the distribution of this tough and versatile generalist are the presence of competitors and the presence of humans (Sunquist & Sunquist 2002). Leopards appear to be very successful at adapting to altered natural habitat and settled environments in the absence of intense persecution (Nowell & Jackson 1996).

1.3.3 *Role of the species in its ecosystem*

The Leopard is a large predator in the ecosystem and fills the role of managing smaller predators and managing prey populations. Leopards are a sign of a healthy, functioning ecosystem as they require large territories and are sensitive to human induced disturbance, habit loss or fragmentation and a reduced prey-base. They are easily blamed for stock losses and many people harbour an irrational fear of Leopards, thus further exposing them to intolerance by humans and unnecessary persecution.

They therefore also indicate the attitude of human beings and the extent of persecution practices such as trapping, poisoning and illegal hunting which usually has spill-over or secondary impacts for other, less visible animals.

1.4 Population

1.4.1 *Global Population size*
Unknown

National Population Size: See below (as per PHVA report, 2005)

Population Size
There is generally poor information on Leopard population because of censusing difficulties. As a solitary and nocturnal animal Leopards are not easily seen. The more successful methods of determining Leopard numbers are spoor counts and camera traps. The spoor count technique is used to determine presence/absence as well as the assessment of numbers using indices. This technique is only effective with high "detectability" of tracks e.g. sandy environments and special tracking skills are needed. Camera traps are also used to determine presence/absence data and monitoring trends.

Given the lack of accurate estimates of Leopard population size in South Africa, workshop participants were asked to give their expert opinion, and consensus on estimates was reached via facilitated group discussion. Maximum, minimum and best guess estimates for current Leopard population numbers were developed as baseline values for the Vortex model using a stable age distribution (Table 2). This process resulted in an estimate of 2185 to 6780 Leopards in South Africa, with a best guess estimate of 4250 Leopards. Maximum and minimum values were explored through sensitivity testing.

The saturation level of Leopards in each core area also was estimated by the participants through discussion and consensus during the plenary discussion to calculate an approximate carrying capacity for each population (*Table 2*). No environmental variation was added to the carrying capacity, as variations in habitat quality are accounted for by environmental variation in reproduction and survival.

Table 2: Population and carrying capacity estimates for each of the 10 identified core Leopard habitats in South Africa.

Population Area	Est. Population Size			Saturation Level	Est. K_{Best}
	Min.	Best	Max.		
Great Kruger	750	1200	1500	100%	1200
Northern Limpopo	500	1250	2000	80%	1563
Waterberg & Mpumalanga	400	850	1600	80%	1063
Northern KwaZulu-Natal	200	400	600	90%	444
Kalahari	30	50	70	90%	56
Orange River	20	30	60	50%	60
Western Cape	200	350	600	80%	438
Eastern Cape Mountain	35	40	80	65%	62
Eastern Cape Valley	30	50	150	70%	71
Wild Coast	20	30	120	100%	30
Total	**2185**	**4250**	**6780**	**86%**	**4987**

Many of the 10 identified core leopard populations are likely connected and allow for occasional movement of leopards between them (Figure 2). Dispersal among populations was included in the model as a small annual probability of leopards (ages 2 – 4 years, both sexes) moving between populations as shown in *Table 3*. These dispersal estimates were based upon expert opinion of habitat connectivity among core areas and estimated population sizes. Additional mortality is expected during dispersal due to the risk of being hit by cars, starvation, intraspecific aggression and other factors; survival during dispersal was modelled as 80% based on expert opinion.

Table 3: Annual probabilities (as percents) of dispersal from source populations (rows) to recipient populations (columns).

	Krugr	N Limp	Wat/ Mp	KZN	Kala	Orng R	W Cape	E Cp Mtn	E Cp Vlly	Wild Cst
Kruger	98.0	1.0	0.5	0.5	-	-	-	-	-	-
N Limpopo	0.5	98.3	1.0	-	0.2	-	-	-	-	-
Water/Mp	0.2	1.0	98.8	-	-	-	-	-	-	-
KZN	0.2	-	-	99.8	-	-	-	-	-	-
Kalahari	-	0.2	-	-	99.8	-	-	-	-	-
Orange R	-	-	-	-	-	99.8	0.2	-	-	-
W Cape	-	-	-	-	-	0.2	97.3	2.0	0.5	-
E Cape Mtn	-	-	-	-	-	-	2.0	96.0	2.0	-
E Cape Vlly	-	-	-	-	-	-	0.5	2.0	97.3	0.2
Wild Coast	-	-	-	-	-	-	-	-	0.2	99.8

Leopards are also estimated to migrate in and out of South Africa along the northern and eastern borders of the country (Figure 2). Migration rates were estimated by workshop participant base on expert opinion of Leopard behavior and habitat connectivity along trans-country boundaries. These losses and additions to the South African Leopard population were modelled as annual harvest and supplementation events in the Vortex model (Table 4). Immigrants were modelled as unrelated to the recipient population and therefore represented new genetic founders to the South African leopard population.

Table 4: Annual immigration and emigration incorporated into the Vortex model.

Population Area	Immigrants	Emigrants	Adjacent Population
Greater Kruger	5	20	Mozambique
N Limpopo	12	0	Botswana, Zimbabwe
Kalahari	10	5	Botswana
Orange River	1	0	Namibia

1.4.2 *Current global population trends*

___increasing ____decreasing ____ stable _X_ unknown

1.5 Conservation status

1.5.1 *Global conservation status (according to IUCN Red List)*

___Critically endangered
___Endangered
___Vulnerable
___Near Threatened
__X Least concern (2002)
___ Data deficient

1.5.2 *National conservation status for the case study country*

- 2004 Least Concern (Red Data Book for the Mammals of South Africa)
- 2007 Vulnerable (National List of Threatened or Protected Species)
- Appendix I CITES

1.5.3 *Main threats within the case study country*

___ No Threats
_X_ Habitat Loss/Degradation (human induced)
___ Invasive alien species (directly affecting the species)
_X_ Harvesting [hunting/gathering]

___ Accidental mortality (e.g. Bycatch)
_X_ Persecution (e.g. Pest control)
___ Pollution (affecting habitat and/or species)
_X_ Other: trade (illegal and legal) and habitat fragmentation
___ Unknown

2. SPECIES MANAGEMENT WITHIN THE COUNTRY FOR WHICH CASE STUDY IS BEING PRESENTED

2.1 Management measures

2.1.1 *Management history*

The management of Leopards is a function of the national and provincial authorities responsible for biodiversity and threatened species conservation. No national plans for Leopard conservation have however been drafted and the work of NGOs, academic institutions and private individuals has largely contributed to filling the significant gaps in Leopard conservation and management. The Population and Habitat Viability Assessment (PHVA) report produced in 2005 fulfils the role of a current national management plan for Leopards and has catalysed much conservation effort for Leopards including increased collaboration and information sharing, shared resources and improve cooperation, mostly through the establishment of the South African Leopard Forum (SALF), as an outcome of the PHVA. Thus, since 2005, an increased national effort to manage Leopards, collate and manage monitoring data, respond to human-wildlife conflict issues involving Leopards, generate improved species information and in general, to implement the recommendations arising from the PHVA, has been in place.

2.1.2 *Purpose of the management plan in place*

- To model various scenarios for management interventions and conservation actions to recommend appropriate courses of action for improved Leopard conservation and management.
- To improve levels of coordination and collaboration between role-players in Leopard conservation.
- To improve on the availability of accurate data to guide and inform decisions on Leopard utilisation, management and conservation.
- To collate current information and to thus provide a more accurate estimation of the current status of Leopards in South Africa.
- To provide informed, practical and effective conservation and management recommendations and objectives.

- To increase awareness of the threats and issues facing Leopards in conservation circles, the media and the public.

2.1.3 *General elements of the management plan*

- Species and habitat data.
- Threats data.
- Relevant presentations and papers.
- Working Group reports on population and biology, habitat and movement, human-wildlife conflict, population dynamics and modelling and utilisation and policy development.
- Management and population dynamics scenario modelling.
- Conservation and management recommendations and options.
- Stakeholder information.
- Relevant appendices, references and supportive information.

2.1.4 *Restoration or alleviation measures*

The PHVA report contains information on proposed management and utilisation options for improved population management, research recommendations, policy interventions and the need for urgent controls to be implemented to curb illegal offtake as the primary restoration measure. Scenarios modelled included future development in the Waterberg/Mpumalanga area (with a net loss of 15% of carrying capacity for Leopards and increase of 5% in illegal harvest), potential outbreak of distemper, corridor development among key populations (Orange River, Western Cape, Eastern Cape Mountain, Eastern Cape Valley, and Wild Coast), increased habitat (i.e., carrying capacity) for small populations, and elimination of illegal harvest.

2.2 Monitoring system

2.2.1 *Methods used to monitor harvest*

There are no formal, national monitoring programs for Leopards in South Africa. A number of projects have been established in recent years in southern Africa to conserve Leopards and their habitats and these are being implemented by non-governmental organizations, provincial nature conservation authorities and universities. There is however, little coordination of or collaboration between these activities and many operate in isolation of one another. It has been identified that accurate data on Leopard distribution, populations and status are fundamental to our ability to make sound, informed decisions, as information is sorely lacking for the species throughout its range. It has furthermore been urged that South Africa undertakes research and censusing projects to develop more accurate estimates of the

national Leopard population. In response to this, in recent years, the efforts by some provincial authorities (for example CapeNature, Ezemvelo KwaZulu-Natal Wildlife and Mpumalanga Parks) have increased, in collaboration with numerous NGOs (Cape Leopard Trust, the Endangered Wildlife Trust, KERI Research, De Wildt Cheetah and Wildlife Trust and others) and most of the relevant role-players in Leopard conservation and research are members of the recently formed South African Leopard Forum (SALF) – primarily in response to the Leopard PHVA outcomes.

The South African government, through the Department of Environmental Affairs and Tourism (DEAT) reviews applications for CITES permits and thus, monitors legal, permitted trade through the CITES quotas.

2.2.2 *Confidence in the use of monitoring*

Monitoring of Leopard population, trends, distribution and offtake remains one of the biggest problems facing the species and the confidence levels are very low.

2.3 Legal framework and law enforcement: Provide details of national and international legislation relating to the conservation of the species

Leopards are included on CITES Appendix I. They are formally protected in most of the Asian range states: Armenia, Bangladesh, Cambodia, China, Georgia, India, Indonesia, Iran, Israel, Jordan, Laos, Malaysia, Nepal, North Korea, Pakistan, Russia, Saudi Arabia, Sri Lanka, Thailand, Turkmenistan, Uzbekistan and Viet Nam. In Africa, most countries also prohibit hunting: Algeria, Angola, Benin, Burkina Faso, Cameroon, Congo, Democratic Republic of Congo, Djibouti, Egypt, Equatorial Guinea, Gabon, Ghana, Guinea Bissau, Ivory Coast, Liberia, Mali, Mauritania, Morocco, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo and Uganda (Nowell & Jackson 1996).

Data obtained from UNEP-WCMC from 1999 to 2002 indicates that South Africa mainly exported hunting trophies, skins and parts and derivatives obtained from hunting trophies.

In South Africa the Leopard is protected in all National Parks and government nature reserves. Leopards occurring outside protected areas are protected through their listing on the Threatened or Protected Species (ToPS) list and the associated regulations, promulgated under the National Environmental Management: Biodiversity Act (2004) which classifies the Leopard as Vulnerable and which implies a level of regulatory protection for the Leopard. Provincial nature con-

servation authorities are required to issue permits to hunt, catch, sell, import, convey, kill or export any Leopards under this legislation. Permits are issued upon a written application and each application is handled on its merits in accordance with environmental legislation and policies.

3. UTILIZATION AND TRADE FOR RANGE STATE FOR WHICH CASE STUDY IS BEING PRESENTED.

3.1 Type of use (origin) and destinations (purposes)

I. Fur / pelts; commercial trade (for clothing, handbags etc) as well as domestic, as symbols of power and strength
II. As a totem or symbol for many sects or tribes
III. Trophies as one of the 'Big Five'
IV. Parts (bones, teeth etc)

No utilization of captive-bred Leopards has been recorded and all captive management and breeding of Leopards is regulated by the ToPS regulations under the National Environmental Management: Biodiversity Act (10 of 2004).

National Environmental Management: Biodiversity Act, 10 of 2004

- A person may not carry out a restricted activity involving a specimen of a listed threatened or protected species without a permit.
- The Scientific Authority is required to carry out non-detriment findings on trade in specimens of listed threatened or protected species

3.2 Harvest

3.2.1 *Harvesting regime*

Leopards are not only harvested as trophies, but are persecuted as a result of human-wildlife conflict in which Leopards are blamed for livestock losses and depredation, often not as a result of the Leopard but other carnivores (including domestic dogs). They are also persecuted in response to competition for resources as they compete directly with people on commercial game farms for their natural prey (wild ungulates). The harvesting or persecution of Leopards is not seasonal but may increase (in the case of human-wildlife conflict) in breeding seasons due to increased conflict. As Leopards seldom prey on calves of all large ungulates older than 4-6 months, depending on the breed and size (Balme, pers comm.), many cattle ranchers have learned to confine breeding cows before they calve to paddocks adjacent to the

homestead, only allowing them to return to paddocks where predation is a risk, when calves are big enough to be at a lesser risk.

3.2.2 *Harvest management/ control (quotas, seasons, permits, etc.)*
In 1983, CITES approved the first requests from seven southern and East African nations to export Leopard skins. The Leopard remains today a CITES Appendix I species, banning commercial trade in skins, but permitting import and export of hunting trophies between countries. By 2005, 11 nations were permitted exports of Leopard trophies under the approval of CITES. Although commercial trade remains prohibited, quotas can include skins from animals killed in government 'problem animal control' operations which is why Leopard skin rugs are sometimes for sale in the airport curio shops of these countries. In total, the number of Leopards approved by CITES for export each year was 2 345 but in 2004, at the 13th CITES Conference of the Parties held in Thailand, this was increased to almost 2 500. This increase was partly due to South Africa applying for an increase in their CITES quota for Leopard trophy exports from 75 to 150. Concern from a number of Parties (including the governments of Cameroon and India and TRAFFIC, the Wildlife Trade regulation body) was expressed over this increase and South Africa was urged, at this conference, to undertake a Leopard census and to improve the available information on Leopard numbers (Hunter & Balme 2004).

In South Africa CITES quotas for Leopard trophies remains at 150 exports per annum. These are however not allocated to provinces based on local take-off potential but rather, on a basis of equitable distribution of the quota and provincial requests. CITES quotas are not based on reliable data on Leopard numbers or trends in any of the countries trading in Leopards.

3.3 Legal and illegal trade levels

Harvest: Leopards are removed from the population each year through a variety of legal and illegal methods. The number of individuals removed each year through trophy hunting, legal and illegal local hunting, and the removal of problem animals was estimated at the PHVA by the workshop participants based on a facilitated plenary discussion based on expert opinion (*Table 5*). Removals were assumed to be adults of equal sex ratio, except for trophy hunting (60% male, 40% female).

Table 5: Annual harvest modeled in each population due to legal and illegal removal methods.

Population Area	Trophy hunting	Local Hunting		Problem animals	Total
		Legal	Illegal		
Great Kruger	6	0	2	2	10
N Limpopo	25	10	40	15	90
Waterberg / Mp	25	10	40	15	90
KwaZulu-Natal	5	2	20	10	37
Kalahari	0	0	2	0	2
Orange River	0	0	2	2	4
Western Cape	0	0	3	4	7
E Cape Mountain	0	0	6	2	8
E Cape Valley	0	0	4	2	6
Wild Coast	0	0	2	0	2
Total	**61**	**22**	**121**	**52**	**256**

The PHVA workshop modelled various scenarios for Leopard conservation and management including trade (illegal and legal) reduction and management options for harvesting. The following results were obtained, based on the available data at the time:

Harvesting Strategies
The removal of Leopards can have major impacts on the persistence and viability of local populations and the number and distribution of Leopards across South Africa. The effects of harvest depend upon the number, sex and location of the Leopards harvested. Several harvesting strategies were explored with the Vortex model to evaluate these effects.

Current Harvest Levels
Model projections over a 100-year timeframe using current best estimates of Leopard population size, structure, and harvest levels (quota = 75) result in a persisting Leopard metapopulation in South Africa (mean population size of 4025 leopards with 0% risk of extinction). Populations in the core areas of Kruger, N. Limpopo, West Cape, and Kalahari show no risk of extinction and may serve as strongholds for the species. The East Cape Valley and Wild Coast populations are at high risk of extinction, and the remaining four populations show moderate risk of extinction, typically within the next few decades under current conditions.

Removing All Harvest
Eliminating all harvest from the model results in the persistence of all 10 local populations and the maintenance of about 5000 Leopards in South Africa (vs. about 4000 projected by the baseline model with current estimated harvest levels).

Removing Illegal Harvest
Illegal local hunting accounts for 47% of the annual harvest in the Vortex model and affects every Leopard population. Elimination of illegal hunting from the model has a very significant impact on the persistence of local populations; all populations are projected to have zero risk of extinction in the next 100 years (except for Wild Coast, which has a 1% probability of extinction) (*Table 6*). Model results suggest that even the smaller Leopard populations might be able to withstand the removal of occasional problem animals if illegal hunting is eliminated. Estimates of the rates of illegal hunting are uncertain, as by definition these activities are not permitted and often go undetected. Efforts to document and reduce / eliminate illegal removal of Leopards, particularly from the smaller populations and from KwaZulu-Natal, would help to improve the viability of these local populations.

Table 6: Effect of removing illegal harvest on Leopard populations.

Population Area	**PE_{100}**		**Mean Pop. Size (extant)**	
	Baseline	**No Illegal Harvest**	**Baseline**	**No Illegal Harvest**
Kruger	0	0	1184	1182
N Limpopo	0	0	1512	1545
Waterbg / Mp	0.08	0	619	1042
KwaZulu-Natal	0.32	0	322	436
Kalahari	0	0	56	56
Orange River	0.25	0	50	58
W Cape	0	0	425	429
E Cape Mtn	0.23	0	29	61
E Cape Vlly	0.87	0	27	69
Wild Coast	0.99	0.01	19	28
Metapopulation	0	0	4025	4909

CITES Hunting Quota: Number of Leopards
At the 2004 CITES CoP meeting, the annual quota for Leopard hunting trophies and skins in South Africa was increased from 75 to 150 indivi-

duals. The impact of this quota increase is unknown, and the development of a Vortex model to assess this factor was a primary concern of the PHVA workshop participants. The baseline and other scenarios incorporated the effects of the past quota of 75 Leopards, specifically by removing adult Leopards (60% male, 40% female) annually from four populations – Kruger, Limpopo, Waterberg / Mpumalanga and KwaZulu-Natal. Although 75 Leopards are allotted in this quota, participants estimated that only about 61 Leopards are removed annually, as some permits have been issued in the past without a Leopard being taken. Several model scenarios were run to assess the impact of increasing the CITES quota while retaining other sources of harvest. Quota levels tested (with full removal) were 0, 75, 90, 105, 120, 135 and 150 (see Table 7 for quota distribution for these scenarios).

Table 7: Quota distribution among populations used in the Vortex model.

Population	**Base**	**0**	**75**	**90**	**105**	**120**	**135**	**150**
Kruger	6	0	6	8	10	12	14	16
N Limpopo	25	0	30	36	42	48	54	60
Waterbg / Mp	25	0	30	36	42	48	54	60
KwaZulu-Natal	5	0	5	6	7	8	9	10
E Cape Mtn	0	0	4	4	4	4	4	4
Total removed	61	0	75	90	105	120	135	150

The number of Leopards harvested through trophy hunting in the range tested (0 to 150 annually) had no effect on the persistence of Leopards in Kruger, Limpopo, Kalahari and Western Cape, despite the fact that much of the harvest occurs in Kruger and Limpopo. The risk of extinction over 100 years remains zero for these populations; mean population size was also relatively unaffected except for Limpopo, where numbers decline slightly. Orange River, Eastern Cape Valley and Wild Coast populations are also relatively unaffected, as no Leopards are removed via trophy hunting from these populations.

As might be expected, Eastern Cape Mountain shows a sharp increase in risk of extinction with all levels of trophy hunting due to the constant removal of four Leopards per year under all quota levels. The allotment of four trophy permits per year to this area increases the risk of extinction in 100 years from 28% to over 60%. Surviving populations average 3-4 animals, possibly emigrants from adjacent populations and suggesting that a resident population may not persist. This small population cannot sustain this level of removal in combination with other threats.

The remaining two populations, Waterberg / Mpumalanga and KwaZulu-Natal, are subject to trophy hunting and become smaller and more susceptible to extinction as hunting quotas increase (Figure 3). The probability of extinction for the Waterberg population increases from 16% to 25% with the increase in quota from 75 to 150 Leopards. Of more concern, however, is the significant decline in mean population size with increased hunting, from over 1000 Leopards with no trophy hunting to 464 with a quota of 75 to only 6 Leopards with the quota of 150. At the 105 level (which equals the annual removal of 42 Leopards from Waterberg), the mean population size drops below 100, suggesting that this level of removal puts this population at high risk.

Increased trophy hunting has the greatest impact on population persistence for the KwaZulu-Natal population, with the risk of extinction rising from 11% with no hunting to 62% under the 150 quota scenario (Figure 3). Mean population size drops from 393 to 217. Despite the relatively large current population size and estimated carrying capacity, the removal of 2-3 additional Leopards per year put this population at substantially greater risk.

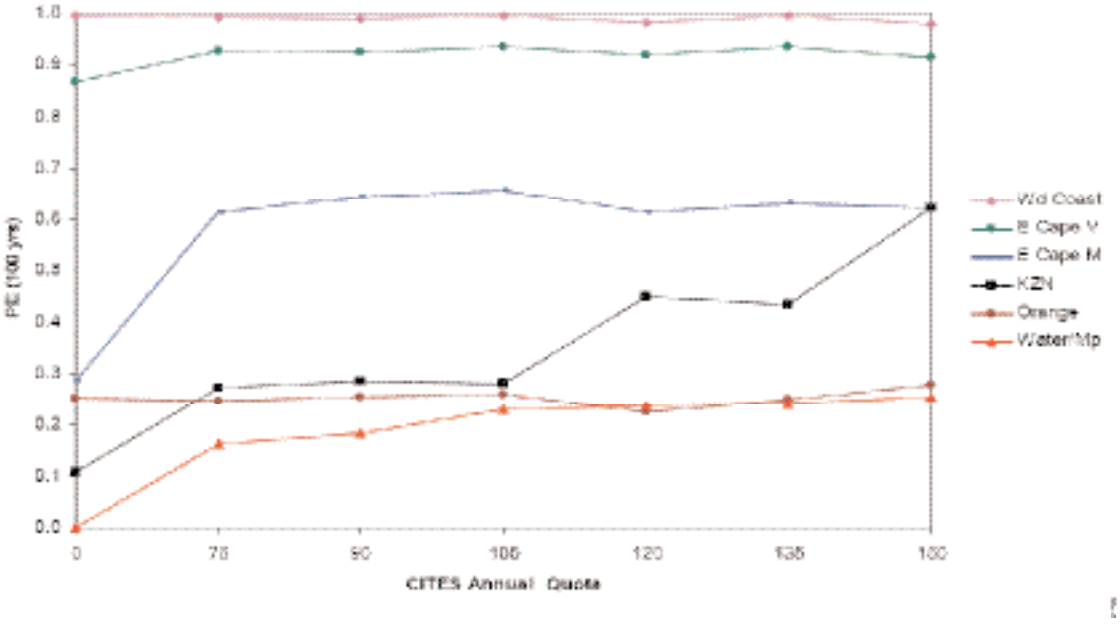


Figura 3: Effect of CITES quota on probability of extinction of Leopard populations.

Because many of the larger Leopard populations have no projected risk of extinction, the increase in the CITES quota from 75 to 150 Leopards does not increase the risk of extinction of Leopards in South

Africa over the next 100 years. The total number of Leopards living in South Africa, however, decreases with increased quota levels, due to the decreasing population size and higher risk of extinction of many of the local populations. Mean metapopulation size falls from 4631 with no trophy hunting, to 3844 with a quota of 75 to 3196 with the 150 quota, representing a decline in saturation from 93% to 64% of the carrying capacity of the habitat. These results suggest that the effects of increased quotas will depend in part upon the areas from which Leopards are taken and can lead to local extinctions and reduced population size.

CITES Hunting Quota: Targeting Males

In polygynous species the removal of breeding age females generally is more detrimental to the population than the removal of adult males. Since a male can mate with more than one female, fewer males are required to maintain the same level of reproduction, while the loss of females reduces the reproductive potential of the population and decreases its ability to respond to reductions in population size. It would be difficult to restrict illegal (and perhaps legal) local hunting and the removal of problem animals to males only, and in fact some populations might not be able to withstand the loss of a large proportion of males each year given the already female-biased sex ratio. However, it may be more feasible and desirable to target adult males for trophy hunting. Vortex was used to explore the effect of hunting males only in conjunction with the CITES quota.

Table 8 gives the results for harvesting 60% males (current situation) vs. 100% males via trophy hunting; all other sources of harvest in the model include equal sex ratio. The effects of only male trophy hunting are modest. Waterberg and Eastern Cape Mountain populations have a lower risk of extinction but few Leopards persist in these areas (probably consisting of immigrants from adjacent populations). The risk of extinction for the KwaZulu-Natal population is substantially lower and mean population size is higher, suggesting that a male-biased sex ratio of trophy hunting may be beneficial in this area. Mean population size is slightly higher in Limpopo and for the entire metapopulation with male-biased trophy hunting.

CITES Hunting Quota: Targeting Problem Animals

When large carnivores such as Leopards live in close proximity of human-inhabited areas, conflicts arise when livestock or human lives are threatened. Workshop participants estimated that about 50 problem Leopards are removed each year from South Africa due to such conflicts. One potential harvest strategy is to target these problem ani-

mals when hunting Leopards under the CITES quota. This in effect would reduce the number of Leopards removed from the population while satisfying both needs. To investigate this strategy, the 150 Quota scenario was tested with 30 of the 150 Leopards hunted being problem animals in Limpopo (11), Waterberg / Mpumalanga (11), KwaZulu- Natal (7), and Eastern Cape Mountain (1), with 60% of them being males.

In this scenario, hunting of problem Leopards for trophies has small effect in Limpopo (larger mean population size) and no effect on the Eastern Cape Mountain population (*Table 8*). Although the risk of extinction remains the same for Waterberg / Mpumalanga, the mean population size of surviving populations increases from just a few animals to 63, suggesting the survival of a small resident population. The greatest impact can be observed in KwaZulu-Natal, where the risk of extinction drops from 62% to 14% and mean population size almost doubles. There is a small increase in the metapopulation under this strategy.

The net impact of targeting problem animals is to reduce the removal of Leopards from the population. The effectiveness of this strategy will depend heavily upon the population area(s) from which problem Leopards are removed.

Table 8: Effect of sex ratio & inclusion of problem animals in trophy hunting takes on Leopard populations.

	Kruger	**Limpopo**	**Water/Mp**	**KZN**	**ECape M**	**Metapop**
PE						
60% male	0	0	0.25	0.62	0.62	0
100% male	0	0	0.19	0.37	0.51	0
Incl. 30 prob.	0	0	0.24	0.14	0.59	0
Mean Population Size						
60% male	1176	1409	6	217	4	3196
100% male	1180	1505	7	343	5	3435
Incl. 30 prob.	1176	1481	63	376	4	3554

Sustainable Harvest for Local Populations

Each local population differs in its ability to withstand harvest. This complicates the assessment of various quota levels or the effects of targeting problem animals for trophy hunting, as the impact of the same strategy will differ depending upon the distribution of harvest across the Leopard's geographical range in South Africa. To address this issue, the baseline model was used to vary annual harvest levels in

each population separately to estimate the maximum level of annual harvest that would meet the PHVA workshop population goals of zero extinction risk for Kruger, KwaZulu-Natal, Kalahari and Western Cape populations and PE < 5% for the remaining six populations.

This analysis resulted in the following estimates for the maximum annual harvest from each population area (*Table 9*). Harvest here includes the loss of Leopards from all sources outside of normal mortality, including trophy hunting, legal and illegal local hunting, removal of problem animals, and emigration of Leopards out of South Africa. Harvest numbers indicate the maximum annual harvest for each population that does not exceed the risk of extinction specified in the PHVA population goals and results in a positive stochastic growth rate. In this scenario, up to 350 adult Leopards (53% males) can be removed each year without unacceptable risk to the populations. All local populations have a low risk of extinction in 100 years, and all populations except the Wild Coast maintain high levels of genetic variation. Mean population size is more variable for Kruger, Limpopo, Kalahari, Western Cape and the metapopulation as a whole as compared with the baseline model (as these are the populations that experience increased harvest under this scenario), while other local populations are more stable in size with lower harvest rates.

Table 9: Results of maximum harvest model on Leopard populations (at 100 years).

Population Area	Total Harvest	PE	Stoch r	Mean N (extant)	SD (N)	% K	GD	Mean TE
Kruger	85	0	0.006	791	482	66	0.980	0
N Limpopo	127	0	0.012	1106	603	71	0.991	0
Watergr/Mp	74	0.05	0.033	991	127	93	0.990	50
KwaZulu-Natal	23	0	0.052	431	25	97	0.997	70
Kalahari	16	0	0.32	38	17	68	0.997	0
Orange River	3	0	0.081	58	5	97	0.946	32
W Cape	12	0	0.044	419	28	96	0.964	0
E Cape Mtn	7	0.01	0.065	57	11	92	0.946	35
E Cape Vlly	3	0	0.068	68	5	96	0.936	16
Wild Coast	0	0	0.072	28	4	94	0.683	60
Metapop	350	0	0.034	3936	1054	79	0.996	0

Current estimates from the PHVA workshop include an annual loss of 77 animals through emigration and the removal of problem animals – sources of loss that may be difficult to manage. Participants estimated another 143 Leopards lost through legal and illegal local hunting, lea-

ving about 130 animals to be harvested through trophy hunting under the maximum harvest strategy. Figure 4 compares the mean metapopulation size projected over the next 100 years with no trophy hunting (Quota 0), current baseline conditions (quota of 75, with actual removal of 61 Leopards annually), new increased quota of 150, and the maximum harvest strategy (approximate quota of 130 given no reduction in local hunting or removal of problem animals). With no trophy hunting, metapopulation size remains relatively stable at current levels. All CITES harvest levels are projected to result on average in population reduction due to local declines and extinctions (but not increased risk of extirpation of Leopards from South Africa). The maximum harvest level closely mirrors the baseline projection but includes the removal of an additional 69 Leopards annually, illustrating the importance of the area from which Leopards are harvested.

The number of Leopards that can be harvested from each population is specific to the input values in this Vortex model (i.e., age- and sex- specific demographic rates, population size and structure, dispersal and migration rates, and harvest estimates) most of which include some level of uncertainty. Therefore, these results should be viewed cautiously and used only as relative guidelines. As better estimates become available regarding rates of loss through these various causes, and as better demographic and population information becomes available, it will be possible to make more confident projections regarding how many Leopards can be sustainably removed both locally and nationally.

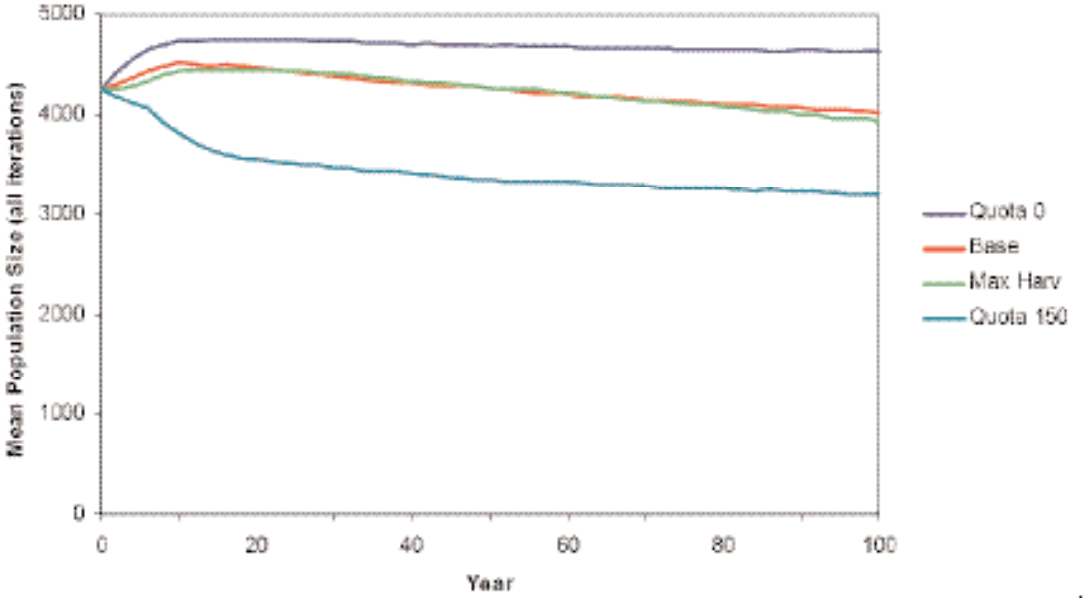


Figura 4: Mean metapopulation size with CITES quotas of 0, 75 (baseline) and 150 compared with maximum harvest strategy.

II. Non-detriment finding procedure (NDFs)

The PHVA workshop, Vortex modelling and the final report form the basis of this finding. A Population and Habitat Viability Assessment (PHVA) workshop brings together a diversity of stakeholders in a structured and facilitated setting to identify, describe and analyze the primary threats to the target species, and to develop goals and recommended actions to address these threats. A stochastic population model is developed using input parameter values based on published data and the consensus expert opinion of the participating stakeholders; this model is then used to project the relative viability of the target population under current and alternative management scenarios. Thirty-three people participated in the South Africa Leopard PHVA workshop, representing the conservation NGO community, the Department of Environmental Affairs and Tourism (DEAT), various academic institutions, SANParks, provincial conservation departments, private game reserves and the Professional Hunters Association of South Africa (PHASA). A Briefing Document was made available to all workshop participants prior to the workshop, covering the latest information on Leopard biology, ecology, population dynamics and trends, distribution, threats and conservation status in South Africa. The final report was peer-reviewed by workshop participants and covered all workshop outputs, management recommendations, modelling scenarios and in essence, fulfils the role of a conservation assessment and management plan for Leopard conservation in South Africa.

1. IS THE METHODOLOGY USED BASED ON THE IUCN CHECKLIST FOR NDFs?

__*yes* ___no

To a large degree, but this was not specifically aimed for.

2. CRITERIA, PARAMETERS AND/OR INDICATORS USED

- Type and degree of harvest: Estimates of total current and proposed levels of export, trade and offtake / harvesting
- Levels of control of harvest and offtake
- Sustainability of the metapopulation and the sub-population based on current and future scenarios and threats
- Estimates of population size and demographics and changes / trends
- Source-sink considerations and supplementation / recruitment
- Status of the species at national levels
- Biological parameters / characteristics of the species

- Threat assessments
- Distribution and population trends
- Mortality trends and demographics factors
- Genetic factors
- Breeding systems and success rates
- Habitat quality and availability
- Habitat carrying capacity
- Possible catastrophes
- Adaptive management strategies
- Management plans and strategies
- Captive breeding impacts
- Efficacy of monitoring and quality of information on the species
- Protection measures afforded to the species

3. MAIN SOURCES OF DATA, INCLUDING FIELD EVALUATION OR SAMPLING METHODOLOGIES AND ANALYSIS USED

- Publications
- Personal communication with a wide selection of stakeholders
- Reports
- Policies and legislation (provincially and nationally)
- CITES records
- Provincial and national records for trade, offtake, problem animal control
- Red Data List assessments
- Anecdotal information and accounts on illegal offtake
- Researchers', government and NGOs reports and documents
- Species management plans
- Vortex modelling was used to process data and produce management scenarios; these models were peer-reviewed by the IUCN Species Survival Commission (SSC) Conservation Breeding Specialist Group (CBSG).

4. EVALUATION OF DATA QUANTITY AND QUALITY FOR THE ASSESSMENT

- Peer reviewed publications were utilised
- Anecdotal information was used by consensus of the PHVA group
- Most input data were reviewed by workshop participants as they received it in a briefing book 6 weeks prior to the PHVA workshop
- All data and information sources were openly discussed and if refuted, were not used
- The final report including the assessment and recommendations were reviewed by all
- PHVA participants before finalisation.
- The final models were reviewed by the IUCN CBSG.

5. MAIN PROBLEMS, CHALLENGES OR DIFFICULTIES FOUND ON THE ELABORATION OF NDF

- Lack of accurate data on Leopard population size, status and trends
- Lack of accurate data on Leopard distribution
- Lack of data on true extent and impact of illegal offtake of Leopards
- Insufficient data on the Leopard demographic rates
- Ineffective monitoring of Leopards and data management by authorities (data accumulation, collation, access, interpretation and availability)
- Lack of capacity and resources in government to implement effective monitoring of Leopards and to implement legislation to control the illegal offtake.

6. RECOMMENDATIONS

If the current CITES quota for Leopards is fully utilized in South Africa, without allocations for the provinces being made on sustainability assessments, the CITES quota will not be sustainable and trade will possibly lead to the decline in the Leopard population.

The baseline population model for Leopards developed at the PHVA is based upon best estimates of Leopard biology and threats to South African Leopard populations and, unless otherwise indicated, assumes that these conditions will remain constant over time. Because our understanding of Leopard population biology and current status is incomplete and conditions are not likely to remain constant, it is difficult to produce accurate population projections over 100 years. However, this model is useful for predicting population trends and evaluating the relative effectiveness of various management and harvest options.

With current estimated rates of legal and illegal harvest of Leopards and movement of Leopards among populations and across international borders, model results indicate that there is little risk of extinction of Leopards in the areas of Greater Kruger, North Limpopo, Western Cape and Kalahari and therefore no risk of extirpation of Leopards from South Africa. Populations in other areas of the country (specifically, Waterberg / Mpumalanga, North KwaZulu-Natal, Orange River, East Cape Mountain and Valley, and Wild Coast) are at some risk of extinction depending upon population size and carrying capacity, demographic rates, dispersal rates among populations and harvest rates. Populations in Eastern Cape Valley and the Wild Coast in particular are highly vulnerable to extinction in the next few decades. Potential strategies to promote the persistence of these six populations include augmentation of natural corridors among adjacent populations and minimizing harvest of Leopards from these populations.

The Vortex Leopard model suggests that *some level* of controlled harvest can be sustained without unacceptable risk to the metapopulation. It is currently difficult however, due to a paucity of reliable data, to determine the exact level of harvest that is sustainable as this is dependent on demographic rates, population size and distribution, available habitat and the sex and location of harvested animals. *The maximum harvest model suggests that no more than an additional 69 Leopards and possibly fewer, can be removed from the South African metapopulation*. If these are restricted to male animals, this may have a slightly less negative impact on the smallest, most isolated populations. An increased off-take (should an increased CITES quota be fully implemented) can only be sustained in four of the populations and in the smaller populations even a slight increase in individuals taken vastly increases the possibility of local extinction.

Eliminating illegal hunting has a significant positive impact on survival of local populations, all of which will then have zero risk of extinction in the next 100 years. Improved protection of Leopards may in the long-term potentially allow an increase in legal hunting quotas. All efforts should therefore be made to minimise illegal hunting in all areas and to prevent the killing or removal of any Leopards from small, fragmented populations to reduce the risk of local extinction.

Increased population monitoring and data gathering is imperative to assess the impact of harvesting and to allow harvesting rates to be adjusted as needed. As better data on Leopard biology and populations become available, the Leopard population model can be revised to improve the ability to project the impact of harvesting on Leopard populations throughout South Africa.