Acinonyx jubatus

CONSERVATION BREEDING SPECIALIST GROUP
SOUTHERN AFRICA

cheetah PHVA

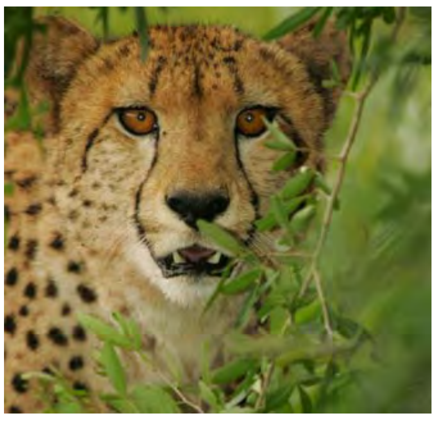
De Beers Venetia Limpopo Nature Reserve

17 – 21 April 2009
South Africa

THE HOWARD G. BUFFETT FOUNDATION

DE BEERS
A DIAMOND IS FOREVER

ENDANGERED WILDLIFE TRUST
www.ewt.org.za



CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

De Beers Venetia Limpopo Nature Reserve, South Africa

WORKSHOP REPORT

Convened by:

ENDANGERED WILDLIFE TRUST
CONSERVATION BREEDING SPECIALIST GROUP SOUTHERN AFRICA

Sponsored by:

HOWARD G. BUFFETT FOUNDATION
DE BEERS CONSOLIDATED MINES

In collaboration with

THE CONSERVATION BREEDING SPECIALIST GROUP (CBSG) of the IUCN Species Survival Commission

Lindsey, P., Marnewick, K., Davies-Mostert, H., Rehse, T., Mills, M.G.L., Brummer, R., Buk, K., Traylor-Holzer, K., Morrison, K., Mentzel, C. and Daly, B. (editors). 2009. Cheetah (*Acinonyx jubatus*) Population Habitat Viability Assessment Workshop Report. Conservation Breeding Specialist Group (SSC / IUCN) / CBSG Southern Africa. Endangered Wildlife Trust.

The photographs on the front cover of this report were supplied by Charl Senekal.

The CBSG Conservation Council

These generous contributors make the work of CBSG possible

$50,000 and above

Chicago Zoological Society
-Chairman Sponsor

$20,000 and above

Minnesota Zoological Garden
-Office Sponsor
Omaha's Henry Doorly Zoo
SeaWorld/Busch Gardens
Toronto Zoo
Zoological Society of London

$15,000 and above

Columbus Zoo & Aquarium - The WILDS
Disney's Animal Kingdom
Saint Louis Zoo
Wildlife Conservation Society
World Association of Zoos and Aquariums (WAZA)

$10,000 and above

Nan Schaffer
San Diego Zoo
White Oak Conservation Center

$5,000 and above

Al Ain Wildlife Park & Resort
Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA)
Cleveland Metroparks Zoo
Evenson Design Group
Linda Malek
Toledo Zoo

$1,000 and above

African Safari Wildlife Park
Albuquerque Biological Park
Alice D. Andrews
Allwetterzoo Münster
Association of Zoos and Aquariums (AZA)
Auckland Zoological Park
Audubon Zoo
Bristol Zoo Gardens
British and Irish Association of Zoos and Aquariums (BIAZA)
Calgary Zoological Society
Central Zoo Authority, India
Chester Zoo
Cincinnati Zoo & Botanical Garden
Colchester Zoo
Conservatoire pour la Protection des Primates
Copenhagen Zoo
Cotswold Wildlife Park
Detroit Zoological Society
Dickerson Park Zoo
Durrell Wildlife Conservation Trust
El Paso Zoo
Everland Zoological Gardens
Fort Wayne Children's Zoo
Fort Worth Zoo
Fota Wildlife Park
Gladys Porter Zoo
Hong Kong Zoological and Botanical Gardens
Japanese Association of Zoos & Aquariums (JAZA)
Kansas City Zoo
Laurie Bingaman Lackey
Los Angeles Zoo
Marwell Zoological Park
Milwaukee County Zoo
North Carolina Zoological Park
Ocean Park Conservation Foundation
Paignton Zoo
Palm Beach Zoo at Dreher Park
Parco Natura Viva
Perth Zoo
Philadelphia Zoo
Phoenix Zoo
Pittsburgh Zoo & PPG Aquarium
Point Defiance Zoo & Aquarium
Prudence P. Perry
Ringling Bros., Barnum & Bailey
Robert Lacy
Rotterdam Zoo
Royal Zoological Society of Antwerp
Royal Zoological Society Scotland – Edinburgh Zoo
Saitama Children's Zoo
San Antonio Zoo
San Francisco Zoo
Schönbrunner Tiergarten – Zoo Vienna
Sedgwick County Zoo
Swedish Association of Zoological Parks & Aquaria (SAZA)
Taipei Zoo
The Living Desert
Thrigby Hall Wildlife Gardens
Twycross Zoo
Union of German Zoo Directors (VDZ)
Utah's Hogle Zoo
Wassenaar Wildlife Breeding Centre
Wilhelma Zoo
Woodland Park Zoo
Zoo Frankfurt
Zoo Madrid – Parques Reunidos
Zoo Zürich
Zoological Society of Wales – Welsh Mountain Zoo
Zoologischer Garten Köln
Zoologischer Garten Rostock
Zoos South Australia

$500 and above

Aalborg Zoo
Akron Zoological Park
Banham Zoo
Fairchild Tropical Botanic Garden
Friends of the Rosamond Gifford Zoo
Givskud Zoo
Jacksonville Zoo & Gardens
Katey & Mike Pelican
Kerzner International North America, Inc.
Knuthenborg Park & Safari
Lincoln Park Zoo
Lisbon Zoo
Nordens Ark
Odense Zoo
Oregon Zoo
Ouwehands Dierenpark
Riverbanks Zoological Park & Garden
Wellington Zoo
Wildlife World Zoo, Inc.
Zoo de Granby
Zoo de la Palmyre

$250 and above

Alice Springs Desert Park
Apenheul Zoo
Arizona-Sonora Desert Museum
Bramble Park Zoo
Brandywine Zoo
David Traylor Zoo of Emporia
Ed Asper
Edward & Marie Plotka
Lee Richardson Zoo
Little Rock Zoo
Mark Barone
Racine Zoological Gardens
Roger Williams Park Zoo
Rolling Hills Wildlife Adventure
Sacramento Zoo
Tautphaus Park Zoo
Tokyo Zoological Park Society
Topeka Zoological Park

$100 and above

African Safari – France
Aquarium of the Bay
Chahinkapa Zoo
International Centre for Birds of Prey
Lincoln Children's Zoo
Lion Country Safari, Inc.
Miami Metrozoo
Safari de Peaugres – France
Steinhart Aquarium
Steven J. Olson
Touroparc – France

$50 and above

Alameda Park Zoo
Darmstadt Zoo
Elaine Douglass
Miller Park Zoo
Oglebay's Good Children's Zoo
Stiftung Natur-und Artenschutz in den Tropen

Thank you for your support!
31 August 2009

Table of Contents

CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

De Beers Venetia Limpopo Nature Reserve, South Africa

WORKSHOP REPORT

SECTION 1

EXECUTIVE SUMMARY AND CBSG WORKSHOP PROCESS

EXECUTIVE SUMMARY

The situation facing Cheetah (*Acinonyx jubatus*) conservation in South Africa is unique - a large portion of the species range occurs outside of protected areas, and private landowners play an essential role in its survival. The fragmented nature of these habitats and the prevalence of small, isolated subpopulations of Cheetah mean that the conservation of the species is best addressed through metapopulation management techniques.

Cheetah occurrence can be divided into three separate management units: 1) large National Parks: Kruger and Kglalgadi, 2) smaller fenced protected areas where Cheetah were reintroduced and 3) the free roaming population which is the largest. Each of the populations faces different threats and challenges.

The Population Habitat Viability Assessment (PHVA) is a multi-stakeholder inclusive process used in the development of a strategic recovery / conservation plan for a specific species and its habitat. Data on population status and trends, distribution, genetics, health status, biology, threats and ecology of the species is assembled and integrated with estimates of human-based threats such as land-use and utilisation patterns. Computer-based models are used to test different management scenarios and to forecast the current and future risk of population decline and / or extinction. Key issues affecting population viability are identified, and goals and recommended actions are developed to address these issues.

The Cheetah conservation community lacks the tools to effectively manage and conserve Cheetah in the unique conditions presented in South Africa. To address this need, a PHVA workshop was held from 17 - 21 April 2009 at the De Beers Venetia Limpopo Nature Reserve near Musina, Limpopo Province. This workshop was considered a vital prerequisite for the development of an effective metapopulation management strategy for Cheetah in South Africa. The PHVA served as a precursor to a National Conservation Action Planning Workshop for Cheetah and Wild Dogs (*Lycaon pictus*) scheduled for June 2009.

THE CBSG PHVA WORKSHOP PROCESS

Twenty people attended the workshop, which included Cheetah experts from South Africa, Zimbabwe and Tanzania as well as four CBSG facilitators and modellers. A briefing document was made available to all workshop participants a week prior to the workshop, which afforded participants the opportunity to become familiar with up-to-date information on the biology, ecology, population dynamics and trends, distribution, threats and conservation status of Cheetah in South Africa.

The workshop was conducted over three and a half days. The morning of the first day was dedicated to various presentations covering the status, distribution and threats to Cheetah at a regional scale, the conservation plan and policies of the Carnivore Conservation Group in preparation for the National Conservation Action Planning (NCAP) Workshop, a review of the status of Cheetah in South Africa, a review of the conservation threats facing Cheetah in South Africa, and an overview of the use of the PHVA process in managed metapopulation planning, using the Wild Dog as a case study. The CBSG population modeller then gave an introduction to population viability analysis (PVA) and simulation modelling, followed by the presentation of preliminary base models developed for Cheetah based on data provided prior to the workshop.

The PHVA workshop process is comprised of a series of plenary and working group sessions in which working groups complete tasks designed to facilitate free thinking, brainstorming, discussion and debate and, finally, synthesis and consensus building. In most PHVA workshops, this process includes the development of specific recommended actions, complete with responsible parties and timelines. This PHVA, however, was designed within the context of a follow-up NCAP Workshop. A plenary discussion among the workshop participants on the first day defined the scope of the PHVA in this context: the relatively small group of technical experts at the PHVA chose to concentrate on compiling and analysing data relevant to developing Cheetah management strategies, including identification of issues and development of broad recommendations. These analyses and recommendations would provide a general management framework for consideration by a broader stakeholder audience at the NCAP Workshop in June, resulting in a national action plan for Cheetah and Wild Dogs in South Africa.

Cheetah live in several different sets of environmental conditions in South Africa, and these correlate to different populations with their own demographic characteristics, threats and management strategies. These include Cheetah living in protected populations, those ranging unrestricted across private lands, and those living in small fenced private reserves. The workshop participants recognised that it is the management of these small reserve populations as an interconnected metapopulation that is least understood and therefore in need of the most analysis and technical advice. After group discussion, the decision was made to address these issues at the PHVA by forming the following three working groups:

1. Managed Reserves Metapopulation Working Group
2. Free Range Population Working Group
3. Population Modelling and Dynamics Working Group

After an initial group brainstorming session, the key issues facing the survival of Cheetah in South Africa were identified. These were consolidated and distributed to the appropriate working group(s) for further exploration and analysis.

The two population-specific working groups spent three days tackling issues specific to their target population and systematically worked through the following tasks: 1) drafting a description and potential roles of their target population; 2) defining viability criteria for the population; 3) identifying and prioritising key issues affecting population viability; 4) assembling and analysing all available information regarding these issues; and 5) developing general recommendations for addressing these issues. Periodic plenary sessions enabled working groups to present the results of their discussions to the entire group and thus obtain the input of all participants, which resulted in additional debate and insight. The modelling working group provided modelling tools to assist the population-based working groups in their analysis of data and the potential consequences of various management strategies on Cheetah population viability.

WORKING GROUP SUMMARIES

Each working group was assigned several tasks, with the goal of providing technical advice on developing effective management recommendations for identified problems affecting Cheetah population viability. Listed below is a summary of the specific issues, analyses and recommendations proposed by the three working groups (see Section 3 for detailed working group reports):

1. Managed Reserves Metapopulation Working Group

This population includes several isolated subpopulations in fenced reserves that are actively managed.

Priority problem statements and recommendations identified by the working group included:

- A lack of knowledge exists of the minimum suitable habitat size required to support acceptable subpopulation sizes. To address this, it was suggested that a proper assessment be done of the ecological requirements of a subpopulation.
- There is no national strategy for the management of the Cheetah metapopulation in South Africa. A 7-step process was drawn up at the workshop to guide the development of a strategy. Please see Appendix 1 for a copy of the Operational Framework for a Managed Cheetah Metapopulation in South Africa.
- An assessment is needed on the viability (genetic and demographic) of Cheetah populations in small fenced reserves. This would be useful in determining if enough suitable habitat is available to sustain a metapopulation and facilitate management among reserves. Recommendations include modelling the data from large populations so as to determine acceptable levels of extinction risk, as well as using PM2000 software for the analysis and management of pedigrees.

Problem statements identified by the working group, but not discussed due to time constrains include:

- The lack of knowledge of suitable available habitat across South Africa.
- The economic value of Cheetah paradoxically complicates metapopulation management.
- The small scale of many of the reserves increases ecosystem sensitivity to population fluctuations.
- The managed population could negatively impact free-ranging wild populations.

The group also discussed whether genetic clustering should be considered an issue and whether the metapopulation should be managed according to the four genetic groups identified in a recent study by De Wildt (De Wildt Cheetah and Wildlife Trust, unpublished data)[1]. Even though all agreed that it is preferable to move animals short distances, the South African managed Cheetah population is already so mixed that genetic clustering was not identified as a pressing issue, but would be resolved under the development of the overall management strategy. It was recommended that translocated Cheetah be moved to ecologically similar areas whenever it is possible.

2. Free Range Population Working Group

This population comprises all Cheetah populations living outside of protected areas, excluding the Kruger and Kgalagadi National Parks. The group identified the following threats to this population:

---

[1] Research conducted by De Wildt and partners has classified Cheetah in metapopulation reserves into four distinct genetic groups: Kalahari, Western Limpopo / Botswana, Eastern Limpopo and a unique captive population that is a mixture of all of them. Is it important to conserve these different clusters or can we mix all of them? The group agreed to flag this for discussion later.

- Conflict - as a result of: lack of Cheetah utilisation options for landowners, predation on livestock and wildlife ranches, predation on livestock on communal land, unrealistic expectations / ignorance on Cheetah biology and ecology.
- Habitat - bush encroachment and habitat fragmentation by predator proof fences throughout the Cheetah range area.
- Land-use - possible changes in land-use due to land reform.
- Governance - difficulty in law enforcement, shortage of staff to do extension and permitting, corruption, lack of capacity and training resulting in an inability to function effectively.
- Illegal removal - illegal and legal trade in live animals or parts, lack of awareness in officials to enforce legislation and "my farm" syndrome where people do not want to be told what to do on their own properties.

Priority problem statements and solutions identified by the working group included:

- Landowner ranching goals and practises often clash with Cheetah conservation. The group identified the importance of continuing with existing conflict resolution programmes. Also recommended are the implementation of education, sensitisation and outreach programmes and determination of the most efficient depredation control methods.
- Removal of Cheetah through uncontrolled live trade and products together with illegal hunting has an unquantifiable effect on both local and regional scale. The group suggested conducting an international investigation and audit through partnerships with neighbouring countries on captive trade.
- Bush encroachment and predator-proof fencing fragment Cheetah populations and remove available habitat for free-ranging Cheetah. To address this, it was suggested that the effects of bush encroachment and predator-proof fencing on Cheetah be investigated and a strategy to address these be developed.
- Lack of capacity, training and motivation prevents effective implementation of legislation, which allows continued illegal removal of Cheetah from the population. Suggested solutions include training programmes and the recording of concerns.
- Land reform and economic triggers could lead to large scale changes in land-use practices away from wildlife, causing loss of wild prey and increasing scope for Human-Cheetah conflict.

3. Population Modelling and Dynamics Working Group

This working group served as a resource to the population-based working groups and was tasked with developing population-specific models to explore options for managing viable populations of Cheetah in South Africa. Discussions prior to and during the workshop lead to the classification of Cheetah populations into three demographic categories based on environmental conditions:

1. High prey density with no competitors (very strong potential growth)
2. High prey density with competitors present (strong potential growth)
3. Low prey density with competitors present (no potential growth)

The three demographic models were then used as a basis to develop specific models for the various Cheetah populations in South Africa, these included:

1. Free-ranging population (FRP)
2. Kruger National Park population (KNP)

3. Kalahari population (Kglalgadi Transfrontier Park)
4. Metapopulation of managed reserves (with competitors)
5. Metapopulation of managed reserves (without competitors)

The baseline free-range population model without any unnatural removals had a stochastic growth rate (r) of 0.13 and no risk of extinction over 100 years and appears to be able to withstand the current estimated rate of removals (losses due to hunting, trade and removal of problem animals). One of the factors having the greatest impact on this population is the percentage of females that breed each year (average interbirth interval). The population within Kruger National Park appears to be able to sustain itself demographically without immigration from adjacent populations with a stochastic growth rate of 0.077, and assuming that juvenile mortality is not significantly greater than estimated. The Kruger Cheetah population is assumed to be genetically connected to adjacent populations. This population may be able to withstand the periodic removal of individuals, depending upon the actual demographic rates, the number, age and sex of those animals removed and the frequency of removal. The Kalahari Cheetah population is not believed to be sustainable in isolation (r = -0.013). However, this population is believed to be contiguous with Cheetah populations in Botswana and to a degree with Namibia. The net addition of one adult pair per year results in a positive population growth rate, emphasising the importance of connectivity to Cheetah populations outside of South Africa if environmental conditions in this arid area are as harsh as suggested and modelled. This also suggests the possibility that this population may act as a sink under the modelled conditions.

A series of reserve metapopulation models were explored to identity the minimum size and number of reserve subpopulations needed for a viable population, defined as one in which the probability of extinction is less than 10 % over 50 years and gene diversity is at least 95 % as compared to the overall wild population. At least 20 subpopulations with at least 15 individuals each, or 10 subpopulations with at least 20 Cheetah each is required for a viable metapopulation. Model results show that translocation of animals among subpopulations every 1 – 5 years (depending on presence of Lions (*Panthera leo*)) will meet the required population viability in terms of gene diversity and risk of extinction. If the minimum acceptable level of gene diversity is lowered to 90 %, a metapopulation of at least 10 subpopulations of 15 individuals each, or 20 subpopulations of 10 individuals each, is required to meet these objectives. Maintaining at least 15 subpopulations, that contain at least 10 individuals, is suitable to maintain a probability of extinction of less than 10 %, although this does not guarantee acceptable levels of genetic diversity. Supplementing the population annually as opposed to every second year does not have a large impact on the model.

Model results illustrated that the size of subpopulations (i.e. the number of individuals within each subpopulation) was more important for metapopulation persistence than the number (i.e. count) of subpopulations.

WORKSHOP FOLLOW-UP

The results of the Cheetah Population and Habitat Viability Assessment Workshop provide a general framework for the management of Cheetah populations in South Africa based on all available published and unpublished data as well as expert opinion. Included in this technical assessment is an exploration of management options for the metapopulation of Cheetah subpopulations on small private reserves. This report and analyses will provide technical advice to the participants of the NCAP Workshop in June 2009 and help guide the development of a national conservation strategy for Cheetah in South Africa.

CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

De Beers Venetia Limpopo Nature Reserve, South Africa

WORKSHOP REPORT

SECTION 2

PRESENTATIONS

STATUS, DISTRIBUTION AND THREATS TO CHEETAH AT THE REGIONAL SCALE

Netty Purchase – Zoological Society of London and Wildlife Conservation Society

Southern Africa supports globally important populations of both Cheetah and Wild Dogs. In recognition of this, a workshop was convened in December 2007 where experts and relevant government officials worked together to determine what was known about the status, distribution and threats to Cheetah and Wild Dog, as well as formulating a regional conservation strategy. This regional strategy is the first step in a programme to develop action plans for the species' conservation across their geographic range. Given Wild Dogs' and Cheetah's similar ecological needs, it makes sense to plan their conservation together. The results of the workshop (summarised for the South Africa Cheetah Population and Habitat Viability Assessment Workshop) shows that Cheetah have experienced a major contractions in their geographic range within Southern Africa, with resident populations known to remain in just 21 % of the historical range. However, for much of the region (approximately 40 %) there are no reliable data available regarding the status and distribution the species.

Protected areas are very important for the conservation of Cheetah, but the majority of animals reside outside the protected areas which are the focus of most conservation effort. 75 % of Cheetah resident range (holding approximately 4500 Cheetah) falls on community and private lands. Given this knowledge it is unlikely that populations inside protected areas would be viable if isolated from unprotected lands, and conservation activity outside protected areas is absolutely critical for the long-term survival of these two species both inside and outside reserves. The main threats to the survival of Cheetah in the region were identified to be habitat loss and fragmentation, conflict with livestock and game landowner, loss of prey populations, accidental snaring, road kills, small population sizes, and hunting for live trade and skins (mainly Cheetah). The strategic plan developed provides a framework to alleviate these threats and ensure the survival of the two species in the region.

A number of areas were identified where participants felt that it would be possible to restore Cheetah populations, these focused predominantly on protected areas that have been poorly managed in the past decade but where improved management is now taking place. However, the percentage range of these recoverable areas was relatively small and the strategic plan therefore focuses on securing the remaining populations with restoration as a lower priority.

The strategic plan for the species' conservation in Southern Africa recognises the need to (i) build capacity within the region in all fields related to the conservation of Cheetah and Wild Dog, (ii) improve knowledge of the conservation biology of both species, (iii) ensure that information collected is made available to all stakeholders, (iv) minimise conflict and promote coexistence between Cheetah, Wild Dogs and people; (v) minimise the adverse effects of land development and to promote best land-use practice for Cheetah and Wild Dog, (vi) ensure that political commitment is obtained; (vii) review, and where necessary revise, existing legislation and policy at international, national and local levels; and (viii) promote the development and implementation of national conservation plans for both species. This last point is important because almost all conservation effort is enacted within national policies, under the jurisdiction of national wildlife authorities. For this reason, the regional strategy was deliberately developed in a format that would facilitate translation into national action plans.

THE CARNIVORE CONSERVATION GROUP, CONSERVATION PLAN AND POLICIES

Harriet Davies-Mostert – Carnivore Conservation Group of the Endangered Wildlife Trust (EWT)

A regional conservation strategy meeting for Cheetah and Wild Dogs was held in Jwaneng, Botswana in late 2007 (convened by the World Conservation Union (IUCN), Wildlife Conservation Society and Zoological Society of London). This workshop defined a vision and goal for Cheetah and Wild Dogs in the region, and developed eight key objectives necessary for achieving these over the next 10 years, the last of which stated that national conservation action plans were to be developed for all range states in the region. South Africa is unique among southern African range states in that Wild Dogs and Cheetah have been extirpated from huge swathes of their historical range, and a large part of the potential recoverable range exists within tiny, isolated, fenced reserves. For many of these areas, reintroduction provides the only potential source of new founders. This means that although conservation issues relevant to Cheetah and Wild Dogs elsewhere in their range still apply in South Africa, the need to manage gene flow between disconnected and fragmented populations adds an additional level of management complexity to the mix.

A Wild Dog Population and Habitat Viability Assessment Workshop in 1997 addressed many of the issues relating to Wild Dogs; however the process had not been undertaken for Cheetah. This Cheetah PHVA workshop held in April 2009 was therefore convened in preparation for the NCAP Workshop, with the focus of addressing those issues specific to the development of a managed metapopulation of Cheetah.

Desired outcomes included:

- a review of the status and viability of various Cheetah populations across South Africa;
- identification and examination of management options for a managed Cheetah metapopulation, including the size and number of subpopulations required to ensure metapopulation persistence, and the frequency of gene transfer between them;
- an assessment of likely impacts on potential source populations;
- a preliminary determination of the desired ecological characteristics of subpopulation reserves; and
- identification of the required logistical and administrative steps required for achieving a functional Cheetah metapopulation in South Africa.

The workshop report will form an integral part of a broader Biodiversity Management Plan for Cheetah and Wild Dogs in South Africa. This plan – which will be developed through a participatory workshop process – will be submitted to the Minister for approval so that it may be passed into legislation [Sections 43 (1) (b) and (c) and 44: National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004].

A REVIEW OF THE STATUS OF CHEETAH IN SOUTH AFRICA

Kelly Marnewick – De Wildt Cheetah and Wildlife Trust

South Africa's Cheetah population can be divided into three categories:
1. The captive population
2. Cheetah in fenced protected areas and
3. The free roaming population.

The captive population consists of Cheetah held in captive conditions in zoological gardens, private collections and breeding programmes. It is estimated that there are more than 500 individuals in captivity in South Africa in 44 facilities (Marnewick *et al.* 2007). Of these 44 facilities only 11 are recorded as breeding Cheetah (Marnewick *et al.* 2007). Cheetah in fenced protected areas include the Kruger National Park, Kgalagadi, smaller parks and Cheetah relocated to private reserves. There are approximately 357 Cheetah in these reserves (Friedmann and Daly 2004). The free roaming population consists of the Cheetah occurring outside protected areas on cattle, stock and wildlife ranches totalling 300 - 450 animals (Friedmann and Daly 2004), however estimates of up to 700 Cheetah have been made by field workers.

The Cheetah is protected by law in South Africa and the following are relevant: Nine provincial nature conservation ordinances, National Environmental Management: Biodiversity Act (NEMBA), CITES is the only international treaty relevant to Cheetah and no CITES hunting quota exists.

References

Friedmann, Y. and Daly, B. (editors) 2004. Red Data Book of the Mammals of South Africa: A Conservation Assessment: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC / IUCN), Endangered Wildlife Trust. South Africa.

Marnewick, K., Beckhelling, A., Cilliers, D., Lane, E., Mills, M.G.L., Herring, K., Caldwell, P., Hall, R. and Meintjes, S. 2007. The status of the Cheetah in South Africa. In: Breitenmoser, C. and Durant, S. (Eds). The Status and Conservation Needs of the Cheetah in Southern Africa. Cat News Special Edition, December 2007.

A REVIEW OF THE CONSERVATION THREATS FACING CHEETAH IN SOUTH AFRICA

Deon Cilliers – De Wildt Cheetah and Wildlife Trust

South Africa is home to four distinct Cheetah populations: These are:

1. Cheetah in large protected areas: This includes the larger unmanaged areas such as the Kruger National Park and the Kgalakgadi Transfrontier Park. The treats to this Cheetah population include illegal trade, genetic integrity of the population of Cheetah, poaching, diseases and uncontrolled relocations or movements of Cheetah out of and into neighbouring conservation areas.

2. Fenced protected areas: This includes the fenced protected areas where Cheetah have been reintroduced and from where they cannot escape due to electric fences. The major threats to this population include: change of land-use and land-use policies, reserve owners who do not want interference and assistance for conservation Non-Government Organisation (NGOs) to manage the reserve population as part of a national metapopulation, other big predators in high densities on the reserve, uncontrolled increase in Cheetah population size, uncoordinated movements / relocations to and from other reserves in SA, inbreeding in resident Cheetah population, poaching and diseases and the small size of reserves in relation to the natural requirements of Cheetah.

3. Free ranging Cheetah on ranchlands outside of protected areas: This includes all Cheetah that occur naturally on ranchlands in South Africa. The major threat here are uncontrolled hunting by locals and foreigners, habitat reduction, game and livestock ranching practices, illegal trade in wild Cheetah to captive facilities and zoos, bribery and corruption in Conservation Authorities, ignorance from the ranching community as well as conservation communities, uncontrolled captive breeding facilities and the need for new genetic material to maintain genetic integrity of the captive population.

4. Captive Cheetah population: This includes all Cheetah that are kept in captive conditions in South Africa, and include commercial captive breeders, zoos and educational facilities and well as private animal collectors. The main threats to this population includes: No national captive Cheetah breeding strategy inline with international strategies, unregulated trade in Cheetah, disease and welfare, ineffective legislation, commercial value of Cheetah, lack of policy / strategy from government, no national breeding studbook for Cheetah and public perception towards Cheetah in captivity.

THE USE OF THE PHVA PROCESS IN METAPOPULATION PLANNING, USING THE WILD DOG PHVA AS A CASE STUDY

Gus Mills – The Tony and Lisette Lewis Foundation

A Population and Habitat Viability Assessment Workshop takes an in-depth look at a taxon's life history, population history, status, and dynamics and attempts to assess the threats putting the species at risk. These data are then incorporated into a computer simulation model VORTEX to determine extinction risk and ways of preventing it.

In the case of the Wild Dog a PHVA was held in Pretoria in 1997 to develop a conservation action plan to improve the status of Wild Dogs in southern Africa. Of particular interest was the investigation of the possibility of using a metapopulation approach to management of the species. Complimentary to the VORTEX modelling process was a communication and deliberation process to identify the key issues affecting the conservation of the species.

The South African Wild Dog recovery strategy commenced with the clearly defined and measurable goal of establishment of at least nine packs of Wild Dogs within ten years. This was achieved. The Wild Dog Advisory Group of South Africa (WAG-SA), comprising an association of scientists and managers, was established to guide and implement the metapopulation strategy.

The managed metapopulation approach is most obviously applicable for species inhabiting fragmented landscapes with little opportunity for natural dispersal, circumstances particularly likely to apply to large mammals including Cheetah.

Inevitably, this entails compromising the 'naturalness' of protected populations as translocated populations (which are often small and isolated) may require ongoing management to ensure genetic vigour. This may limit the value of the biodiversity outcomes of a managed metapopulation

The density of competing carnivores was less problematic in practice than had been anticipated during the PHVA. However, prey numbers and the impact of Wild Dogs on the prey at metapopulation sites emerged as a recurrent topic for discussion at WAG-SA meetings. More research to determine the extent to which small fenced reserves can absorb fluctuations in predator and prey populations – in the context of what is both ecologically and economically acceptable – is needed to define the minimum size and prey thresholds for predator reintroductions.

The relative value of conserving species assemblages against that of conserving functional biodiversity needs careful consideration. Therefore it might be valuable to include the biodiversity potential of an area when considering its value as a Cheetah metapopulation reserve. Size will always be an issue and conservationists need to be far more innovative in ways to encourage landowners to form conservancies and contractual parks. Fencing is not only expensive but ecologically unsatisfactory. We also need to try to create natural corridors for movement of animals between reserves.

CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

De Beers Venetia Limpopo Nature Reserve, South Africa

WORKSHOP REPORT

SECTION 3

WORKING GROUP REPORTS

Managed Reserves Metapopulation Working Group

WORKING GROUP PARTICIPANTS

1.	Charlene Bissett:	Kwandwe Private Game Reserve
2.	Christine Mentzel:	Endangered Wildlife Trust
3.	Deon Cilliers:	De Wildt Cheetah and Wildlife Trust
4.	Emma Lucy Robinson:	Jubatus Cheetah Reserve
5.	Gus Mills:	The Tony and Lisette Lewis Foundation
6.	Harriet Davies-Mostert:	Carnivore Conservation Group of the EWT
7.	Kenneth Buk:	Tshwane University of Technology (Student)
8.	Marion Burger:	Carnivore Conservation Group of the EWT
9.	Netty Purchase:	Zoological Society of London (Zimbabwe)
10.	Tracy Rehse:	National Zoological Gardens of South Africa

DESCRIPTION OF POPULATION AND STATUS

Each group member was asked to define the Cheetah metapopulation and the following list of definitions was obtained:

- Clusters of small fragmented populations, isolated from each other, with no reserves containing viable populations.
- Cheetah as a functional member of the ecosystem including hunting, breeding and avoiding predators.
- Populations may or may not have natural predators in these systems.
- The metapopulation constitutes a backup recovery plan in case natural (free-ranging) populations become extinct.
- Active management intervention will be necessary to maintain subpopulations.
- The development of a formal metapopulation strategy will allow for incorporation of new areas and unrepresented habitats.
- Theoretically the national metapopulation should include KNP and Kgalagadi National Park but it is so big it is considered to be viable on its own and hence it is excluded from this discussion.

The following provides a descriptive summary of the managed fenced reserve population:

- Comprised of several isolated subpopulations in fenced reserves;
- A population that is actively managed, including managing dispersal;
- Only partially ecologically functional as the Cheetah feed themselves but predator-prey dynamics are unlikely to be naturally balanced given the management limitations imposed in small reserves; and
- The metapopulation should be designed (within limits) to interface with the free-ranging population.

POTENTIAL ROLES OF POPULATION

The potential role of the metapopulation is to:

- Expand the range of Cheetah and reintroduce them into currently unrepresented habitats that fall within the historical range.
- Utilise existing resources - there are a number of reintroduced populations at present that need to be properly managed.
- Improve Cheetah management in the context of population biodiversity.
- Provide a tool for education and awareness. Small fenced reserves play an important role in raising public awareness of Cheetah conservation issues.
- Contribute to economic development and job creation.
- Represent an alternative conservation strategy to complement the conservation of other populations in South Africa. This includes providing a potential source of animals for other populations.
- Present a blueprint for the management of fragmented populations of Cheetah and other species both within South Africa and beyond.
- Act as a catalyst for establishing viable free-ranging populations in areas where they currently do not exist. This includes areas in the Eastern Cape (Mountain Zebra, Addo, etc.) and northern KwaZulu-Natal (KZN) where eventually fences could come down and the population unit could become big enough to require minimal management. This would be similar to Kgalagadi National Park and Kruger National Parks.

VIABILITY CRITERIA

What constitutes viability for the managed Cheetah metapopulation in South Africa?

The group proposed that a viable Cheetah metapopulation would *maintain gene diversity (expected heterozygosity) at 95 % of the overall wild population over a period of 50 years through management interventions spaced not less than 2 years (18 - 24 months) apart on average, except if dictated by catastrophes or demographic stochasticity. The time interval for management interventions should be based on natural population processes.*

There was a discussion about whether to use generation length (defined as the average age of reproduction) as a measure of time intervals, but this was felt to be too long[2]. There were also some issues around putting time limits to management interventions, as it was felt that management should be adaptive and dynamic, responding to the needs of the metapopulation rather than strict time intervals. It was agreed that management interventions should be linked to age at dispersal, as it is important to mimic natural population processes as closely as possible.

The group discussed the relative merits of aiming for 95 % gene diversity over 50 years versus 90 % over 100 years and agreed to use the former as this presented a more realistic time scale. The gene diversity goal will convert into actual numbers in the models.

Several potential management interventions were identified:

- Translocation
- Contraception
- Lethal control (including euthanasia, culling, hunting, etc.)

[2] The VORTEX models generated during this workshop produced generation lengths of between 5-6 years.

IDENTIFYING AND PRIORITISING THE PROBLEMS

It has been suggested that the conservation of the Cheetah metapopulation is a fairly low priority on a global and even national scale. The present population needs to be assessed and its conservation value determined. The group discussed whether the current population in small fenced reserves was viable: is it at threshold / carrying capacity or can it expand without requiring additional input from other populations? Even if the current population is viable (i.e. does not require further input to persist), then this will not preclude the addition of other areas from within the historical range of Cheetah if they are important. The group identified the following suite of broad issues relating to the establishment and maintenance of a managed Cheetah metapopulation:

1. Extent to which the metapopulation acts as a sink to wild populations
2. Problems associated with economic benefit
3. Population management (including protocol for managing excess Cheetah)
4. Ecological viability (including size, habitat, prey)
5. Genetic viability (inbreeding, keeping genetic clusters unique?)
6. Adverse changes in behaviour and physiology brought about by lack of exposure to other predators
7. Contribution of small reserves to Cheetah conservation in South Africa

The issues were expanded through brainstorming and then assigned to the following ten categories (see Figure 1):

1. Population sink effects
2. Economic impacts
3. Overpopulation
4. Inbreeding in small populations
5. Movement between different environments (limited selection)
6. Reserve characteristics
7. Coordination and management
8. Viability requirements
9. Understanding the role of small reserves in Cheetah conservation
10. Genetic clusters

Group members then used these issues as a basis for discussion and identification of the root problems regarding metapopulation viability, which led to the development of eight statements. These problems were then prioritised according to two different criteria: impact and urgency. The first considered those problems that are likely to have the greatest impacts on the viability of the managed metapopulation (or of Cheetah in the region), and the second considered problems that most urgently needed management attention. This dual criteria approach was adopted because factors that have the biggest impact might not always be the most urgent ones and *vice versa*. Ranking based on each criterion was accomplished using the CBSG dot method.

Although the ecological and biodiversity value of Cheetah populations should be paramount when deciding which issues are most important, it was agreed that the prioritisation process would be solely in terms of the implementation of the metapopulation strategy. It would not consider impacts on populations outside the metapopulation and the role of the metapopulation for Cheetah conservation overall.

Figure 1: Problem affecting Cheetah metapopulation viability.

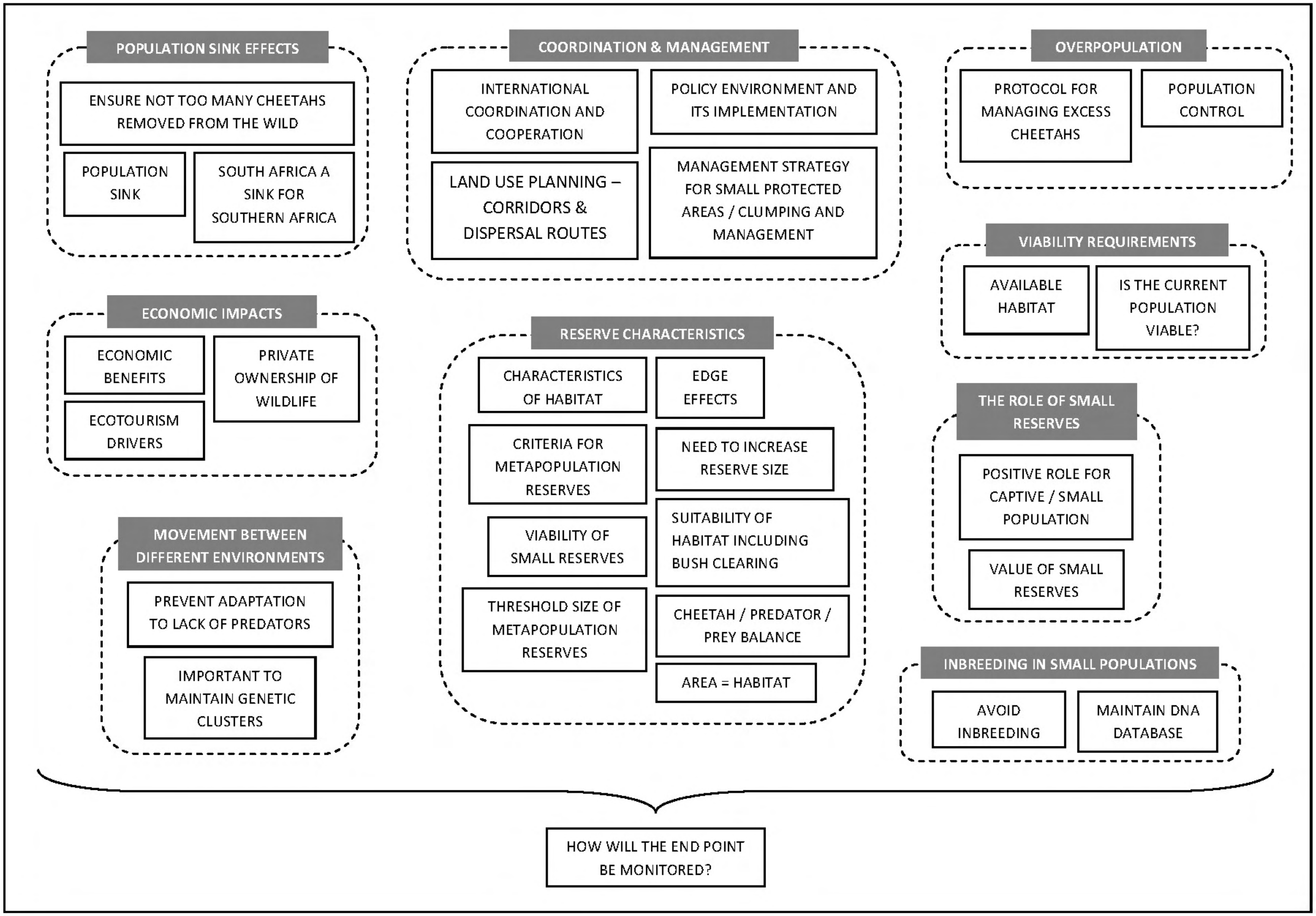


Table 1: Ranked list of factors likely to affect the implementation of a national Cheetah metapopulation strategy.

Factor / problem	Impact (N=27)	Urgency (N=27)	Total (N=54)
1. Minimum habitat requirements	9	6	15
2. Lack of strategy	6	9	15
3. Assessment of viability	5	6	11
4. Available habitat	3	4	7
5. Impact of economic value	1	2	3
6. Impact of scale	2	0	2
7. Impact on wild populations	1	0	1
8. Human-Cheetah conflict	0	0	0

The group noted that both management-oriented and research-related issues were highlighted as important. Some regarded this as an indication that working group participants had considered a broad range of issues and the results were not skewed according to participant representation at the workshop.

PROBLEM STATEMENTS

PROBLEM 1

THERE IS A LACK OF KNOWLEDGE OF MINIMUM SUITABLE HABITAT SIZES REQUIRED TO SUPPORT ACCEPTABLE SUBPOPULATION SIZES[3].

Lack of knowledge on the minimum habitat size required to support Cheetah was considered to be the factor most likely to impact on the successful implementation of a managed Cheetah metapopulation in South Africa. It was agreed that minimum habitat requirements was a catch-all term encompassing all aspects of reserves that affect their suitability for inclusion into a metapopulation programme, including ecological, socio-economic, logistical and technical considerations.

Some work has already been done to standardise the process by which suitability of reintroduction sites is measured. The current process is that reserves are required to submit a management plan to the relevant provincial authorities before they can apply to receive Cheetah. The authority (or designated representative) then visits the reserve to ground-truth the management plan, and make a decision on whether various site-selection / suitability criteria are adequately met.

A model has already been developed, using Bayesian Network Modelling, to assess reserve suitability for Cheetah, and to facilitate prioritisation of reserves for inclusion into the metapopulation (Figure 2: Johnson *et al.* in prep.). The Managed Reserves Metapopulation Working Group agreed that this model was a very useful first step towards determining suitability of release sites, and it was recommended that the existing template be peer-reviewed by the metapopulation management forum once it is established. It is important that the process becomes written into legislation and is not seen to be driven by the NGO sector.

Specific Recommendations

[3] The government criteria states that a reserve must be able to sustain Cheetah for a minimum of two years without supplementation of prey populations, and it should be fenced. It is not clear whether these criteria are the desirable ones.

Several pieces of information need to be collected to properly assess the requirements of subpopulation reserves, including:

- Assess the carrying capacity for Cheetah in different areas / parts of the country, including some kind of scaling factor.
- Collate all ecological data for existing relocation sites and map these against existing biomes to determine additional potential release sites.
- Determine the relationship between size of reserve and Cheetah numbers – i.e. Cheetah densities in different biomes.

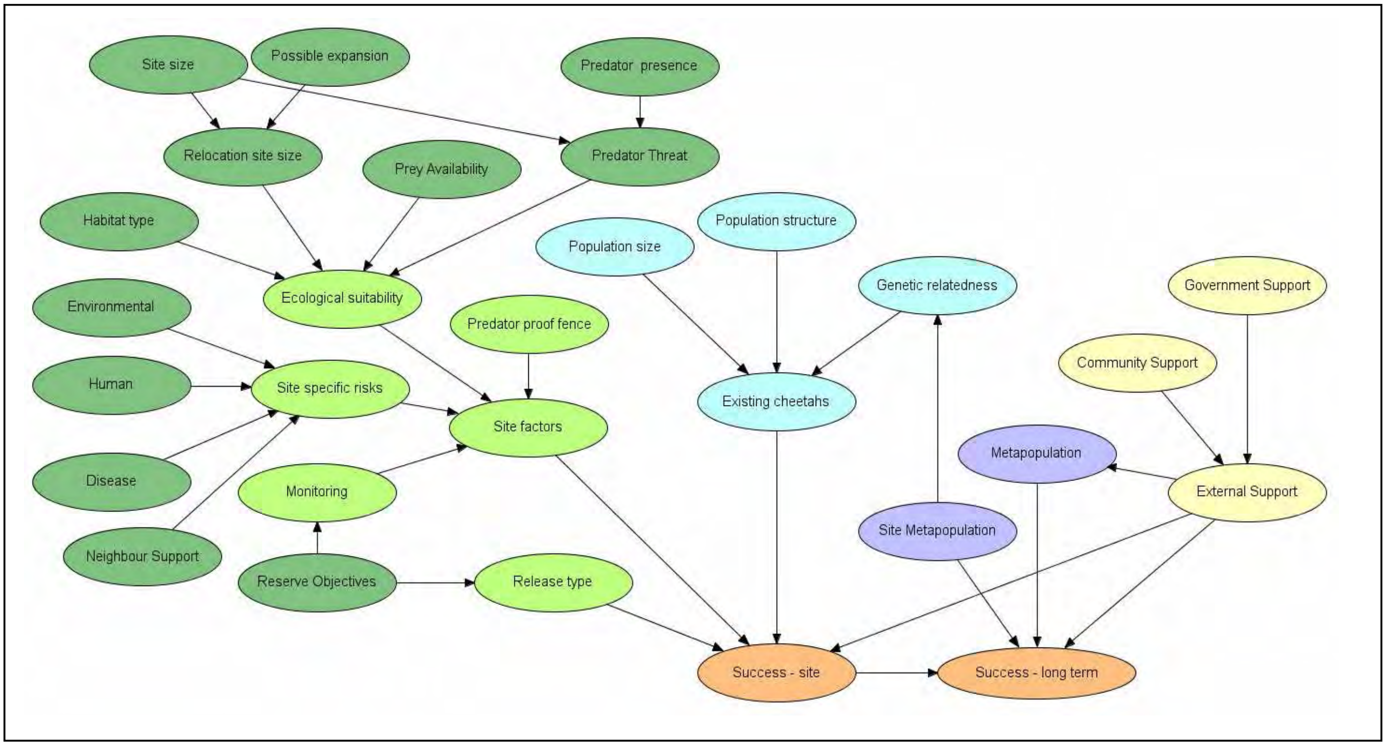


Figure 2: Conceptual network for relocation into protected fenced areas (Johnson *et al.* in prep.). This figure presents a first template of the various site characteristics to be evaluated when considering a site for Cheetah reintroduction.

PROBLEM 2

THERE IS NO FORMAL NATIONAL STRATEGY FOR THE MANAGEMENT OF THE CHEETAH METAPOPULATION IN SOUTH AFRICA.

The working group participants felt that the lack of any formal national metapopulation strategy was an issue requiring the most urgent attention.

DEVELOPMENT OF A NATIONAL STRATEGY

The Managed Reserves Metapopulation Working Group brainstormed several considerations for developing a formal national strategy for the management of a Cheetah metapopulation in South Africa:

1. Who will be tasked with taking this forward?

The most difficult decision is going to be deciding who is going to do this and how is it going to be done. A committee needs to be formed, containing a wide range of stakeholders and interested parties including some of the landowners. This committee should convene a meeting to draw up the detailed strategy. Once the plan is drawn up it should be circulated for comment and everyone asked whether they want to participate in the programme.

A committee will be needed with the relevant technical expertise, and it will also be vital to include the landowners who will be part of the metapopulation. To expand the metapopulation into other areas, more representation from new areas is needed. The National Cheetah Conservation Forum (NCCF) has a sub-group that might be suited to developing this strategy.

We need to consider whether or not this process should be run by government. This process must be linked to the Threatened and Protected Species (TOPS) regulations. The government is supposed to draft species protection plans and this will be a tool for government. If it has the necessary credibility (i.e. the right people involved) then this should be easier to implement. The planning workshop should include representatives from both provincial and national government.

2. How will a national Cheetah metapopulation strategy be developed?

The group recommended a seven-step process to achieving a formal national strategy:

Step 1. The results from this PHVA are presented at the NCAP Workshop in June 2009. This will be in the form of a draft framework that contains options and recommendations for the way forward.

Step 2. The broader forum forms a committee that represents all stakeholders, including:
- DEAT
- Provincial conservation authorities
- South Africa National Parks (SANParks)
- NGOs (The Tony and Lisette Lewis Foundation, EWT, De Wildt, Nature Conservation Trust)
- Private landowners and their associations (Indalo)
- Wildlife Ranching SA, including regional committees
- Research institutions (National Zoological Gardens of South Africa (NZG), South African National Biodiversity Institute, Rhodes University, Pretoria University, Tshwane University of Technology, etc.)

Step 3. The committee fleshes out the draft strategy using data presented and additional information.

Step 4. The revised draft goes out to the broader forum for review and comments.

Step 5. Revised by the committee again.

Step 6. Final draft presented by email.

Step 7. Finalised and presented to government for ratification.

The group then developed a specific objective pertaining to metapopulation management that would be presented for comment at the NCAP Workshop for Cheetah and Wild Dogs to be held in June 2009.

Objective: Develop, coordinate and implement a national Cheetah metapopulation strategy to establish additional populations outside of their current distribution range, and within the historical range, and which meets acceptable targets for genetic and demographic viability.

Action 1: Draft a metapopulation management strategy to be presented to all stakeholders at the NCAP Workshop in June 2009.

- Using data from the PHVA workshop report and other data sources – collect information to fill the data gaps (Peter Lindsey, Deon Cilliers and other workshop participants).
- Prepare a draft strategy to be circulated to everyone at the PHVA workshop (Peter Lindsey, Deon Cilliers and other workshop participants).
- Present the draft strategy at the NCAP meeting and agree on proposed protocol for acceptance.

Action 2: Setup a national committee to develop and coordinate the metapopulation strategy

- Members and chairperson to be selected according to the recommended stakeholder groups at the national planning meeting in June.
- The committee is to meet within three (3) months of the NCAP meeting.
- Initially consider four regional sub-committees: Eastern Cape, Natal, Savanna and Arid Region.
- Ensure that stakeholders understand the role of the metapopulation within the context of Cheetah conservation in the country / region through public awareness and sensitisation programmes.

Action 3: To develop and utilise a nationally accepted model for assessing the suitability of properties for participation in the metapopulation.

- Present the draft model to the national meeting for comments and suggestions.
- Committee to incorporate the comments from NCAP to finalise the model.
- Committee to utilise the model to re-assess existing metapopulation sites and assess potential new sites, and to provide guidance to provinces over permits.

Action 4: Incorporate new suitable areas into the metapopulation.

- Map suitable habitats for metapopulation management across South Africa.

- Assess suitable available habitat for Cheetah metapopulation management across South Africa.
- Promote the development of corridors and linkages between reintroduced populations.
- Engage relevant stakeholders (including existing and potential) to stimulate and facilitate metapopulation participation.

Action 5: Ensure the viability of the metapopulation over the long-term.

- Propose a definition of metapopulation viability to the NCAP meeting, which incorporates both demographic and genetic factors and sets acceptable levels of extinction risk.
- Conduct a viability assessment of the current population and compare this to projections of population models (PM2000 and VORTEX).
- Adjust the metapopulation management strategy to ensure that the population is viable. This includes recommendations for the future management of existing populations and inclusion of additional ones.
- Conduct an annual viability assessment. Also a means to ensure data are collected.
- Maintain a database of metapopulation subpopulations containing demographic, genetic and ecological information (the basic information that comprises a management plan).

Action 6: Minimise the negative influence of commercial considerations on Cheetah metapopulation management.

- Assess the importance of the economic value of Cheetah to landowners in relation to their participation in the national metapopulation.
- Consider various custodianship options to promote metapopulation participation and facilitate management. This could be a combination of approaches. Another option would be to reward metapopulation participation by supporting the costs of relocations for areas that are large and very suitable. Several levels of support are possible – belonging to the committee and getting technical advice, to on-the-ground support for relocation costs, etc.

Action 7: Ensure that the metapopulation does not impact negatively on wild populations through harvest and increased conflict, and that the programme is not seen as a means of reducing conflict by removing animals from the wild.

- Determine the circumstances under which the removal of Cheetah from ranchlands is acceptable.
- Examine the current liability model for dealing with break-outs.
- Conduct an outreach / sensitisation programme to inform neighbours about reintroduction programmes and explore options for value-added economic activities for neighbours.

It was agreed that a metapopulation management framework would be drafted for presentation at the NCAP Workshop (as part of the regional plan), which will be circulated prior to the workshop for comment by a very wide range of stakeholders.

Data Assembly and Analysis

The purpose of this session was to develop a detailed working knowledge of the facts and assumptions that are pertinent to the issues identified by the Managed Reserves Metapopulation Working Group.

Known facts	Source of data (or potential sources)	Assumptions	Justification for assumptions	Data gaps
TOPS regulations (under NEMBA) require that permits are issued before any animals are transported or reintroduced into new areas. All reintroduction sites must register.	DEAT (now DWEA)			None
SA is a member of the IUCN and therefore should follow the Species Survival Commission, Reintroduction Guidelines and also principles of the Cat Specialist Group.		Current reserves in the metapopulation are following these guidelines.	None	None
Various provinces have different requirements for reintroductions of predators (specifically the standards of fencing). These can be more stringent than the national requirements.	Available			Need specifications for all provinces and go through these to determine the minimum standards for reintroduction sites.
A preliminary site selection model has been developed using Bayesian Network Analysis which weights criteria to determine reserve suitability.	De Wildt			Quantifiable parameters need to be tested for robustness. Need participation and input.
There is a list of reserves that could potentially be part of the metapopulation but which are not yet based on a number of criteria including location, size, and protected area status.	Regional workshop held in Botswana			The wish list needs to be reassessed based on the outcomes of the Bayesian Network Modelling as well as the PHVA models, and other factors relating to habitat suitability.

Known facts	Source of data (or potential sources)	Assumptions	Justification for assumptions	Data gaps
There is a database of Cheetah population dynamics and demographic rates in existing participating reserves.	De Wildt	That all current reintroduction sites will participate going forward.		Need to collate historical data on population trends.
Currently landowners sign an agreement with De Wildt prior to receiving Cheetah.				Need to determine whether this is the most practical and effective process.
Some important populations are not cooperating in the process, and unrecorded translocations are definitely taking place.	(Provincial permit records)	Some landowners do not understand the importance of the process / the economics outweigh the conservation value.	Several landowners have indicated as such to De Wildt.	Require a national database and a strategy to prevent / reduce undocumented translocations, probably through collaboration with permitting officers in the provinces.
Provincial permitting criteria for approving translocations and reintroductions.	Limpopo, North West	That provinces have drawn up criteria for reintroductions of predators / Cheetah.		Need to obtain sets of criteria from each province.
There is an existing network of reserves that already contain Cheetah populations that could form a metapopulation.		The assumption is that these reserves are suitable for metapopulation management but this is not known.	Expertise from De Wildt and past experience.	We are lacking a set of guiding principles under which the metapopulation should operate. These include recommendations for whether very tiny populations should form part of the larger metapopulation or just a managed breeding system.
There is an existing DNA genetic database but it is out of date.	NZG			Need more DNA samples which need to be analysed.

Specific recommendation

The Managed Reserves Metapopulation Working Group only discussed and developed one specific recommendation, which was to develop a formal strategy for the management of the national Cheetah metapopulation. A 7-step process was drawn up to guide the development of a strategy, please see above.

PROBLEM 3

THERE IS A LACK OF KNOWLEDGE AND ASSESSMENT ON THE VIABILITY (GENETIC AND DEMOGRAPHIC) OF THE CURRENT CHEETAH POPULATION IN SMALL FENCED RESERVES.

The group held a discussion about whether a demographic definition of viability was required. It was suggested that data available from large populations is used to model the populations. It is important not to have wildly skewed sex ratios or unusual age distributions, and so it is important to look at populations with stable-age structures from KNP and elsewhere. Currently the average age of Cheetah relocated into reserves is between 4 - 6 years old and this could have differential impacts on source populations than taking subadults of dispersal age. It will also be important to determine acceptable levels of extinction probability [p(E)] over a specified time period.

Two types of metapopulation management reserves are likely to emerge: large areas with populations that do not need to be managed intensively (in terms of breeding recommendations) and the smaller reserves that are essentially captive breeding facilities with a bit of environmental variation thrown in. The latter might be effectively managed using population management software such as PM2000.

It would be useful to assess whether there was enough suitable habitat available to develop an arid region metapopulation and to develop regional clusters, as this would facilitate management among reserves. It would be useful to define suitable habitat and biomes for Cheetah, where potential reserves are and what sort of contribution they will be able to make to the metapopulation.

Data Assembly and Analysis

Known facts	Source of data (or potential sources)	Assumptions	Justification for assumptions	Data gaps
A detailed list of founder animals and their offspring from the reserves that provide these is available.	De Wildt, private reserves	That reserves will continue to submit data.		There are reserves with Cheetah that have not submitted data and this could be a big information gap.
The current population of Cheetah in fenced reserves is fewer than 120 individuals on 543 000 ha.	De Wildt	Those current reserves will continue to be interested in participating.		
There are potential areas for expansion that can be included in the metapopulation.	Group participants			
We have developed a definition of viability that needs fine-tuning. This includes definitions of desired genetic diversity, demographic viability, and acceptable extinction probability.	This working group	That our arbitrarily chosen criteria are appropriate. That current data are available on population dynamics and these are sufficient to test the model.		Models need to be tested to determine the reserve sizes and number of reserves needed to ensure both genetic and demographic viability within acceptable management intervention intervals.
Population models such as PM2000 and VORTEX can be used to manage the population to maximise genetic diversity.	NZG	Use this type of intensive population management tool for all of the populations. It might be useful to split the metapopulation into reserves that require this and those that do not.		Need to get accurate and reliable pedigree and parentage data from participating reserves. Need to make a decision about how to manage the metapopulation. Need to reassess the requirements of models such as PM2000 and VORTEX.

PROBLEM 4

THERE IS A LACK OF KNOWLEDGE OF SUITABLE AVAILABLE HABITAT ACROSS SOUTH AFRICA.

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
A list of reserves is available with details of the biome and at which rainfall gradient.	De Wildt, private reserves such as Kwandwe			Potential new reserves and in which areas (linkages, optimal habitat etc.)
Current population per reserve is known, for those reporting to De Wildt.	De Wildt	We can use density estimates across biomes to make broad assessments of carrying capacity given the current and potential network of metapopulation reserves.		Is there capacity for growth of these populations within existing participating reserves? How useful are current population densities for determining future potential? Biome and rainfall gradient may not be sufficient criteria e.g. other landscape features and prey availability may need to considered.
There are human factors such as activities associated with reserves that may make otherwise suitable sites potentially unsuitable for Cheetah reintroductions. These include livestock ranching, high-speed roads, lack of adequate fencing to contain reintroduced animals.				There is a need to develop a list of factors likely to reduce suitability.

PROBLEM 5

THE ECONOMIC VALUE OF CHEETAH PARADOXICALLY COMPLICATES METAPOPULATION MANAGEMENT.

This is due to the fact that:

- reserves may be reluctant to participate in a national conservation management programme due to ownership issues (Cheetah seen as private assets and have commercial value), and
- there are sometimes eco-tourism-driven incentives to reintroduce populations into non-viable areas.

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
Currently Cheetah have a commercial value associated with them.	De Wildt, Kwandwe			
Commercial value provides incentives for unsuitable and unplanned reintroductions and irresponsible population management.				
The commercial value of Cheetah compromises the willingness of reserves to participate in the metapopulation process.	De Wildt			
Compensation values (for capture of free-ranging stock) set a benchmark for the prices for inter-reserve trade.	De Wildt	Assumes that compensation scheme will continue.		Need to explore more deeply the economic cascading effects of the current compensation scheme.
Ownership of Cheetah rests with the reserve owners and not with the committee in charge of managing the metapopulation, and this could complicate management. The current agreement is that 50 % of the offspring belong to De Wildt and should be made available to the broader management plan.	National legislative documents,			Need to explore the potential for a custodianship framework whereby reserve owners participate in the programme but do not own the animals.
The value of Cheetah is dependent on supply and demand, and the growth of a metapopulation might lead to a drop in future prices.		People are struggling to sell Cheetah.		

PROBLEM 6

THE SMALL SCALE OF MANY OF THE RESERVES (I.E. IN TERMS OF AVAILABLE SUITABLE HABITAT) INCREASES ECOSYSTEM SENSITIVITY TO POPULATION FLUCTUATIONS.

This is due to:

- the timescales operating on predator-prey relationships becoming compressed.
- Cheetah reproduce very well in unconstrained environments.

PROBLEM 7

THE MANAGED POPULATION COULD NEGATIVELY IMPACT THE FREE-RANGING WILD POPULATIONS.

This is because:

- it may be erroneously perceived as a solution to alleviate conflict on ranchland; and
- an unsustainable number of animals may be removed from the wild.

PROBLEM 8

THERE IS THE POTENTIAL FOR HUMAN-CHEETAH CONFLICT ON THE BOUNDARIES OF RESERVES, PARTICULARLY WHEN ANIMALS ESCAPE.

This problem statement was not discussed further due to time constraints and the group's primary focus directed towards the formulation of a National Strategy.

Plenary Discussion of Reserve Metapopulation Management

The following topics and questions arose during the plenary sessions and resulted in the following discussion:

Question: Any suggestions for how to go about developing a strategy?

The formation of a group similar to the Wild Dog Advisory Group will be critical to this process. This is a good model that can be replicated. A meeting should be convened where all data are brought together to develop detailed structure of a strategy. The NCCF already exists, but has become less active in recent years and falls under Wildlife Ranching SA. The NCCF comprises different working groups – one is the relocation sub-committee, which might be well suited to metapopulation management. However it was suggested that a specific management group be formed. There are also issues around Lions in the small reserves and it was suggested that this could be rolled into one predator management forum. However, concern was raised around the danger of the group losing focus. The kinds of questions the committee should be answering are quite technical, although it is important to include stakeholders and provide a platform for participation.

Question: Would it be useful to regionalise the forums to make management easier?

It was suggested that permits to reintroduce Cheetah are linked to participation in the national process; however some feel that it should be a voluntary framework. Some good models do exist: e.g. Elephant Managers and Owners Association and the Rhino Management Association, which are registered advisory bodies to government.

Question: One problem is that reserve owners become very attached to their animals and would never give them up for management. How is this going to be dealt with?

This might not actually be an issue, as the desirable state is that most of the Cheetah that are being moved would be young subadults and owners are less likely to be sentimentally attached to these animals. One way to resolve this is to educate owners to see the bigger picture and the importance of participation in the national strategy. The "owner attachment" is also exacerbated by the fact that some Cheetah have higher ecotourism potential (i.e. are tamer / more habituated) and so reserves might be reluctant to give up "prime" animals.

Question: Did the group come up with any definition of what suitable habitat is?

No – that will be done later.

Question: What about Cheetah populations within the current range?

A discussion ensued as to whether fenced-off reserves should be established within the existing free-ranging population. The expansion of Cheetah friendly private areas should be encouraged. However within the existing free-ranging range, the fencing in of Cheetah presents an interesting "Catch 22" effect of removing habitat that would have been available to the free-ranging Cheetah. These issues need to be discussed in more detail by the metapopulation forum when it is established. It was agreed that in principle isolated fenced reserves within the free-ranging range should be discourage, but some leeway might be needed as there are already populations within the range that might be keen to participate.

Fenced reserves within the Cheetah range area are problematic because:

- They fragment natural Cheetah habitat.
- Fences are often permeable from the outside allowing free roaming Cheetah to get into fenced reserves, but not able to get out again.
- The presence of reintroduced populations can cause conflict with neighbouring landowners, especially in areas where breakouts have occurred. This then results in all Cheetah seen outside the reserve being perceived to originate from the reserve and increasing the possibility of conflict between landowners and free roaming Cheetah.
- Free roaming Cheetah are often attracted by the reintroduced Cheetah, the free roaming cats can end up pacing along the fence on the outside of the reserve, again causing increased conflict with landowners.

Question: If we prevent reserves within the range from having Cheetah, are we not reducing available range?

Many ranches are not erecting fences for Cheetah – they have other predators already. However, the smaller ranches cannot support large predators such as Lions. Perhaps a minimum reserve size for areas within current Cheetah range should be considered. This is limited by the capacity to work with the reserves: as the number of reserves grows, it is going to become more difficult to manage the metapopulation. It might be possible to have a rating system whereby reserves are prioritised according to whether they are large or small: the former requiring less management and the later requiring more.

A further consideration is that placing Cheetah into reserves within existing Cheetah range might exacerbate perceptions of Human-Cheetah conflict. Reserves involved in relocations should be required to carry out extension work with their neighbours to try to alleviate conflict and also share the experience. Neighbouring landowners need to feel that there is a bit of give and take.

Free-ranging Cheetah also tend to walk the fences and might get into subpopulation reserves if they are not fenced "properly", but then be unable to leave due to internal electric wiring.

Deriving economic benefit from free-ranging Cheetah becomes less likely when there are lots of "fenced-in" Cheetah; however, as free-ranging Cheetah are typically not very visible the possibility of deriving benefits from them is pretty minimal. There are additional ethical problems on whether free-ranging animals should be habituated for ecotourism, as this could lead to them being more easily persecuted.

It is important to explore the trade-off between fencing metapopulation Cheetah in and fencing free-ranging Cheetah out. It is important to be seen not to be penalising people who are prepared to invest energy and money into Cheetah conservation. There are models from the Lowveld where there are high ecotourism areas and Cheetah are seen as an asset to the community. It is possible to use Cheetah for economic advantage without having to track them – added value due to existence use and the perception that Cheetah occur in an area. Innovative hunters / landowners could use this to experience "wilderness". Peter Lindsey has done some work on this and the hunters tended to want to hunt in areas with wilderness value. This needs to be considered further. It might be useful to engage a marketing company to think about effective ways to use Cheetah to market property.

It was also noted that electric fences have been shown to increase mortality of small mammals, such as pangolins, and reptiles, such as tortoises and snakes. Electric fence specifications should be designed to minimise the impacts on non-target species.

Free Range Population Working Group

WORKING GROUP PARTICIPANTS

1. Kelly Marnewick: De Wildt Cheetah and Wildlife Trust
2. Michelle Thorn: University of Brighton / University of Pretoria
3. Peter Lindsey: Carnivore Conservation Group of the EWT
4. Reinhardt Holzhausen: Wildlife Ranching SA (WRSA)
5. Rox Brummer: Carnivore Conservation Group of the EWT
6. Sarah Durant: Zoological Society of London (Tanzania)
7. Vastie Jacobs: Northwest Department of Agriculture, Conservation and Environment

DESCRIPTION OF POPULATION AND STATUS

The South African free-ranging population (FRP) is comprised of naturally occurring Cheetah that occur outside of protected areas and were not reintroduced. The size of the FRP is not known. However, during discussions, Kelly Marnewick estimated that approximately 40 - 60 Cheetah occur in Thabazimbi, and so if one extrapolated that density (0.6 Cheetah / 100 km^2) to their entire range of approximately 108 000 km^2 (derived from ArcView files from the Regional Meeting held December 2007) outside of protected areas, the population would be 648 Cheetah. The *Red Data Book of the Mammals of South Africa: A Conservation Assessment* suggests that the FRP population is approximately 300 - 450 (Friedmann and Daly, 2004). However, participants felt that a range of 300 - 700 was more likely. Consequently, the FRP is the largest component of the South African Cheetah population and comprises approximately 53 % of the national (non-captive) population (if one assumes a mid-point of 500 individuals in the FRP population). Significantly, the FRP is contiguous with the population occurring in adjacent countries, which is the largest population of Cheetah in the world (approximately 6,000 individuals). Discussions with landowners indicated that the Cheetah population appeared to be increasing in number until 2005 or so, after which there is some suggestion that the population has become more stable or perhaps even started to decline (e.g. between Venetia and Martin's drift). A survey in the North West Province indicated that landowners perceive an increase in the Cheetah population over the past 5 years (Michelle Thorn *pers. comm.*). However, these impressions may not be accurate.

Please note: this section only applies to the free roaming Cheetah population i.e. the ones outside fenced protected areas and excluding Kruger and Kgalagadi National Parks.

POTENTIAL ROLES OF THE POPULATION

- The FRP is the largest component of the national population.
- The FRP increases the viability of the national Cheetah population.
- The FRP provides an important link between Cheetah populations in Kruger and Kgalagadi.

- The FRP functions as a natural population, and may have significant 'biodiversity value' by virtue of the fact that natural ecological processes occur (e.g. immigration, emigration, dispersal, social interaction, competition [the latter point to some extent]).
- The FRP may act as a significant sink for the contiguous regional population.
- In the past, the FRP has been an important source population for reintroductions into the metapopulation.
- The FRP plays an economic role, both positive and negative, on ranchland by adding value to ecotourism operations, and also by imposing (perceived or real) financial impacts through losses of livestock and valuable game.
- The FRP may hold higher genetic diversity than Cheetah inside small reserves by virtue of the fact that it is relatively large, and because processes of immigration and emigration from the regional population, and populations in protected areas occur.

VIABILITY CRITERIA

The working group members discussed how they define viability for this population and recommended the following definition:

The population should *be sufficiently large to generate enough mutations to offset loss in genetic diversity due to genetic drift*.

Lande, R. 1995 suggested that the effective population should be around 5,000 individuals for the purposes of achieving the viability criterion mentioned above. If the effective population size required is 5,000 individuals, then the actual population size would probably have to be much greater.

IDENTIFYING AND PRIORITISING THE PROBLEM

The members of the Free Range Population Working Group prioritised the threats facing Cheetah based on two separate criteria: urgency (a threat that was decided to need immediate action) and regional importance (a threat, thought to have a large impact at a regional level) with respect to the conservation of Cheetah using the CBSG's dot method. The numbers below reflect the number of dots that each threat received from working group members (7 group members x 3 votes each, resulting in a total of 21 dots per criterion):

Problem Statement	Urgency	Regional Importance
Conflict	11	2
Removals	6	4
Habitat	0	1
Governance	2	5
Land-use change	2	9

PROBLEM STATEMENTS

PROBLEM 1: Cheetah – Human Conflict

THE BEST INTERESTS OF LANDOWNERS MAY CONFLICT WITH THE BEST INTERESTS OF CHEETAH CONSERVATION, WHICH CAN LEAD TO REMOVAL OF CHEETAH FROM THE POPULATION.

The group recognised that losses of livestock and wildlife due to predators are a reality; however, conflict is often driven by other factors. It was also recognised that not all landowners persecute predators and that many landowners have a good understanding of predators and their role in the ecosystem.

- In some cases, lethal control is driven by prejudice and attitudes rather than by actual costs incurred.
- Provincial authorities rarely (in the case of North West Province, never) receive applications for permits to set cage-traps; landowners or managers just go ahead and trap or shoot Cheetah. This may be partially due to the fact that some landowners or managers feel that the permit application process takes too long.
- Conflict can have many causes, such as hostility towards a protected area, a feeling of entitlement towards the land and social and cultural factors.
- Conflict may be reduced by taking note of a landowners problems and providing channels of communication.
- There is a perception among some landowners that Cheetah have no value because they cannot be legally hunted and because sightings cannot be guaranteed for tourists.
- There is conflict between landowners and conservation departments, for example landowners often describe predators as being the responsibility of the conservation department.
- An important driver of persecution is ignorance – for example landowners not knowing the difference between species, and so potentially shooting the wrong species. In Thabazimbi, during Kelly Marnewick's study, approximately 5 - 6 Cheetah were shot per year. In North West Province, Michelle Thorn found that nine Cheetah were persecuted in a year and Deon Cilliers estimated that in the Limpopo Province, ~ 20 - 30 Cheetah are killed per year.
- Education can have a significant positive impact: in Thabazimbi, landowners who have been shown how widely Cheetah move have often been placated when they realise that it is not just their property that is affected, and that the Cheetah only spend short periods on their property.

Data Assembly and Analysis

The working group developed a detailed working knowledge of the facts and assumptions that are pertinent to conflicts between Cheetah and landowners.

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
a) *Information on landowner attitudes* **Bray area**: ▪ 100 % of landowners had seen Cheetah on their property, 88 % said Cheetah were a liability, 50 % have removed Cheetah from their property. ▪ Most commonly made solutions to conflict: breeding and selling of Cheetah, hunting, live capture and sale of Cheetah. ▪ These data suggest that Bray may be a sink area because Cheetah are often seen, but also frequently removed.	K. Marnewick, De Wildt unpublished data	Data on attitudes: that the findings are broadly applicable to ranchers throughout the Cheetah range and that information from surveys is accurate.	The justification for this assumption was that research has been conducted widely throughout the Cheetah range, and generally involved a randomised design.	Accurate information on: ▪ the population size of Cheetah outside protected areas ▪ trends in the population of Cheetah outside project areas ▪ the status of Cheetah in communal lands and the extent of conflict in those areas ▪ the net movement of Cheetah from countries adjacent to South Africa.
Lephalale and Vhembe areas: ▪ In Lephalale and Vhembe, 161 landowners were interviewed and information was obtained for 299 ranches, of these 6,5 % had sighted Cheetah. ▪ In Lephalale, commonly suggested solutions to conflict with Cheetah were: ‘don’t know; simply accepting losses: and compensation.’ ▪ In Vhembe, 20 % of respondents said the Cheetah population had increased. ▪ 60.1 % felt that Cheetah were a problem. ▪ In Vhembe – most commonly made solutions to conflict with Cheetah were; ‘don’t know; to just accept losses to Cheetah; compensation; and, local hunting of Cheetah.’	K. Marnewick, De Wildt Unpublished data			

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
Thabazimbi area: ▪ Attitudes of landowners in Thabazimbi appear to be improving. ▪ During the initial survey in 2000-2001: o 199 landowners were interviewed, providing data from 366 different ranches. o 39 % of landowners had seen Cheetah in the last 5 years o 72 % thought Cheetah were increasing. o 71 % considered Cheetah to be a liability. ▪ During a repeat survey in March 2009: o 62 landowners were interviewed for 100 properties. o Cheetah were present on 61 % of properties. o 65 % of ranchers were positive towards Cheetah 20 % were negative and 15 % were neutral.	K. Marnewick, MSc thesis and recent unpublished data			
North West Province: ▪ Survey work was conducted on attitudes of landowners towards predators in the North West Province: ▪ Tswana speakers were more negative towards predators than other cultural groups ▪ Length of tenure of landowners on a piece of land was correlated with negative attitudes to predators ▪ Increasing number and proportion of livestock lost, and increasing financial losses were correlated with negative attitudes to predators ▪ Landowners in more arid areas were less negative than those in high rainfall areas ▪ Landowners who had changed land-use recently (e.g. from livestock to game) were more negative than landowners who had not made such a change recently ▪ The trend in land-use in North West Province is from	M. Thorn, unpublished data			

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
livestock to game ranching ▪ Landowners whose main income was from livestock were more negative than those whose main income was from game ▪ There was a threshold of losses of ~R30,000 to predators beyond which landowners were more negative towards predators ▪ Eyewitness accounts confirmed that Cheetah killed domestic Calves, Cows, Blesbok and Impala. ▪ Only 21 % of the 77 % experiencing depredation actually witnessed the predation they reported. ▪ Respondents considered depredation to be less costly than drought and poaching, but more costly than fire and disease outbreaks. ▪ Respondents considered there to have been an increase of 15 % in the Cheetah population in NWP over 5 years.				
Limpopo Valley, Central Lowveld, Zululand: ▪ Randomised survey work on attitudes to all predators, including Cheetah ▪ Attitudes towards Cheetah were intermediate, relative to those towards Spotted Hyaenas (*Crocuta crocuta*), Lions and Wild Dogs (more negative), and those towards Leopard and Jackal spp. (more positive) ▪ Most common reasons for negative attitudes towards Cheetah were: 'they kill too much wildlife; they kill livestock; they are wasteful.' ▪ Most common reasons for positive attitudes towards Cheetah were: 'recognition of their ecological role; their ecotourism value; because they don't kill too much.'	P. Lindsey 2005			

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
b) Information on complaints				
Survey data from North West Province: ▪ 99 landowners were interviewed of which 77 % had experienced depredation by predators, of which 7 % identified Cheetah as being responsible.	M. Thorn, unpublished data			
North West Province Nature Conservation data: ▪ From the Bray / Tosca area, four complaints of problem Cheetah were received during 11 April 2007 through to the present (mid April 2009)	V. Jacobs			

General recommendations

- Continue existing conflict resolution programmes.
- A short list of *in-situ* tests of the efficacy of depredation control methods should be compiled and a brief review done of tested livestock depredation control methods from other study areas should be compiled to see what methods would likely be applicable to South African conditions (perhaps paying particular attention to the review by Inskip and Zimmerman and work of Laurie Marker, Amy Dickman, Laurence Frank, etc). It is important to see what work has already been done in South Africa e.g. Bool Smuts at LandMark Foundation and Cyril Stannard at Cheetah Outreach.

Specific recommendations

- Implement education, sensitisation and outreach programmes involving landowners and professional hunters in focal areas where conflict is severe and the conservation importance of the population is considered higher. Bray and Alldays-Mussina areas were identified as important. Bray (because the conflict is severe there and it likely represents a severe sink for Botswana), Alldays-Musina (because it forms an important corridor between the free ranging population and the Kruger population). The ideal approach for the Bray area would be to target both commercial landowners as well as subsistence communal areas.
- Conduct baseline questionnaire surveys in communal areas (perhaps by De Wildt) and conduct educational and awareness work at the same time – **it was suggested that this is done before the NCAP meeting as little is known about issues in communal areas.**

PROBLEM 2: Removal of Cheetah through hunting and trade

REMOVALS THROUGH UNCONTROLLED LIVE TRADE, TRADE IN CHEETAH PARTS AND HUNTING HAVE AN UN-QUANTIFIABLE IMPACT ON LOCAL AND REGIONAL CHEETAH POPULATIONS.

- Legal and illegal trade in Cheetah and Cheetah parts is a problem.
- Illegal trade includes landowners getting clients to hunt Cheetah and then exporting their skins hidden in Kudu skins.
- In South Africa it seems that captured Cheetah are roughly 50 / 50 males and females – though males get caught more readily in traps, females get chased down more readily with dogs (Deon Cilliers and Kelly Marnewick, *pers. obs*.).
- 'Legal' trade is partly due to loopholes in the law – such as the simple requirement that a Cheetah be micro-chipped as a prerequisite for obtaining an export permit. There is no requirement for proving parentage genetically and also no compulsory studbook.
- One of the problems is the attitudes of landowners – especially the 'my farm syndrome' – whereby landowners feel they can do whatever they want on their land.

Data Assembly and Analysis

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
a) *Information on Cheetah removals from farms*				
North West Province Nature Conservation data: ▪ Since 11 April 2007, eight Cheetah have been removed from the Bray / Tosca area. ▪ One of those Cheetah died and the others were relocated by De Wildt.	V. Jacobs	That information from surveys is reliable; that De Wildt and Nature Conservation keep good records.		Accurate information on: ▪ removals of Cheetah from ranchlands through persecution and capture ▪ field tests of livestock protection techniques ▪ factual information on financial losses to predators and on which predators are responsible.
De Wildt records: ▪ 160 Cheetah were removed from ranchland across the Cheetah range area from 2000 to the present and relocated to fenced protected areas (mid April 2009) (more information is available from K. Marnewick's chapter in the Hayward / Somers book, "Reintroduction of top order predators"	K. Marnewick, De Wildt	Data on removals: that because Cheetah are removed, there must be significant conflict between landowners and Cheetah		Threshold level of removals / killings of Cheetah beyond which South Africa becomes a sink for the regional population. The impacts of removals and persecution on Cheetah social structure.
b) *Guesstimates on extent of persecution of Cheetah on ranchlands*				
North West Province: ▪ Nine Cheetah were killed in the NWP during the last 12 months.	M. Thorn unpublished data	Data on persecution: that all reports of Cheetah killings are true, and that reports have not been duplicated		

General recommendations

- Conduct an external / international investigation and audit of the extent and dynamics of captive trade, perhaps by co-opting the Environmental Investigation Agency, TRAFFIC (regional office), or the Green Scorpions.

Specific recommendations

- Develop partnerships with Botswana (Cheetah Conservation Botswana) and Namibia (Cheetah Conservation Fund) because the trade issues affect the Cheetah populations in neighbouring countries.
- Analyse and lobby for a compulsory studbook and genetic testing for verifying parentage of traded Cheetah.

PROBLEM 3: Habitat fragmentation

BUSH ENCROACHMENT AND PREDATOR-PROOFED CAMPS AND RANCHES EFFECTIVELY FRAGMENT AND REDUCE AVAILABLE HABITAT FOR CHEETAH.

- The construction of predator-proof fencing in some areas is causing fragmentation of habitat and reduction in the availability of habitat for Cheetah.
- Inheritance and subdivision of ranches is reducing the size of properties and increasing the prevalence of fencing.
- Conversely, there is the feeling among field workers that the purchasing of ranches by wealthy landowners to create larger properties is also occurring.
- The increasing value of land is reducing the size of ranches to some extent – 400 ha 5 years ago went for R1 million, but now goes for around R8 million.
- 80-90 % of ranches in Limpopo have some of their land predator-proofed to keep valuable antelope such as Roan and Sable antelope safe (Reinhard Holtzhausen *pers. comm*.).

Data Assembly and Analysis

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
a) Impressions of land-use change				
▪ Walmsley (2002) in a document on the state of the environment provides a list of stressors to the NWP environment. ▪ There are nine predator-proof camps in North West province for canned Lion hunting, the minimum legal size of which 1,000 ha, but some are smaller. ▪ 80-90 % of ranches in Limpopo have predator-proof camps for valuable game species such as Roan and Sable antelope. ▪ At least 5 2,000 ha ranches in the Thabazimbi area have been fenced with predator-proof fencing to keep predators out. ▪ Thaba Tholo in the Thabazimbi (36,000 ha), and the Russian property in the Bray area (100,000 ha) are predator-proof fenced (though Cheetah have been fenced in). ▪ Parks such as Marakele, Pilanesberg and Madikwe have been predator-proof fenced.	V. Jacobs, R. Holzhausen, K. Marnewick, M. Thorn			The extent to which mining is proposed within Cheetah ranges.

General recommendations

- Consider how bush encroachment affects Cheetah by checking available literature and consulting with experts such as Laurie Marker, Amy Dickman and Charlene Bisset.
- Investigate potential for developing strategies to address bush encroachment, perhaps by working with Working for Water.

Specific recommendations

- Conduct an assessment of the loss of available habitat and document best, medium and worst case scenarios.
- Map and document the extent of loss of habitat through predator-proof fencing, and industrialisation (mining, power stations and power lines).

PROBLEM 4: Ineffective implementation of legislation

LACK OF CAPACITY, TRAINING, KNOWLEDGE AND MOTIVATION, SOMETIMES COUPLED WITH CORRUPTION, PREVENTS EFFECTIVE IMPLEMENTATION OF LEGISLATION WHICH ALLOWS CONTINUED ILLEGAL REMOVALS.

- Motivation of staff is undermined when poorly qualified staff are instated in senior positions.
- Staff shortages is a common problem in the problem animal sections of the Provincial Departments:

    1. Information on staffing levels should be included in strategic plans for each province.
    2. In general, Nature Conservation authorities are understaffed by at least 40 %.
    3. The Mpumalanga Province estimate that they are 60 % understaffed.
    4. In North West Province should have four problem animal control staff, but they only have one.
    5. Lephalale is supposed to have two nature conservators (the staff meant to interface with landowners and respond to problem animal complains), but they have one; Thabazimbi are supposed to have two but have none; Bela Bela are supposed to have two but have none; Modimolle is supposed to have two but only has one.
    6. This all results in a lack of effectiveness of the problem animal control service which additionally causes frustration amongst landowners.

- There is also a severe shortage of regulatory staff – i.e. those in charge of prosecutions, resulting in lack of legal repercussions for illegal trade etc.
- Nature Conservation staff are limited in their efficacy by resources: e.g. in Limpopo, staff are only allowed to travel ~2,000 km / month in official vehicles to attend problem animal complaints; in the North West Province, staff are granted 2,000-3,000 km / month, staff also have limits on cell phone usage etc.
- Several examples of inadequate / inappropriate qualifications and corruption were presented by participants, but specifics are inappropriate to include in this report.

- TOPS regulations are in place but are not implemented throughout the country due to various reasons, such as staff shortages, lack of training, etc.
- Lack of training is a huge problem – for example resulting in failure to prosecute landowners who shoot predators due to a lack of knowledge among staff on the correct procedure to do so.

Data Assembly and Analysis

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
a) *Personal experiences of governance*				
▪ Additional information is likely to be included in Magdel Boshoff's Masters thesis and in a report being compiled by Rynette Coetzee of the EWTs Law and Policy Working Group on Law and Order Compliance.	R. Holzhausen, V. Jacobs, K. Marnewick	Opinions on governance: that the personal experience of participants is broadly applicable (for example to Northern Cape where participants had no experience)		The impact of poor governance on Cheetah survival. The efficacy of governance in the Northern Cape.

General recommendations

- NGOs should offer training programmes for Nature Conservation on issues such as problem animal control.
- Ensure that concerns regarding ineffective, incompetent and corrupt governance of wildlife issues be recorded at the NCAP Workshop for Cheetah in June 2009.

PROBLEM 5: Land use change

LAND REFORM OR ECONOMIC TRIGGERS COULD LEAD TO CHANGES IN LAND-USE PRACTICE AWAY FROM WILDLIFE, CAUSING LOSS OF WILD PREY AND INCREASING SCOPE FOR HUMAN-CHEETAH CONFLICT

- 95 % of wildlife ranches in KZN and 85 % in Mpumalanga are under land claims (Reinhardt *pers. comm*.).
- By 2010, 100 % of ranches in KZN will be under land claims (Reinhardt *pers. comm.*).
- The government has a very poor understanding of the number of ranches that have been claimed, on the status of land claims, or on what is happening on land that has been transferred and no information appears to be available on change in land-uses after reform.
- More profitable land-use options may result in a change in land-use to options that are less positive for Cheetah conservation: examples include mining, or if small stock ranching happened to become more profitable, etc.
- The future profitability of different land-use options is hard to predict.
- Industrialisation, and specifically the development of mining, is a threat: for example, power lines and power station are planned from Ellisras to Johannesburg.

Data Assembly and Analysis

Known facts	Source of data	Assumptions	Justification for assumptions	Data gaps
a) Impressions of land-use change ▪ Peace Parks Foundation may have a map of ranches under land claim. ▪ Warwick Mostert may have a good impression of the land being considered for conversion to mining in the Limpopo Valley. ▪ The EWT may have information on the route of proposed power lines from Ellisras to Johannesburg.				Information on the extent of land claims, the number and distribution of claims that have been processed and the impacts on land-use.

General recommendations

- Develop research projects in the game ranching industry to assess land-use changes within the industry; the conservation role of the industry; the use of different types of fencing; management of predators; genetic manipulation of prey; issues relating to stocking (overstocking); the management of bush encroachment and erosion, etc.

INSIGHTS REQUIRED FROM THE PHVA MODELLING

Working group participants indicated that modelling would be useful to provide insights into the following issues:

- The impacts of changing carrying capacity on Cheetah persistence.
- Identifying the threshold level of removals / persecution from the South African FRP, beyond which it becomes a sink for regional populations.
- To what extent do annual fluctuations in the level of removals and persecutions affect the probability of persistence?

REFERENCES

Friedmann, Y. and Daly, B. (editors) 2004. Red Data Book of the Mammals of South Africa: A Conservation Assessment: CBSG Southern Africa, Conservation Breeding Specialist Group (SSC / IUCN), Endangered Wildlife Trust. South Africa.

Lande, R. 1995. Mutation and conservation. Conservation Biology 9:782 – 791.

Lindsey, P.A., Alexander, R.R., Du Toit J.T. and Mills, M.G.L 2005. The potential contribution of ecotourism to African Wild Dog *Lycaon pictus* conservation in South Africa. Biological Conservation 123: 339 – 348.

Walmsley, R.D. and Pretorius, J.P.R. 1996. Environmental Indicators. Report No. 1. State of the Environment Series. Department of Environmental Affairs and Tourism. Pretoria.

Population Modelling and Dynamics Working Group

WORKING GROUP PARTICIPANTS

1. Brenda Daly: CBSG Southern Africa
2. Harriet Davies-Mostert: Carnivore Conservation Group of the EWT
3. Kathy Traylor-Holzer: Conservation Breeding Specialist Group (IUCN)
4. Kerryn Morrison: CBSG Southern Africa
5. Peter Lindsey: Carnivore Conservation Group of the EWT
6. Tracy Rehse: National Zoological Gardens of South Africa

INTRODUCTION

The task of the Population Modelling and Dynamics Working Group was to provide a simulation modelling tool to assist in the evaluation of various population management options for Cheetah in South Africa. In particular, models were developed to explore options for managing the metapopulation of privately owned reserves through translocation, including the potential for other Cheetah populations to serve as donor populations for this metapopulation. Modellers were also asked to explore the potential impact of South African Cheetah populations on those in neighbouring countries to the north and east (i.e. Namibia, Botswana, Zimbabwe, Mozambique). Simulation modelling was used to explore management options to guide the development of a national conservation strategy for Cheetah in South Africa.

Computer modelling is a valuable and versatile tool for quantitatively assessing risk of decline and extinction of wildlife populations, both free ranging and managed. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA).

The simulation software programme Vortex (v9.94) was used to examine the viability of South African Cheetah populations under a set of assumed environmental and management conditions. Vortex is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. Vortex models population dynamics as discrete sequential events that occur according to defined probabilities. The programme begins by either creating individuals to form the starting population or importing individuals from a studbook database and then stepping through life cycle events (e.g. births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate both demographic stochasticity and annual environmental variation. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of Vortex and its use in population viability analysis, see Lacy

(1993, 2000) and Miller and Lacy (2005). PVA using Vortex has been found to predict the future fate of populations without bias for well-studied populations (Brook *et al*. 2000).

VORTEX SIMULATION MODEL

Development of Base Demographic Models

Cheetah populations live in a variety of environmental and ecological conditions throughout South Africa. Differences in habitat, prey density, competing carnivore species, and other factors suggest that intrinsic demographic rates such as reproduction, survival and population growth are likely to vary among these environments.

Participant discussions prior to and during the workshop led to the classification of South African Cheetah populations into the following three demographic categories:

1. <u>High Prey Density / No Competitors</u>:
   This represents a matrix of privately owned habitats (e.g. ranchlands, private reserves) characterised by good prey density and the relative absence of Lions and other large competing carnivores. High potential reproduction and survival is expected to lead to very strong potential growth rates in the absence of stochastic processes or additional factors affecting mortality or reproduction, such as persecution or contraception.

2. <u>High Prey Density / Competitors Present</u>:
   Kruger National Park epitomises this environment, with good habitat (mixture of woodland and savannah), good prey densities, presence of competing large carnivore species (primarily Lions, thought to be an important factor in Cheetah cub mortality), and little to no human persecution. Population growth is expected to be strong in the absence of stochastic processes or additional mortality factors, but less than that when competitors are absent.

3. <u>Low Prey Density / Competitors Present</u>:
   Represented by the Kalahari desert, this environment is associated with lower prey densities and potentially lower fecundity. Competitors (Lions) are present. Population growth is expected to be low due to the relatively poor environmental conditions.

Data were taken from either South African populations or other Cheetah populations under similar ecological conditions to develop base models for each of these three situations. While many parameters used common values across models (see below), fecundity measures and annual mortality rates were varied across these base models to develop models that reflect differing potential growth rates as expected relative to each other. The input values used are described in detail below.

General Model Input Values

Data were taken from a variety of sources to parameterise the Cheetah models, including scientific publications, unpublished field data supplied by workshop participants, captive population data and expert opinion. When possible, data were used from similar environmental conditions either in South Africa or elsewhere in Africa. For example, data from Namibia were used for the High Prey / No Competitor conditions (e.g., ranchlands), while data from the Serengeti were thought to be more applicable to the High Prey / Competitors model (e.g., KNP, select private reserves). Due to the difficulty in observing cubs in the early weeks of life, all input values were based on post-emergence data (e.g., litter size, cub survival). Long-term data were not available to determine good estimates of annual environment variation (EV) in demographic rates; given the relatively stable environment in South Africa, EV was calculated as 20 % of the mean value (COV = 20 %) for the relevant parameters. Models were run for 500 iterations over 100 years (50 years for the reserve metapopulation models); with population extinction defined as only one sex remaining in the population.

Reproductive Parameters

Mating system: Short-term polygyny
Cheetah do not form pair bonds but mate with multiple partners. Gottelli *et al.* (2007) suggested that females mate with more than one male, even sometimes producing cubs sired by more than one male within the same litter, and that mates change annually. In addition, both territorial and non-territory (transient) males mate with females. Short-term polygyny was selected as the best option in Vortex to represent this breeding strategy (polyandry is not an option in Vortex, but given other model input values, the omission of occasional multi-paternity litters is unlikely to affect the model results).

Age of first offspring: 3 years (females and males)
Vortex defines the onset of reproduction as the average age of first reproduction, rather than the age of sexual maturity or the earliest observed age of reproduction. In the Cheetah model, reproduction was defined as producing cubs that emerge from the lair.

The mean age of first reproduction of females is 2.4 years in the Serengeti (Kelly *et al*. 1998), 2.6 years in the KNP (Broomhall, 2001), and 2.5 - 3 years in Namibian ranchlands (Marker *et al*. 2003). S. Durant noted at the workshop that the minimum age of first reproduction for females was 24 months. Workshop participants agreed that 3 years was the best estimate for this parameter.

Males are physiologically able to reproduce at approximately 2 years of age (Berry *et al.* 1996; Marker *et al*. 2003). The workshop participants agreed that 3 years would be a viable average first age of breeding for males.

Density-dependent reproduction
No evidence for density-dependence reproduction was available at the workshop; therefore, participants agreed not to include density-dependent reproduction in the model.

Percent adult females breeding (per year):
This parameter defines the mean percent of adult females producing a litter (to emergence from the lair) each year. This value is directly related to the mean interbirth interval (with “birth” defined as emergence). Surviving offspring stay with the female until about 17 months of age (Kelly *et al.* 1998). Therefore, if the survival of dependent young is high, the interbirth interval (IBI) may be relatively long, resulting in fewer females producing emerging litters each year. If cub survival is low, females may become sexually receptive (exhibit oestrus) and mate sooner, shortening the IBI and leading to a greater proportion of females producing emerging litters each year. Thus, this parameter may interact with cub survival under various environmental conditions.

High Prey / No Competitors: *55.4 % per year (EV = 11 %)*
Data were analysed from Marker *et al*. (2003) based on radio-collared Cheetah in Namibia ranchlands, an area that best approximates this environmental situation. Six females were observed to produce multiple litters (15 litters in total) between 1994 and 1999; the mean IBI = 21.65 months based on 9 IBIs, which represents 55.4 % adult females producing an (emergent) litter per year. This assumes that essentially all adult females are breeders due to the relatively good environmental conditions.

High Prey / Lions: *68 % (EV = 13.6 %)*
The average IBI following litters that were raised to independence is 20.1 months (1.675 years) in the Serengeti (n=36 females) (Kelly *et al.* 1998), an area representative of this environmental situation. If all females bred and successfully raised their litters, this would result in about 60 % of adult females breeding each year. It was estimated that, in the presence of Lions and other large predators, entire litters would be lost more frequently, resulting in the female re-breeding earlier and thus shortening the average IBI. The percent breeding was increased to 68 %, which would represent about 20 % of the females losing their entire litter prior to emergence and producing an emerging litter within the same year. This may be reasonable, given the high cub mortality observed in the Serengeti, the majority of which (73 %) is due to predation by Lions or Spotted Hyaenas (Laurenson *et al.* 1995). Females can conceive quickly after losing a litter (19 days) (Laurenson *et al*. 1992).

Low Prey / Lions: *40 % (EV = 8 %)*
This value was estimated from field data from the Kalahari provided by G. Mills at the workshop based on observations of IBIs in several females. IBI is believed to be longer in this environment due to relatively lower prey densities.

Percentage of adult males in the breeding pool (potential breeders): 90 – 100 %
No data were available for this parameter. Since both territorial and non-territorial males have the potential to breed, it was estimated that most adult males are available in the breeding pool (i.e. potential breeders). Due to relatively low Cheetah densities in the Kalahari, it was agreed that all males were in the breeding pool. Participants estimated that 95 % of males were in the breeding pool in private lands (High Prey, No Competitors) and due to intense competition, about 90 % of males were in the breeding pool in areas such as KNP (High Prey, Competitors).

Maximum number of (emergent) litters per year: 1
Female Cheetah will exhibit oestrus again within three weeks of losing a litter, and conceive again in about 19 days (Laurenson *et al*. 1992). This means that 2 litters may be produced within one year. Since, the model was developed with 'birth' defined as emergence from the lair, participants agreed that in such instances typically the first litter is lost whilst still in the lair and hence a maximum of only 1 emerging litter per year was considered in the model.

Maximum number of cubs per (emergent) litter: 5 - 6
Relocated Cheetah were recorded as having up to 7 cubs per litter (Marnewick *et al*. 2009). Broomhall (2001) recorded a maximum of 6 cubs per litter in the KNP and G. Mills (*pers. comm.*) observed a maximum of 5 cubs per litter in the Kalahari. For the model, a maximum litter size of 6 was used for all models with good prey, and 5 was used as a maximum for low prey conditions (i.e. Kalahari).

<u>Mean litter size:</u> 3.33 - 3.4 cubs

Several authors published estimates of the litter size for Cheetah, all of which fall within a narrow range: 3.20 (Marker *et al*. 2003); 3.43 (Skinner and Smithers, 1990); and 3.50 (Laurenson *et al*. 1992). Mean litter size of 3.4 (SD = 0.4) was used for populations with good prey densities based on actual data that C. Bisset bought to the workshop from the Kwandwe Private Game Reserve. A mean litter size of 3.33 (SD = 0.8) was calculated from field data provided by G. Mills for the Kalahari (low prey density conditions).

Mortality Parameters

<u>Age- and sex-specific mortality rates</u>

The age- and sex- specific mortality rates used for each of the models are outlined below in Table 1.

<u>High Prey / No Competitors</u>

Data were analysed from Marker *et al*. (2003) based on radio-collared Cheetah in Namibia ranchlands, an area that best approximates this environmental situation. Due however to their small sample size and no justification as to the difference in male and female mortality rates in the 0 – 1 age class the mortality rate was averaged for the two sexes for this model. Also, it was agreed by the participants that the 25 % mortality rate for females and 18 % mortality rate for males in the 1 – 2 age class found by Marker *et al.* (2003) was more likely reversed and hence was reversed for the purposes of the model.

<u>High Prey / Competitors</u>

Data were analysed from Broomhall (2001) based on studies in the Kruger National Park.

<u>Low Prey / Competitors</u>

Data were used from Kelly *et.al.* (1998) from their work in the Serengeti and from personal observations made by G. Mills as discussed at the workshop.

Table 1: Mean annual age specific mortality rates for male and female Cheetah

Age class	High Prey / No Competitors		High Prey / Competitors		Low Prey / Competitors	
	Female	Male	Female	Male	Female	Male
0 - 1	25	25	50	50	52	61
1 – 2	18	25	20	30	25	25
2 – 3	22	30	25	35	15	34
Adult	15	15	15	15	15	15

<u>Inbreeding depression:</u> Included (as 1.57 lethal equivalents, 50 % due to lethal alleles)

Inbreeding can negatively impact a broad spectrum of life history traits that affect fecundity and survival. Quantitative analysis of inbreeding effects is difficult, however, particularly for wild populations for which pedigrees and inbreeding levels are unknown. Ralls *et al*. (1988) estimated the effects of inbreeding depression on juvenile mortality in captive populations for 38 mammalian species and found the median impact to be 3.14 lethal equivalents (LE). Inbreeding effects are believed to be greater in wild, more stressful environments than that observed in captive conditions. In addition, other traits are subject to inbreeding effects. A meta-analysis by O'Grady *et al*. (2006) using data on wild populations for 10 mammalian and avian species found an average of over 12 LE (6.3 LE attributed to fecundity and first-year survival, and 6.0 affecting survival after 1 year of age). The inclusion of inbreeding depression in simulation models can substantially affect viability projections, and unrealistic recovery or management goals may be developed if the potential effects of inbreeding are not considered (O'Grady *et al*. 2006).

Cheetah are believed to have experienced a genetic bottleneck, which may have purged some of the lethal alleles from the population, resulting in a smaller genetic load and reduced impacts of inbreeding depression. A preliminary analysis of data from the *2008 International Cheetah Studbook* at the workshop revealed no evidence of inbreeding depression on juvenile mortality in captive Cheetah. However, inbreeding depression may be a significant consideration in the management of small subpopulations as part of a metapopulation of managed reserves. After discussion, it was agreed that inbreeding depression should be included in the model, but most likely at a lower rate than the default of 3.14 LE based on captive population. A conservative figure of one-half of this would be used in the model, i.e.1.57 LE. Since Vortex models inbreeding depression only through juvenile mortality, it is recognised that in general this is an underestimate of its potential effects on the population.

Concordance between environmental variation in reproduction and survival: Yes
Environmental variation (EV) is the annual variation in reproduction and survival due to random variation in environmental conditions. By linking EV, this means that 'good' years for reproduction are also relatively 'good' years for survival, and conversely, 'bad' years for reproduction are also 'bad' years in terms of survival. This is typical of most species, and there is no evidence that they are unrelated for Cheetah.

Maximum age: 12 years
Vortex assumes that animals can reproduce throughout their adult life and does not model reproductive senescence. Individuals are removed from the model after they pass the maximum age. The oldest Cheetah observed by Kelly *et al.* (1998) in the Serengeti was 13 years old (Kelly *et al.* 1998; Durant *et al*. 2004), although the maximum age of reproduction for females was about 12. Similarly, Marker *et al.* (2003) found 12 years to be the maximum age of reproduction for Cheetah in Namibia, though few individuals reach that age. The workshop participants agreed to use 12 years in the model.

Number of catastrophes: 1
Vortex has the capability to simulate extreme events in environmental variation that affect reproduction and / or survival. Reed *et al.* (2003) examined data for wild populations of 88 vertebrate species and concluded that the probability of a severe catastrophe (defined as a loss of 50 % of the population in one year) across all causes was 14 % per generation, or about once every 7 generations. Generation time based on demographic rates in the Cheetah model is 5.7 years, resulting in this kind of catastrophe occurring every 40 years on average (probability of 2.5 % per year). In the absence of data on catastrophes for Cheetah, it was agreed to include a generic catastrophe with an annual probability of 2.5 %, with no effect on reproduction but a 50 % reduction in survival.

Base Model Deterministic Values

Given the input values outlines above, the three base models were examined to ensure that the deterministic rates appeared biologically reasonable and in expected relation to each other, assuming no stochastic processes or human-related factors impacting survival or reproduction. The input values used and resulting deterministic rates are given in Table 2.

The deterministic growth rate (r) is high in High Prey / Competitor conditions (r = 0.093) and even stronger in the absence of competitors (r = 0.142). While quite high, this level of growth may be realistic for Cheetah, which can produce relatively large litters. Discussions among workshop participants revealed that reintroduced Cheetah into protected areas with good conditions often result in very rapid population growth that may necessitate population management through removal or contraception. The input values for areas with Low Prey / Competitors results in a relatively zero growth situation (r = 0.002), suggesting that populations under such conditions, if isolated, are likely to experience population decline under realistic (stochastic) conditions. Generation times lengthen slightly as conditions decline. These rates appear reasonable given the participants' assumptions about the factors affecting Cheetah under these three different environmental conditions.

Table 2: Key input parameters and deterministic results for the three base demographic models.

	High Prey / No Competitors	**High Prey / Competitors**	**Low Prey / Competitors**
% adult ♀♀ breeding	55.4	68	40
% ♂♂ breeding pool	95	90	100
Maximum litter size	6	6	5
Mean litter size (SD)	3.4 (0.4)	3.4 (0.4)	3.33 (0.8)
Annual mortality (%)	♀ / ♂	♀ / ♂	♀ / ♂
0 – 1 yr*	25 / 25	50 / 50	52 / 61
1 – 2 yr	18 / 25	20 / 30	25 / 25
2 – 3 yr	22 / 30	25 / 35	15 / 34
Adult	15 / 15	15 / 15	15 / 15
Deterministic r	0.142	0.093	0.002
Generation time (yrs)	5.66	5.81	6.12

* *From emergence to age 1 year*

Population-Specific Model Values

The three demographic models were used as a basis to develop specific models for the various Cheetah populations in South Africa. Current population size and habitat carrying capacity for Cheetah were estimated for each population, and, where appropriate, harvest rates were added to account for human persecution via removal of problem animals or as a result of illegal hunting (Table 3). This resulted in the development of population-specific baseline models that then were used for projections of the future viability of these populations given the current estimated conditions. The following five population models were developed:

1. Free-ranging population:
   This model depicts the geographically widespread free-ranging Cheetah population living outside of contained reserves and moving freely among ranches. Prey availability is estimated to be good in these areas. These Cheetah are not impacted by Lions; however, many are removed due to illegal hunting and

trade as well as legal removals in efforts to reduce conflicts. Although this population extends into Botswana and Zimbabwe, it was modelled as a closed population. This may suggest whether or not the population may act as a sink population under various removal rates by drawing Cheetah in from neighbouring areas. The current population is estimated 400, with the population believed to be 800 at carrying capacity. Removals were estimated to include all Cheetah removed from the wild as a result of them being problem animals or due to illegal hunting. Using past removal data from D. Cilliers available at the workshop, the number of individuals removed each year was determined for each age class and then averaged across years to provide the following annual removal estimates (modelled as annual removals for each year of the simulation):

Age class	Females	Males
1 – 2 years	4	4
2 – 3 years	2	3
Adults (3 - 12 years)	5	13

2. Kruger National Park:
   This population is maintained within the KNP in South Africa, but is open to both Mozambique to the east and Zimbabwe to the north. The population was modelled as a closed population to ascertain whether it could be acting as a source or sink for neighbouring populations. These Cheetah are impacted upon by Lions and the prey base is good. The current population is estimated at 150 and is thought to be close to or at carrying capacity, which for the model was set at 160. There are currently no removals from the population through hunting or for the purposes of relocation.

3. Kalahari:
   This population is connected with the Cheetah population in Botswana to the north, but was modelled as an isolated population of 80 individuals (K = 90) in order to estimate the net influx of Cheetah needed to sustain the population. Because this population has genetic flow with adjacent populations, inbreeding depression was removed from this specific model, as its inclusion would impose unrealistic impacts upon this small population.

4. Metapopulation of managed reserves (with competitors):
   The subpopulations within the metapopulation are considered closed populations with no natural movement into or out of them, as a result of the predator-proof fences that encircle them. Each of the subpopulations was started through a relocation programme of “problem” Cheetah caught from the free ranging population, and for the purposes of the model, was initiated at carrying capacity at the start of the model, assuming that they already had Cheetah. Each of the subpopulations in this model used the same parameters as those used for the KNP model due to the very similar situation of high prey levels and the presence of other predators such as Lions. Relocations among reserves were also considered for this model to provide information on the sustainability of the population both from a genetic and a viability perspective. A series of models was developed with a differing number of subpopulations and size of populations in each, from which a minimum number and size of subpopulations required to meet the viability objectives of the metapopulation programme could be obtained. The models were run both with and without a translocation programme. For the translocation programme, 1 male and 1 female Cheetah from the 2-year-old age class were removed every 2 years from any subpopulation during years in which the subpopulation exceeded K. The model simulated the placement of these individuals into a boma to form a donor population from which 1 female and 1

male were transferred every second year to supplement subpopulations that fell below K.

5. Metapopulation of managed reserves (without competitors):
The subpopulations within the metapopulation are considered closed populations with no natural movement into or out of them – except through planned translocations. The free ranging parameter values were used for each of the subpopulations in this model due to its closest fit with high prey levels and no competitors, especially Lions. However, the population growth rate here was known to be very high and the mortalities were taken at 10 % less than those used for the free ranging Cheetah population. The translocation programme followed the same process as outlined above for the metapopulation of managed reserves with competitors.

Table 3: Key input values for the population-specific baseline models.

Population	Base model	Current N	K	Removal
Free-ranging	High Prey / No Competitors	400	800	13 sub-adults and 18 adults per yr
KNP	High Prey / Competitors	150	160	None
Kalahari	Low Prey / Competitors	80	90	None
Metapopulation (Lions)	High Prey / Competitors	Variable	Variable	1 male and 1 female (2-yr-old) every 2 yrs when N > K
Metapopulation (no Lions)	High Prey / No Competitors	Variable	Variable	1 male and 1 female (2-yr-old) every 2 yrs when N > K

FREE RANGING POPULATION AND SENSITIVITY TESTING

The free ranging population model was developed both with and without any unnatural losses to the population (i.e. removal of Cheetah by humans). Removals were considered here as those Cheetah removed from the population due to hunting, trade, or as part of the relocation programme of "problem" Cheetah.

The baseline free ranging model without any unnatural removals had a stochastic growth rate (r) of 0.13 and no risk of extinction over 100 years, allowing the population to grow, on average, relatively quickly to near carrying capacity (Figure 3). The growth rate remained high and risk of extinction low even when Cheetah were removed from the population at the estimated current rate of removal. With an initial population of 400 Cheetah and an annual growth rate of about 14 % per year, an annual removal of 31 animals (as estimated for the model) accounts for less than 8 % of the population, and an even smaller proportion if the population is larger than 400. As long as r is greater than the percentage of individuals removed from the population and adult females are not disproportionately removed, the free ranging population is likely to be able to sustain this level of removal. These results should be viewed cautiously, however, due to the various sources of uncertainty in the model. Population size, carrying capacity, actual potential growth rate, and reliability of the removal data (bearing in mind that only known removals were included in the model) all play a significant role in the model results. In addition, the sex and age of the animals removed will also play a role, as suggested below in the sensitivity analysis.

Given the current model input values, the population does not appear to serve as sink for neighbouring populations in Zimbabwe and Botswana. The free ranging population might even potentially be a source population for other populations once carrying capacity is reached. There is also a high probability that there is significant movement between the South African Cheetah free ranging population and those populations further north. Again, caution should be exercised when interpreting these data, and the reliability of the data outlined above considered carefully, as these could influence the outcomes considerably.

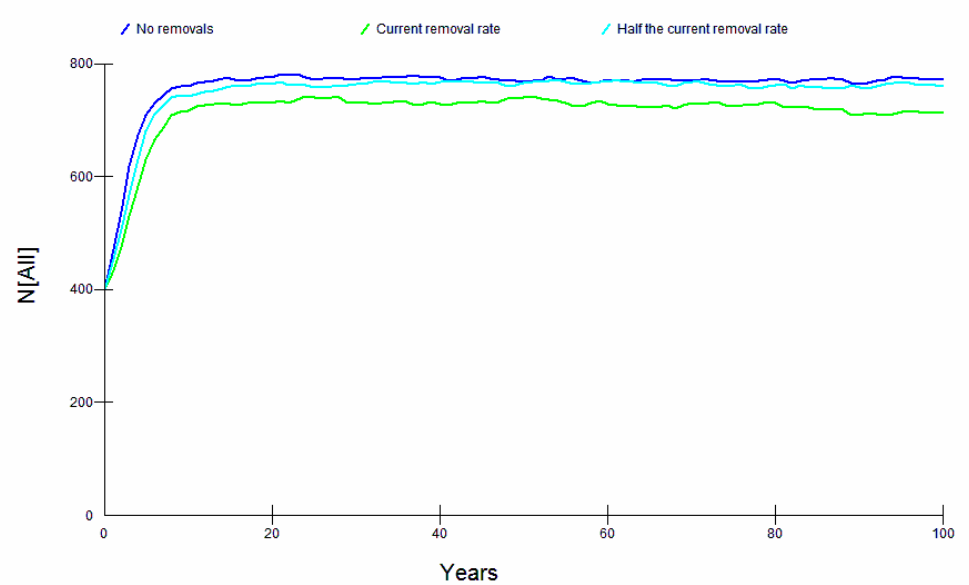


Figure 3: Mean population size of the free ranging population, showing a comparison of current removal (harvest) levels, 50 % current removal levels, and no removals (baseline).

It was against the free ranging population model with no current removal levels (baseline model) that sensitivity testing for each of the input parameters was conducted. Sensitivity testing was conducted to determine the sensitivity of the model results to any uncertainty or changes in input values. In general, each of the variables tested was varied by both increasing and decreasing the baseline value by 10 % and the outcomes compared to the baseline scenario results. Exceptions were the following tested input values: maximum age (10, 11 years); inbreeding depression (removed from the model); maximum progeny per litter (5); catastrophe (removed); and carrying capacity (500, 600, 700). The results of the sensitivity analyses are outlined in Table 4.

Most of the analyses showed little difference in population measures in comparison to the baseline model. All scenarios resulted in a strong stochastic growth rates of at least r = 0.11. The parameters showing the greatest impact on the population were catastrophes (Table 4), the percent of adult females breeding each year and adult female mortality rates. These latter two parameters affect the reproductive potential and therefore potential growth rate for this polygynous species. The baseline values for these three variables were estimated from the data available but had not been specifically outlined or researched with adequate sample sizes. Additional research is required on these variables to better understand the population dynamics and the influence of various conservation actions on the population.

There was considerable discussion at the workshop around mortality factors and the degree of environmental variation (EV) in mortality rates. The baseline model set EV as 20 % of the mean rate (COV = 20 %); different degrees of EV were tested using COV = 30 % and COV = 40 % of the mean mortality rate. Greater variation in mortality rates resulted in modest impacts on the population over 100 years.

Table 4: Summary results obtained from sensitivity testing for the free ranging population with current levels of removal (at 100 years). Det r = deterministic r; stoch r = stochastic r; Mean N = mean population size; PE = probability of extinction; GD = gene diversity; Mean TE = mean time to extinction in years.

Scenario	Det r	Stoc r	Mean N	PE	GD	Mean TE
Baseline	**0.142**	**0.133**	**771**	**0**	**0.97**	**--**
With current removal levels	0.142	0.107	712	0.04	0.96	32
With half the current removal level	0.142	0.122	760	0	0.97	--
No inbreeding depression	0.142	0.136	772	0	0.97	--
No catastrophes	0.155	0.152	795	0	0.97	--
Maximum age = 11	0.139	0.131	767	0	0.97	--
Maximum age = 10	0.134	0.126	770	0	0.97	--
Max cubs per litter = 5	0.142	0.133	765	0	0.97	--
% female breed = 60.9 (10 % incr.)	0.161	0.151	770	0	0.97	--
% female breed = 49.9 (10 % decr.)	0.123	0.113	757	0	0.97	--
Female mort 0 - 1 (10 % incr.)	0.136	0.126	771	0	0.97	--
Female mort 0 - 1 (10 % decr.)	0.149	0.139	770	0	0.97	--
Female mort 1 - 2 (10 % incr.)	0.138	0.129	771	0	0.97	--
Female mort 1 - 2 (10 % decr.)	0.146	0.139	775	0	0.97	--
Female mort 2 - 3 (10 % incr.)	0.137	0.127	761	0	0.97	--
Female mort 2- 3 (10 % decr.)	0.148	0.139	770	0	0.97	--
Female mort adult (10 % incr.)	0.135	0.127	766	0	0.97	--
Female mort adult (10 % decr.)	0.150	0.141	777	0	0.97	--

Male mort 0 - 1 (10 % incr.)	0.142	0.133	766	0	0.97	--
Male mort 0 - 1 (10 % decr.)	0.142	0.134	772	0	0.97	--
Male mort 1 - 2 (10 % incr.)	0.142	0.133	770	0	0.97	--
Male mort 1 - 2 (10 % decr.)	0.142	0.135	773	0	0.97	--
Male mort 2 - 3 (10 % incr.)	0.142	0.133	766	0	0.97	--
Male mort 2 - 3 (10 % decr.)	0.142	0.133	772	0	0.97	--
Male mort adult (10 % incr.)	0.142	0.133	772	0	0.97	--
Male mort adult (10 % decr.)	0.142	0.134	773	0	0.97	--
EV on mortality COV = 30 %	0.142	0.133	762	0	0.97	--
EV on mortality COV = 40 %	0.142	0.132	751	0	0.97	--
K=700	0.142	0.132	670	0	0.97	--
K=600	0.142	0.132	572	0	0.96	--
K=500	0.142	0.132	479	0	0.95	--

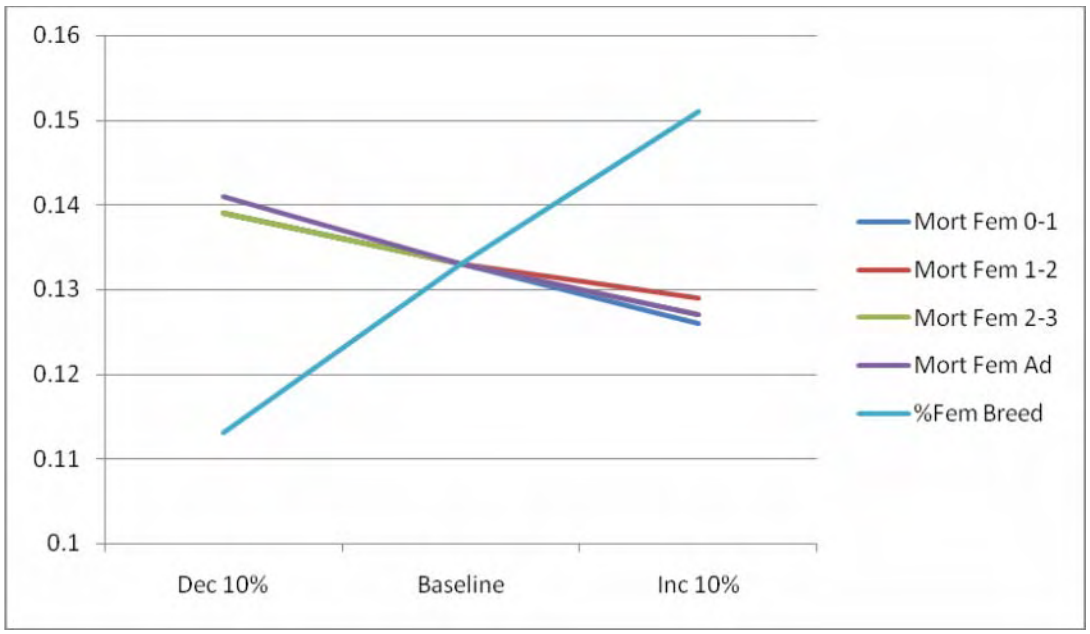


Figure 4: A comparison of stochastic r when comparing the baseline model to those variables that were most sensitive in the model, i.e. percent of adult females breeding and age-specific female mortality rates.

KRUGER NATIONAL PARK POPULATION

The population within Kruger, if modelled as a closed population, with no immigration or emigration, is stable near carrying capacity, with a stochastic growth rate of 0.077 (deterministic r = 0.093) and no risk of extinction over 100 years. The lower r compared to that observed for the free ranging population was expected due to the higher mortality rates experienced in Kruger as a result of Lions and other predators and was a defining attribute of the base demographic model. Although the model results suggest a substantial loss of gene diversity (GD = 85 %), realistically this population is in fact connected to other adjacent Cheetah populations and is not believed to be genetically isolated.

The parameters that were least well understood for the Kruger population were the percentage of adult females breeding (IBI), juvenile (first-year) mortality, and current population size and carrying capacity. Scenarios were run using a range of reasonable values for these variables for less optimal conditions in order to assess whether the model results may be too optimistic. Although lower percentages of females breeding lead to reductions in population growth (as expected), growth is still substantially positive (r $\geq$ 0.043) and extinction risk very low, suggesting that uncertainty in this parameter alone does not drastically alter model results (Table 5). Additional information on the percentage of females breeding should be obtained to improve the model.

It was assumed that juvenile mortality is about 50 % post-emergence from the lair, primarily due to Lion predation. Higher juvenile mortality rates (60 %) can be sustained with only modest decreases in population growth and size and little risk of extinction (Table 5). However, a juvenile mortality rate of 70 % results in population decline (r = -0.007) and a substantial probability of extinction over 100 years (PE = 0.31) (Fig. 6). Given the other demographic values used in the model, it appears that between a juvenile mortality rate of 60 % and 70 % the population starts to decline; hence it may be important to obtain an improved understanding of causes and rates of juvenile mortality.

Population estimates for the Cheetah population in Kruger National Park have been as low as around 100 individuals in recent years (although this number has been suggested to be an underestimate of the actual population size). A scenario with an initial population size of 100 and carrying capacity of 110 was run to assess the importance of population size on the long-term viability of this population. Population growth and extinction risk are relatively unaffected (Table 5). The smaller population size results in lower gene diversity; however, this is unlikely to be a realistic estimate of genetic variation, as this population is not believed to be a closed population as modelled.

Although harvesting scenarios were not explicitly run, the relatively strong population growth rate (about 8 % annual growth) under estimated demographic rates suggests that some removal of individuals from the population could be sustained. The impact of such removals would be dependent upon the number, age and sex of the individuals removed, the frequency of removal, the actual demographic rates of the Kruger Cheetah population, and the extent of movement of animals between Kruger and adjacent populations.

Table 5: Model results from sensitivity testing for the Kruger population (baseline scenario results in bold).

Scenario	Det r	Stoc r	Mean N	PE	GD	Mean TE
% female br = 68 (IBI = 18mo.)	**0.093**	**0.077**	**142**	**0.00**	**0.85**	**--**
% female br = 60 (IBI = 20mo.)	0.071	0.054	133	0.01	0.84	66
% female br = 55 (IBI = 22mo.)	0.057	0.043	125	0.01	0.84	65
Juvenile mortality = 50 %	**0.093**	**0.077**	**142**	**0.00**	**0.85**	**--**
Juvenile mortality = 60 %	0.054	0.043	126	0.01	0.84	66
Juvenile mortality = 70 %	0.005	-0.007	47	0.31	0.76	71
N (K) = 150 (160)	**0.093**	**0.077**	**142**	**0.00**	**0.85**	**--**
N (K) = 100 (110)	0.093	0.074	96	0.01	0.79	83

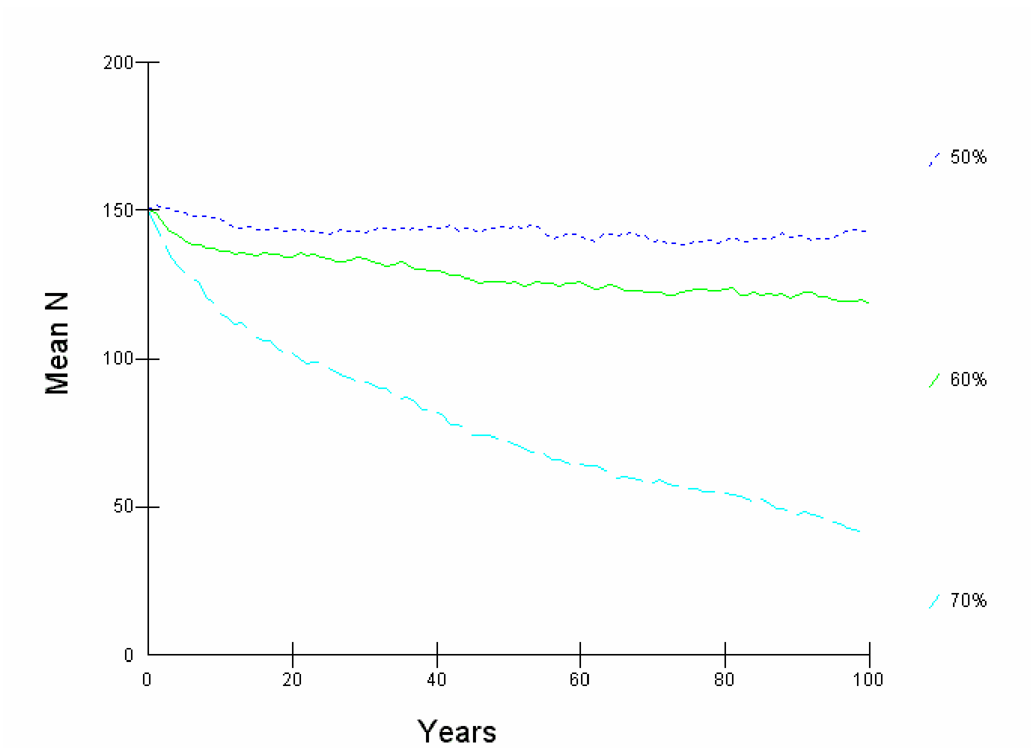


Figure 5: A comparison of models for the Kruger National Park population using varying juvenile mortality figures.

KALAHARI POPULATION

The results of a closed population model with no immigration or emigration suggests that the Kalahari population is not sustainable without a net flux of individuals from adjacent Cheetah populations (stochastic r = -0.013)(Table 6). This is not surprising, as this model was developed to simulate environmental conditions expected in an arid region. However, this population is not closed, but is contiguous with Cheetah populations in Botswana and possibly also Namibia. By including a supplementation of one unrelated adult pair of Cheetah per year, the population growth rate becomes positive and the population is sustainable demographically and genetically with no risk of extinction (Figure 6). We can assume that there is free movement between the South African Kalahari population and those in neighbouring countries and hence that the population is most likely stable. This suggests that, under the current assumptions of the model, the Kalahari population is dependent upon this connectivity for long-term viability, may potentially serve as a sink population to adjacent populations, and may not be a viable option as a source population for planned translocation activities. These conclusions also assume that environment conditions are more productive and therefore demographic rates are higher in the adjacent populations, allowing these populations to serve as source populations for the Kalahari. However, there may also be some movement from this population into Botswana and Namibia.

The primary changes to the demographic rates for the Kalahari model were the maximum litter size (from 6 to 5 cubs) and the percentage of adult females breeding annually (to 40 %), thought to be a result of low prey density (G. Mills, *pers. comm*.). The impact of the uncertainty of these two parameters was investigated through sensitivity testing across realistic values. Increasing maximum litter size to 6 cubs, the value used in all other Cheetah models at the PHVA, made little difference to the model results. Changes in the percentage of adult females breeding annually, on the other hand, produced substantially different results, as evidenced in the impacts on both deterministic and stochastic growth rates (Table 6). Other measures of population viability are less informative for this model, as they assume (unrealistically) a closed population. This result suggests that a better understanding of reproductive rates (average percentage of adult females breeding or average interbirth interval) is important to assessing the growth rate and viability of this population.

Table 6: Model results from sensitivity testing for the Kalahari population (baseline scenario results in bold).

Scenario	Det r	Stoc r	Mean N	PE	GD	Mean TE
Supplement 1 adult pair / year	0.002	0.027	71	0.00	0.96	--
Maximum litter size = 5	**0.002**	**-0.013**	**24**	**0.46**	**0.63**	**64**
Maximum litter size = 6	0.002	-0.011	24	0.42	0.60	65
% female br = 50 (IBI = 2yrs)	0.039	0.027	61	0.10	0.71	66
% female br = 40 (IBI = 2.5yrs)	**0.002**	**-0.013**	**24**	**0.46**	**0.63**	**64**
% female br = 33 (IBI = 3yrs.)	-0.029	-0.041	4	0.83	0.52	56

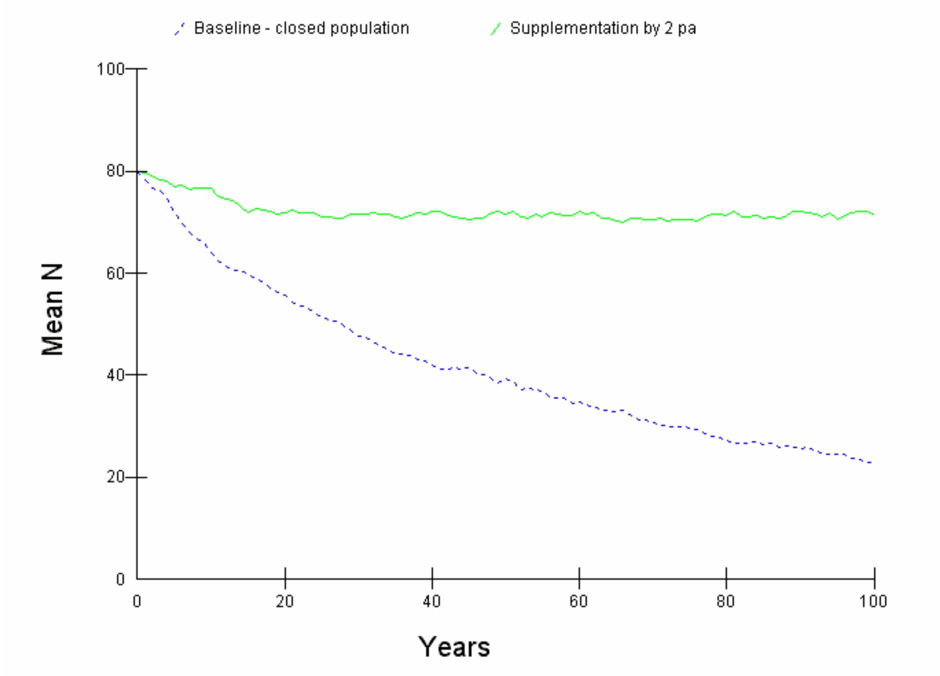


Figure 6: Model results for the Kalahari population assuming a closed population and under a supplementation schedule of one unrelated adult pair annually.

METAPOPULATION MODELLING (SMALL RESERVES)

This section addresses a modelling exercise designed purely to guide conservation action, and not to project the viability of any currently existing population or metapopulation. These scenarios explore the potential structure of a series of small subpopulations with potential management as a metapopulation. By varying several factors it is possible to quickly generate a large number of scenarios that can be run. For the purposes of this modelling exercise, several scenarios that vary four primary parameters were explored to act as a guide and are simplistic in their outline. They should provide a range within which decisions can be guided, but should be adapted and rerun as improved data are collected or alternative factors wish to be explored.

The free ranging population of Cheetah often comes into conflict with landowners in South Africa. Whether the Cheetah are actually involved in the killing of domestic stock or game, or are only perceived as a problem, a programme is currently in place to remove such problem animals from the point of conflict. These animals are then relocated to a safer closed environment, most often small in size. A number of reserves now house Cheetah from this programme, with each holding between 2 and 15 Cheetah. As these reserves are enclosed, there is no movement into or out of the areas and hence genetic inbreeding is of concern. In addition, most of these reserves do not have Lions and hence the stochastic growth rate is relatively high.

The modelling team was asked to provide guidance on the number of subpopulations (reserves), size of subpopulations, and rate of translocation required for a sustainable metapopulation. A sustainable metapopulation was defined as one that maintains at least 95 % gene diversity (expected heterozygosity) and has less than a 10 % risk of extinction over 50 years (about 8 generations).

Each of the subpopulations in essence represents a small reserve. Two environmental conditions were modelled – either with Lions or without Lions. The input variables for the reserves with Lions were taken from the Kruger model, with 68 % of females breeding and a mean litter size of 3.4 (EV = 0.4). The model for the subpopulations with no Lions was based on the free ranging population baseline model. This included the percentage of females breeding at 55.4 % with a mean litter size of 3.4 (EV = 0.4). The group felt, though, that the free ranging mortality rates were too high for reserves with no Lions and hence agreement was reached that the free ranging mortality rates be decreased by 10 % for the reserves with no Lions.

Mortality rates for reserves with no Lions:

Age Class	Female	Male
0-1	22.5	22.5
1-2	16.2	22.5
2-3	19.8	27
Adult	13.5	13.5

Models were developed for metapopulations consisting of 10, 15, 20 or 30 subpopulations. Within each of these, a series of models was constructed with 5, 10, 15 or 20 individuals in each subpopulation (initial population size). The carrying capacity was set at 1 greater than the population size (i.e. 6, 11. 16 and 21) to prevent truncation in *Vortex* when the carrying capacity was reached (in *Vortex*, the population is truncated to carrying capacity at the end of each year if it exceeds it).

Cheetah can reproduce quickly in small reserves, often necessitating some form of population control. In these models, this was accomplished by the periodic removal of 2-year-old subadults. In any year in which the subpopulation exceeded K (before truncation), two 2-year-old subadults (1 male, 1 female) were removed from the subpopulation. Individuals were only removed if at least one 2-year-old of the specified sex existed in the population.

In model scenarios that include translocation, the removed 2-year-olds were placed in a simulated "boma" (special population in *Vortex*) and were available for translocation to supplement other subpopulations. Survival during translocation was assumed to be 100 %. Any individuals remaining in the "boma" at the end of the year were subject to the same age- and sex-specific mortality rates as the rest of the population, but they were not allowed to reproduce.

In supplementation years (which was modelled every second year), a reserve that had a subpopulation below K gained 2 individuals (1 male and 1 female) from the boma, provided that such individuals were available. Selection of individuals was random with regard to genetic background or source subpopulation. Model results for the metapopulation excluded animals in the boma.

Results

Metapopulation with no Lions in the reserves and no translocation

Table 7: Overall metapopulation results for isolated reserves with no Lions (no translocations) [(r = stochastic growth rate; P[E] = probability of extinction; N = mean population size across all populations; Time [E] = mean time to extinction in years; GD = gene diversity (expected heterozygosity)]. Cells in green meet the working group's full definition of viability, blue cells have a less than 10 % risk of extinction and a gene diversity (expected heterozygosity) of greater than 90 %.

No of subpopulations		Subpopulation size			
		5	**10**	**15**	**20**
	10	r =-0.01 P[E] = 0.93 N = 0.4 Time[E] = 29 GD = 0.17	r = 0.008 P[E] = 0.02 N = 31 Time[E] = 44 GD = 0.75	r = 0.03 P[E] = 0 N = 102 Time[E] = n / a GD = 0.91	r = 0.03 P[E] = 0 N = 189 Time[E] = n / a GD = 0.94
	15	r = 0.072 P[E] = 0.90 N = 0.7 Time[E] = 33 GD = 0.20	r = 0.02 P[E] = 0.002 N = 46 Time[E] = 47 GD = 0.83	r = 0.03 P[E] = 0 N = 177 Time[E] = n / a GD = 0.94	r =0.04 P[E] = 0 N = 283 Time[E] = n / a GD = 0.94
	20	r = 0.08 P[E] = 0.91 N = 0.66 Time[E] = 36 GD = 0.25	r = 0.01 P[E] = 0 N = 61 Time[E] = n / a GD = 0.87	r =0.03 P[E] = 0 N = 237 Time[E] = n / a GD = 0.96	r = 0.03 P[E] = 0 N = 376 Time[E] = n / a GD = 0.97
	30	r = 0.04 P[E] = 0.77 N = 1.5 Time[E] = 38 GD = 0.22	r = 0.01 P[E] = 0 N = 94 Time[E] = n / a GD = 0.92	r = 0.03 P[E] = 0 N = 349 Time[E] = n / a GD = 0.97	

If a viable metapopulation is defined as one in which the probability of extinction is less than 10 % over 50 years with at least 95 % gene diversity retained, then the metapopulation must consist of at least 20 subpopulations with at least 15 individuals in each (green cells in Table 8). If, however, the minimum gene diversity criterion is lowered to 90 %, the metapopulation would require a minimum of 10 subpopulations with at least 15 Cheetah in each or 30 subpopulations with a minimum of 10 Cheetah each (blue cells). The yellow cells indicate scenarios in which extinction risk is acceptable but loss of gene diversity too high. These results indicate that the exact substructure of the population is important, and that sub population size has a greater effect than the number of populations due to the increased risk to small populations due to stochastic events, including inbreeding.

Metapopulation with Lions and no translocation

Table 8: Overall metapopulation results for isolated reserves with Lions (no translocations) (r = stochastic growth rate; P[E] = probability of extinction; N = mean population size across all populations; Time [E] = mean time to extinction in years; GD= gene diversity). Cells in green meet the working group's full definition of viability, blue cells have a less than 10 % risk of extinction and a gene diversity (expected heterozygosity) of greater than 90 %.

		Subpopulation size			
		5	**10**	**15**	**20**
No of subpopulations	**10**	r = -0.14 P[E] = 0.99 N = 0.1 Time[E] = 24 GD = 0.17	r = -0.05 P[E] = 0.37 N = 9 Time[E] = 40 GD = 0.52	r = -0.01 P[E] = 0.01 N = 46 Time[E] = 45 GD = 0.81	r = -0.002 P[E] = 0.002 N = 115 Time[E] = 50 GD = 0.92
	15	r =-0.13 P[E] = 0.99 N = 0.1 Time[E] = 27 GD = 0.29	r = -0.05 P[E] = 0.17 N = 14 Time[E] = 44 GD = 0.59	r = -0.01 P[E] = 0.002 N = 85 Time[E] = 49 GD = 0.90	r = 0.01 P[E] = 0 N = 171 Time[E] = n / a GD = 0.95
	20	r = -0.12 P[E] = 0.98 N = 0.1 Time[E] = 29 GD =0.21	r = -0.07 P[E] = 0.09 N = 18 Time[E] = 45 GD =0.66	r = -0.001 P[E] = 0 N = 114 Time[E] = n / a GD = 0.92	r = -0.005 P[E] = 0 N = 224 Time[E] = n / a GD = 0.96
	30	r = 0.01 P[E] = 0.97 N = 0.2 Time[E] = 31 GD =0.23	r = -0.04 P[E] = 0.04 N = 26 Time[E] = 46 GD =0.74	r = 0.01 P[E] = 0 N = 173 Time[E] = n / a GD = 0.95	

If a viable metapopulation is defined as one in which the probability of extinction is less than 10 % over 50 years with at least 95 % gene diversity retained, then the metapopulation must consist of at least 20 subpopulations with at least 20 individuals in each or at least 30 subpopulations with at least 15 individuals in each (green cells in Table 9). If, however, the minimum gene diversity criterion is lowered to 90 %, the metapopulation would require a minimum of 15 subpopulations with at least 15 Cheetah in each or 10 subpopulations with a minimum of 20 Cheetah each (blue cells). The yellow cells indicate scenarios in which extinction risk is acceptable but loss of gene diversity too high.

With Lions present in the reserves, bigger populations in each of the reserves is required to meet the objectives, but a greater number of reserves will contribute as well. There will also most likely be fewer individuals in the metapopulation if Lions are present, and the gene diversity will be slightly lower than if no Lions were present.

Metapopulation with no Lions and with translocations

Table 9: Overall metapopulation results for reserves with no Lions and with translocations every two years (r = stochastic growth rate; P[E] = probability of extinction; N = mean population size across all populations; Time [E] = mean time to extinction in years; GD = gene diversity). Cells in green meet the working group's full definition of viability, blue cells have a less than 10 % risk of extinction and a gene diversity (expected heterozygosity) of greater than 90 %.

No of subpopulations		Subpopulation size			
		5	**10**	**15**	**20**
	5	r = -0.01 P[E] = 0.90 N = 0.8 Time [E] = 28 GD = 0.26	r = 0.07 P[E] = 0.03 N = 32 Time [E] = 41 GD = 0.71	r = 0.11 P[E] = 0 N = 69 Time [E] = n / a GD = 0.85	r = 0.11 P[E] = 0 N = 99 Time [E] = n / a GD = 0.89
	10	r = 0.04 P[E] = 0.82 N = 1.6 Time [E] = 34 GD = 0.40	r = 0.09 P[E] = 0 N = 66 Time [E] = n / a GD = 0.85	r = 0.12 P[E] = 0 N = 141 Time [E] = n / a GD = 0.92	r = 0.13 P[E] = 0 N = 208 Time [E] = n / a GD = 0.95
	15	r = 0.06 P[E] = 0.81 N = 1.4 Time [E] = 36 GD = 0.26	r = 0.10 P[E] = 0 N = 65 Time [E] = n / a GD = 0.86	r = 0.13 P [E] = 0 N = 194 Time [E] = n / a GD = 0.94	r = 0.14 P[E] = 0 N = 282 Time [E] = n / a GD = 0.96
	20	r = 0.07 P[E] = 0.75 N = 1.9 Time [E] = 37 GD = 0.36	r =0.10 P[E] = 0 N = 85 Time [E] = n / a GD = 0.90	r = 0.13 P[E] = 0 N = 259 Time [E] = n / a GD = 0.96	r = 0.14 P[E] = 0 N = 379 Time [E] = n / a GD = 0.97
	30	r = 0.08 P[E] = 0.66 N = 2.6 Time [E] = 40 GD = 0.35	r = 0.10 P[E] = 0 N = 127 Time [E] = n / a GD = 0.93	r = 0.13 P[E] = 0 N = 385 Time [E] = n / a GD = 0.97	

If a viable metapopulation is defined as one in which the probability of extinction is less than 10 % over 50 years with at least 95 % gene diversity retained, then the metapopulation must consist of at least 10 subpopulations with at least 10 individuals in each or at least 20 subpopulations with at least 15 individuals in each (green cells in Table 10). If, however, the minimum gene diversity criterion is lowered to 90 %, the metapopulation would require a minimum of 15 subpopulations with at least 10 Cheetah in each or 20 subpopulations with a minimum of 20 Cheetah each (blue cells). The yellow cells indicate scenarios in which extinction risk is acceptable but loss of gene diversity too high.

In comparison to the metapopulation with no translocation, but also with Lions, each reserve still requires at least 15 individuals but fewer reserves are required to maintain viability. Also, the metapopulation size is slighter higher when translocations are included and approaches carrying capacity. This is not too surprising as animals involved in the translocations are maintained in the population and, for this model, are sexually active and ready to breed when released into a reserve that drops below carrying capacity. Although reserves loose 2 year olds when they exceed carrying capacity, they gain back 2 year olds whenever they drop below carrying capacity again – which serves to maintain the age structure and breeding potential of the metapopulation.

Metapopulation with Lions and with translocations

Table 10: Overall metapopulation results for reserves with Lions and with translocations in the form of supplementing 2 individuals every second year (r = stochastic growth rate; P[E] = probability of extinction; N = mean population size across all populations; Time [E] = mean time to extinction in years; GD = gene diversity). Cells in green meet the working group's full definition of viability, blue cells have a less than 10 % risk of extinction and a gene diversity (expected heterozygosity) of greater than 90 %.

No of subpopulations		Subpopulation size			
		5	**10**	**15**	**20**
	10	r = -0.03 P[E] =0.97 N = 0.2 Time[E] = 27 GD = 0.22	r = 0.02 P[E] = 0.12 N = 20 Time[E] = 42 GD = 0.66	r = 0.06 P[E] = 0 N = 81 Time[E] = n / a GD = 0.88	r = 0.07 P[E] = 0 N = 145 Time[E] = n / a GD =0.93
	15	r = -0.03 P[E] = 0.96 N = 0.3 Time[E] = 30 GD = 0.27	r = 0.03 P[E] = 0.06 N = 30 Time[E] = 45 GD =0.75	r = 0.06 P[E] = 0 N = 122 Time[E] = n / a GD = 0.92	r = 0.08 P[E] = 0 N = 218 Time[E] = n / a GD = 0.95
	20	r = -0.03 P[E] = 0.95 N = 0.3 Time[E] = 32 GD = 0.27	r = 0.03 P[E] = 0.02 N = 41 Time[E] = 46 GD =0.81	r = 0.06 P[E] = 0 N = 160 Time[E] = n / a GD = 0.94	r = 0.08 P[E] = 0 N = 293 Time[E] = n / a GD =0.97
	30	r = -0.03 P[E] = 0.86 N = 1 Time[E] = 35 GD = 0.40	r = 0.4 P[E] = 0.002 N = 64 Time[E] = 48 GD = 0.88	r = 0.07 P[E] = 0 N = 262 Time[E] = n / a GD = 0.96	r = 0.08 P[E] = 0 N = 477 Time [E] = n / a GD = 0.98

If a viable metapopulation is defined as one in which the probability of extinction is less than 10 % over 50 years with at least 95 % gene diversity retained, then the metapopulation must consist of at least 15 subpopulations with at least 20 individuals in each or at least 30 subpopulations with at least 15 individuals in each (green cells in Table 10). If, however, the minimum gene diversity criterion is lowered to 90 %, the metapopulation would require a minimum of 15 subpopulations with at least 15 Cheetah in each or 20 subpopulations with a minimum of 20 Cheetah each (blue cells). The yellow cells indicate scenarios in which extinction risk is acceptable but loss of gene diversity too high. Orange cells indicate options that neither meet neither the gene diversity nor the probability of extinction criteria. In effect, if Lions are present, a minimum sub population size of 10 is required if translocations happen every second year.

Annual supplementations were also tested to see the effect (Table 11). This however, may not be practical or may be too resource intensive. The outcomes of the model were for annual translocations were almost always the same as that for translocations every second year, with only minimal differences. The only consistent difference between the two scenarios was the slightly better gene diversity (expected heterozygosity) with annual translocations between reserves that had a carrying capacity of only 5 each. However, the sustainability of these scenarios remained unviable. It can therefore be assumed that annual translocations will have no additional benefit to the metapopulation, and added to the increased time and financial implications involved, would not be recommended.

Table 11: Overall metapopulation results for reserves with Lions and with translocations in the form of supplementing 2 individuals annually (r = stochastic growth rate; P[E] = probability of extinction; N = mean population size across all populations; Time [E] = mean time to extinction in years; GD = gene diversity). Cells in green meet the working group's full definition of viability, blue cells have a less than 10 % risk of extinction and a gene diversity (expected heterozygosity) of greater than 90 %.

No of subpopulations		Subpopulation size			
		5	**10**	**15**	**20**
	10	r = -0.03 P[E] = 0.98 N = 0.2 Time[E] = 27 GD = 0.29	r = 0.02 P[E] = 0.13 N = 14 Time[E] = 42 GD = 0.65	r = 0.06 P[E] = 0 N = 82 Time[E] = n / a GD = 0.88	r = 0.07 P[E] = 0 N = 145 Time[E] = n / a GD = 0.93
	15	r = -0.03 P[E] = 0.95 N = 0.4 Time[E] = 30 GD = 0.30	r = 0.03 P[E] = 0.04 N = 31 Time[E] = 45 GD = 0.74	r = 0.06 P[E] = 0 N = 121 Time[E] =n / a GD = 0.92	r = 0.08 P[E] = 0 N = 219 Time[E] = n / a GD = 0.95
	20	r =-0.03 P[E] = 0.94 N = 0.4 Time[E] = 33 GD = 0.36	r = 0.03 P[E] = 0.01 N = 40 Time[E] = 43 GD = 0.80	r = 0.07 P[E] = 0 N = 161 Time[E] = n / a GD = 0.94	r = 0.08 P[E] = 0 N = 289 Time[E] = n / a GD = 0.96
	30	r = -0.03 P[E] = 0.88 N = 1 Time[E] = 35 GD = 0.42	r = 0.04 P[E] = 0.004 N = 63 Time[E] = 47 GD = 0.87	r = 0.07 P[E] = 0 N = 264 Time[E] =n / a GD = 0.96	r = 0.08 P[E] = 0 N = 479 Time [E] = n / a GD = 0.98

Summary of Metapopulation Results

Fewer subpopulations and fewer individuals per population are required for a metapopulation in reserves where no Lions are present and in reserves that are supplemented rather than isolated. Population structure affects viability, given the same number of animals, with population size having a greater impact than number of subpopulations (i.e., it is better to have fewer large subpopulations rather than many very small ones). Retaining individuals in the metapopulation through translocation to other subpopulations increases viability and reduces the number of individuals and subpopulations needed to meet viability criteria. The frequency of supplementation needed will depend on the number of subpopulations and the number of individuals in each. The minimum size and number of subpopulations and the minimum frequency of supplementation required will depend upon the specific viability criteria imposed and the presence or absence of Lions. A metapopulation containing reserves with 5 individuals were under no circumstances viable.

Cautions

- The impact of contraception as a method to control population growth was not evaluated in the metapopulation models and may influence the results.
- All models assume that initial populations consisted of all unrelated individuals. This is not the case, particularly in historically small populations; therefore, the relatedness of individuals (and therefore the impact of inbreeding depression) is likely underestimated.
- All model results are dependent upon the demographic rates, population sizes, and other conditions in the model, and are subject to error if actual conditions are substantially different. It is recommended that these models be updated as new and more accurate data estimates are available.

Bibliography and References

Berry, H., Forge, O., Marker-Kraus, L., Nowell, K. and Seal, U.S. 1996. Namibian Cheetah Population and Habitat Viability Assessment. In: Population and Habitat Viability Assessment for the Namibian Cheetah (*Acinonyx jubatus*) and Lion (*Panthera leo*). Apple Valley, MN: Conservation Breeding Specialist Group (IUCN / SSC).

Bothma, J. du P. and Walker, C. 1999. Larger carnivores of the African savannahs. J.L. van Schaik Publishers, Pretoria. 277 pp.

Brooks, B.W., O'Grady, J.J. Chapman, A.P. Burgman, M.A. Akcakaya H.R. and Frankham, R. 2000. Predictive accuracy of population viability analysis in conservation biology. Nature 404:385 - 387.

Broomhall, L.S. 2001. Cheetah *Acinonyx jubatus* in the Kruger National Park: a comparison with other studies across the grassland-woodland gradient in African savannas. Pretoria, South Africa: Department of Zoology and Entomology, University of Pretoria.

Durant, S.M., Kelly, M. and Caro, T.M. 2004. Factors affecting life and death in Serengeti Cheetah: environment, age, and sociality. Behavioral Ecology Vol. 15 No. 1: 11 – 22.

Gottelli, D., Wang, J., Bashir, S and Durant, S.M. 2007. Genetic analysis reveals promiscuity among female Cheetah. In: Proceedings of the Royal Society B. 274: 1993 – 2001.

O'Grady, J.J., Brook, B.W., Reed, D.H, Ballou, J.D, Tonkyn, D.W and Frankham, R. 2006 Realistic levels of inbreeding depression strongly affect extinction risk in the wild populations. Biological Conservation 133: 42 – 51.

Hunter L. 1999. Large felid restoration: Lessons from the Phinda Resource Reserve, South Africa, 1992-1999. Cat News. pp. 20 - 21.

Johnson, S., Mengersen, K., de Waal, A., Marnewick, K., Cilliers, D., Houser, A. and Boast, L. in prep. An Iterative Bayesian Network Development Cycle for modelling Cheetah relocation success in southern Africa. Submitted to: Ecological Modelling.

Kelly, M.J, Laurenson, M.K, FitzGibbon, C.D., Collins, D.A, Durant, S.M. Frame, G.W, Bertram, B.C.R and Caro, T.M. 1998. Demography of the Serengeti Cheetah (*Acinonyx jubatus*) population: the first 25 years. J. Zool., Lond. 244: 473 - 488.

Lacy, R.C. 1993. Vortex: A computer simulation model for population viability analysis. Wildlife Research 20:45-65.

Lacy, R.C. 2000. Structure of the Vortex simulation model for population viability analysis. Ecological Bulletins 48:191 - 203.

Laurenson, M. K. 1994. High juvenile mortality in Cheetah (*Acinonyx jubatus*) and its consequence for maternal care. Journal of Zoology 234:387 - 408.

Laurenson M.K., Caro T.M. and Borner M. 1992. Female Cheetah reproduction. National Geographic Research and Exploration 8(1):64 - 75.

Laurenson, M.K., Wielebnowski, N. and Caro, TM. 1995. Extrinsic factors and juvenile mortality in cheetahs. Conservation Biology 9(5): 1329 - 1331.

Marker, L.L., Dickman, A.J., Jeo, R.M., Mills, M.G.L. and Macdonald, D.W. 2003. Demography of the Namibian Cheetah, *Acinonyx jubatus jubatus*. Biological Conservation 114, 413 - 425.

Marker, L. 2008. International Cheetah Studbook.

Marker, L.l., Dickman, A.J., Jeo, R.M., Mills, M.G.L. and Macdonald, D.W. 2003. Demography of the Namibian Cheetah, *Acinonyx jubatus jubatus*. Biological Conservation 114: 413 - 425.

Marnewick, K., Haywards, M., Cilliers, D. and Somers, M. 2009. Survival of Cheetah relocated from ranchland to fenced protected areas in South Africa. Chapter 13 in Reintroduction of Top-Order Predators, 1st edition. M. Hayward and M. Somers (Eds.), Wiley-Blackwell, London.

Miller, P.S. and R.C. Lacy. 2005. Vortex: A Stochastic Simulation of the Extinction Process. Version 9.50 User’s Manual. Apple Valley, MN: Conservation Breeding Specialist Group (SSC / IUCN).

O’Grady, J.J., B.W. Brook, D.H. Reed, J.D. Ballou, D.W. Tonkyn, and R. Frankham. 2006. Realistic levels of inbreeding depression strongly affect extinction risk in wild populations. Biological Conservation 133:42 - 51.

Ralls, K.R., J.D. Ballou and A. Templeton. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. Conservation Biology 2(2):185 - 193.

Reed, D.H., J.J. O'Grady, J.D. Ballou and R. Frankham. 2003. Frequency and severity of catastrophic die-offs in vertebrates. Animal Conservation 6:109 - 114.

Skinner, J.D. and Smithers, R.H.N. 1990. The mammals of the southern African subregion. University of Pretoria, Pretoria, South Africa.

Wielebnowski, N. 1996. Reassessing the relationship between juvenile mortality and genetic monomorphism in captive Cheetah. Zoo Biology 15: 353 - 369.

List of Acronyms

DEAT	Department of Environmental Affairs and Tourism (now Department of Water and Environmental Affairs)
CBSG	Conservation Breeding Specialist Group
CITES	Convention on International Trade in Endangered Species
EWT	Endangered Wildlife Trust
FRP	Free-ranging population
IBI	Interbirth interval
IUCN	International Union for the Conservation of Nature
KNP	Kruger National Park
KZN	KwaZulu-Natal
NCAP	National Conservation Action Planning Workshop
NCCF	National Cheetah Conservation Forum
NEMBA	National Environmental Management Biodiversity Act
NGO	Non-Government Organisation
NWP	North West Province
NZG	National Zoological Gardens of South Africa
SANParks	South Africa National Parks
SSC	Species Survival Commission
TOPS	Threatened or Protected Species
WAG-SA	Wild Dog Advisory Group of South Africa

CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

De Beers Venetia Limpopo Nature Reserve, South Africa

WORKSHOP REPORT

SECTION 4

APPENDICES

Appendix 1: Operational Framework for a Managed Cheetah Metapopulation in South Africa

Authors: Lindsey, P., Cilliers, D., Davies-Mostert, H. and Marnewick, K.

1. INTRODUCTION

1.1. List of acronyms

Acronym	Meaning
CBSG	Conservation Breeding Specialist Group
DEAT	Department of the Environment And Tourism
IUCN	International Union for the Conservation of Nature
KTP	Kgalagadi Transfrontier Park
KZN	Kwa-Zulu Natal
MOU	Memorandum of Understanding
NCAP	National Conservation Action Planning
NCCF-SA	National Cheetah Conservation Forum of South Africa
NEMBA	National Environmental Management Biodiversity Act
NP	National Park
NZG	National Zoological Gardens
PHVA	Population and Habitat Viability Assessment
TOPS	Threatened or Protected Species
UNEP	United Nations Environment Programme
WAG-SA	Wild dog Advisory Group South Africa
WCS	Wildlife Conservation Society
ZSL	Zoological Society of London

1.2. Glossary

IUCN Red Data List - a list providing information on a species risk of extinction (usually by taxonomic group) published by the International Union for the Conservation of Nature.

Metapopulation - a metapopulation can be defined as series of unstable, local subpopulations inhabiting discrete habitat patches, connected by migration (Levins 1969; Hanski 1998).

Sub-species - a taxonomic subdivision of a species consisting of an interbreeding, usually geographically isolated population of organisms.

Species - a kind of animal, plant or other organism that does not normally interbreed with individuals of another species, and includes any sub-species, cultivar, variety, geographic race, strain, hybrid or geographically separate population.

Stakeholder - a natural or juristic person(s) that have an interest in a particular decision, either as individuals or representatives of a group.

Stochastic events – those with a random, unpredictable element without pattern or order.

Subpopulation – for the purposes of this document, the term subpopulation refers to a population of Cheetah contained within a fenced reserve, connected to the wider metapopulation through translocation.

Threat - any human action that causes a decline and compromises the future survival of a species or anything that has a detrimental effect on a species.

1.3. Acknowledgement

We extend thanks to the Conservation Breeding Specialist Group (CBSG) of the IUCN for the provision of expertise that made the Population and Habitat Viability Assessment (PHVA) Workshop and associated metapopulation modelling possible. Thank you to the Wildlife Conservation Society, the Zoological Society of London and the IUCN for their role in guiding the regional conservation strategy for Cheetah. This acted as the basis for the development of the metapopulation management plan as part of the national conservation strategy for Cheetah in South Africa. Thanks to all participants at the PHVA workshop and to De Beers Consolidated Mines Ecology Division for hosting the event. Particular thanks go to Gus Mills, Netty Purchase and Charlene Bisset who provided invaluable comments on preliminary drafts of this document. The document was subsequently circulated to invitees to the National Conservation Action Planning workshop for Cheetah and Wild Dogs. Valuable input was subsequently received from Pete Goodman, Penny Spiering, Rynette Coetzee and Magdel Boshoff, for which we are grateful. Thanks to the Department of Water and Environmental Affairs for providing insights into the protocol regarding incorporating this document into a Biodiversity Management Plan for Species. Finally, thanks to the Howard G. Buffett Foundation for providing funds through the African Cheetah Initiative to support the PHVA workshop and compilation of this document.

Cheetah were first reintroduced as part of a metapopulation process several years ago as part of a National Cheetah Conservation Forum (NCCF) programme, implemented by the De Wildt Cheetah and Wildlife Trust. This work was made possible through support from a number of donors including the Howard G. Buffett Foundation, the Cincinnati Zoo (Angel Fund), Columbus Zoo, Scoville Zoo, Miami Metro Zoo, Carson Springs Wildlife Foundation, Duemke Family Trust and Sasol-Chevron. They are thanked for their ongoing support, which made the relocation programme possible.

2. EXECUTIVE SUMMARY

This document presents a strategy for the development and coordinated management of a national metapopulation of Cheetah in South Africa.

Cheetah are listed as Vulnerable by the IUCN's Red Data Book of Mammals (Bauer *et al.* 2008), and by the South African Threatened and Protected Species (TOPS) regulations (DWEA 2006). The Red Data Book of the mammals of South Africa: a conservation assessment (Friedman *et al.* 2002) lists the Cheetah as vulnerable due to persecution and illegal trade.

The unregulated and uncoordinated reintroduction of Cheetah into small and medium sized fenced protected areas by private individuals poses a significant conservation threat to Cheetah in South Africa due to:

- The risk of mixing of sub-species of Cheetah

- The risk of inbreeding due to the small size of reintroduced populations and lack of monitoring of the relatedness of founders
- Potential impacts on free ranging populations due to the sourcing of Cheetah from ranchlands for reintroductions

During a PHVA workshop for Cheetah in South Africa held in April 2009, the decision was taken by the stakeholders present to manage the current population of reintroduced Cheetah as a metapopulation overseen by an advisory body of experts to avoid these problems and maximise conservation value of reintroduced Cheetah.

At the PHVA workshop, modelling was conducted to estimate the size and structure of the metapopulation necessary to achieve viability, defined as:

The scenario whereby gene diversity (expected heterozygosity) is maintained at 90-95 % of the overall wild population over a period of 50 years through management interventions spaced not less than 2 years (18 - 24 months) apart on average, except if dictated by catastrophes or demographic stochasticity

Based on conservative estimates of the effective population size of Cheetah within small to medium sized fenced reserves, there are not presently enough subpopulations of sufficient size to achieve 90 % heterozygosity of the overall wild population within 50 years. Key targets for the development of the metapopulation are to:

i) have all reserves with Cheetah to buy-in to and adhere to the metapopulation management plan by 2011, and
ii) have enough subpopulations of sufficient size to achieve viability at the 95 % heterozygosity level by 2019.

Within this national framework, provinces will be expected to develop strategic plans with which to maximise their contribution to the South African metapopulation of Cheetah.

To qualify for participation in the metapopulation, participants at the PHVA workshop agreed that reserves with Cheetah should fulfil the following basic criteria:

- Both adult male and adult female Cheetah must be present in the reserve or there must be the intention to have both sexes present within six months where attainable
- Offspring should not be removed from their parents before the age at which they would naturally disperse (though in some cases it may be necessary to capture or collar animals shortly before dispersal age for ease of management)
- Cheetah must be allowed to hunt for themselves
- Cheetah must not be prevented from reproducing unless the recommended population threshold for that reserve has been exceeded (except in cases where temporary contraception is desired to enable females to acclimate to their new surroundings for a period before breeding)
- Reserve owners / managers must be willing to:
    - Participate in the metapopulation management process;
    - Make Cheetah available for translocation to other metapopulation reserves when possible and as is necessary, and receive Cheetah as deemed necessary following consultation between the reserve manager and the advisory group

- Maintain their fences to the standard required to contain Cheetah effectively
- Cover the costs of translocations of Cheetah into their reserve and subsequent housing of Cheetah for reintroduction in pre-release bomas if donor funds are not available
- Assist with the process of capture and translocation of Cheetah from their reserve to other reserves when necessary
- Monitor their subpopulation of Cheetah effectively and report findings to the advisory body
- Keep and regularly submit records on the demography, genetics and pedigrees of Cheetah in their subpopulation
- Submit DNA samples to a central DNA database / databank

All reserves within the metapopulation will have equal status and will be provided with official recognition of their participation in the metapopulation conservation strategy. Population Management 2000 (PM2000) software (Lacy and Ballou 2002) will be used as a tool to assist with guiding translocations of Cheetah among reserves, and identifying individual animals to move based on pedigree data (submitted by metapopulation reserves, and managed by the National Zoological Gardens).

To be considered as a reintroduction site for expansion of the metapopulation, a reserve / reserve owner must fulfil the following criteria:

- Be willing to participate in the metapopulation management plan
- Be willing to follow the metapopulation reintroduction protocol
- The reserve must have potential to house a breeding population of Cheetah (i.e. a minimum of one pair plus up to six cubs)
- The reserve must have necessary infrastructure (i.e. predator-proof fencing and pre-release bomas, monitoring systems etc)
- The reserve must comply with provincial legislation / guidelines for fencing specifications
- Reserve owner / manager must obtain written approval from neighbouring landowners prior to the reintroduction
- Reserve owners must be willing to monitor Cheetah post-release and report findings to the advisory body

Reserves for future Cheetah reintroductions will be prioritised by the advisory body based on the following criteria:

- Category of reserve (i.e. state-owned protected area, private reserve, in that order)
- Reserve size and / or potential for expansion (larger reserves gaining preference)
- Reserves in biomes currently under-represented in the Cheetah distribution range (but within the historic range) will be given preference
- Reserves outside of the current range of overall wild Cheetah (within historic range) will be prioritised
- Reserve owners / managers with a past record of participating in conservation processes will be granted priority

The process of identifying reserves for expansion of the metapopulation will commence immediately and will be ongoing. Due to the large size of the existing reintroduced population, founder animals for future reintroductions should be sourced from other subpopulations within the metapopulation, and not from free-ranging populations of Cheetah. Under no circumstances should Cheetah from overall wild populations enter captive populations.

3. BACKGROUND INFORMATION

3.1. Conservation and legislative context

3.2.1. International legislation

Cheetah are considered to be 'Vulnerable' by the IUCN and are listed on CITES Appendix I (Bauer *et al*. 2008). South Africa does not have an export quota for Cheetah hunting trophies, though some animals are exported illegally. Cheetah were listed on Appendix I of the United Nations Environment Programme's Convention on the Conservation of Migratory Species of Wild Animals during the latest meeting, held in Rome in December 2008. South Africa is a signatory to both CITES and the convention on the conservation of migratory species.

3.2.2. National legislation

The management and utilization of Cheetah and Wild Dogs is governed by the National Environmental Management: Biodiversity Act (Act No. 10 of 2004) (NEMBA) and by the Threatened or Protected Species (TOPS) regulations (Table 1). According to the TOPS regulations, Cheetah are listed as being 'Vulnerable' and Wild Dogs as 'Endangered'. TOPS regulations control hunting and captive breeding of species listed as threatened or endangered, including Cheetah and Wild Dogs.

3.2.3. Provincial legislation

Provincial legislation is summarized in Table 1.

Table 1: Summary of South African national and provincial legislation pertaining to Cheetah

National	**Western Cape**	**North West**	**Mpumalanga**	**Northern Cape**	**Limpopo**	**Gauteng**	**Free State**	**KZN**	**Eastern Cape**
Listed as a Vulnerable species in terms of TOPS	Listed as an Endangered Wild Animal in terms of the Western Cape Nature Conservation Laws Amendment Act, 3 of 2000	Listed as a Protected Wild animals (Schedule 4) Section 15 (1)(c)) in terms of the Transvaal Nature Conservation Ordinance 12 of 1983	Listed as a Protected Wild Animals (Schedule 4) Section 4 (1) (d) in terms of the Mpumalanga Nature Conservation Act, 10 of 1998	Listed as an Endangered Wild Animal in terms of the Nature and Environmental Conservation Ordinance, 19 of 1974	Listed as a Protected Wild Animal, as well as an animal to which section 31 (1) (f) applies, in terms of the Limpopo Environmental Management Act, 7 of 2003	Listed as a Protected Wild animals (Schedule 4) Section 15 (1)(c)) in terms of the Nature Conservation Ordinance, 12 of 1983	Not listed in terms of the Nature Conservation Ordinance, 8 of 1969	Listed as Specially Protected Game in terms of the Nature Conservation Ordinance, 15 of 1974	Listed as an Endangered Wild Animal in terms of the Cape Nature and Environmental Conservation Ordinance, 19 of 1974

3.2. The distribution and status of Cheetah in South Africa

Historically, Cheetah were distributed throughout South Africa in all suitable habitats (Marker 1998). However, the current range comprises a small fraction of the historical distribution (Marnewick *et al*. 2007). The South African *in-situ* Cheetah population is estimated to be approximately 550 individuals (Bauer *et al*. 2008). Cheetah currently occur in three scenarios (Marnewick *et al*. 2007) as follows:

3.2.1. Free-ranging Cheetah occurring on ranchland

The majority of Cheetah in South Africa occur outside of protected areas. The extent of Cheetah distribution appears to have increased during recent years due to the shift from livestock to wildlife ranching and an increase in tolerance of Cheetah among wildlife ranchers (Marnewick *et al*. 2007). South Africa's free ranging Cheetah population is contiguous with populations in Botswana and Zimbabwe.

3.2.2. Cheetah in large protected areas

The two largest protected areas in South Africa, Kruger National Park and the South African portion of the Kgalagadi Transfrontier Park (KTP), contain significant populations of Cheetah. Several estimates of the number of Cheetah in Kruger National Park have been made, including: 219 individuals (Pienaar 1963); 172 (Bowland and Mills 1994); and, 103 (Kemp and Mills 2005). The 2005 population estimate of 103 individuals (Kemp and Mills, 2005) may represent an under-estimate due to the short duration of the study. Preliminary analysis of the 2009 data suggests a population of ~135 individuals in Kruger.

A photographic survey conducted during the late 1990s suggested that approximately 80 Cheetah occur in the South African portion of the KTP (Knight 1999).

3.2.3. Cheetah that have been reintroduced or occur naturally in small to medium sized reserves

Cheetah have been reintroduced into 37 reserves, including five state-owned parks and 32 privately owned parks. In addition, Cheetah occur naturally in two state owned parks (Marakele National Park and Hluhluwe-iMfolozi Park) and one private reserve (Thaba Tholo) which are now surrounded by predator-proof fencing (Table 2). Together, a population of ~281 Cheetah occurs in fenced small to medium sized reserves in South Africa. It is expected that some Cheetah have been relocated to other smaller conservation areas / reserves for which information is not available. These reserves are all adequately fenced and Cheetah cannot easily disperse or escape. Cheetah reintroductions have generally been done to exploit the value of the species for ecotourism.

3.3. Threats facing Cheetah in South Africa

The primary threats to free ranging Cheetah populations in South Africa are killings by ranchers, the illegal capture of free ranging Cheetah for sale to captive breeding facilities and legal capture for reintroduction into fenced reserves (Marnewick *et al.* 2007).

3.3.1. Killing of Cheetah

Killing of Cheetah on cattle and wildlife ranchlands due to conflict over livestock or valuable wildlife species appears to be a severe threat to Cheetah populations occurring outside protected areas. A questionnaire survey in the Thabazimbi district of South Africa suggested that at least 26 Cheetah were killed by ranchers in the area during 1999-2005 (Marnewick *et al*. 2007). In the Lephalale (Limpopo), Vhembe (Limpopo), and Bray (North West) areas, 48.6 %, 34.4 %, and 88 % of ranchers respectively consider Cheetah to be a liability (Marnewick *et al.* 2007). In the Bray area 50 % of ranchers admitted to having removed Cheetah from their property (either through lethal control or capture and live sale). Accurate records regarding retaliatory killings are not available due to the fact that ranchers are reluctant to divulge such information. At the PHVA meeting it was estimated that a minimum of 60 Cheetah per year are killed on ranchland.

3.3.2. Illegal trade in Cheetah

The illegal capture of wild, free ranging Cheetah for sale to captive breeding institutions and wildlife traders is also believed to represent a significant threat to populations in South Africa (Marnewick *et al.* 2007). The presence of a microchip is the only proof required for Cheetah to be considered to be ‘captive-bred’ for export (Marnewick *et al.* 2007). Wild Cheetah are frequently captured, micro-chipped and claimed to be captive bred animals, enabling the ‘owner’ to obtain a CITES permit for the sale and export of the animals to overseas captive breeding facilities (Marnewick *et al.* 2007). Cheetah are also captured in neighbouring Botswana and Namibia and illegally imported into South Africa for sale to captive breeding facilities, or re-export to overseas zoos and safari parks (Marnewick *et al*. 2007). Conversely, free ranging Cheetah are also captured in South Africa, sold and exported illegally to Namibia to ‘canned hunting’ facilities where they are hunted in small fenced camps, taking advantage of Namibia’s CITES quota for trophy-hunted Cheetah (Marnewick *et al.* 2007). Approximately 60 wild Cheetah are illegally captured from ranchland in South Africa each year (Marnewick *et al.* 2007). During 1996-2005, 428 Cheetah were exported from South Africa, 93 % of which were listed as being of ‘captive’ origin (Marnewick *et al.* 2007). The rate of export appears to be increasing, and now approximately 50 Cheetah are exported from South Africa per year (Marnewick *et al.* 2007).

3.3.3. Uncoordinated reintroduction of Cheetah

Lack of coordinated management of reintroduced populations limits the conservation value of reintroduction programmes, introduces the risk of genetic problems and potentially threatens free-ranging Cheetah occurring on ranchland. Most reserves into which Cheetah have been reintroduced are relatively small (mean 228.5 ± 38.4 km^2, range 10-1,000 km^2, n=40) and support small populations of Cheetah (mean 7.20 ± 1.27 individuals, range 1-42), which are not viable in isolation (Table 2). As a result without active and coordinated management, there is a risk that genetic variability and local genetic adaptations will be compromised.

Relocating Cheetah from ranchland to fenced protected areas has been seen as a short-term solution for resolving conflict between Cheetah and landowners. However, Vortex modelling indicates that depending on the levels of mortality factors such as killing of Cheetah by ranchers, such Cheetah removals could threaten the viability of free-ranging populations. Due to the large numbers of Cheetah available within the metapopulation, there is no need to use wild-sourced Cheetah for reintroduction.

4. MOTIVATION FOR THE METAPOPULATION MANAGEMENT PLAN

4.1. Metapopulation management

A metapopulation can be defined as a series of unstable, local subpopulations inhabiting discrete habitat patches, connected by migration (Levins 1969; Hanski 1998). Persistence of a metapopulation is dependent on the rate of local extinction of subpopulations in habitat patches being equalled or exceeded by the re-colonization of those habitat patches, or initial colonization of new habitat patches (Hanski 1998). In the context of Cheetah conservation in South Africa, habitat patches are comprised of individual reserves into which Cheetah have been (or could be) reintroduced. Predator-proof fencing prevents dispersal among habitat patches, and so management intervention in the form of translocation is required to simulate dispersal. The coordinated management of reintroduced Cheetah populations has the potential to create a viable managed metapopulation from a series of unviable subpopulations occupying habitat fragments.

4.2. Why Cheetah require a metapopulation management plan

The lack of a national coordinated management of reintroduced populations of Cheetah represents a significant conservation threat to the species in South Africa. Where De Wildt is and has been involved in reintroductions, care was taken to introduce unrelated Cheetah. However, in cases where Cheetah were reintroduced or translocated by private individuals, there is a risk that there was inadequate consideration of the genetic origin of the animals being introduced, management to prevent inbreeding, or consideration of the impacts of sourcing Cheetah from the free-ranging populations. Coordinated management of the entire reintroduced population in South Africa is required to prevent genetic problems, negative impacts of sourcing animals from free-ranging populations for reintroductions, and to maximise the conservation and functional biodiversity value of Cheetah in small to medium sized fenced reserves. This document presents a strategy for the development and coordinated management of a national metapopulation of Cheetah in South Africa.

4.3. Benefits and anticipated outcomes of the metapopulation management plan

The metapopulation management plan will ensure:

4.3.1. Effective coordination and management

- A body of experts coordinates and oversees Cheetah management on a regional and national basis in South Africa
- Guidelines are established for the management of Cheetah in reserves into which they have already been reintroduced, and reserve owners agree to follow them
- Management of existing subpopulations of reintroduced Cheetah is coordinated effectively with input and buy-in of all relevant stakeholders
- Only suitable reserves are used for reintroductions and that correct protocol is followed prior, during and following reintroductions
- National databases are kept and maintained to allow effective monitoring of the genetics and demographics of the reintroduced Cheetah population

- Functional biodiversity, genetic and conservation considerations are given higher priority than economic and ecotourism considerations

4.3.2. Genetic and demographic viability

- Reintroduced subpopulations are demographically and genetically viable
- Cheetah translocations are designed to mimic natural events as closely as possible
- Subpopulations are re-established in the event of local extinctions due to stochastic events
- Only Cheetah from South Africa, from the southern African sub-species, are used for reintroductions

4.3.3. Improvement in conservation status of Cheetah

- Cheetah for reintroductions are not sourced from the free ranging population (except under exceptional circumstances, see below).
- Cheetah distribution is expanded to include currently unrepresented habitats and biomes falling within the historical range.
- The existence of a second managed population of Cheetah in SA will increase the overall survival of the species in the country given the threats facing the free ranging population. The metapopulation should not be seen as an alternative to the free ranging population but as an addition to it.
- The metapopulation acts as a catalyst for establishing viable free-ranging populations in areas where they currently do not exist including areas in the Eastern Cape (e.g., Addo) and northern KZN, where the prospects for reserve expansion and amalgamation are such that subpopulations could become large enough to require minimal management.
- Reintroduced Cheetah contribute effectively to biodiversity conservation through re-establishment of their ecological role and ecological relationships with other species.
- Reintroduced Cheetah act as a tool for education and awareness of the public, local landowners and communities.

4.3.4. Economic contribution

- Reintroduced Cheetah contribute to economic development by boosting scope for ecotourism, and creating jobs through the labour intensive processes of reintroduction, translocation and post-release monitoring

4.3.5. Blue print for metapopulation management

- A blue print is created for the metapopulation management of Cheetah in other countries, and to provide experience in metapopulation management that may be applicable to the conservation of other species in South Africa and elsewhere

4.4. Biodiversity justification

The biodiversity justification of the metapopulation management plan is that Cheetah are recognised by the NEMBA as a “threatened species in need of national protection”. The development of a coordinated metapopulation management strategy would contribute significantly to such protection.

4.5. Overview of the legal mandate

To be effective, the metapopulation management plan requires a legal mandate such that following the protocol for reintroducing Cheetah and managing them in reserves into which they have been reintroduced is required by law and is enforced by provincial nature conservation authorities. This metapopulation will form part of a Biodiversity Management Plan for Species, which will provide such a legal mandate if it is approved by the Minister for Water and Environmental Affairs. Future reintroductions of Cheetah should not be permitted unless the reserve owners / managers sign a Memorandum of Understanding (MOU) outlining the principles of metapopulation management (a template for which has been developed by De Wildt, which can be fine tuned by the advisory body, Annex 4).

Table 2: Subpopulations of Cheetah in small to medium sized fenced reserves in South Africa (estimates are approximate, numbers inevitably vary with time)

Reserve	Size km^2	Tenure	Province	Biome	Adult males	Adult females	Sub-adults	Cubs	Total	Lions present?
KweKwe	?	Private	EC	Thicket	1	0	0	0	1	0
Phumba	40	Private	EC	Thicket	1	1			2	1
Lalibela	75	Private	EC	Thicket	1	1			2	1
Hopewell	10	Private	EC	Thicket	1	1	1	0	3	0
Bushman Sands	70	Private	EC	Thicket	2	1			3	0
Amakhala	80	Private	EC	Thicket	1	1	2	0	4	1
Blaauwbosch	30	Private	EC	Nama Karoo	2	2			4	1
Shamwari	180	Private	EC	Thicket	3	3	0	0	6	1
Samara	140	Private	EC	Nama Karoo	2	2	0	3	7	0
Kuzuko/Addo	140	Private	EC	Nama Karoo	2	2	4	0	8	1
Kwandwe	240	Private	EC	Thicket	2	3	3	0	8	1
Mountain Zebra NP	280	State	EC	Grasslands	2	2	8	0	12	0
Hlambanyati	100	Private	KZN	Savannah	2	2	0	0	4	0
Zululand Rhino Reserve	500	Private	KZN	Savannah	2	2	0	0	4	0
Mkuze Falls	80	Private	KZN	Savannah	2	2	1		5	1
Nambiti	80	Private	KZN	Savannah	7	1	0		8	1
Mkhuze	400	State	KZN	Savannah	1	2	8	0	11	0
Hluhluwe-iMfolozi	960	State	KZN	Savannah	?	?	?	?	30	1
Phinda	240	Private	KZN	Savannah	5	10	0	27	42	1
Witwater	80	Private	LP	Savannah	1	1	0	0	2	0
Mokolo River Game Reserve	90	Private	LP	Savannah	2	0	0	0	2	0
Shambala	120	Private	LP	Savannah	1	1	0	0	2	1
Makulu Makete	40	Private	LP	Savannah	1	1	0		2	0
Ka Ingo	80	Private	LP	Savannah	2	1	0	0	3	1
Entabeni	80	Private	LP	Savannah	2	1	0	0	3	1
Welgevonden	400	Private	LP	Savannah	1	2	0	0	3	1
Jubatus	25	Private	LP	Savannah	2	1	0	0	3	0
Makoutsi	40	Private	LP	Savannah	1	1	0	3	5	0
Greater Kuduland	80	Private	LP	Savannah	4	2		3	8	0

Reserve	Size km²	Tenure	Province	Biome	Adult males	Adult females	Sub-adults	Cubs	Total	Lions present?
Thornybush	80	Private	LP	Savannah	5	2		4	11	1
Karongwe	80	Private	LP	Savannah	2	4	7	0	13	1
Makalali	240	Private	LP	Savannah	7	3	4	0	14	1
Thaba Tholo	340	Private	LP	Savannah	20	?	?	?	20	1
Marakele NP	450	State	LP	Savannah	?	?	?	?	?	?
Nkomazi	240	Private	MP	Grasslands	2	0			2	1
Tswalu	1000	Private	NC	Savannah	3	2	0	0	5	1
Glen Lyon	100	Private	NC	Savannah	1	1	4	0	6	0
Pilanesberg NP	600	State	NW	Savannah	2	0	0	0	2	1
Madikwe	600	State	NW	Savannah	3	0	0	0	3	1
Sanbona	500	Private	WC	Succulent Karoo	2	2	4	0	8	1 1
Total/average	229				103	63	46	40	281	62.5 %

5. PHVA WORKSHOP AS A BASIS FOR A METAPOPULATION MANAGEMENT PLAN

In April 2009, a Cheetah PHVA workshop was held at the De Beers Venetia Limpopo Game Reserve. The PHVA was coordinated by the Endangered Wildlife Trust, the IUCN Conservation Breeding Specialist Group (CBSG) and other partners, including the De Wildt Wild Cheetah Project, and attended by a variety of stakeholders, including; local and international Cheetah researchers; the WCS / ZSL regional coordinator for Cheetah conservation; provincial nature conservation officials; and representatives from the private sector (Annex 5). Vortex modelling was conducted to guide the development and management of a metapopulation, and to answer *inter alia* the following questions:

- How many sub populations should there be?
- What are the ideal sizes of subpopulations?
- What impact do removals of Cheetah from free-ranging populations on ranchland have on those populations?
- What impact would removal of Cheetah from populations in Kruger and Kgalagadi for reintroduction into the metapopulation have on those populations?

The methods and underlying assumptions used to construct the models are outlined in the PHVA meeting report (Lindsey *et al*. 2009).

6. RECOMMENDATIONS FOR MANAGEMENT OF THE METAPOPULATION

6.1. Institutional arrangements

6.1.1. Alignment with legislation

This metapopulation management plan was developed as an outcome of the PHVA meeting. The management plan will be reviewed at the National Conservation Action Planning meeting to be held in June 2009, and then if approved, will form part of a Biodiversity Management Plan for Species. If approved by the Minister of Water and Environmental Affairs, compliance with the metapopulation management plan will become compulsory and provincial conservation authorities will be obliged to enforce the requirements of the plan.

6.1.2. The metapopulation memorandum of understanding

An MOU will be developed which will outline the requirements for reserves to become part of the metapopulation, using the current MOU used by De Wildt for Cheetah relocations as a draft. The MOU will be signed prior to entry of existing Cheetah reserves into the metapopulation, or reintroduction of Cheetah into new reserves.

Working with reserve owners who have Cheetah or are considering reintroducing the species is crucial to raise awareness of the importance of a formalized, coordinated metapopulation management approach to conserving Cheetah in fenced reserves. Such an awareness programme would likely increase the willingness of reserve owners to allow Cheetah to be moved within and from their properties to mimic dispersal events and to abide by the metapopulation management recommendations outlined in this document.

6.1.3. Establishing a South African Cheetah Advisory Group

A coordinating advisory group is required to oversee the development and management of the Cheetah metapopulation. The National Cheetah Conservation Forum of South Africa (NCCF-SA) has been developed as a consultative forum and advisory group consisting of varied stakeholders, including conservationists, landowners, government officials, hunters to discuss matters related to Cheetah conservation in South Africa (Secretariat: Rachel Barlow-Steenkamp, Wildlife Ranching South Africa). The NCCF-SA has a number of sub-committees, each focussing on specific aspects of Cheetah conservation, including: captive breeding; education; relocation and, gene flow sub-committees. A separate sub-committee should be established to oversee the development and management of a metapopulation of Cheetah, including individuals with sufficient expertise to manage genetic aspects of the metapopulation. An individual should be appointed to oversee coordination of the metapopulation, of data associated with the metapopulation, and to organise meetings.

Discussion point: The re-naming of the NCCF and revising the objectives of the organisation should be considered?

One opinion among the reviewer group was that the NCCF is already in place and that it would make no sense to reinvent the wheel by replacing it with another group

Another opinion was that seeing that the NCCF is inactive at the moment, and so developing a new group designed specifically to develop and coordinate the metapopulation should not be a problem. Also, it was considered by some that a new organisation would be more likely to be considered to be a neutral body.

The advisory group should meet four times per year. However, because subpopulations of Cheetah occur widely, in all South African provinces, three regional working groups should be established, namely: Southern – Eastern / Western Cape; Arid-region (Northern Cape / North West) and Savannah region (Limpopo / Mpumalanga / Kwa-Zulu Natal). The regional working groups will also meet four times per year and a representative from each will attend all advisory group meetings. The structure and membership of the national advisory body should be established within three months of the NCAP meeting, and regional working groups within six months.

6.2. Management interventions required to achieve viability

6.2.1. Target size of the metapopulation and subpopulation

During the PHVA, participants agreed on the following definition of viability for the metapopulation:

The scenario whereby gene diversity (expected heterozygosity) is maintained at 90-95 % of the overall wild population over a period of 50 years through management interventions spaced not less than 2 years (18 - 24 months) apart on average, except if dictated by catastrophes or demographic stochasticity

In plain English the definition of viability is such that genetic diversity within the metapopulation will be maintained, and negative impacts associated with inbreeding avoided.

Modelling was conducted to determine the size and number of subpopulations required to achieve viability. The required number and size of subpopulations depends on whether Lions are also present on the reserves in which Cheetah are reintroduced, due to the negative impacts Lions have on Cheetah survivorship (Table 3).

Table 3 The number and size of subpopulations required to retain 90-95 % of the heterozygosity of the free ranging Cheetah population in the metapopulation over 50 years, with an extinction risk of <10 %

Heterozygosity	Lions present		No Lions present	
	90 %	95 %	90 %	95 %
Subpopulations required	15	30	20	20
Required size of subpopulations	15	15	10	15

Viability of the metapopulation will be achieved if its structure and size is such that it falls to the right of the lines in Figure 1.

The population of reintroduced Cheetah currently consists of:

a) Reserves without Lions (discounting those with <10 Cheetah): two subpopulations containing a total of 23 Cheetah, with a mean of 11.5 Cheetah / reserve, equating to an equivalent of 2.3 reserves with 10 Cheetah.
b) Reserves with Lions (discounting reserves with <15 Cheetah): three subpopulations containing a total of 92 Cheetah, equating to an equivalent of 6.3 reserves with ≥15 Cheetah.

The VORTEX models developed at the PHVA workshop strongly indicated that the viability of the metapopulation is more likely to be influenced by the size of the component subpopulations than the number of subpopulations, with viability increasing significantly if the subpopulations contain more individuals. Two methods have been used to determine the current status of the metapopulation and compare it to the viability goals identified at the PHVA workshop:

- The first conservative method includes only those sites whose Cheetah populations are over the threshold size to achieve viability from the VORTEX modelling (i.e. n=15). Only animals in these subpopulations are tallied, and the effective metapopulation size is determined by dividing these totals by 15 for reserves with and without Lions.
- The second optimistic method tallies the number of animals in all current subpopulations and divides these by 15. This effectively gives tiny populations the same weight as large ones.

Results from both methods are presented in Figure 1. It must be noted that although the conservative method might be overly cautious in its assessment of current effective population size, the optimistic method is definitely not cautious enough. Population dynamics become increasingly erratic with diminishing population size, and therefore individuals from tiny populations are less likely to contribute to overall metapopulation viability.

If the effective population size is calculated more conservatively, by including only reserves with ≥15 Cheetah, there are not enough subpopulations of sufficient size to form a metapopulation viable at the 90 % heterozygosity level.

Key targets for the development of the national metapopulation are:

i) To have all reserves with Cheetah, to buy-in to and adhere to the metapopulation management plan by 2011.
ii) To have enough subpopulations of sufficient size to achieve viability at the 95 % heterozygosity level by 2019.

Provinces will be expected to develop their own strategic plans for the conservation of Cheetah which outline targets for maximizing their contributions to the development of the national metapopulation, in a manner analogous to the way Ezemvelo Kwa-Zulu Natal Wildlife developed norms and standards for the management of Wild Dogs *Lycaon pictus.*

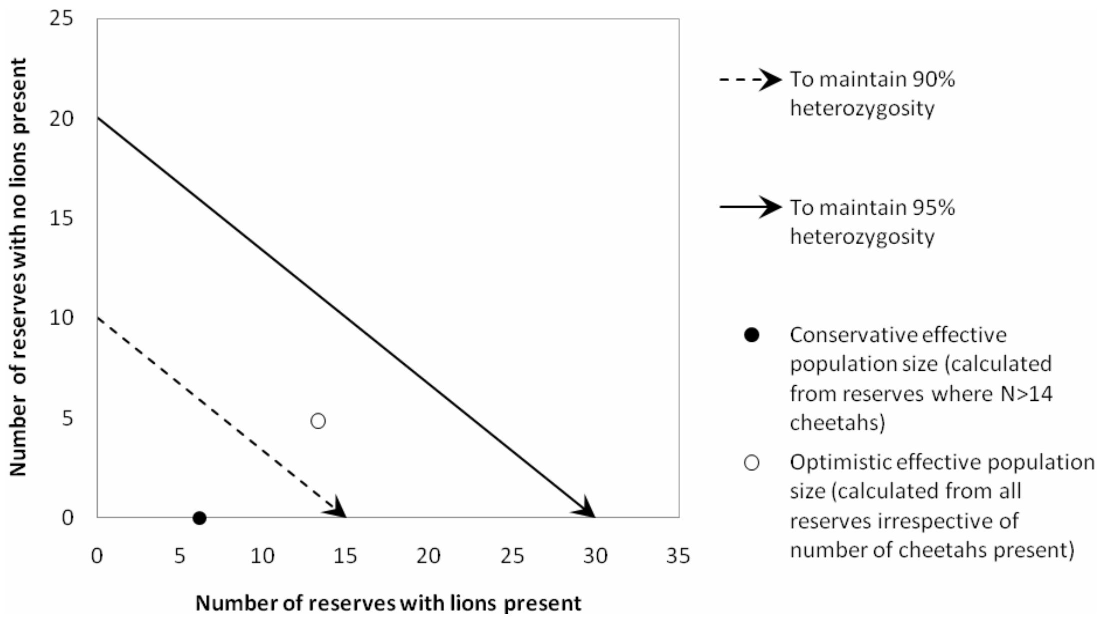


Figure 1: Required metapopulation size and structure required to achieve viability at the 90 % and 95 % levels of heterozygosity over 50 years, based on VORTEX modelling (reserves with no Lions require subpopulations to have ≥10 or ≥15 Cheetah to achieve 90 % or 95 % heterozygosity, whereas those with Lions require ≥15 Cheetah) (Note: the direction of the arrows indicate desired state, i.e. it is preferable to have Cheetah in reserves with Lions than without them so that natural ecological relationships are restored).

Vortex modelling indicated that viability is better achieved through fewer large subpopulations than larger numbers of small subpopulations (Table 4). This finding stresses the importance of prioritizing reintroductions of Cheetah into large reserves capable of supporting significant populations.

Table 4: Heterozygosity within metapopulations comprised of varying numbers and sizes of subpopulations in reserves in which Lions are present

		Size of subpopulations			
		5	**10**	**15**	**20**
Number of subpopulations	10	0.22	0.66	0.88	0.93
	15	0.27	0.75	0.92	0.95
	20	0.27	0.81	0.94	0.97
	30	0.40	0.88	0.96	0.98

6.2.2. Required frequency of translocations

Translocations should not be undertaken more frequently than once per 18 months. Thereafter, translocations should be undertaken as dictated by the situation in each reserve. Prior to joining the metapopulation, an assessment of each reserve will be conducted by experts within the advisory group to determine the ideal Cheetah population range for that subpopulation. When Cheetah numbers move above or below the ideal population range, Cheetah would be added or removed through translocation to / from other subpopulations as necessary. Population Management

2000 software (PM2000, Lacy and Ballou 2002) will be used to assist with the genetic management of the metapopulation, and to provide recommendations on which individual Cheetah to translocate. Assistance with the PM2000 modelling will be provided by the National Zoological Gardens, based on data on Cheetah pedigrees submitted by metapopulation reserves.

Management interventions should mimic natural processes as closely as possible. For example, translocation events should be timed to coincide with the age at which Cheetah disperse naturally: cubs stay with their mothers for an average of 509.4 days (18.2 months), after which the cubs remain together for an average of 186 days (6.7 months) (Laurenson *et al.* 1992). Females with cubs, or cubs younger than 18 months should not be translocated. If Cheetah numbers fall below the minimum recommended population threshold, the subpopulation should be augmented promptly. However, if the number of individuals exceeds the ideal population range, reserve owners will not be required to remove Cheetah, but may do so if they wish.

Where excess Cheetah are removed, they must be made available for translocation to other subpopulations. If (according to the advisory body) such Cheetah are not presently required for translocation to other subpopulations, then reserve owners may adopt alternative population control strategies, such as contraception.

6.2.3. Should genetic clusters of Cheetah be kept separate?

Research at De Wildt suggests that Cheetah in South Africa belong to three distinct genetic groups: Kalahari (western Limpopo / Botswana); Eastern Limpopo; and, a unique captive population comprising a mixture of the previous two (De Wildt, unpublished data). Participants at the PHVA felt that the degree of mixing of Cheetah resulting from the translocations conducted to date is such that it is too late to try to keep local genotypes separate from one another. However, Cheetah should be moved to reserves in the same biome where possible to ensure that behavioural adaptations of individual Cheetah to their habitat of birth are not wasted.

6.3. Pre-requisites for membership of the metapopulation

6.3.1. Criteria for metapopulation status

The following basic criteria must be fulfilled for reserves with existing Cheetah populations to form part of the metapopulation:

- The reserve must have potential to house a breeding population of Cheetah (i.e. a minimum of one pair plus up to six cubs) within the natural restrictions of the reserve’s carrying capacity, and on the understanding that cubs younger than 18 months will not be moved out of the reserve.
- Both male and female Cheetah must be present in the reserve or there must be the intention to have both sexes present within six months (where possible).
- Cheetah must be allowed to hunt for themselves and be subjected to natural ecological pressures.
- Cheetah must not be prevented from reproducing unless the recommended population threshold for that reserve has been exceeded, after which management intervention needs to be applied on recommendation of the advisory body (except in cases where temporary contraception is desired to enable females to acclimate to their new surroundings for a period before breeding)
- Reserve owners / managers must be willing to:

- Participate in the metapopulation management process.
- Make Cheetah available for translocation to other metapopulation reserves when possible and as is necessary, and receive Cheetah as deemed necessary following consultation between the reserve manager and the advisory group.
- Maintain their fences to the standard to maintain Cheetah effectively
- Contribute to the costs of translocating Cheetah to their reserve and holding them in pre-release bomas if donor funds are not available
- Monitor their subpopulation of Cheetah.
- Keep and submit records of the demography, genetics and pedigrees of Cheetah of their subpopulation.

Discussion point for advisory group to decide on:

One opinion within the reviewing group is that when participating in the metapopulation, reserve owners should be willing to provide Cheetah to other metapopulation reserves without requiring payment, on the grounds that they will receive Cheetah from other reserves for free. This would help to make sure the whole process is sustainable and not donor-dependent.

Another opinion is that reserve owners have paid for Cheetah and so should not be expected to give them away for free - so reserves receiving Cheetah should pay the source reserve for the Cheetah at their market value.

One possible compromise is that reserves receiving Cheetah for the first time could pay for the founders, but that when Cheetah are moved among reserves with existing populations, no payment is made for the Cheetah.

Formal recognition will be granted to reserves that sign the MOU and form part of the metapopulation. The optimal form of recognition to be granted is something that will be decided by the advisory body, but may include *inter alia* an official plaque for reserve entrances and acknowledgement on the Cheetah metapopulation website. All reserves forming part of the metapopulation will be granted equal status.

6.4. Managing reintroduced Cheetah populations not part of the metapopulation

Some reserves with Cheetah will not fulfil criteria for entry into the metapopulation and some reserve owners may refuse to abide by the metapopulation management protocol. Cheetah from such properties must be prevented from entering the metapopulation due to the possibility that they may be genetically compromised.

In the event of this action plan being accepted as part of a biodiversity management plan for species, the Department of Water and Environmental Affairs should prohibit future reintroductions of Cheetah unless the reserve owner agrees to form part of the metapopulation and signs the MOU.

7. EXPANDING THE METAPOPULATION: FUTURE REINTRODUCTIONS

7.1. Assessing the acceptability of reserves for future reintroductions

To be considered as a reintroduction site for expansion of the metapopulation, a reserve / reserve owner must fulfil the following criteria:

7.1.1. Willingness to participate in the metapopulation management plan

Reserve owners / managers must demonstrate a willingness and keenness to participate in the metapopulation management plan and to sign the MOU.

7.1.2. The reserve must have potential to sustain a breeding population of Cheetah

The reserve must have potential to sustain a breeding population of Cheetah
The reserve must have potential to sustain a breeding population of Cheetah (i.e. a minimum of one pair plus up to six cubs) within the natural restrictions of the reserve's carrying capacity, and on the understanding that cubs younger than 18 months will not be moved out of the reserve

The owner / manager of a prospective reintroduction site would submit the following details to the advisory body for assessment by experts: reserve size; vegetation / habitat type; prey population status; and, populations of competing predators, predator / Cheetah management plan.

7.1.3. Willingness to follow reintroduction guidelines

The reserve must be willing to follow correct protocol during the reintroduction of Cheetah. De Wildt has developed reintroduction guidelines which will be used as a basis for the development of a reintroduction protocol for the expansion of the metapopulation.

7.1.4. The reserve must have necessary infrastructure

A prospective reintroduction site must have Cheetah-proof fencing to specifications required by the province, and in the metapopulation reintroduction protocol (Annex 4). Preventing escape of Cheetah from metapopulation reserves is crucial to prevent conflict with local landowners, and the possibility that conflict may increase with naturally occurring free-ranging Cheetah due to a misconception that they originated from the reintroduction.

Pre-release holding facilities of at least one hectare in size must be present on the reserve (Marnewick *et al*. 2009). 'Soft-release' methods (i.e. where Cheetah are kept in a pre-release boma for a period prior to their release) are generally more successful than 'hard release' (i.e. where Cheetah are released immediately into the reserve without a holding period in a boma) for reintroductions (Johnson *et al*. in review).

7.1.5. Reserve owner / manager must work to obtain approval from neighbouring landowners

External support from conservation authorities, conservation NGOs, and the local ranching community improves the prospects of a Cheetah reintroduction being successful (Johnson *et al*. in review). Prior to a Cheetah reintroduction, approval should be obtained from the local nature conservation authorities. The reserve owner should be able to demonstrate that s/he has notified surrounding landowners of his / her intention to reintroduce Cheetah. Education and awareness work should be conducted with local landowners to inform them of the proposed reintroduction and to request their tolerance and assistance in the event of a breakout.

7.1.6. Reserve owners must be willing to monitor Cheetah post-release

To be considered as a reintroduction site for expansion of the metapopulation, a reserve must be willing to monitor Cheetah after release and provide updates on the status and dynamics of the sub-population to the advisory body in time for each meeting of the group.

7.2. Basis for prioritizing reserves for future reintroductions

In the event that multiple reserve owners request Cheetah for reintroduction from a limited pool of available animals, the advisory group will prioritise reserves using tools such as Bayesian Networks (BNs) to assist in selection (Johnson *et al*. in review), and based on the following criteria:

7.2.1. Reserve size and / or potential for expansion

Reintroductions into large reserves are more successful than those into small reserves (Johnson *et al*. in review). Furthermore, given the importance of large subpopulations for ensuring viability of the metapopulation, large reserves (or reserves with realistic potential for future expansion) should be the priority for new reintroductions.

Prioritising reintroductions in under-represented biomes

Most Cheetah reintroductions have been made into reserves in savannah (65 %) or thicket biomes (20 %), with relatively few in other South African biomes (e.g. Grassland [5 %], Nama Karoo [8 %], Succulent Karoo [2.5 %], Fynbos [0 %] and Forest [0 %] (Table 2, Acocks 1998). Reintroductions should focus on under-represented biomes suitable for Cheetah (i.e. Grassland, Nama and Succulent Karoo) such that the ecological role of Cheetah can be re-established in such habitat.

Prioritising reintroductions outside of the current range of overall wild Cheetah

Reserves occurring within the historic range of the species, but outside of the present range of overall wild Cheetah should be prioritised. The establishment of predator-proof fencing required for reintroductions would exclude free-ranging Cheetah from land on which they would otherwise be tolerated, increasing the proportion of their range comprised of land on which they are not tolerated. Furthermore, if Cheetah are reintroduced into a reserve within current Cheetah range, and subsequently escape, such a reserve may be held liable by neighbouring landowners for perceived damages associated with Cheetah irrespective of whether the responsible individuals originated from that reserve. Finally, the nature of predator proof fencing is such that Cheetah attracted by the presence of conspecifics are likely to be able to gain entry into metapopulation reserves, but not be able to escape. Consequently, metapopulation reserves have potential to act as sinks for the local free-ranging Cheetah population. Alternatively, free-ranging Cheetah may spend time pacing along the fence line trying to gain access to the reserve and create conflict with neighbouring landowners.

7.2.2. Past record of reserve owners in participating in conservation processes

Reserve owners with a track-record in participating in conservation processes would be considered as priorities for expansion of the metapopulation as they could be relied on to adhere to metapopulation management principles.

7.2.3. Demonstrable support for the reintroduction from neighbouring landowners

If a reserve owner / manager is able to demonstrate that neighbouring landowners are supportive of the reintroduction, that that reserve should be granted priority over reserves where the owners cannot demonstrate such support.

7.3. Source of founders

Due to the large size of the existing reintroduced population, founder animals for future reintroductions should be sourced from other subpopulations within the metapopulation. Under no circumstances will Cheetah from the free ranging population be used for initial reintroductions. Presently, capturing Cheetah for reintroduction into reserves has been used as a short-term solution for human-Cheetah conflict on ranchland. Modelling indicates that the free-ranging population is highly sensitive to harvest and such removals probably limit the expansion of Cheetah to fill a greater proportion of available suitable habitat. Cheetah from the free-ranging population will only be used for reintroductions in cases where the advisory body agrees that the animal in question cannot be re-released into the wild or where the chance of that animal being persecuted is high (in cases where they have been captured by landowners). Under no circumstances should animals from the free-ranging population be allowed to enter captive populations (other than for the purposes of temporary holding prior to reintroductions, in cases where the animal(s) cannot be re-released into the wild). Large protected areas containing Cheetah (namely Kruger and Kgalagadi) will not be viewed as possible source populations for reintroductions. Modelling at the PHVA indicated that even removal of as few as five individuals per annum would likely drive a decline in the Kruger and Kgalagadi populations.

8. INFORMATION MANAGEMENT

8.1. Monitoring of the metapopulation

8.1.1. National level – the metapopulation database

Monitoring through the acquisition, maintenance and compilation of data are crucial to effective metapopulation management. A primary function of the advisory body and partners (e.g. the National Zoological Gardens of South Africa, NZG) will be to maintain databases of information relating to the metapopulation. Such databases will be used to assess progress towards achieving the targets for the national metapopulation of Cheetah. The following information should be captured:

a) Compiling and updating as much information as possible from each metapopulation reserve on the origins of their Cheetah, the size, structure and composition of subpopulations, the degree of relatedness of animals and their pedigrees (advisory body).

b) Keeping records of the date and details of all translocations of Cheetah into the metapopulation and among subpopulations within the metapopulation (advisory body).
c) Taking genetic samples from any Cheetah moved within the metapopulation and recording the details in a national metapopulation studbook (to be managed by the NZG)

An interactive database should be developed to enable the managers of metapopulation reserves to update information on the demographic and genetic status of their subpopulation. Reserve managers will be able to keep track of the status of the metapopulation as a whole and learn of translocation events involving other reserves. In this way, managers of subpopulations of Cheetah will be kept abreast of the developments of the metapopulation and appreciate the importance of their subpopulation as part of a larger, connected metapopulation.

8.1.2. Provincial level

Provinces will be expected to develop an explicit monitoring component as part of the provincial strategic plans for the management of Cheetah. Provinces will be expected to provide feedback on the demographic and genetic status of their subpopulations of Cheetah at regional and national meetings of the advisory body.

8.1.3. Subpopulation level

Monitoring of Cheetah is a prerequisite for membership of the metapopulation of Cheetah, and for future reintroductions to expand the metapopulation. Representatives from each metapopulation reserve will be expected to provide updates on the demographic and genetic status of their subpopulation of Cheetah to regional and national meetings of the advisory body.

8.2. Informational shortcomings: research needs

There are significant gaps in available information which affect our ability to manage a metapopulation of Cheetah effectively.

8.2.1. Genetic make-up of Cheetah in the metapopulation

Knowledge of the origin and genetic make-up of the reintroduced Cheetah population is incomplete. The NZG of South Africa keeps a studbook of Cheetah in captivity and of wild Cheetah reintroduced by De Wildt. The studbook should be expanded to include all Cheetah moved among reserves in the metapopulation, and be used to provide guidance on Cheetah translocations to maximise genetic benefits. Keeping track of the whereabouts of related Cheetah is crucial to prevent inbreeding and permit effective genetic management of the population. Sampling existing subpopulations is required to obtain this information. Furthermore when new Cheetah are reintroduced into metapopulation reserves, genetic samples should be taken, analysed and the results kept on file by the advisory body and the NZG.

8.2.2. Minimum habitat requirements of Cheetah

Research is required to estimate the minimum areas required to support Cheetah subpopulations in different biomes as a basis for selecting reintroduction sites. Specifically, an understanding is required of the minimum areas required to provide: sufficient prey for ≥5 Cheetah (without Lions) and ≥15 Cheetah (with Lions present) without prey augmentation more frequently than once every two years; sufficient space to prevent excessive adverse intraspecific interactions; and, sufficient space to permit avoidance of competitively superior predator species.

9. REFERENCES

Acocks, J.P.H., 1988. Veld Types of South Africa. Acocks, J.P.H., 1988. Veld Types of South Africa.

Bauer, H., Belbachir, F., Durant, S., Hunter, L., Marker, L., Packer, K. and Purchase, N. 2008. *Acinonyx jubatus*. In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.1. <www.iucnredlist.org>.

Bowland A. E. and Mills M. G. L. 1994. The 1990 / 1991 Cheetah photographic survey. Scientific Report 6 / 94. SANParks, Skukuza.

Davies-Mostert, H., Mills, G. and Macdonald, D. 2009. A critical assessment of South Africa's managed metapopulation recovery strategy for African Wild Dogs and its value as a template for large-carnivore conservation elsewhere. Chapter 2 in Reintroduction of Top-Order Predators, 1st edition, M. Hayward and M. Somers (Eds.), Wiley-Blackwell, London.

Lindsey, P., Marnewick, K., Davies-Mostert, H., Rehse, T., Mills, M.G.L., Brummer, R., Buk, K., Traylor-Holzer, K., Morrison, K., Mentzel, C. and Daly, B. (editors). 2009. Cheetah (*Acinonyx jubatus*) Population Habitat Viability Assessment Workshop Report. Conservation Breeding Specialist Group (SSC / IUCN) / CBSG Southern Africa. Endangered Wildlife Trust.

DWEA 2006. Threatened and Protected Species Regulations. South African Department of Water and Environmental Affairs.

Graf, J., Gusset, M., Reid, C., Janse van Rensburg, S., Slotow, R. and Somers, M. 2006. Evolutionary ecology meets wildlife management: artificial group augmentation in the re-introduction of endangered African Wild Dogs (*Lycaon pictus*), Animal Conservation, 9: 398-403.

Friedman, Y., Daly, B., Keith, M., Peddemors, V., Chimimba, C. and Byers, O. 2002. Conservation assessment and management plan for the mammals of South Africa. Draft report. Conservation Africa / Endangered Wildlife Trust. Conservation Breeding Specialist Group (SSC / IUCN), Apple Valley, MN, USA.

Hanski, I. 1998. Metapopulation dynamics. Nature, 396: 41-49.

Johnson, S., Mengersen, K., de Waal, A., Marnewick, K., Cilliers, D., Houser, A. and Boast, L. In prep. Modelling Cheetah relocation success in southern Africa using an Iterative Bayesian Network Development Cycle.

Kemp L. V. and Mills M. G. L. 2005. The 4th Wild Dog and 2nd Cheetah photographic census in the greater Kruger region September 2004 – April 2005. Unpublished report Endangered Wildlife Trust, Johannesburg.

Knight, A. 1999. Cheetah numbers in a changing environment: Kalahari Gemsbok National Park. Endangered Wildlife Trust, Johannesburg.

Lacy, R.C. and Ballou, J.D. 2002. Population Management 2000 User's Manual. Chicago Zoological Society, Brookfield, IL.

Laurenson, M.K., Caro, T. and Borner M. 1992. Female Cheetah Reproduction. Patterns of female reproduction in wild Cheetah: Implications for conservation. National Geographic Research and exploration 8(1): 64-75.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of America. 15: 237-240.

Lindsey, P.A., Alexander, R. du Toit, J.T., and Mills, M.G.L., 2005. The cost efficiency of Wild Dog *Lycaon pictus* conservation in South Africa. Conservation Biology. 19(4): 1205-1214.

Lindsey, P.A. and Davies-Mostert, H. In prep. A complete census of the South Africa's population of endangered African Wild Dogs *Lycaon pictus*.

Marker L. 1998. Current status of the Cheetah (*Acinonyx jubatus*). Proceedings of a symposium on Cheetah as Game Ranch Animal. Onderstepoort Faculty of Veterinary Science, University of Pretoria, 17pp.

Marnewick, K., Beckhelling, A., Cilliers, D., Lane, E., Mills, M.G.L., Herring, K., Caldwell, P., Hall, R. and Meintjes, S. 2007. The status of the Cheetah in South Africa. In: Breitenmoser, C. and Durant, S. (Eds). The Status and Conservation Needs of the Cheetah in Southern Africa. Cat News Special Edition, December 2007.

Marnewick, K., Hayward, M., Cilliers, D. and Somers, M. 2009. Survival of Cheetah relocated from ranch land to fenced protected areas in South Africa. Chapter 13 in Reintroduction of top order predators. 1st edition. M. Hayward and M. Somers (eds.) Wiley-Blackwell, London.

Mills, M., Ellis, S., Woodroffe, R., Maddock, A., Stander, P., Rasmussen, G., Pole, A., Fletcher, P., Bruford, M., Wildt, D., Macdonald, D. and Seal, U. (eds.) 1998. Population and Habitat Viability Assessment for the African Wild Dog (*Lycaon pictus*) in southern Africa. Apple Valley, MN: IUCN / SSC Conservation Breeding Specialist Group.

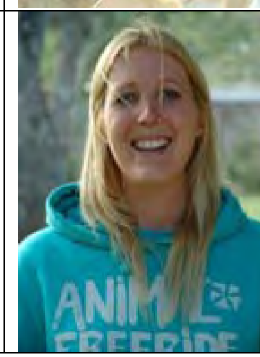
Pienaar U. de V. 1963. The large mammals of the Kruger National Park – their distribution and present-day status. Koedoe 6, 1-37.

Van Dyk, G. and Slotow, R. 2003. The effects of fences and Lions on the ecology of African Wild Dogs reintroduced into Pilanesberg National Park, South Africa. African Zoology, 38: 79-94.

Appendix 2: Cheetah PHVA Workshop Participant List

Bissett, Charlene Kwandwe Private Game Reserve P.O.Box 448, Grahamstown, 6140, South Africa +27 46 603 3400 +27 46 603 3401 +27 83 501 3671 charlene@kwandwe.co.za		Brummer, Rox Carnivore Conservation Group of the EWT P.O. Box 215, Alldays, 0909, South Africa +27 72 640 9388 roxb@ewt.org.za	
Buk, Kenneth Tshwane University of Technology and De Wildt Cheetah and Wildlife Trust 16 McHardy, Cassandra, Kimberley, 8301 +27 72 262 1919 kenbuk@kenbuk.com		Burger, Marion Carnivore Conservation Group of the EWT Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 marionb@ewt.org.za	
Cilliers, Deon De Wildt Cheetah and Wildlife Trust P.O. Box 52071, Dorandia, 0188, South Africa +27 866 529 444 +27 82 853 1068 deon@dewilt.org.za		Daly, Brenda CBSG Southern Africa Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 brendad@ewt.org.za	

Davies-Mostert, Harriet Carnivore Conservation Group of the EWT Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 +27 82 507 9223 harrietd@ewt.org.za		Durant, Sarah Zoological Society of London / Wildlife Conservation Society Regents Park, London, NW1 4RY +44 207 449 6688 +44 790 551 5092 sdurant@wcs.org	
Holtzhausen, Reinhardt Wildlife Ranching SA (WRSA) Posbus 23073, Gezina, Pretoria, 0031, South Africa +27 12 335 6994 +27 12 335 1059 +27 83 611 0467 manager@wrsa.co.za		Jacobs, Vasti Northwest Department of Agriculture, Conservation and Environment Post Net Suite 107, Private Bag X 2230, Mafikerg South, 2791, South Africa +27 18 389 5201 +27 18 389 5640 +27 83 761 7497 mia@nwpg.gov.za	
Lindsey, Peter Carnivore Conservation Group of the EWT Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 +27 82 342 7329 peterl@ewt.org.za		Marnewick, Kelly De Wildt Cheetah and Wildlife Trust P.O. Box 52071, Dorandia, 0188, South Africa +27 82 477 4470 +27 82 477 4470 kelly@dewildt.org.za	

Mentzel, Christine Endangered Wildlife Trust Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 christinem@ewt.org.za		Mills, Gus The Tony and Lisette Lewis Foundation Private Bag X5890, Upington, 8800, South Africa +27 54 561 2033 +27 54 561 2005 gusm@sanparks.org	
Morrison, Kerryn CBSG Southern Africa Private Bag X11, Parkview, 2122, South Africa +27 11 486 1102 +27 11 486 1506 +27 82 877 5126 kerryn@ewt.org.za		Purchase, Netty Zoological Society of London and Wildlife Conservation Society P.O. Box 2633, Bulawayo, Zimbabwe +263 9 242 837 +263 9 242 837 +263 913 016 295 dnp@mweb.co.zw	
Rehse, Tracy National Zoological Gardens of SA P.O. Box 754, Pretoria, 0001, South Africa +27 12 328 3265 +27 12 323 4540 +27 83 334 7839 tracy@nzg.ac.za		Robinson, Emma Lucy The Nature Conservation Trust (Jubatus Cheetah Reserve) Post Net Suite 232, Private Bag X1604, Bela Bela, 0480 +27 14 734 7600 +27 14 734 7603 +27 72 086 7231 elr@hgbfoundation.org	

Thorn, Michelle University of Brighton / Pretoria P.O. Box 3664, Sun City, 0316, South Africa +27 73 685 7001 thorn_green@hotmail.com		Traylor-Holzer, Kathy Conservation Breeding Specialist Group 12101 Johnny Cake Ridge Road, Apple Valley, Minnesota 55124, USA +1 952 997 9804 +1 952 997 9803 kathy@cbsg.org	

LIST OF INVITEES UNABLE TO ATTEND THE PHVA

Invitee	**Institution**
Blignaut, Christiaan	Limpopo Economic Development Environment and Tourism
Boshoff, Willem	North West Province
Buss, Peter	South African National Parks
Dell, Steve	Pilanesberg National Park
Else, Rubin	Thaba Tholo Private Reserve
Ferreira, Sam	South African National Parks
Friedmann, Yolan	Endangered Wildlife Trust
Goodman, Pete	Ezemvelo KZN Wildlife
Hayward, Ronnie	Limpopo Economic Development Environment and Tourism
Hofmeyr, Markus	South African National Parks
Klein, Rebecca	Cheetah Conservation Botswana
Lines, Robin	Namibia Nature Foundation
Marker, Laurie	Cheetah Conservation Fund
Meintjes, Sonja	Department of Environmental Affairs and Tourism
Parker, Dan	Rhodes University
Peinke, Dean	Eastern Cape Parks
van Dyk, Gus	Tswalu Kalahari Reserve

Appendix 3: Participant Goals and Expectations

At the beginning of the workshop, participants were asked to write down the answers to the following three questions:

1. What do you hope will be accomplished during this workshop?
2. What do you hope to contribute to this workshop?
3. What, in your view, is the primary challenge for developing a viable meta-population for Cheetah in South Africa?

Hope the PHVA accomplishes	I wish to contribute	Primary challenge
A future plan for how best to conserve and manage Cheetah in SA. Point out needs for a metapopulation. Management plan for a metapopulation of Cheetah in SA.	I hope to contribute ideas that will help reach a definite plan for Cheetah conservation.	Finding adequate land / space and getting people to participate / communicate and to realise that people are trying to work towards the same goal.
Clear and realistic steps towards metapopulation management in the future	Recent knowledge of Cheetah distribution, habitat preferences, prey preferences, livestock depredation, human persecution and landowner attitudes regarding co-existence with predators. Methods for Cheetah population census and monitoring.	Unregulated killing of Cheetah in non-protected areas.
More effect sharing of information between different conservation agencies to work out a plan which will assist in the conservation of Cheetah in the future. Learn methods of assisting in the conservation of Cheetah in my area of work. Find ways of protecting the Cheetah from different threats.	Working for government – would like to assist in the handling of conflict situations between local farmers and predators (Cheetah).	Change people's (farmers) attitudes towards predators on their land.
Workable framework to manage Cheetah metapopulation with buy-in from relevant stakeholders.	Ideas on metapopulation management and experience from other areas. Facilitation (learn + support)	Private land / fences Attitudes and private ownership of wildlife.
Personally, I hope to get input to focus my Ph.D. Secondly, I hope for a conservation strategy that all interested parties – including the ones not represented at the workshop – can agree to.	I hope to be able to eventually fill in one or two of the knowledge gaps identified at the workshop.	Collaboration between the interested parties.

Hope the PHVA accomplishes	I wish to contribute	Primary challenge
Develop a practical and workable strategy for Cheetah management in South Africa to ensure long-term viability of these populations without seriously impacting negatively on the population.	Knowledge and practical solutions to Cheetah management in a South African context.	Stakeholder buy-in (managers and owners of Cheetah). Linkages between various populations.
I hope to see a practical plan for a Cheetah metapopulation that takes all stakeholders into account.	As someone who is on both sides of the conservationist / farmer fence, I hope to be able to contribute a balanced perspective on the threats to Cheetah in this area in particular.	Ranch sizes in South Africa are typically very small, so I would consider the shortage of suitable sites for re-establishment of populations to be a challenge.
Consensus on a way forward for the management of a metapopulation for Cheetah.	Modelling skills and assistance through modelling to provide guidance to the metapopulation plan.	Getting people to work together.
A clear implementable plan for the metapopulation management of Cheetah that will be readily adapted by wildlife policy makers and practitioners at the National Cheetah Action Plan meeting.	General expertise on conservation issues facing Cheetah in South Africa.	Co-ordinating metapopulation management with the large number of reserves that have Cheetah.
Information to facilitate effective and efficient management of the South African metapopulation of Cheetah to ensure long-term viability.	Information from a long-term study of Cheetah in Serengeti that may be relevant and useful.	Maintaining and enlarging reserves to support viable subpopulation of Cheetah.
An increased understanding of the status of Cheetah in South Africa, free roaming especially, and how the small interactivity of managed populations can contribute to conservation of the species as a whole in the region.	Conservation needs of Cheetah in the region.	To ensure that the metapopulation remains viable without negatively impacting on the wild Cheetah population and increasing the area within the region where viable Cheetah population exists.
Framework for a national action plan for Cheetah. Indication of how captive Cheetah management and / or research can contribute to the overall conservation effort of Cheetah.	Small population management – demographic and genetic management strategy.	Logistical challenges, cooperation from all participants (and the Cheetah).

Hope the PHVA accomplishes	I wish to contribute	Primary challenge
Understand more of what makes metapopulations work. Also where to, if more land (reserves) is not available – how do you maintain a species that need space.	I would be learning more than contributing as I was not trained to work in the carnivore field and never had to deal with population management coming from an invertebrate background.	The idea for the metapopulation is the only way forward but there are a lot of private reserves and parks that do not work together which can make the idea collapse.
Drawing up an effective framework for Cheetah metapopulation management in South Africa which has enough technical detail to be easily transformed into a workable management plan following input from additional stakeholders.	Experience with a similar process for Wild Dogs and have been thinking about these management issues as part of both my job and the EWT, role of chairperson of the Wild Dog Advisory Group and also my Ph.D. thesis.	The biggest obstacle lies in the coordination of the process and getting a hugely diverse range of stakeholders to work together to achieve a viable metapopulation. This lies in identifying a common goal and then cooperating to achieve it.
Highlight areas that need to be worked on to help Cheetah conservation metapopulation development.	Information on Cheetah population in small enclosed reserves with other large predators such as Lions.	Getting landowners to buy into the metapopulation idea and to work together with conservation organisations.
Influence policy to be more effective. Highlight important threads to Cheetah.	Information collected during 10 years of working with Cheetah outside conservation areas (conflict management and research)	In-efficient policing / legislation. Lack of recognition and cooperation among stakeholders.
Development of a plan to establish a metapopulation Cheetah process in RSA.	My knowledge and experience of large carnivore biodiversity issues, Cheetah behavioural ecology and metapopulation management.	Getting landowners and managers to work together in the best interests of Cheetah biodiversity conservation.
Highlight issues to feed into the management strategy.	A well documented workshop report.	Available space (fence off the humans)

Appendix 4: Workshop Programme

CHEETAH POPULATION AND HABITAT VIABILITY ASSESSMENT

17 - 21 April 2009

Venetia Limpopo Nature Reserve, South Africa

FRIDAY 17TH	**APRIL 2009**
14h00 **–**	Delegates arrive and register at Mopane Camp.
16:30 – 19:00	**Riverbed Bush Braai (Icebreaker)**

SATURDAY 18TH	**APRIL 2009 - DAY 1**
07:00 – 07:30	**BREAKFAST**
08:00 – 13:00	Welcome – Warwick Davies-Mostert (De Beers) Introduction to CBSG, CBSG Southern Africa and the workshop process Participant introductions Presentations (15 minutes) ▪ Status, distribution and threats to Cheetah at the regional scale (Netty Purchase, Zoological Society of London and Wildlife Conservation) ▪ The Carnivore Conservation Group, Conservation Plan and Policies. (Harriet Davies-Mostert, Carnivore Conservation Group of the Endangered Wildlife Trust) ▪ A review of the status of Cheetah in South Africa (Kelly Marnewick, De Wildt Cheetah and Wildlife Trust) ▪ A review of the conservation threats facing Cheetah in South Africa (Deon Cilliers, De Wildt Cheetah and Wildlife Trust) ▪ Presentation on the use of the PHVA process in metapopulation planning, using the Wild Dog as a case study. (Gus Mills, The Tony and Lisette Lewis Foundation). ▪ Introduction to small population biology, PVA and the use of Vortex within the PHVA process (Kerryn Morrison, CBSG Southern Africa) Review and discussion of the preliminary Cheetah base models (demographic rates) (Kerryn Morrison, CBSG Southern Africa)
13:00 – 14:00	**LUNCH BREAK**
14:00 – 17:30	Discussion of workshop scope Clustering of key issues Formation of population-specific working groups and overview of Task 1 (population goals / issue generation) Working groups convene and begin Task 1
17:30 – 19:00	Night drive and sundowners
19:30 – 20:30	**DINNER**

SUNDAY 19TH	APRIL 2009 - DAY 2
07:00 – 07:30	**BREAKFAST**
07:30 – 13:30	Working groups convene to complete Task 1 Plenary session – working group reports
13:30 – 14: 00	**LUNCH BREAK**
14:00 – 15:30	Instructions for Task 2 (data assembly) Working groups reconvene to revise issues and begin Task 2
15:30 – 19:00	A visit to the Shashe-Limpopo Confluence
19:30 – 20:30	**DINNER**
MONDAY 20TH	**APRIL 2009 - DAY 3**
07:00 – 07:30	**BREAKFAST**
07:30 – 13:30	Working groups convene to complete Task 2 Plenary session – working group reports Presentation of modelling results Identification of additional modelling scenarios / revisions
13:30 – 14:00	**LUNCH BREAK**
14:00 – 17:30	Working groups reconvene to revise data and begin Task 3 (development of recommendations)
19:00 – 20:00	**DINNER**
20:00	Working groups reconvene as needed
TUESDAY 21ST	**APRIL 2009 - DAY 4**
07:00 – 07:30	**BREAKFAST**
07:30 – 11:30	Working groups convene to complete Task 3 Plenary session – working group reports (Task 3) Presentation of modelling results Plenary discussion of workshop recommendations for metapopulation management Workshop closure
11:30	Departure by delegates

Appendix 5: PVA SIMULATION MODELLING

Phil Miller, Bob Lacy
Conservation Breeding Specialist Group (IUCN / SSC)

Introduction

Thousands of species and populations of animals and plants around the world are threatened with extinction within the coming decades. For the vast majority of these groups of organisms, this threat is the direct result of human activity. The particular types of activity, and the ways in which they impact wildlife populations, are often complex in both cause and consequence; as a result, the techniques used to analyse their effects often seem to be complex as well. But scientists in the field of conservation biology have developed extremely useful tools for this purpose that have dramatically improved our ability to conserve the planet's biodiversity.

Conservation biologists involved in recovery planning for a given threatened species usually try to develop a detailed understanding of the processes that put the species at risk, and will then identify the most effective methods to reduce that risk through active management of the species itself and / or the habitat in which it lives. In order to design such a programme, we must engage in some sort of predictive process: we must gather information on the detailed characteristics of proposed alternative management strategies and somehow predict how the threatened species will respond in the future. A strategy that is predicted to reduce the risk by the greatest amount – and typically does so with the least amount of financial and / or sociological burden – is chosen as a central feature of the recovery plan.

But how does one predict the future? Is it realistically possible to perform such a feat in our fast-paced world of incredibly rapid and often unpredictable technological, cultural, and biological growth? How are such predictions best used in wildlife conservation? The answers to these questions emerge from an understanding of what has been called "the flagship industry" of conservation biology: Population Viability Analysis, or PVA. And most methods for conducting PVA are merely extensions of tools we all use in our everyday lives.

The Basics of PVA

To appreciate the science and application of PVA to wildlife conservation, we first must learn a little bit about population biology. Biologists will usually describe the performance of a population by describing its demography, or simply the numerical depiction of the rates of birth and death in a group of animals or plants from one year to the next. Simply speaking, if the birth rate exceeds the death rate, a population is expected to increase in size over time. If the reverse is true, our population will decline. The overall rate of population growth is therefore a rather good descriptor of its relative security: positive population growth suggests some level of demographic health, while negative growth indicates that some external process is interfering with the normal population function and pushing it into an unstable state.

This relatively simple picture is, however, made a lot more complicated by an inescapable fact: wildlife population demographic rates fluctuate unpredictably over time. So if we observe that 50 % of our total population of adult females produces offspring in a given year, it is almost certain that more or less than 50 % of our adult females will reproduce in the following year. And the same can be said for most all other demographic rates: survival of offspring and adults, the numbers of offspring born, and the offspring sex ratio will almost always change from one year to the next in a way that usually defies precise prediction. These variable rates then conspire to make a population's growth rate also change unpredictably from year to year. When wildlife populations are very large – if we consider seemingly endless herds of wildebeest on the savannahs of Africa, for example – this random annual fluctuation in population growth is of little to no consequence for the future health and stability of the population. However, theoretical and practical study of population biology has taught us that populations that are already small in size, often defined in terms of tens to a few hundred individuals, are affected by these fluctuations to a much greater extent – and the long-term impact of these fluctuations is always negative. Therefore, a wildlife population that has been reduced in numbers will become even smaller through this fundamental principle of wildlife biology. Furthermore, our understanding of this process provides an important backdrop to considerations of the impact of human activities that may, on the surface, appear relatively benign to larger and more stable wildlife populations. This self-reinforcing feedback loop, first coined the "extinction vortex" in the mid-1980's, is the cornerstone principle underlying our understanding of the dynamics of wildlife population extinction.

Once wildlife biologists have gone out into the field and collected data on a population's demography and used these data to calculate its current rate of growth (and how this rate may change over time), we now have at our disposal an extremely valuable source of information that can be used to predict the future rates of population growth or decline under conditions that may not be so favourable to the wildlife population of interest. For example, consider a population of primates living in a section of largely undisturbed Amazon rain forest that is now opened up to development by logging interests. If this development is to go ahead as planned, what will be the impact of this activity on the animals themselves, and the trees on which they depend for food and shelter? And what kinds of alternative development strategies might reduce the risk of primate population decline and extinction? To try to answer this question, we need two additional sets of information: 1) a comprehensive description of the proposed forest development plan (how will it occur, where will it be most intense, for what period of time, etc.) and 2) a detailed understanding of how the proposed activity will impact the primate population's demography (which animals will be most affected, how strongly will they be affected, will animals die outright more frequently or simply fail to reproduce as often, etc.). With this information in hand, we have a vital component in place to begin our PVA.

Next, we need a predictive tool – a sort of crystal ball, if you will, that helps us look into the future. After intensive study over nearly three decades, conservation biologists have settled on the use of computer simulation models as their preferred PVA tool. In general, models are simply any simplified representation of a real system. We use models in all aspects of our lives; for example, road maps are in fact relatively simple (and hopefully very accurate!) 2-dimensional representations of complex 3-dimensional landscapes we use almost every day to get us where we need to go. In addition to making predictions about the future, models are very helpful for us to: (1) extract important trends from complex processes, (2) allow comparisons among different types of systems, and (3) facilitate analysis of processes acting on a system.

Recent advances in computer technology have allowed us to create very complex models of the demographic processes that define wildlife population growth. But at their core, these models attempt to replicate simple biological functions shared by most all wildlife species: individuals are born, some grow to adulthood, most of those that survive mate with individuals of the opposite sex and then give birth to one or more offspring, and they die from any of a wide variety of causes. Each species may have its own special set of circumstances – sea turtles may live to be 150 years old and lay 600 eggs in a single event, while a chimpanzee may give birth to just a single offspring every 4-5 years until the age of 45 – but the fundamental biology is the same. These essential elements of a species' biology can be incorporated into a computer programme, and when combined with the basic rules for living and the general characteristics of the population's surrounding habitat, a model is created that can project the demographic behaviour of our real observed population for a specified period of time into the future. What's more, these models can explicitly incorporate random fluctuations in rates of birth and death discussed earlier. As a result, the models can be much more realistic in their treatment of the forces that influence population dynamics, and in particular how human activities can interact with these intrinsic forces to put otherwise relatively stable wildlife populations at risk.

Many different software packages exist for the purposes of conducting a PVA. Perhaps the most widely-used of these packages is Vortex, developed by the IUCN Conservation Breeding Specialist Group (CBSG) for use in both applied and educational environments. Vortex has been used by CBSG and other conservation biologists for more than 15 years and has proved to be a very useful tool for helping make more informed decisions in the field of wildlife population management.

The Vortex Population Viability Analysis Model

For the analyses presented here, the Vortex computer software (Lacy 1993a) for population viability analysis was used. Vortex models demographic stochasticity (the randomness of reproduction and deaths among individuals in a population), environmental variation in the annual birth and death rates, the impacts of sporadic catastrophes, and the effects of inbreeding in small populations. Vortex also allows analysis of the effects of losses or gains in habitat, harvest or supplementation of populations, and movement of individuals among local populations.

Density dependence in mortality is modelled by specifying a carrying capacity of the habitat. When the population size exceeds the carrying capacity, additional morality is imposed across all age classes to bring the population back down to the carrying capacity. The carrying capacity can be specified to change linearly over time, to model losses or gains in the amount or quality of habitat. Density dependence in reproduction is modelled by specifying the proportion of adult females breeding each year as a function of the population size.

Vortex models loss of genetic variation in populations, by simulating the transmission of alleles from parents to offspring at a hypothetical genetic locus. Each animal at the start of the simulation is assigned two unique alleles at the locus. During the simulation, Vortex monitors how many of the original alleles remain within the population, and the average heterozygosity and gene diversity (or "expected heterozygosity") relative to the starting levels. Vortex also monitors the inbreeding coefficients of each animal, and can reduce the juvenile survival of inbred animals to model the effects of inbreeding depression.

Vortex is an individual-based model. That is, Vortex creates a representation of each animal in its memory and follows the fate of the animal through each year of its lifetime. Vortex keeps track of the sex, age, and parentage of each animal. Demographic events (birth, sex determination, mating, dispersal, and death) are modelled by determining for each animal in each year of the simulation whether any of the events occur. (See figure above.) Events occur according to the specified age and sex-specific probabilities. Demographic stochasticity is therefore a consequence of the uncertainty regarding whether each demographic event occurs for any given animal.

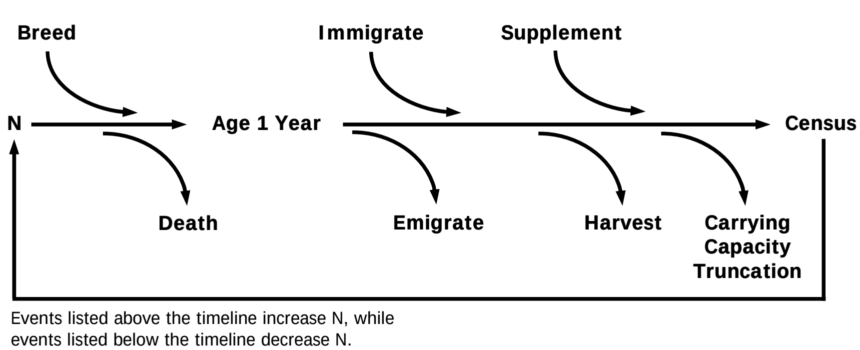
Vortex requires a lot of population-specific data. For example, the user must specify the amount of annual variation in each demographic rate caused by fluctuations in the environment. In addition, the frequency of each type of catastrophe (drought, flood, epidemic disease) and the effects of the catastrophes on survival and reproduction must be specified. Rates of migration (dispersal) between each pair of local populations must be specified. Because Vortex requires specification of many biological parameters, it is not necessarily a good model for the examination of population dynamics that would result from some generalised life history. It is most usefully applied to the analysis of a specific population in a specific environment.

Further information on Vortex is available in Lacy (2000) and Miller and Lacy (2003).

Results reported for each scenario include:

Deterministic r -- The deterministic population growth rate, a projection of the mean

VORTEX Simulation Model Timeline



rate of growth of the population expected from the average birth and death rates. Impacts of harvest, inbreeding, and density dependence are not considered in the calculation. When r = 0, a population with no growth is expected; r < 0 indicates population decline; r > 0 indicates long-term population growth. The value of r is approximately the rate of growth or decline per year.

The deterministic growth rate is the average population growth expected if the population is so large as to be unaffected by stochastic, random processes. The deterministic growth rate will correctly predict future population growth if: the population is presently at a stable age distribution; birth and death rates remain constant over time and space (i.e., not only do the probabilities remain constant, but the actual number of births and deaths each year match the expected values); there is no inbreeding depression; there is never a limitation of mates preventing some females from breeding; and there is no density dependence in birth or death rates, such as a Allee effects or a habitat “carrying capacity” limiting population growth. Because some or all of these assumptions are usually violated, the average population growth of real populations (and stochastically simulated ones) will usually be less than the deterministic growth rate.

Stochastic r -- The mean rate of stochastic population growth or decline demonstrated by the simulated populations, averaged across years and iterations, for all those simulated populations that are not extinct. This population growth rate is calculated each year of the simulation, prior to any truncation of the population size due to the population exceeding the carrying capacity. Usually, this stochastic r will be less than the deterministic r predicted from birth and death rates. The stochastic r from the simulations will be close to the deterministic r if the population growth is steady and robust. The stochastic r will be notably less than the deterministic r if the population is subjected to large fluctuations due to environmental variation, catastrophes, or the genetic and demographic instabilities inherent in small populations.

P(E) -- the probability of population extinction, determined by the proportion of, for example, 500 iterations within that given scenario that have gone extinct in the simulations. “Extinction” is defined in the Vortex model as the lack of either sex.

N -- mean population size, averaged across those simulated populations which are not extinct.

SD(N) -- variation across simulated populations (expressed as the standard deviation) in the size of the population at each time interval. SDs greater than about half the size of mean N often indicate highly unstable population sizes, with some simulated populations very near extinction. When SD(N) is large relative to N, and especially when SD(N) increases over the years of the simulation, then the population is vulnerable to large random fluctuations and may go extinct even if the mean population growth rate is positive. SD(N) will be small and often declining relative to N when the population is either growing steadily toward the carrying capacity or declining rapidly (and deterministically) toward extinction. SD(N) will also decline considerably when the population size approaches and is limited by the carrying capacity.

H -- the gene diversity or expected heterozygosity of the extant populations, expressed as a percent of the initial gene diversity of the population. Fitness of individuals usually declines proportionately with gene diversity (Lacy, 1993), with a 10 % decline in gene diversity typically causing about 15 % decline in survival of captive mammals (Ralls *et al.* 1988). Impacts of inbreeding on wild populations are less well known, but may be more severe than those observed in captive populations (Jiménez *et al.* 1994). Adaptive response to natural selection is also expected to be proportional to gene diversity. Long-term conservation programmes often set a goal of retaining 90 % of initial gene diversity (Soulé *et al.* 1986). Reduction to 75 % of gene diversity would be equivalent to one generation of full-sibling or parent-offspring inbreeding.

Strengths and Limitations of the PVA Approach

When considering the applicability of PVA to a specific issue, it is vitally important to understand those tasks to which PVA is well-suited as well as to understand what the technique is not well-designed to deliver. With this enhanced understanding will also come a more informed public that is better prepared to critically evaluate the results of a PVA and how they are applied to the practical conservation measures proposed for a given species or population.

The dynamics of population extinction are often quite complicated, with numerous processes impact the dynamics in complex and interacting ways. Moreover, we have already come to appreciate the ways in which demographic rates fluctuate unpredictably in wildlife populations, and the data needed to provide estimates of these rates and their annual variability are themselves often uncertain, i.e., subject to observational bias or simple lack of detailed study over relatively longer periods of time. As a result, the elegant mental models or the detailed mathematical equations of even the most gifted conservation biologist are inadequate for capturing the detailed nuances of interacting factors that determine the fate of a wildlife population threatened by human activity. In contrast, simulation models can include as many factors that influence population dynamics as the modeller and the end-user of the model wish to assess. Detailed interactions between processes can also be modelled, if the nature of those interactions can be specified. Probabilistic events can be easily simulated by computer programmes, providing output that gives both the mean expected result and the range or distribution of possible outcomes.

PVA models have also been shown to stimulate meaningful discussion among field biologists in the subjects of species biology, methods of data collection and analysis, and the assumptions that underlie the analysis of these data in preparation for their use in model construction. By making the models and their underlying data, algorithms and assumptions explicit to all who learn from them, these discussions become a critical component in the social process of achieving a shared understanding of a threatened species' current status and the biological justification for identifying a particular management strategy as the most effective for species conservation. This additional benefit is most easily recognised when PVA is used in an interactive workshop-type setting, such as the Population and Habitat Viability Assessment (PHVA) workshop designed and implemented by CBSG.

Perhaps the greatest strength of the PVA approach to conservation decision-making is related to what many of its detractors see as its greatest weakness. Because of the inherent uncertainty now known to exist in the long-term demography of wildlife populations (particularly those that are small in size), and because of the difficulties in obtaining precise estimates of demographic rates through extended periods of time collecting data in the field, accurate predictions of the future performance of a threatened wildlife population are effectively impossible to make. Even the most respected PVA practitioner must honestly admit that an accurate prediction of the number of mountain gorillas that will roam the forests on the slopes of the eastern Africa's Virunga Volcanoes in the year 2075, or the number of polar bears that will swim the warming waters above the Arctic Circle when our great-grandchildren grow old, is beyond their reach. But this type of difficulty, recognised across diverse fields of study from climatology to gambling, is nothing new: in fact, the Nobel Prize-winning physicist Niels Bohr once said "Prediction is very difficult, especially when it's about the future." Instead of lamenting this inevitable quirk of the physical world as a fatal flaw in the practice of PVA, we must embrace it and instead use our very cloudy crystal ball for another purpose: to make relative, rather than absolute, predictions of wildlife population viability in the face of human pressure.

The process of generating relative predictions using the PVA approach is often referred to as sensitivity analysis. In this manner, we can make much more robust predictions about the relative response of a simulated wildlife population to alternate perturbations to its demography. For example, a PVA practitioner may not be able to make accurate predictions about how many individuals of a given species may persist in 50 years in the presence of intense human hunting pressure, but that practitioner can speak with considerably greater confidence about the relative merits of a male-biased hunting strategy compared to the much more severe demographic impact typically imposed by a hunting strategy that prefers females. This type of comparative approach was used very effectively in a PVA for highly threatened populations of tree kangaroos (*Dendrolagus sp*.) living in Papua New Guinea, where adult females are hunted preferentially over their male counterparts. Comparative models showing the strong impacts of such a hunting strategy were part of an important process of conservation planning that led, within a few short weeks after a participatory workshop including a number of local hunters (Bonnaccorso *et al.* 1998), to the signing of a long-term hunting moratorium for the most critically endangered species in the country, the tenkile or Scott's tree kangaroo (*Dendrolagus scottae*).

PVA models are necessarily incomplete. We can model only those factors which we understand and for which we can specify the parameters. Therefore, it is important to realize that the models often underestimate the threats facing the population, or the total risk these threats collectively impose on the population of interest. To address this limitation, conservation biologists must try to engage a diverse body of experts with knowledge spanning many different fields in an attempt to broaden our understanding of the consequences of interaction between humans and wildlife.

Additionally, models are used to predict the long-term effects of the processes presently acting on the population. Many aspects of the situation could change radically within the time span that is modelled. Therefore, it is important to reassess the data and model results periodically, with changes made to the conservation programmes as needed (see Lacy and Miller, 2002, Nyhus *et al.* 2002 and Westley and Miller, 2003 for more details).

Finally, it is also important to understand that a PVA model by itself does not define the goals of conservation planning of a given species. Goals, in terms of population growth, probability of persistence, number of extant populations, genetic diversity, or other measures of population performance must be defined by the management authorities before the results of population modelling can be used.

Further Reading

Beissinger, S. and D. McCullough (eds.). 2002. Population Viability Analysis. University of Chicago Press, Chicago.

Bonaccorso, F., P. Clark, P.S. Miller and O. Byers. 1999. Conservation Assessment and Management Plan for the Tree Kangaroos of Papua New Guinea and Population and Habitat Viability Assessment for Matschie's Tree Kangaroo (Dendrolagus matschei): Final Report. IUCN / SSC Conservation Breeding Specialist Group, Apple Valley, MN.

Gilpin, M.E., and M.E. Soulé. 1986. Minimum viable populations: processes of species extinction. Pages 19 – 34 in: Soulé, M.E. (ed.). Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Sunderland, MA.

Jiménez, J.A., K.A. Hughes, G. Alaks, L. Graham, and R.C. Lacy. 1994. An experimental study of inbreeding depression in a natural habitat. Science 266:271-273.

Lacy, R.C. 1993. Impacts of inbreeding in natural and captive populations of vertebrates: implications for conservation. Perspectives in Biology and Medicine 36:480-496.

Lacy, R.C. 2000. Structure of the Vortex simulation model for population viability analysis. Ecological Bulletins 48:191-203.

Lacy, R.C., and P.S. Miller. 2002. Incorporating human activities and economics into PVA. Pages 490 – 510 in: Beissinger, S. and D. McCullough (eds.), Population Viability Analysis. University of Chicago Press, Chicago.

Miller, P.S., and R.C. Lacy. 2005. Vortex: A Stochastic Simulation of the Extinction Process. Version 9 User's Manual. IUCN SSC Conservation Breeding Specialist Group, Apple Valley, MN.

Morris, W.F., and D.F. Doak. 2002. Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis. Sinauer Associates, Sunderland, MA.

Nyhus, P.J., F.R. Westley, R.C. Lacy, and P.S. Miller. 2002. A role for natural resource social science in biodiversity risk assessment. Society and Natural Resources 15:923-932.

Ralls, K., J.D. Ballou, and A. Templeton. 1988. Estimates of lethal equivalents and the cost of inbreeding in mammals. Conservation Biology 2:185-193.

Reed, J.M., L.S. Mills, J.B. Dunning Jr., E.S. Menges, K.S. McKelvey, R. Frye, S.R. Beissinger, M.-C. Anstett, and P.S. Miller. 2002. Emerging issues in population viability analysis. Conservation Biology 16:7-19.

Soulé, M., M. Gilpin, W. Conway, and T. Foose. 1986. The millennium ark: How long a voyage, how many staterooms, how many passengers? Zoo Biology 5:101-113.

Westley, F.W., and P.S. Miller (eds.). 2003. Experiments in Consilience: Integrating Social and Scientific Responses to Save Endangered Species. Island Press, Washington, DC.

Appendix 6: IUCN / SSC Guidelines for Reintroductions

Prepared by the SSC Re-introduction Specialist Group*

Approved by the 41st Meeting of the IUCN Council, Gland Switzerland, May 1995

Introduction

These policy guidelines have been drafted by the Re-introduction Specialist Group of the IUCN's Species Survival Commission, in response to the increasing occurrence of reintroduction projects worldwide, and consequently, to the growing need for specific policy guidelines to help ensure that the re-introductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in re-introduction exercises.

These guidelines are intended to act as a guide for procedures useful to re-introduction programmes and do not represent an inflexible code of conduct. Many of the points are more relevant to re-introductions using captive-bred individuals than to translocations of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each re-introduction proposal should be rigorously reviewed on its individual merits. It should be noted that re-introduction is always a very lengthy, complex and expensive process.

Re-introductions or translocations of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue and beyond the scope of these guidelines. These include fishing and hunting activities. This document has been written to encompass the full range of plant and animal taxa and is therefore general. It will be regularly revised. Handbooks for re-introducing individual groups of animals and plants will be developed in future.

Context

The increasing number of re-introductions and translocations led to the establishment of the IUCN / SSC Species Survival Commission's Re-introduction Specialist Group. A priority of the Group has been to update IUCN's 1987 Position Statement on the Translocation of Living Organisms, in consultation with IUCN's other commissions.

It is important that the Guidelines are implemented in the context of IUCN's broader policies pertaining to biodiversity conservation and sustainable management of natural resources. The philosophy for environmental conservation and management of IUCN and other conservation bodies is stated in key documents such as "Caring for the Earth" and "Global Biodiversity Strategy" which cover the broad themes of the need for approaches with community involvement and participation in sustainable natural resource conservation, an overall enhanced quality of human life and the need to conserve and, where necessary, restore ecosystems. With regards to the latter, the re-introduction of a species is one specific instance of restoration where, in general, only this species is missing. Full restoration of an array of plant and animal species has rarely been tried to date.

Restoration of single species of plants and animals is becoming more frequent around the world. Some succeed, many fail. As this form of ecological management is increasingly common, it is a priority for the Species Survival Commission's Re-introduction Specialist Group to develop guidelines so that re-introductions are both justifiable and likely to succeed, and that the conservation world can learn from each initiative, whether successful or not. It is hoped that these Guidelines, based on extensive review of case - histories and wide consultation across a range of disciplines will introduce more rigour into the concepts, design, feasibility and implementation of re-introductions despite the wide diversity of species and conditions involved.

Thus the priority has been to develop guidelines that are of direct, practical assistance to those planning, approving or carrying out re-introductions. The primary audience of these guidelines is, therefore, the practitioners (usually managers or scientists), rather than decision makers in governments. Guidelines directed towards the latter group would inevitably have to go into greater depth on legal and policy issues.

1. Definition of terms

"Re-introduction": an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct ("Reestablishment" is a synonym, but implies that the re-introduction has been successful).

"Translocation": deliberate and mediated movement of wild individuals or populations from one part of their range to another.

"Re-enforcement / Supplementation": addition of individuals to an existing population of conspecifics.

"Conservation / Benign Introductions": an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and ecogeographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

2. Aims and objectives of reintroduction

a. Aims:

The principle aim of any re-introduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct, or extirpated, in the wild. It should be re-introduced within the species' former natural habitat and range and should require minimal long-term management.

b. Objectives:

The objectives of a re-introduction may include: to enhance the long-term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and / or restore natural biodiversity; to provide long-term economic benefits to the local and / or national economy; to promote conservation awareness; or a combination of these.

3. Multidisciplinary approach

A re-introduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as government personnel, they may include persons from governmental natural resource management agencies; non-governmental organisations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and / or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

4. Pre-project activities

4a. Biological

(i) Feasibility study and background research

- An assessment should be made of the taxonomic status of individuals to be reintroduced. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the re-introduction area, as well as molecular genetic studies, should be undertaken in case of doubt as to individuals' taxonomic status. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.

- Detailed studies should be made of the status and biology of wild populations (if they exist) to determine the species' critical needs. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. For plants, it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g. with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire re-introduction scheme.

- The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the effect the re-introduced species will have on the ecosystem is important for ascertaining the success of the reintroduced population.

- The build-up of the released population should be modelled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.

- A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Re-introductions

- Thorough research into previous re-introductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing re-introduction protocol.

(iii) Choice of release site and type

- Site should be within the historic range of the species. For an initial reinforcement there should be few remnant wild individuals. For a re-introduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a re-introduction or reinforcement may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.

- A conservation / benign introduction should be undertaken only as a last resort when no opportunities for re-introduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.

- The re-introduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of re-introduction site

- Availability of suitable habitat: re-introductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the for-seeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal / political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying capacity to sustain growth of the re-introduced population and support a viable (self-sustaining) population in the long run.

- Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programmes; competition with domestic livestock, which may be seasonal. Where the release site has undergone substantial degradation caused by human activity, a habitat restoration programme should be initiated before the re-introduction is carried out.

(v) Availability of suitable release stock

- It is desirable that source animals come from wild populations. If there is a choice of wild populations to supply founder stock for translocation, the source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preference) to the original sub-population.

- Removal of individuals for re-introduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.

- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.

- If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.

- Re-introductions should not be carried out merely because captive stocks exist, nor solely as a means of disposing of surplus stock.

- Prospective release stock, including stock that is a gift between governments, must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for non-endemic or contagious pathogens with a potential impact on population levels, must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.

- Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimise this risk.

- Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

(vi) Release of captive stock

- Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.

- Care should be taken to ensure that potentially dangerous captive bred animals (such as large carnivores or primates) are not so confident in the presence of humans that they might be a danger to local inhabitants and / or their livestock.

4b. Socio-economic and legal requirements

- Re-introductions are generally long-term projects that require the commitment of long-term financial and political support.

- Socio-economic studies should be made to assess impacts, costs and benefits of the re-introduction programme to local human populations.

- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long-term protection of the re-introduced population, especially if the cause of species' decline was due to human factors (e.g. over-hunting, over-collection, loss or alteration of habitat). The programme should be fully understood, accepted and supported by local communities.

- Where the security of the re-introduced population is at risk from human activities, measures should be taken to minimise these in the re-introduction area. If these measures are inadequate, the re-introduction should be abandoned or alternative release areas sought.

- The policy of the country to re-introductions and to the species concerned should be assessed. This might include checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.

- Re-introduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in re-introductions in border areas, or involving more than one state or when a reintroduced population can expand into other states, provinces or territories.

- If the species poses potential risk to life or property, these risks should be minimised and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory / mobile species, provisions should be made for crossing of international / state boundaries.

5. Planning, preparation and release stages

- Approval of relevant government agencies and landowners, and coordination with national and international conservation organisations.

- Construction of a multidisciplinary team with access to expert technical advice for all phases of the programme.

- Identification of short- and long-term success indicators and prediction of programme duration, in context of agreed aims and objectives.

- Securing adequate funding for all programme phases.

- Design of pre- and post- release monitoring programme so that each re-introduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data. Monitoring the health of individuals, as well as the survival, is important; intervention may be necessary if the situation proves unforeseeeably favourable.

- Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the reintroduction area.

- If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.

- If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.

- Appropriate veterinary or horticultural measures as required to ensure health of released stock throughout the programme. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to the release site.

- Development of transport plans for delivery of stock to the country and site of reintroduction, with special emphasis on ways to minimise stress on the individuals during transport.

- Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).

- Establishment of policies on interventions (see below).

- Development of conservation education for long-term support; professional training of individuals involved in the long-term programme; public relations through the mass media and in local community; involvement where possible of local people in the programme.

- The welfare of animals for release is of paramount concern through all these stages.

6. Post-release activities

- Post release monitoring is required of all (or sample of) individuals. This most vital aspect may be by direct (e.g. tagging, telemetry) or indirect (e.g. spoor, informants) methods as suitable.
- Demographic, ecological and behavioural studies of released stock must be undertaken.
- Study of processes of long-term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g. supplemental feeding; veterinary aid; horticultural aid) when necessary.
- Decisions for revision, rescheduling, or discontinuation of programme where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of re- introduction techniques.
- Regular publications in scientific and popular literature.

Footnotes:

1. Guidelines for determining procedures for disposal of species confiscated in trade are being developed separately by IUCN.

2. The taxonomic unit referred to throughout the document is species; it may be a lower taxonomic unit (e.g. subspecies or race) as long as it can be unambiguously defined.

3. A taxon is extinct when there is no reasonable doubt that the last individual has died.

The IUCN / SSC Re-introduction Specialist Group

The IUCN / SSC Re-introduction Specialist Group (RSG) is a disciplinary group (as opposed to most SSC Specialist Groups which deal with single taxonomic groups), covering a wide range of plant and animal species. The RSG has an extensive international network, a reintroduction projects database and re-introduction library. The RSG publishes a bi-annual newsletter RE-INTRODUCTION NEWS.

If you are a re-introduction practitioner or interested in re-introductions please contact:

IUCN / SSC Re-introduction Specialist Group (RSG),
C/o African Wildlife Foundation (AWF),
P.O. Box 48177,
Nairobi,
Kenya.
Tel:(+254-02) -710367, Fax: (+254-02) - 710372 or
E-Mail: awf.nrb@tt.gn.apc.org

Appendix 7: The Endangered Wildlife Trust and CBSG Southern Africa

The Endangered Wildlife Trust is a non-governmental, non-profit, conservation organisation, founded in 1973 and operating throughout southern Africa. The EWT conserves threatened species and ecosystems in southern Africa by initiating research and conservation action programmes, implementing projects which mitigate threats facing species diversity and supporting sustainable natural resource management. The EWT furthermore communicates the principles of sustainable living through awareness programmes to the broadest possible constituency for the benefit of the region.

The EWT has developed a unique operational structure through which the mission and objectives of the EWT can be achieved. The EWT achieves its conservation goals through specialist, thematic Working Groups, designed to maximise effectiveness in the field and enhance the development of skills and capacity. These Working Groups form the backbone of the organisation and are essentially self-managed programmes harnessing the talent and enthusiasm of a dynamic network of individuals who specialise in an area of conservation importance and have developed unique expertise in response to the challenges they face. Working Groups comprise multiple stakeholders and harness their diverse but relevant expertise to address environmental priorities.

Stakeholders include national and provincial government, landowners, local communities, ranch workers, conservancies, academic institutions and industry. The EWT also acts as a public watchdog, often taking government and industry to task for decision-making which does not meet sustainability criteria.

EWT Mission:

The Endangered Wildlife Trust is dedicated to conserving threatened species and ecosystems to the benefit of all the people of southern Africa.

The EWT, with its access to a rich and diverse range of conservation expertise, established CBSG Southern Africa in partnership with the CBSG, SSC / IUCN in 2000. Nine CBSG regional networks exist worldwide, including CBSG Indonesia, India, Japan, Mesoamerica, Mexico, Sri Lanka, Europe and South Asia. Regional CBSG networks are developed in regions requiring intensive conservation action and each network operates in a manner best suited to the region and local species.

CBSG tools are adapted according to the needs and requirements of regional stakeholders and species, as well as local expertise being utilised to best effect.

CBSG Southern Africa, operating under the banner of the EWT is a non-profit, non-governmental organisation, serving the needs of the *in-situ* and *ex-situ* conservation community in southern Africa through the provision of capacity building courses, species and organisational Action Planning, Population and Habitat Viability Assessment (PHVA) and Conservation Assessment and Management Planning (CAMP) workshops, communication networks, species assessments and a host of other CBSG processes for species and ecosystem conservation. CBSG Southern Africa works with all stakeholders in the pursuit of effective biodiversity conservation throughout southern Africa.

CBSG Southern Africa's Mission:

To catalyse conservation action in southern Africa by assisting in the development of integrated and scientifically sound conservation programmes for species and ecosystems, building capacity in the regional conservation community and incorporating practical and globally endorsed tools and processes into current and future conservation programmes.

Contact CBSG Southern Africa on +27 (0)11 486 1102 / cbsgsa@ewt.org.za / www.ewt.org.za/cbsg