

A new policy for the management of the Kruger National Park's elephant population

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Arising from public debate held in Midrand on 4 May 1995, the South African National Parks undertook to review its policy for the management of elephant in the Kruger National Park. The new policy focuses on the extent and intensity of elephant impacts on biodiversity rather than on numbers of elephants *per se*, and is based on four fundamental principles: a) That ecosystems are not static; fluctuations of conditions and population responses are an inherent attribute of ecosystems and contribute to biodiversity. A range of elephant impacts in different areas at different times, is thus also natural and desirable; b) That elephants are important agents of habitat modification and thus contribute to biodiversity (intermediate disturbance hypothesis); c) That elephant populations which are confined will increase in number until negative impacts on the system's biodiversity will ultimately result; d) That elephants should not be viewed in isolation, but as one component of a broader, integrated system, and their impacts should be managed in conjunction with other ecosystem process (such as fire) to promote biodiversity in its broadest sense. The new policy proposes that the Kruger National Park be divided into six zones—two botanical reserves, two high-elephant-impact zones (no population reduction) and two low-elephant-impact zones (where numbers will be actively reduced). A history of the elephant population is given, and a resumé of previous policies.

Key words: elephants, elephant management, culling, heterogeneity, biodiversity, Kruger National Park.

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Introduction

Although a broad cross section of the South African public had come to accept the reasons proposed by earlier managers for the necessity of culling elephants in the Kruger National Park (KNP) which was initiated in 1967, this policy has always been somewhat controversial. In late 1994 the issue was again debated when the reasons for culling and the ethical morality of killing elephants

were raised by certain animal rights groups. This resulted in a public debate being held in Midrand on 4 May 1995, at which South African National Parks (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. Though

the authors were responsible for the write-up of this policy, it is the product of many hours of consultative debate between SANP and a wide diversity of interested and affected people and organisations.

The processes followed

The first of these workshops was held in Skukuza on 8 February 1996 in conjunction with members of the African Elephant Specialist Group (AfESG). This was followed up by a meeting two days later with delegates of the AfESG and the International Fund for Animal Welfare (IFAW). The new rationale was summarised in a document prepared by Hall-Martin & Novellie (1996).

On 30 October 1996 at a workshop held in Skukuza, a wide-ranging series of possible management options were listed and debated. The results of this meeting were reported on by Whyte & Biggs (1997). The options debated were:

- A the previous management policy was just about right;
- B there are too many elephants;
- C there are too few elephants;
- D1 the KNP ecosystem needs natural fluctuations of elephants;
- D2 the KNP ecosystem needs controlled fluctuations of elephants;
- E "animal rights" (*laissez-faire*) type of policy (no culling);
- F community involvement/sustainable consumptive utilisation;
- G maximising economic opportunities.

The resolutions accepted by this meeting

The National Parks Board mandate and primary responsibility within the KNP was to conserve all elements of biodiversity and not to manage selectively for the benefit of a single species such as elephant. Elephants are not more important than any other component, although they are important and major ecosystem components.

Wildlife populations do not remain static through time and space, and consequently elephants should not be maintained at a stable unvarying population ceiling, but rather that fluctuation in numbers and density should be introduced to simulate ecosystem processes and enhance biodiversity.

In contrast with all other known animal species, elephant (and possibly rhino) do not respond to short-term climatic cycles so that, in recognition of the negative impact unimpeded population growth would have on other wildlife in an unnaturally limited "conservation island", some form of population control would be necessary for elephant (and perhaps eventually rhino)

There is evidence of severe impact by elephant at current densities in certain areas of the park so that such areas may already have reached threshold levels of elephant density.

The implication therefore was that Option D2 would be how the elephant population management issue should be approached in future. There was consensus that the consequences of unrestricted elephant population growth resulting in an ultimate self-induced population crash are not acceptable.

These resolutions were presented to the public during the debate held at Midrand on 12 November 1996. Very little comment was voiced by the meeting participants, either to these resolutions or the Hall-Martin & Novellie (1996) document, which was then accepted by the SANP as a mandate to proceed with defining the detail of this new policy proposal.

The first step in doing this was the convening of a workshop to discuss the maintenance of biodiversity in the KNP. A wide variety of scientific expertise both nationally and internationally was invited to attend and participate in this workshop which was held between 11-13 February 1997. The focus of the workshop was to develop means for the determination of "Thresholds of Potential

Concern”—also known as “Limits of Acceptable Change”. TPCs can be 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:

- management action to moderate such cause(s), or
- re-calibration of the threshold to a more realistic or meaningful level.

The new policy recommendation, as described here, was then formulated at a final meeting of National Parks Board staff held in Skukuza on 17 March 1997.

The finalised policy document was presented on the internet for further public scrutiny, and on 31 October 1998 was also presented at a public meeting convened in Nelspruit. Almost unanimous public support was given at this meeting, the only objection coming from the animal rights group FALCON who felt that at least another 10 years was necessary before implementation, as new technologies may be forthcoming (such as contraception) to solve the problem in non-lethal ways (South African National Parks 1998). As there is no guarantee of this, and acknowledging the support of the majority of the people and organisations represented, the SANP Board approved the policy on 12 March 1999.

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 subcontinental), 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. 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 result are seen as organised in a hierarchy of scales (Wiens 1997). If many levels of (say) herbivory are naturally superimposed on, for example, 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 there should very likely exist certain species which are not favoured or are even absent at intermediate levels. 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 disequilibrium 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 an 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 (hundreds of metres to 10 km) effects, e.g., 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 places 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 genuinely 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 to 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). Park 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 it is predicted with a degree of certainty that sustained trajectories will exceed TPC’s. More drastic intervention may be needed when gross overshoot of TPCs has taken place due to modern human influence, though if the adaptive management and TPC-monitoring system works well, this may not often be necessary. Understanding of the scales at which these different processes related to elephant impact occur, is an awesome task, 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.

History of the KNP elephant population

In order to put the new policy for the management of the elephant population of the Kruger National Park (KNP) into perspective, a brief account of the history of the population and the evolution of the previous management policy are given. This was derived from more detailed accounts of the history of the KNP elephant population (Whyte 1997).

The Sabi Game Reserve was initially proclaimed in 1898, and Colonel James Stevenson-Hamilton arrived as first resident Warden of the Sabi Game Reserve in July 1902. His initial conclusion was that there were no elephants (Stevenson-Hamilton 1903a, 1903b). By 1905, spoor had been found of a few elephants near the confluence of the Letaba and Olifants rivers (Stevenson-Hamilton 1905) after which a steady increase in numbers was noted.

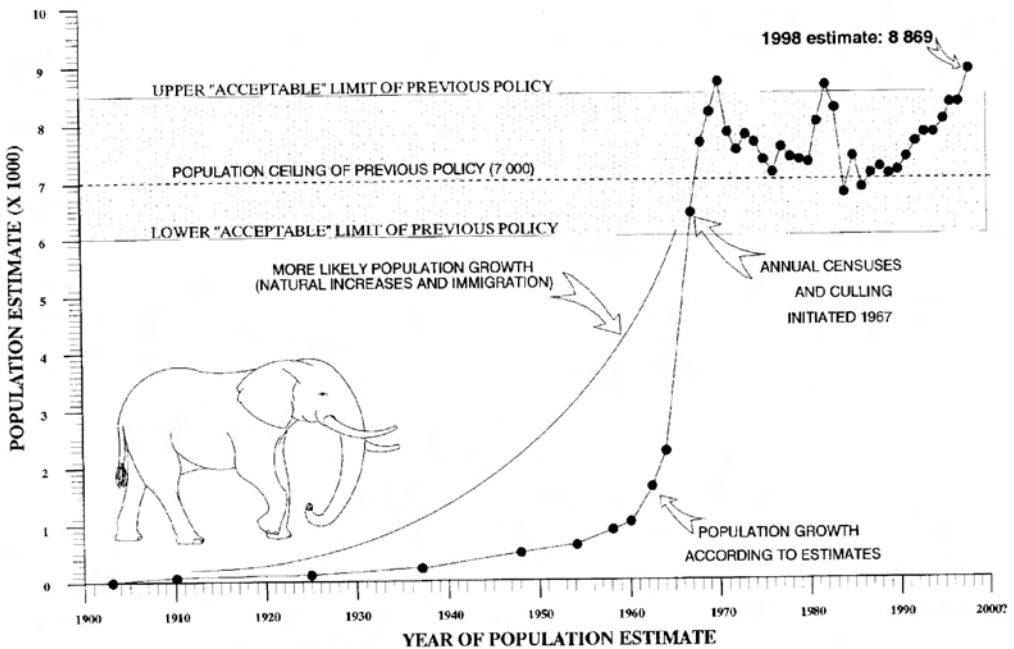


Fig. 1. Kruger National Park elephant population trends between 1903 and 1998.

Table 1
Estimates of numbers of elephants in the Kruger National Park between 1903-1995

Year	Number	Nature of estimate	Source
1903	0	Estimate	Stevenson-Hamilton 1903a, 1903b
1905	10	Estimate	Stevenson-Hamilton 1905
1908	25	Estimate	Stevenson-Hamilton 1909b
1925	100	Estimate	Stevenson-Hamilton 1925
1931	135	Estimate	c.f. Pienaar, van Wyk & Fairall 1966
1932	170	Estimate	Stevenson-Hamilton 1932
1933	200	Estimate	Stevenson-Hamilton 1933
1936	250	Estimate	Stevenson-Hamilton 1936
1937	400	Estimate	Stevenson-Hamilton 1937
1946	450	Estimate	Sandenberg 1946
1947	560	Estimate	c.f. Pienaar, van Wyk & Fairall 1966
1954	740	Estimate	Steyn 1958
1957	1 000	Estimate	Steyn 1958
1960	1 186	Aerial survey	c.f. Pienaar, van Wyk & Fairall 1966
1962	1 750	Fixed-wing survey	Pienaar 1963
1964	2 374	Helicopter count	Pienaar, van Wyk & Fairall 1966
1967	6 586	Helicopter count	Pienaar 1967
1968	7 701	Helicopter count	Pienaar 1968
1969	8 312	Helicopter count	Pienaar 1969
1970	8 821	Helicopter count	Pienaar & van Wyk 1970
1971	7 916	Helicopter count	Joubert & Pienaar 1971
1972	7 611	Helicopter count	Joubert & Pienaar 1972
1973	7 965	Helicopter count	Joubert & Pienaar 1973
1974	7 702	Helicopter count	Joubert & Pienaar 1974
1975	7408	Helicopter count	Joubert & Pienaar 1975
1976	7 257	Helicopter count	Joubert, et al. 1976
1977	7 715	Helicopter count	Joubert & Pienaar 1977
1978	7 478	Helicopter count	Joubert & Pienaar 1978
1979			No census
1980	7 454	Helicopter count	Joubert 1980
1981	7 343	Helicopter count	Joubert 1981
1982	8 051	Helicopter count	Joubert 1982
1983	8 678	Helicopter count	Joubert 1983
1984	8 273	Helicopter count	Joubert 1984
1985	6 887	Helicopter count	Joubert 1985
1986	7 617	Helicopter count	Joubert, Hall-Martin & Whyte 1986
1987	6 898	Helicopter count	Hall-Martin, Whyte & Viljoen 1987
1988	7 344	Helicopter count	Whyte & Viljoen 1988
1989	7 468	Helicopter count	Whyte 1989
1990	7 278	Helicopter count	Whyte 1990
1991	7 470	Helicopter count	Whyte 1992
1992	7 632	Helicopter count	Whyte & Wood 1993
1993	7 834	Helicopter count	Whyte & Wood 1994a
1994	7 806	Helicopter count	Whyte & Wood 1994b
1995	8 064	Helicopter count	Whyte & Wood 1995
1996	8 320	Helicopter count	Whyte & Wood 1996
1997	8 371	Helicopter count	Whyte 1998
1998	8 869	Helicopter count	Whyte 1998

The trend in the population between 1903 and 1998 is shown graphically in Fig. 1 and it is clear from this that the increase between the years 1960 and 1967 cannot be due to biological increase alone. In all likelihood the reported totals prior to 1967 were gross under-estimates and that the first aerial census yielded a result much closer to the actual figure, suggesting a massive increase over the period between 1964 and 1967. It is unlikely that any of the estimates prior to 1967 have any real value compared with the latter ones using aerial census techniques. Another curve has been added to the graph which probably reflects the actual population increase more closely. This would include biological increase as well as immigration from the neighbouring territories—Zimbabwe (then Rhodesia) and Mozambique.

In 1967, annual aerial censusing of the population as well as population control (culling) were initiated. Estimates for the population given in the respective annual reports and census reports up to 1996 are summarised in Table 1 along with the nature of the estimate and the source reference. Fig. 1 shows this data graphically.

The historical evolution of the previous elephant management policy

It is clear that the question of controlling elephant numbers in the KNP had been discussed among staff as far back as at least the early 1940s. This is illustrated by an amusing excerpt which has been translated here from the diaries of one of the Rangers of the time (Steyn 1942). *“With regard to the question of the control (culling) of elephants in certain areas where it may become necessary, the following idea came to mind, i.e. to use a 10 or 12 ton armoured car to remove them from any region. This will naturally only be possible after the present war and I leave the details to the imagination of the reader”.*

During the 1950s and early 1960s there was a growing feeling among some biologists in Africa that elephant numbers should be con-

trolled to prevent habitat change. Beuchner *et al.* (1963) concluded that in Murchison Falls National Park (Uganda) 4.5–5.5 elephants/mile² was exceeding the carrying capacity and that *“their numbers must be regulated to avoid damage to the vegetation and for the future welfare of the population of elephants”*. Similarly Glover (1963) felt that for Tsavo National Park (Kenya) *“one elephant/mile² is apparently the highest stocking rate possible...”* and *“If the habitat is to be preserved in its present form for all of the animals in the park, then the numbers of elephants will have to be controlled”*.

These feelings were shared by the KNP’s biologists who also felt that it may become necessary to limit elephant population growth in the KNP. This feeling was expressed by Pienaar (1960): *“The desirability of elephant control measures on a more general basis, which may become necessary in the near future, is a much more sensitive problem and will only be successfully solved after attention has been paid and information has been acquired regarding the actual numbers of elephant in the South, the number of breeding herds, herd composition, seasonal movements, ... as well as aspects such as how and where control should be applied”*. In conclusion, Pienaar (1960) made (among others) the following recommendations regarding the management of the elephant population:-

- that the collection of the information mentioned above be regarded as a matter of urgency—an aerial census was suggested as the best means of obtaining the information;
- that in the light of the above information, an elephant population level be prescribed for the Southern District;
- that all surplus elephants be destroyed annually through culling operations—preferably in the boundary areas and with due respect for outstanding individuals;
- that during normal years, elephants be denied the strip along the Crocodile River as well as a belt along the western boundary;

- that quantitative culling be applied elsewhere with great caution, if necessary”.

On 30 November 1965, a symposium was convened in Pretoria by the National Parks Board of Trustees (hereafter referred to as “the Board”) which many South African biologists of the time attended. The symposium focused on “over-protection”. Papers delivered at this symposium were on general principles (Knobel 1965), ecological regions of the KNP (Brynard 1965), problem areas (Van Wyk 1965), reproduction and biological control (Fairall 1965), control by diseases and parasites (Van Niekerk 1965), animals, areas and populations; desirability of culling and methods (Pienaar 1965), byproducts (Labuschagne 1965) and publicity (Van der Merwe 1965). The recommendation to the Board emanating from this conference was that population numbers of seven species be artificially controlled by means of culling. The species involved were elephant, buffalo, hippo, giraffe, wildebeest, zebra and impala. At its next meeting the Board decided that the culling of these species should take place (National Parks Board of Curators 1966).

Reporting on the census results of 1964, Pienaar *et al.* (1966) concluded that “*It would appear that theoretically a carrying capacity of 1–4 elephants per square mile, depending on the existing vegetation, available water supplies and size of the area, holds for the majority of elephant habitats in Africa*”. Following this, Van Wyk & Fairall (1969), from the results of their research on the impact of elephants on the vegetation of the KNP, recommended that “*... the highest number of elephants which could be carried ... would be 0,75/mile² (i.e. 6000 elephants) if the total destruction of the vulnerable areas near water is not to result*”.

Pienaar (1996) also stated that the above recommendations were supported by results obtained during the first helicopter census in 1964, “*... 1139 elephants occurred in the Letaba River and its main tributaries (namely the Ngwenyene, Tsende, Shipikane, Makhadzi and Mbyashishe). This was appar-*

ently the preferred habitat of these animals ... in which they stayed during the recolonisation years until they approached a natural saturation point before they, in ever increasing numbers, began to disperse northward and later southward ... Because the recolonisation of the Letaba-Tsende area, which can be considered as prime elephant habitat, could occur without hindrance or human interference, it must be accepted that the elephant density per unit area during the continuing process of dispersal would give a very good indication of a self-imposed (i.e. natural) saturation level for elephants in this habitat. A planimetric calculation of the area of this original elephant homeland yielded an area of 1 030 mile² - that is one elephant per mile²”.

Based on the various meetings and the research reported by Van Wyk & Fairall (1969), the then Director of the National Parks Board (Mr Rocco Knobel) recommended to the Board at a meeting held on 17 June, 1968, that the recommendation contained in Annexure “B” of the agenda with respect to the culling of elephant and buffalo in the KNP be adopted. The Annexure read as follows: “*Until the water provision program has been finalised in its entirety, both the elephant and buffalo populations of the KNP should be held at their current level...*”. At this time the latest estimate for the elephant population (1967 census) was 6586. This recommendation was adopted by the Board. Although it is obscure when or for what reasons it was changed, this figure was later rounded to 7000.

In 1986 the management plan (Masterplan) for the KNP was completed (Joubert 1986b) and many of the management policies (including those pertaining to the elephant population) were formalised. This Masterplan acknowledged, however, “*that policies represent the dynamic aspects of wildlife management and are subject to amendments with the accumulation of information and revised interpretations*” and it is the duty of the Standing Committee for Wildlife Management to “*revise the Masterplan ... on*

an ongoing basis, i.e. that additions and amendments to policies be recorded where applicable on an annual basis and that such additions/amendments be incorporated in a comprehensively revised Masterplan at five-yearly intervals and be submitted to the Board". It is therefore clear that, given information which indicates that current policies are not appropriate, they can be changed at any time. The following are brief, quoted summaries of the relevant principles and policies embodied in the most recent (1993) update:

The National Parks Act: ecosystem preservation—the basic issue

"The concept of ecosystem preservation is well established in nature conservation practice ... and is the primary objective for the proclamation of National Parks as defined in the National Parks Act (1976, as amended).

"This being the highest priority ... and, in fact, the legal responsibility of the Board, ... the preservation of structural and species diversity ... is an inherent part of ecosystem preservation".

Policies applicable to high-density species

"In the case of species whose population cycles extend over ... two or more climatic cycles, and especially where this situation may lead to:

- a. artificially high densities due to spatial limitations of the KNP,*
- b. material changes in either the structure and/or composition of the woody element of the vegetation, and*
- c. changes in the structure and/or composition of the animal communities which may result in the impoverishment of such communities by affecting their structural and species diversity,*
- d. the artificial manipulation of such populations is accepted as a realistic and responsible management option".*

"The only two known species to fall within this category are elephant and buffalo ... (it has become accepted since the writing of the 1986 Masterplan that buffalo do in fact respond to short-term climatic cycles, as amply illustrated during the severe 1982 and 1992 droughts). In both cases it is accepted, however, that under more natural situations their populations would also reach peaks and troughs and that such changes in population densities form an integral part of the functional aspects of ecosystems. Under the present circumstances it has become virtually impossible to assess the full implications of their ecological role in ecosystems. In spite of this situation it is imperative that special attention be paid to:

- *"the accumulation and assessment of data which could be of relevance in evaluating medium and long term population cycles,*
- *"the influence of the long term maintenance of relatively stable population levels on other components of ecosystem, in particular the vegetation and consequently also the associated animal populations, and*
- *"the possibility of simulating natural fluctuations in the management of these populations".*

"Until such time that the required information is available, the objective continues to be to maintain the elephant population at 7000 ..., but accepting fluctuations between 6000 and 8000".

Culling methods

Between 1967 and 1990, culling was carried out through remote intra-muscular injection (darting) of the compound Scoline (Succinylcholine chloride) from a helicopter. This compound acts as a neuro-muscular blocker, preventing the nervous impulse from the brain reaching the musculature. This induces paralysis, initially of the locomotory muscles, followed by the diaphragm and ultimately also the cardiac muscles. The advantage of this method is that the animals

are paralysed, guaranteeing the safety of the personnel on the ground. Physiological research showed however that this is not a humane way of killing elephants, as the brain remains unaffected by the scoline and in effect the animal, while fully conscious, suffocates until dead from lack of oxygen.

An attempt was then made to improve the culling method by darting the elephant initially with scoline but then brain-shooting the animal as soon as it became recumbent and before the effects of suffocation would be experienced. In practice, however, this could not always be ensured and some animals could not be shot before suffocation commenced. In an attempt to use only the most humane method, the most recent technique excludes the use of scoline completely, and every animal is brain shot from the helicopter. This has proven satisfactory so far, but the possibility of wounding of the animals remains a concern as this increases the risk to ground personnel.

Current thinking and approach to elephant management

Principles

The new elephant management policy rests on three fundamental principles on which there was consensus at the meeting of 30 October 1996. These are:

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.

It is accepted that elephants are important agents of disturbance and as such create heterogeneity and thus contribute to biodiversity (intermediate disturbance hypothesis). This means that in the absence (or very low densities) of elephants, biodiversity will be negatively affected as no disturbance occurs. At excessively high densities, biodiversity will also be negatively affected as the

disturbance becomes excessive (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).

It is also accepted that elephant populations which 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:

- 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);
- 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 maintaining it at a lower level (this may have moral or ethical considerations);
- 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.
- 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.

Translocation (live transfer)

Before the development of methods to translocate adult elephants, juvenile animals were captured at culling operations for translocation. Up to 1994, 1339 juveniles were translocated in this way to other conservation areas. By 1994, methods enabling the live transfer of adult elephants had been developed and since then, 300 elephants in family units have also been translocated. 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 from now on.

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.

Contraception

The current state of contraception technology can not yet offer a satisfactory method of population control in elephants. At present there are two methods of preventing conceptions being researched in the KNP which were reviewed by Whyte & Grobler (1997). These are the so called “immuno-contraception” in which the animal’s immune system is activated to prevent conception by vaccination (Kirkpatrick undated), and hormonal control by inserting slow-release oestradiol implants under the skin (Meyer *et al.* undated). Both of these projects are still at very early stages. Due to the costs and logistics of applying these methods, they have been shown by Whyte *et al.* (in press) to be unsuitable for use in large populations in large conservation areas.

a. Immuno-contraception

The immuno-contraception project has now been underway since October 1996 and will take several more years to complete. If shown to be successful, it would appear to offer some options for use in small popula-

tions. One aspect of this project that has yet to be demonstrated is that the vaccine will not induce permanent damage to the ovaries of elephant cows, causing permanent sterility. If this should be the case, the method might be considered ethically unacceptable and therefore unlikely as an option for the future.

b. Oestradiol implants

This project has also been underway since October 1996 but monitoring of the treated animals has shown that the hormonal disturbances arising from the high levels of circulating oestrogen make the method ethically unacceptable in its present form. Treated cows are induced into a state of false oestrus and are therefore attractive to bulls. The constant attention of these bulls drives the cow away from her still dependant calf and from her family unit. Monitoring of these animals has suggested that this results in increased mortality of the calves. Unless these side effects can be satisfactorily overcome the method will not hold an option for either large or small populations.

Opposition to the contraception option has been voiced by adjacent communities as they hold the belief that sustainable utilisation of the population should be practised. However, the National Parks Board 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.

Proposed new policy for the management of the KNP elephant population

As with other aspects of the management of the KNP, 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. The manage-

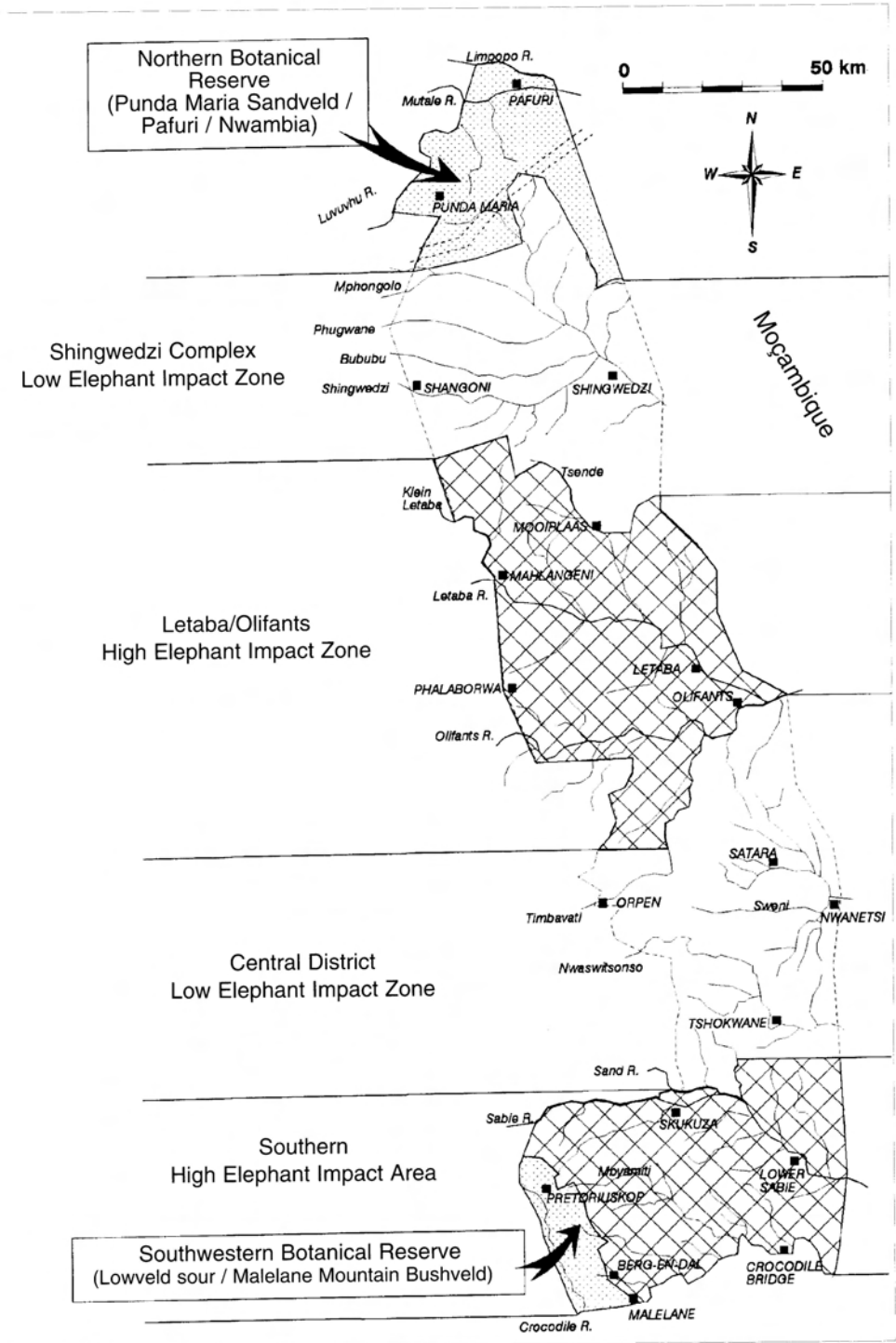


Fig. 2. Zonation of the Kruger National Park for elephant management.

ment 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".

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 where 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 with increasing knowledge and experience.

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 Fig. 2). These zones are: two botanical reserves; two high-density elephant zones; and 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 increase at around 7 % per year (Whyte *in prep.*). 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 of 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 (and initially in the Southern High-density Zone), medium densities are to be maintained. "Medium density" is here considered to be the density prescribed in the previous Masterplan (Joubert 1986) which was one elephant per 2.86 km² (7 000 elephants in 20 000 km²). 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 being 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, as there is some concern that increased elephant densities in the zones allocated may affect biodiversity in a way that is not reversible by a subsequent reduction in the elephant population.

A theoretical example may be that a high elephant population may induce a decline in the population of some tree species which may then not be able to 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 have been defined so as to roughly conform to the known boundaries of elephant clans as defined by Whyte (In prep). This is to allow meaningful elephant management without disrupting the natural 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.

Northern botanical reserve (Sandveld / Pafuri / Nwambia)

a. Rationale

This area encompasses some of the vegetation types/landscapes which it is felt 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. Whyte et al. (1996) have suggested that elephants may be partially responsible for a decline in the baobab population of this area.

b. Boundaries

The southern boundary extends from Dothole eastward along the Manangananga Firebreak to Magamba; then northward along the Shingwedzi/ Pafuri tarred road (HI-8) to Klopperfontein; then eastward along the Masokosa road to Masokosa Pan; then southward along the military service

road; then turning eastward to the Eastern boundary along the firebreak between Burning blocks 41 and 42. The other boundaries are constituted by the eastern, northern and western boundaries of the KNP. According to the KNP GIS system, the area of this zone is 1552 km².

c. Elephant management

Elephant densities are to be initially maintained at a density of one elephant per 2.86 km². 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 550. 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.

South-western botanical reserve (Lowveld Sour/Malelane Mountain Bushveld)

a. Rationale

This area also encompasses some of the vegetation types/landscapes which it is felt should not be placed at risk of excessive elephant impacts. These are the Lowveld Sour and Malelane Mountain Bushveld landscapes (Landscapes 1 and 2).

b. Boundaries

The northern and eastern boundaries of this zone extend from Thlothloma on the western boundary eastward along the northern and eastern boundaries of Burning block 35; then along the northern and eastern boundaries of Burning block 57; then southward along the eastern boundary of Burning block 90; then following the western boundary of Burning blocks 103 and 87 as far south as Malelane Restcamp. The western boundary of the zone follows the western boundary of the KNP from Thlothloma southward to Sigaas mouth, and the southern boundary of the zone is the Crocodile River between Sigaas

Southern high elephant impact zone

a. Rationale

Although this area has been zoned as a high elephant impact zone, there would be some clear advantages to zoning it in stead as a low-impact zone, and the "Central District High-impact Zone" as a low-impact zone, though this still requires some debate. The advantages are that it would create a single core high-impact zone in the middle of KNP, and there will be no "hard edge" between the high-impact zones and the botanical reserves. This would afford the botanical reserves a greater degree of protection. The two back-to-back high-impact zones could still be treated as separate zones after TPCs have been exceeded, and the decision has been taken to reverse the elephant management actions. This decision has not yet been taken, but if this option is chosen, it will not significantly affect the basic new policy as approved. There would still be four zones, two high- and two low-impact zones whose elephant management strategies could be alternated and reversed.

It is considered strategically unwise to allow elephant numbers to concurrently increase unchecked in two zones of the KNP, as this may lead to both areas simultaneously reaching a state in which TPCs have been exceeded due to high densities of elephants. Simultaneous reduction of elephant numbers in two areas may prove logistically unfeasible. As it may yet be shown that changes induced by impacts of high densities of elephants may not be reversible through subsequent reduction of their numbers, a five year time lapse between the two high-density zones is considered prudent. Elephant numbers will therefore be held at the current status quo (one elephant per 2.86 km²) for another five years before allowing them to increase. Thereafter, as with the Letaba\Olifants high density zone, no reduction of elephant numbers will occur through either culling or live removal.

b. Boundaries

The western boundary of this zone is a common boundary between the high-density elephant zone and the South-western Botanical Reserve. The southern boundary extends eastward along the Crocodile River from Malelane to the Mozambique Border; the eastern border of the zone then extends northward along the Mozambique border to the Rietpan Firebreak; the Northern border extends along the Rietpan Firebreak westwards to the Nwatindlopfu River; then southward along this river to its confluence with the Sabie River; then westwards along the Sabie River to the KNP's western boundary. According to the KNP GIS system, the area of this zone is 3436 km².

c. Elephant management

Until the mentioned five year delay has elapsed, the number of elephants in the zone should not be allowed to exceed 1220. After the five year delay period has elapsed, no reduction of elephant numbers will occur through either culling or live removal. Numbers are expected to increase at a mean rate of around 7 % per year. Elephant numbers will be allowed to increase until one or more of the defined TPCs are reached or exceeded and then systematically reduced so as to induce the desired flux (unless experience gained in the Letaba/Olifants High-density Elephant Zone should indicate a different course of management action).

Monitoring of specific indicator components of biodiversity will occur to determine the impacts of 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 (see under "Elephant management policy" above).

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

a. 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.

By reducing numbers in two 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 level which would not exceed our management capabilities should the high density zones prove to be detrimental to biodiversity.

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

b. Boundaries

The northern boundary of this zone is a common boundary with the Northern Botanical Zone's southern boundary; the southern boundary of this zone is a common boundary with the Letaba/Olifants high density zone's northern boundary. The eastern and western boundaries of the zone follow the eastern and western boundaries of the KNP. According to the KNP GIS system, the area of this zone is 4 026 km².

c. 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 (see "Elephant management policy" above). 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.

Central District low elephant impact zone

a. 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.

By reducing numbers in two 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.

b. Boundaries

The northern boundary of this zone is a common boundary with the Letaba/Olifants high density zone's southern boundary; the southern boundary of this zone is a common boundary with the Southern high density zone's northern boundary. The eastern and western boundaries of the zone follow the eastern and western boundaries of the KNP. According to the KNP GIS system, the area of this zone is 4149 km².

c. 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 (see "Elephant management policy" above). Elephant densities will be monitored annually during aerial censuses. Quotas for culling or live removals will be determined after the annual census result has

Table 2
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) 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 homogeneous. Sensitive landscapes examined independently as well.	30 % of all plots homogeneous. 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 reedbeds, 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. Recolonisation 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 - recolonisation from perennials rivers assumed.
Birds as functional class representatives in riparian corridors (what about outside riparian corridors as well, with own TPC's?).	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/pio-sphere.	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%.

become available. Elephant movements in and out of the area will be monitored through the ongoing movement study using radio-collared animals.

Thresholds for potential concern relevant to elephant impact

Table 2 is directed at high and low elephant zones, not at botanical reserves which need their own specific TPCs geared at plant community viability and optimum chance for rare species survival. The so-called "whole-park" measures given here thus refer to the whole park excluding the botanical reserves.

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 given here presuppose 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 it is believed that a very high density elephant population has evoked a TPC, this is of particular importance in the manner that the populations are to be reduced. While both initial fast reduction (say bringing one compartment down to by 2/3 of the density within a few years, then slowly thereafter) and slow reduction (bringing the high density down by say 7 % a year net reduction in growth rate after such a very high density phase) have been modelled, the TPCs given here presuppose the 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 may at first seem strange, 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.

Although this list focuses on TPCs believed to be directly related to elephant and discussed as such at the biodiversity meeting, other categories of TPCs (e.g., riparian health) may be exceeded due to elephant influence. These obviously qualify as valid TPCs in their own right.

Decision-making

Recommendations to the KNP Director as to appropriate actions for the management of elephants in the respective zones should be made by the Standing Committee for Nature Conservation. The Standing Committee should co-opt appropriate senior management and research staff to appraise the results of the respective biodiversity monitoring projects and the annual elephant census results. Such appraisal should be done on an annual basis.

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