THE POLICY FOR THE MANAGEMENT OF THE ELEPHANT POPULATION OF THE KRUGER NATIONAL PARK

(All SANParks management policies are reviewed every five years or so. This policy is currently under review, and therefore may change in the near future)

INTRODUCTION

This version was compiled from the SANParks' new elephant management policy for the Kruger National Park (KNP), which was published (Whyte *et al.* 1999) for wider dissemination.

The policy of culling elephant as part of the management strategy of the KNP has always been somewhat controversial. In late 1994 the ethical morality of killing elephants was again raised by certain animal rights groups. This resulted in a public debate being held in Midrand on 4 May 1995, at which SANP undertook to review its policy for the management of elephant in the KNP. In accordance with this undertaking, a series of meetings and workshops were held in order to reconsider the policy and make recommendations on appropriate management for the future. The policy is the product of many hours of consultative debate between SANP and a wide diversity of interested and affected people and organisations. The SANP Board approved the policy presented here on 12 March 1999 (this policy is currently under review, and therefore may change in the near future).

THEORETICAL BASIS OF THE NEW POLICY

The KNP is committed to a mission emphasising biodiversity in the widest sense (i.e. structure, function and composition across scales from genetic to landscape and even sub-continental), and makes specific mention of fluxes as part of this. The theoretical basis of quantifying and managing for biodiversity and flux has its origin in the emergent heterogeneity paradigm (e.g. Christensen 1997; Fiedler *et al.* 1997), but still has many unknown dimensions in practice.

Driving variables in savannas include nutrients, moisture, fire, herbivory and others (e.g. Wiens 1997). Elephant herbivory is considered particularly significant, as in some studies, elephants at high densities have been shown to negatively affect biodiversity (Cumming *et al* 1997, Western & Gichohi 1989). If there is variation in these driving variables over time and space, an ever-changing mosaic should be the outcome. The patches, which results are seen as organised in a hierarchy of scales (Wiens 1997). If, for example, many levels of herbivory are naturally superimposed on a fire mosaic, then at certain scales even more diversity should result.

The intermediate disturbance hypothesis claims that the greatest species richness (and perhaps overall biodiversity) at one point in time and space is likely to result from intermediate levels of disturbance. At extreme levels of both low and high disturbance, there might indeed be fewer species, but certain species that are not favoured or are even absent at intermediate levels would very likely prosper. Thus, if the ecosystem can pass through various stages of disturbance in different places and at different times, the patchwork created might support the greatest overall diversity desirable in a natural system, though spatial variation can in many ways substitute for temporal variation and *vice versa*.

An equally important issue is the rate of change, as influenced by the pattern and intensity of disturbance - a rapidly increasing disturbance regime often has different ecological effects to a slowly increasing one, even if the final intensity is the same.

In recent years there has been increasing belief that most of the important changes in savannas are event-driven. They may occur only occasionally, when a certain co-occurrence of events (perhaps drought plus rapidly-rising levels of herbivory plus fire at a critical period, followed by good rain) brings about a particular shift from one state to another (perhaps an invasion of bush into grassland). Different ecological pressures then prevail which may stabilise the system in a new state for years or even decades. Current ecosystem theory takes cognisance of the likelihood of the existence of multiple stable states (Dublin 1995) as well as considering several other models of ecosystem dynamics. These differing ideas about how systems function, span a range from the classical homogeneity/stability paradigms through to the relatively revolutionary disequilibrial notions (Behnke *et al.* 1993). Each of these models appears to have had some validity at some location and scale over some time span, our current understanding falling short of integration of these into a unified theory. Holling (1995) and others assert that by finding a particular apparent "winning recipe for ecosystem management" at a locality (the more homogeneous, seemingly the more dangerous) and keeping it static for too long, invariably leads to catastrophic change when an extreme event occurs, usually because of lack of resilience.

Scaling is a historically underrated issue and its understanding forms the crux of much new insight. Elephant impacts may operate at various scales, and much of what is presented here assumes that animals with such large body sizes, home ranges, walking ability and propensity for fast-increase are likely to create landscape-scale effects. Equally they may, perhaps at lower densities, create a mosaic of medium-scale (100's of metres to 10 km) effects with patches of riverine vegetation being "stripped completely" and other patches nearby not being touched. At the individual tree level, different fine-scale sequelae of their feeding on some parts and not others of the tree, might lead to habitat diversity for different insects. Time scales are equally important: long-term views often place shorter-term fluctuations into the perspective of making up the natural flux.

What does all this mean for management? Managers of natural systems are now entering an era where heterogeneity needs not only to be understood, but also implemented in some practical way. The outcome of this elephant management strategy is an attempt to meet this challenge, even if the scales at which the processes occur needs further understanding. The belief is, in the first place, that this management strategy will enhance biodiversity. Secondly, at the same time, it will provide an opportunity to learn by managing, a crucial element of adaptive management. Although much use will be made of the outcomes to learn more about future elephant management, it should not be seen primarily as an experiment - the options chosen are intended to meet the primary biodiversity objective of the KNP, rather than constitute any contrived or forceful experiment. Obviously, "unnatural over-heterogenisation" is possible, and is indeed practised by smaller ecotourism operations specifically to create habitat diversity for more species than might naturally occur at these sites. It is not the intention of the SANP to take the management of the KNP to this unnatural level, indeed where this has happened (artificial waterholes can lead to heterogenisation or homogenisation, obviously depending on the context) it is being reversed. In the same vein, the SANP would like to vary rates of change (thus increasing diversity, also through the differential resilience of different species and systems to different rates) but in a natural regime. The word "natural", as also embodied in the mission statement, thus provides an important cornerstone of this action. The TPCs, which will be continuously refined as knowledge, experience and hopefully wisdom grow, provide an attempt to outline the "envelopes" of acceptability to management. They are meant to delineate thresholds beyond which (it is believed) the system will have exceeded its inherent elasticity, and from which it may not have the ability to return to a healthy state.

The occurrence of the kinds of events which bring about changes, even drastic-seeming changes, should not be suppressed if they are natural, as they may contribute significantly to system resilience in the long-run (Holling 1995). KNP management should thus be geared to allowing these to take place. Management has to be capable of tracking ecosystem changes to see that they fall within TPCs, and may need to nudge the system in the "correct" direction if sustained trajectories towards (and believed to be going to exceed) TPCs are predicted. More drastic intervention may be needed when TPCs have been grossly exceeded due to modern human influence, though if the adaptive management and TPC-monitoring system is effective, this may not often be necessary. An understanding of the scales at which these different processes related to elephant impact occur, is extremely difficult to achieve, and will demand much research and modelling. Certainly, the SANP is trying to adopt a longer-term view, though realising the importance of perhaps shorter-term considerations such as the immediate tourism value of this unique species, as well as moral and ethical considerations.

CURRENT THINKING AND APPROACH TO ELEPHANT MANAGEMENT

Principles

This elephant management policy rests on three fundamental principles. These are:

i. In accordance with the new Vision Statement of the KNP, it is accepted that flux in ecosystems is natural and desirable as this contributes to biodiversity, and that this is probably also true for the elephant population.

ii. It is accepted that elephants are important agents of disturbance and as such create heterogeneity and thus contribute to biodiversity (Intermediate Disturbance Hypothesis). This was demonstrated in Amboseli National Park by Western & Gichohi (1989). This means that in the absence (or very low densities) of elephants, biodiversity will be negatively affected as no disturbance occurs. Excessive disturbances at high densities will also affect biodiversity negatively (these high and low end-points may also be shown to be desirable as it is believed that certain species will benefit from the conditions thus created, provided that they do not occur over a large area for too long).

iii. It is accepted that elephant populations that are confined but not managed, will increase in number to a level where negative impacts on the system's biodiversity will result.

In recognising the above three principles, the following corollaries have to be considered:

i. To *maintain* an elephant population at a *high* level will require the culling and/or translocation of a larger number of individuals than when maintaining it at a lower level (this may have moral or ethical considerations).

ii. The *reduction* of an elephant population from a high level to a lower level will require the culling and/or translocation of a larger number of individuals than when maintaining it at a lower level (this may have moral or ethical considerations).

iii. Wherever possible, management of the elephant population should be conducted by non-lethal means (translocation, contraception, etc.) but that where these methods prove inadequate, culling must remain an option for use.

iv. When culling is necessary, only the most humane method available should be used.

Options for controlling elephant numbers other than culling

When or wherever elephant population control is considered necessary, the priority will always be to do so by non-lethal means. It is stressed that these options are not likely to fulfil the requirements needed to manage the KNP elephant population successfully. Where these options are not feasible, culling is currently the only practical option available to do so.

i. Translocation (live transfer)

Before the development of methods to translocate adult elephants, juvenile animals were captured at culling operations for translocation. Up to 1994, 1 339 juveniles were translocated in this way from KNP to other conservation areas. By 1994, methods enabling the live transfer of adult elephants had been developed and with the advent of this technology, it is now believed that the translocation of juvenile animals is inhumane and therefore undesirable. This latter option will no longer be practised - only animals in intact family units will be transferred live out of the KNP. Opportunities for translocations are now extremely limited as there is little space left into which elephants can be moved. Most areas in Southern Africa that can potentially accommodate elephants now have them, while those that still can (e.g. Limpopo National Park in Mozambique), will not be able to accommodate the numbers that need to be moved.

It is believed that over the long term, the limited market for live animals will not provide the option of removing all excess elephants from the KNP through live transfer.

ii. Contraception

The current state of contraception technology is such that it cannot yet offer a satisfactory method of population control in elephants (Whyte & Grobler 1997; Whyte *et al.* 1998). While porcine zona pellucida (pZP) vaccines have been shown to be an effective and acceptable contraceptive in elephants, oestrogen (oestradiol-17ß) implants caused behavioural aberrancies and post-treatment affects that were considered unacceptable. But for both of these techniques, the logistics preclude their use in large populations. In order to stabilize an elephant population, 75% of all breeding females must be constantly under treatment (Whyte *et al.* 1998). In a normal population, this equates to around 35% of the population total. These animals all require "boosters" or replenishments at specific times, which means that each animal must be individually locatable, and each one must therefore be fitted with a radio collar. This all pushes the costs (economically and logistically) to a level that is beyond that affordable by most conservation agencies. There are some developments that may change this situation.

Sterilization is another form of contraception. Its major drawback is that it is not reversible, which means that a population under regulation using this technique would be severely at risk from either a poaching or disease epidemic. Its ability to recover would be greatly impaired if most of its adult females (or males) had been permanently sterilized.

This level of interference in a large national park also poses many unanswered moral questions - the longer-term side effects on structure and behaviour in a contraceived population are also poorly understood.

Another problem with all contraception techniques is that they cannot reduce a population over the short term. Elephants are long-lived animals, so once a population has been stabilized by contraception, there will be a time lag before natural mortalities will eventually begin to reduce it.

Finally, opposition to the contraception option has been voiced by communities adjacent to KNP as they hold the belief that sustainable utilisation of the population should be practised. However, SANP will continue to support research on contraception technology with the hope that it will ultimately provide an additional practical and affordable option for the control of the KNP (and other) elephant populations.

THE NEW POLICY FOR MANAGING THE KNP ELEPHANT POPULATION

The new elephant management policy will differ from the old one in that the elephant population will be managed according to measured impacts on biodiversity rather than on absolute numbers of elephants. Different management options will be practised in different zones and aspects of biodiversity will be monitored. This management option will continue until there is clear evidence that the prevailing density of elephants is having a negative impact on some aspect of biodiversity which warrants concern. This point will be known as a "Threshold of Potential Concern" (TPC), which can defined as those upper and lower levels along a continuum of change in a selected environmental indicator which, when reached, prompts an assessment of the causes which led to such an extent of change, and results in either:

i. Management action to moderate such cause(s), or

ii. Re-calibration of the threshold to a more realistic or meaningful level.

Such TPCs are initially established at somewhat arbitrary levels on "best-available-knowledge-and-experience". It is absolutely necessary when deciding to use such TPCs that it must be accompanied by monitoring at appropriate intervals, and that there must be considerable understanding of the factors causing change in the parameter being monitored.

TPCs have the advantage that management has definite proactive objectives or parameters within which to manage a system, in contrast to previous practices which reactively managed events or processes to minimise or avoid crises. Nevertheless, TPCs should be constantly challenged as to their appropriateness or validity, and adaptively modified as knowledge and experience increase.

The appropriate TPCs for the management of the KNP elephant population have been set "widely" which will allow for considerable fluctuation in the populations of the respective management zones. The TPCs for elephant are given (in their current form) at the end of this elephant management policy proposal.

A zoning system for management of elephant impact

The KNP will be divided into six zones, which will receive different treatments in terms of the management of their respective elephant populations (see Figure 1). These zones are:

i. two botanical reserves,

ii. two high-density elephant zones,

iii. two low-density elephant zones.

In the high-density elephant zones the population will be allowed to increase (no culling or live removals) until there are indications that one or more of the Thresholds of Potential Concern (TPCs) have been reached or exceeded. It is expected that the elephant population of these zones will increases at 7% per year (see Chapter 5). In the low-density elephant zones the population will be decreased (through culling or live removals) until there are indications that low densities of elephants have induced change to a point that one or more of the TPCs have been reached or exceeded. This decrease will be achieved through the reduction of the populations in these zones by 7% per year. As the numbers of elephants in these zones are also expected to increase at 7% per year, it will mean the setting of a removal quota of 14% of the total recorded during the census to achieve a 7% reduction. In the Botanical Reserves medium densities are to be maintained. "Medium density" is here considered to be the density prescribed in the previous Masterplan (Joubert 1986), which were 0.35 elephants per km^2 (7 000 elephants in 20 000 km^2). Should one or more of the defined TPCs be reached or exceeded in these zones, then elephant numbers should be systematically reduced to negate this.

It is hoped that it will prove feasible for the management actions applied in the high- and low-density zones to be alternated, so that once a TPC has been reached or exceeded in any of the management zones, the alternate action will then be applied. High-density areas can then be treated as low-density zones and their populations systematically reduced while the elephant populations of the low-density zones can simultaneously be allowed to increase. While it is accepted in principle that this managed form of flux in the elephant population may prove to be beneficial and contribute to the maintenance of biodiversity in the KNP, it is felt that this should be demonstrated before it becomes permanently embodied in the elephant management policy.

There is some concern that increased elephant densities in the allocated zones may affect biodiversity in a way that is not reversible by a subsequent reduction in the elephant population. Theoretically a high elephant population may induce a decline in the population of some tree species, which may then not recover under the pressure of even a much lower elephant population. A more cautious approach will be followed - once the effects of an increased elephant population are better understood, this part of the policy should be reviewed.

Elephant management zones

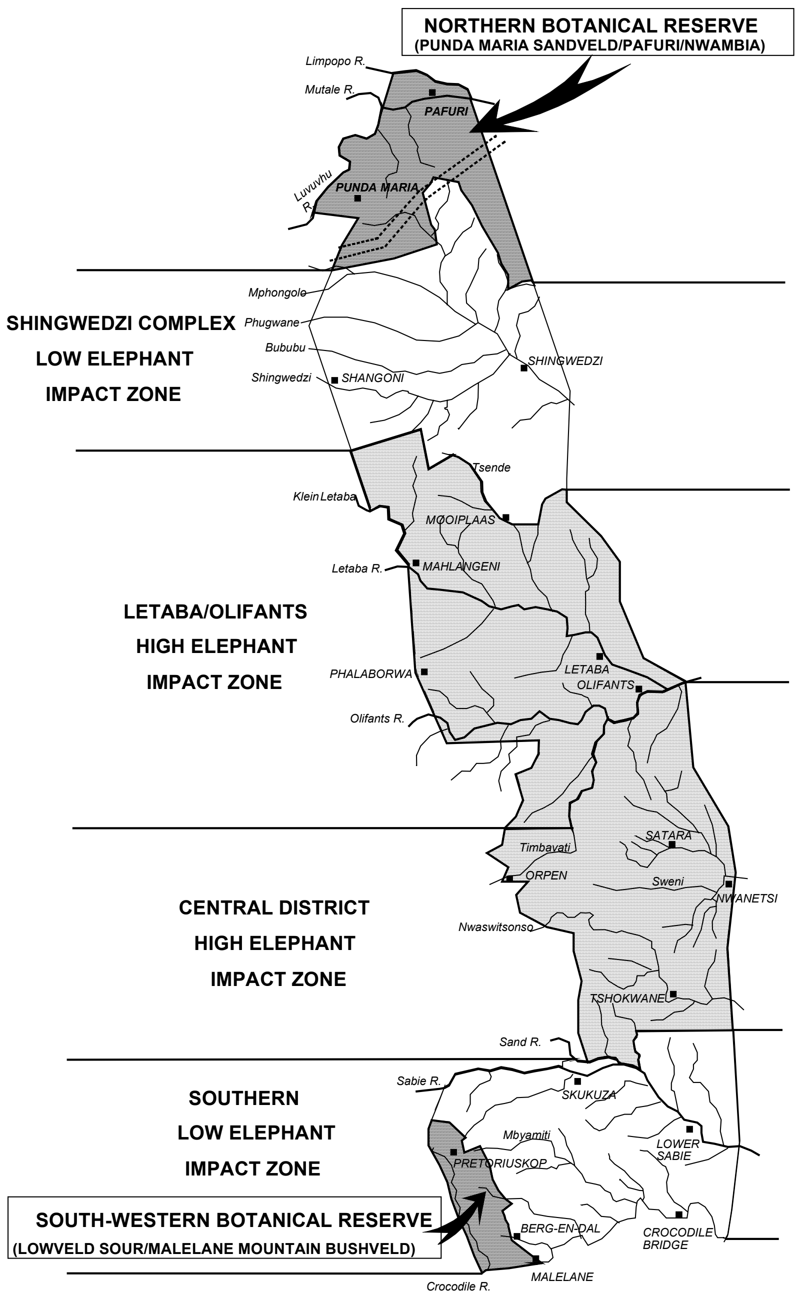
The boundaries of the respective elephant management zones were designated to roughly conform to the known boundaries of elephant clans. This is to allow meaningful elephant management without disrupting the home ranges of these clans. The boundaries have also been defined so as to ensure that the four major zones (excluding the botanical reserves) are of a similar size.

The two high-impact zones have been placed adjacent to one another in the centre of KNP to establish a large core area of "no-management". The two low-impact zones then lie between the high-impact zones and the botanical reserves to obviate the problems of a hard edge between high densities of elephants and the botanical reserves. Once TPCs have been exceeded and the management actions in the respective high- and low-impact zones have been reversed, it is accepted that these problems will become a reality and will have to be addressed. But it may transpire that the elephants' home-ranges will remain intact through the management processes, and that little movement will occur across these boundaries.

The management of the Botanical Reserves will result from TPCs especially formulated for these areas.

It may be expected that by reducing numbers in the two low-impact zones, the total number of elephants in the KNP will not be greatly influenced by the increases in the other two zones, keeping the total population at a manageable level. However, this is not expected to be the case as modelling of the responses of these zones to the planned management actions shows that the total KNP population will probably increase dramatically (Whyte 2001).

Figure 1: The elephant management zones of the Kruger National Park



Northern Botanical Reserve (Sandveld/Pafuri/Nwambia)

Rationale

This area includes some of the vegetation types/landscapes which, due to their floral uniqueness in the KNP (Gertenbach 1983), should not be placed at risk of excessive elephant impacts. The landscapes and vegetation types concerned are the *Colophospermum mopane* forest (Landscape 15 (Gertenbach 1983)), the *Adansonia digitata/Sterculia rogersii* area and the Nwambia sandveld communities.

Elephant management

Elephant densities the botanical reserves are to be initially maintained at a density of 0.35 elephants/km^2. This is the density that was prescribed in the earlier Masterplan for the Kruger National Park (Joubert 1986) at which it was felt that minimum impacts of elephants had been experienced. These densities will be monitored annually during aerial censuses and elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals. The number of elephants in the area should not exceed the prescribed density of 0.35 elephants per km^2 (i.e. 550). However, should one or more of the defined TPCs (see Table 1) be reached or exceeded, then elephant numbers should be systematically reduced (or increased) to negate this, as understanding indicates.

South-western Botanical Reserve (Lowveld Sour/Malelane Mountain Bushveld)

Rationale

This area also includes some of the vegetation types/landscapes of floral uniqueness in the KNP (Gertenbach 1983), which should not be placed at risk of excessive elephant. These landscapes are the Lowveld Sour- and Malelane Mountain Bushveld (Landscapes 1 and 2).

Elephant management

Elephant densities are to be maintained at a density of 0.35 elephants/km^2. These densities will be monitored annually during aerial censuses and elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals. The number of elephants in the area should not exceed 250. However, should one or more of the defined TPCs be reached or exceeded, then elephant numbers should be systematically reduced (or increased) to negate this, as understanding indicates.

Letaba/Olifants High Elephant Impact Zone

Rationale

It is the expectation of KNP managers that fluctuations in elephant numbers (as with all other biotic elements) will benefit natural ecological processes and other components of biodiversity, though this will require confirmation through the monitoring program. Elephant numbers in this zone will not be managed. The intention is to allow elephant numbers to increase over a period of many years until one or more of the defined TPCs are reached or exceeded (as more than one may be reached concurrently). Following this, the zone may revert to a "low-density elephant zone" with systematic reduction of elephant numbers, thus inducing the desired population flux and the varying environmental impacts associated with it.

Elephant management

In this area elephant numbers will not be reduced either through culling, live removals or contraception programs. Numbers are expected to increase at a mean rate of approximately 7% per year. Monitoring of defined components of biodiversity will occur to determine the impacts of this increasing elephant density. The increase will be allowed to continue until one or more of the defined TPCs has been reached or exceeded. Appropriate management actions will then be debated by the KNP Standing Committee for Nature Conservation and all other interested or affected parties, with all the relevant data and reports under consideration.

It is hoped that the trans-frontier conservation area (TFCA) in Mozambique (Braack 2000) will become a reality and that the removal of the fence on this zone's eastern boundary will allow a natural expansion of these elephants into Mozambique.

Elephant densities will be monitored annually during aerial censuses. Elephant movements in and out of the area will be monitored through the movement study using radio-collared animals.

Central District High Elephant Impact Zone

Rationale

As with the Letaba/Olifants High Elephant Impact Zone, it is expected that fluctuations in elephant numbers (as with all other biotic elements) will benefit natural ecological processes and other components of biodiversity, therefore elephant numbers in this zone will not be controlled. The intention in this zone is also to allow elephant numbers to increase over a period of many years until one or more of the defined TPCs are reached or exceeded, following which this zone may revert to a "low-density elephant zone" with systematic reduction of elephant numbers, thus inducing the population flux desired by managers and the expected varying environmental impact associated with it.

Elephant management

In this area, elephant numbers will not be reduced either through culling, live removals or contraception programs. Numbers are expected to increase at a mean rate of around 7% per year. Monitoring of defined components of biodiversity will occur to determine the impacts of this increasing elephant density. The increase will be allowed to continue until one or more of the defined TPCs has been reached or exceeded. Appropriate management actions will then be considered.

Elephant densities will be monitored annually during aerial censuses and elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals.

Shingwedzi Complex Low Elephant Impact Zone

Rationale

As with an increasing elephant population, it is expected that declining elephant numbers will also adversely affect biodiversity as the positive benefits of elephant impacts on heterogeneity are reduced. Elephant numbers will be systematically reduced at a rate of approximately 7% per year. By reducing the number of elephants at a consistent rate of 7% per year the actual number to be removed gradually declines each year so that the effects of the decline will diminish gradually.

It is hoped that the removal of the eastern boundary fence once the TFCA has been established in Mozambique, will allow for some natural movement out of this zone which will reduce the number elephants to be artificially removed (either through culls or translocations).

The reduced elephant density in this zone will also act as a buffer between the Letaba/Olifants High Elephant Impact Zone and the Northern Botanical Reserve.

Elephant management

Elephant densities will be reduced in this zone by 7% per year until one or more of the defined TPCs has been reached or exceeded. Appropriate management actions will then be considered. Elephant densities will be monitored annually during aerial censuses. Quotas for culling or live removals will be determined after the annual census result has become available. Elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals.

Southern Low Elephant Impact Zone

Rationale

As with the Shingwedzi complex low-density elephant zone, elephant numbers will be systematically reduced at a rate of approximately 7% per year. By reducing the number of elephants at a consistent rate of 7% per year the actual number to be removed gradually declines each year so that the effects of the decline will diminish gradually.

Elephant management

Elephant densities will also be reduced in this zone by 7% per year until one or more of the defined TPCs has been reached or exceeded. Appropriate management actions will then be considered. Elephant densities will be monitored annually during aerial censuses. Quotas for culling or live removals will be determined after the annual census result has become available. Elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals.

THRESHOLDS OF POTENTIAL CONCERN FOR ELEPHANT IMPACT

Rationale

Table 1 lists TPCs for the high and low elephant impact zones, but not for the botanical reserves which need their own specific TPCs addressing plant community viability and optimum chance for rare species survival. The so-called "whole-park" measures given here thus refer to the whole KNP excluding the botanical reserves. TPCs for the botanical reserves have not yet been formulated.

Any one TPC reached is meant to act as a significant warning sign on its own, and although evaluated in overall context with the rest, must be taken seriously in its own right.

The TPCs assume that any action then taken will significantly alter the predisposing environment which allowed that TPC to be reached. If at some stage in the future a very high density elephant population has evoked a TPC, the manner in which the populations are to be reduced will be of particular importance. Theoretically, there are many ways in which a large elephant population can be reduced. It might, if it were logistically possible, be reduced by 50% per year (fast removal), which may be necessary after a high-density phase to prevent further exceeding of the TPC. They might also be reduced by as little as 7% or less (slow removal). The TPCs given here presuppose fast removal. If slow removal is chosen, it will be important to tone down the TPCs somewhat to take into account the continued almost-as-high impact, which will follow for many years after the peak is reached.

The relationship between the percentages given for within-zone and for the whole park TPCs (Table 1) may at first seem incongruous, given that the areas of the high and low zones are approximately equal (i.e. one might expect never to reach the whole-park TPCs). However, it is possible that only one of the two high (or for that matter low) zones may show severe changes, justifying the operational use of 30% (i.e. less than half of the 80%) as a TPC.

The list in Table 1 focuses on TPCs believed to be directly related to elephant, but other categories of TPCs (e.g. riparian health) may be exceeded due to elephant influence. These would obviously qualify as valid TPCs in their own right but are still in the formulation phase.

Table 1: Thresholds of Potential Concern for Elephants in the Kruger National Park

Criterion	Measure	Within-zone TPC	Whole-park TPC
Vegetation heterogeneity at coarse (mega) scale	Coverage (km^2) of landscape scale units (e.g. Gertenbach 1983) determined every 5 years. Result compared to any previous time, including historical.	80% change (cumulative) in the area of any landscape scale classification unit	30% change (cumulative) in the area of any landscape scale classification unit
Vegetation structure at community scale using size classes for a range of indicator woody species	Assume, e.g. 4 size classes. Then homogenisation is 90% dominance of any 2 size classes.	80% of all plots homogenous. Sensitive landscapes examined independently as well.	30% of all plots homogenous. Sensitive landscapes examined independently as well.
Woody canopy cover at community scale	% Woody (within stratified landscapes, e.g. riparian) as determined from aerial photographs, done every 3 years	80% decline in canopy cover; specified increase with asymptote (see graph)	30% decline in canopy cover; specified increase with asymptote (see graph)
Rare, sensitive or characteristic (of the Lowveld) woody species (only in relation to elephant utilisation – short list)	Population size and structure fed into pv model	None, prepared to accept local loss or definite trend towards local loss of certain species (provided same species not declining seriously in lo/hi zones at the same time. i.e. species should NOT survive only in botanical reserves.)	99% probability of population persistence for next 100 years
Birds as surrogates for structural riparian health	Presence of species using reed beds, mudflats, litter, lower stratum, middle stratum, upper stratum	Because all perennial rivers are in or border on current high elephant areas, there is need for an in-zone TPC - when species from any category are no longer represented on any particular perennial river. Recolonization thus assumed between zones.	Perennial rivers dealt with as within-zones issue per river; for seasonal rivers there will be a whole-park TPC, namely : when species from any category no longer represented in park as a whole

Criterion	Measure	Within-zone TPC	Whole-park TPC
			– recolonization from perennial rivers assumed.
Birds as functional class representatives in riparian corridors (what about outside riparian corridors as well, with own TPCs?)	Frugivores, gramnivores, insectivores (bark foragers, hawkers, leaf-gleaners), piscivores, raptors, nectarivores Frugivores, Gramnivores etc.	See above	See above
Invertebrate functional class representation	Ground and grass insects and spiders, tree dwelling insects and spiders, dung beetles, termites (harvester and macrotermes mounds), millipedes, pollinators.	When any class disappears from any zone (see proviso in whole-park TPC). Assumes recolonisation.	provided there are not serious concomitant decline of same classes in alternate zones.
Erosion/piosphere	RS classification – bare ground index	When affected area > unaffected area (ie. index >50%) or when affected area < 5% (latter to guarantee some eroded habitat in any zone)	when aggregated whole-park bare ground index less than 2.5% or > 25%

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