

TRANSBOUNDARY SPECIES PROJECT

Background Study

ELEPHANTS

Rowan B. Martin

AFRICA
HUNTING.com



The Transboundary Mammal Project
of the
Ministry of Environment and Tourism, Namibia
facilitated by
The Namibia Nature Foundation

April 2005

CONTENTS

1. BIOLOGICAL INFORMATION	1
a. Taxonomy	1
b. Physical description	3
c. Reproduction and Population Dynamics	6
d. Habitats	9
e. Distribution	11
f. Numbers	22
g. Behaviour	37
h. Limiting Factors	39
2. SIGNIFICANCE OF THE SPECIES	42
a. Conservation Significance	42
b. Economic Significance	43
c. CITES matters	47
3. STAKEHOLDING	49
a. Stakeholders	49
b. Stakeholder Institutions – Present and Future	50
c. Towards Trans-Boundary Institutions	52
4. MANAGEMENT	54
a. Elephant management	56
b. Monitoring	67
c. Transboundary Issues	69

List of Appendices

1. Population Estimates for Etosha, the North-West, Khaudum & Nyae Nyae, Caprivi	71
2. Etosha elephant population: Mortality, immigration and emigration	79
3. The north-western elephant population of Zimbabwe	86
4. Financial values of elephants	88
5. Trophy hunting quotas	93

BIBLIOGRAPHY AND REFERENCES	96
------------------------------------	-----------

List of Figures

1. Evolution of Elephants	1
2. Taxonomy of the Subungulata based on MacDonald (2001)	2
3. Tusk weights and age	3
4. Ear of the Kaokoveld Elephant (<i>Loxodonta africana zukowsky</i>)	4
5. Identification of adult male and female elephants	5
6. Distribution of elephants in Africa	14
7. Distribution of elephants in southern Africa	15
8. Elephant range in Namibia	19
9. The future range of elephants in Namibia ?	20
10. The transboundary range of elephants in relation to the Namibian population	21
11. Etosha: migrations	24
12. Elephant population estimates for Etosha and the North-west	25
13. Etosha elephant population: Influence of mortality, rainfall and migration	26
14. Elephant population estimates for Khaudum and Nyae Nyae	28
15. Elephant population estimates for the Caprivi	30
16. Elephant population estimates for Namibia	32
17. Botswana elephant population estimates	33
18. Zimbabwe elephant population estimates	35
19. Land capability and economic returns from land use in Namibia	40
20. Institution for Botswana-Namibia management of shared wildlife species populations	53
21. Effect of hunting quotas on age structure of adult males in the population	61
22. Definition of 'central mortality'	79
23. Etosha: Influence of assumed finding factor on mortality and immigration	82
24. Etosha: Immigration, emigration and mortality	84
25. Etosha: Significance levels of immigration and emigration	85

List of Tables

1. Shoulder heights for elephant	4
2. Reproductive parameters for savanna elephant	6
3. Sensitivity of an elephant population to changes in adult and juvenile survival	8
4. Elephants on private land in Namibia	29
5. Elephant incidents in the Caprivi	38

PREFACE

Given the high profile which elephant conservation has achieved globally and in the southern African region, I consider it an honour to have been asked to do this Background Study and the Management Plan which follows it. The work has taken far longer than intended and no doubt this has been because I am highly conscious that a large number of people will scrutinise it critically. After the favourable comments received on the previous species management plans in this series, I have been anxious to live up to the expectations of the Ministry of Environment and Tourism that it will be as thorough a study as possible. I am grateful that neither the Ministry nor the Namibia Nature Foundation placed any pressure on me to complete the work in a hurry and this has allowed me time to review the literature and to explore the population dynamics responses of elephant to a number of management treatments.

I draw attention to a few of the analyses in the report. The population model for Etosha uses a new analytic technique which produces a unique outcome for the resolution of several key variables affecting both Etosha and the north-western elephant population. From population modelling, some counterintuitive and unexpected results have been obtained for the response of elephant populations to sport hunting, problem animal control and culling.

Given the potentially controversial reactions to any suggestions that elephants should be managed, the main recommendations of the report may create a furore. However, I back these up with a considered discussion of all the issues and have confidence that, given its enlightened wildlife policies, the Namibian government will not find the proposals outrageous. All of the recommendations are consistent with the far-reaching vision for land use in Namibia developed in the recent UNDP/GEF study.

I have not given a list of acronyms at the start of this report because I have tried to avoid using them in the text and, where one is used, the meaning is given together with the acronym. This draft has not benefitted by having another person review it and is therefore likely to contain numerous typing errors, omissions and spelling mistakes. I seem to be deficient in noticing my own errors but, hopefully, any such mistakes can be corrected in a second draft.

I would like to thank all those people who gave so kindly of their time and valuable experience to this project. In particular, I thank Chris Brown of the Namibia Nature Foundation, who has accommodated my personal constraints in this work and whose enthusiasm, support, drive and organising ability has resulted in the study coming to fruition. I thank Malan and Pauline Lindeque, Ben Beytell, Rudy Loutit, Peter Erb (who has responded to my every request for data with amazing speed and efficiency), Joe Tagg, John Barnes, Uatjavi Uanivi, Holger Kolberg and Werner Kilian in the Ministry of Environment and Tourism who spared considerable time to discuss the key issues in the study. Simon Mayes at NNF has allowed me to make unreasonable intrusions on his time and expertise to assemble map data and extract information from the Event Book database. I am indebted to John Mendelsohn whose outstanding Caprivi Atlas data base has been central to all these studies, Chris Weaver of the WWF LIFE programme, Garth Owen-Smith and Keith Leggatt all of whom helped me to understand the Namibian elephant situation. Finally, I thank David Cumming in Zimbabwe who has tolerated my interruptions of his own work, provided much data and acted as a sounding board and reality check for my ideas.

1. BIOLOGICAL INFORMATION

a. Taxonomy (from MacDonald 2001)

The Savanna Elephant (*Loxodonta africana* Blumenbach 1779) evolved with the other live-bearing mammals (Theria) from the Cynodonts (mammal-like reptiles) of the Triassic (225-195 million years ago). First to diverge from the stem were egg-laying mammals (Monotremes) during the Jurassic age. In the early Cretaceous era (about 130 million years ago), the Theria diverged into 3 major groups, one of which was the Marsupials. The other two became the placental mammals (Eutheria).

The earliest ungulates, the Condylarthra, appeared at the end of the Cretaceous period some 65 million years ago and the Subungulates evolved from an offshoot of this group early in the Paleocene. The modern ungulates are now placed in an entirely separate group (Laurasiatheria).

The group which included the ancestors of modern elephants (Afrotheria) diverged further during the Paleocene and separated into several distinct orders. The Aardvark (*Orycteropus*), regarded by some taxonomists as belonging to the Subungulata, diverged early in the Paleocene, preceded by the Tenrecs, Golden Moles and Xenarthrans.

By the early Eocene (54 million years ago), the Subungulates proper consisted of 3 distinct orders – the Dugongs and Manatees (Sirenia), the Hyraxes (Hyracoidea) and the elephant progenitors.

The first proboscidean was *Phosphatherium* (58 million years ago) from which *Moeritherium* evolved at the start of the Oligocene. Amongst the numerous elephant ‘models’ which followed were *Gomphotherium*, *Trilophodon*, and *Platybelodon* and, in the Pleistocene, the Imperial Mammoth which became extinct in recent times.

The full taxonomy of the Elephant family (Proboscidea) is shown in **Fig.2** on the next page.

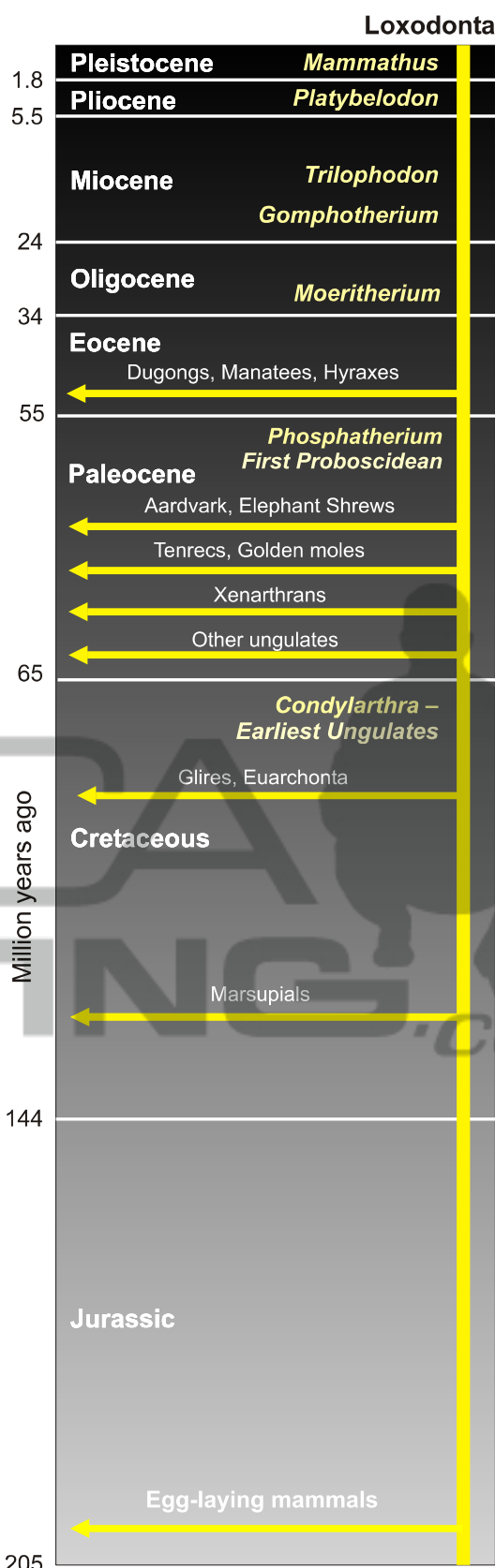


Figure 1: Evolution of Elephants

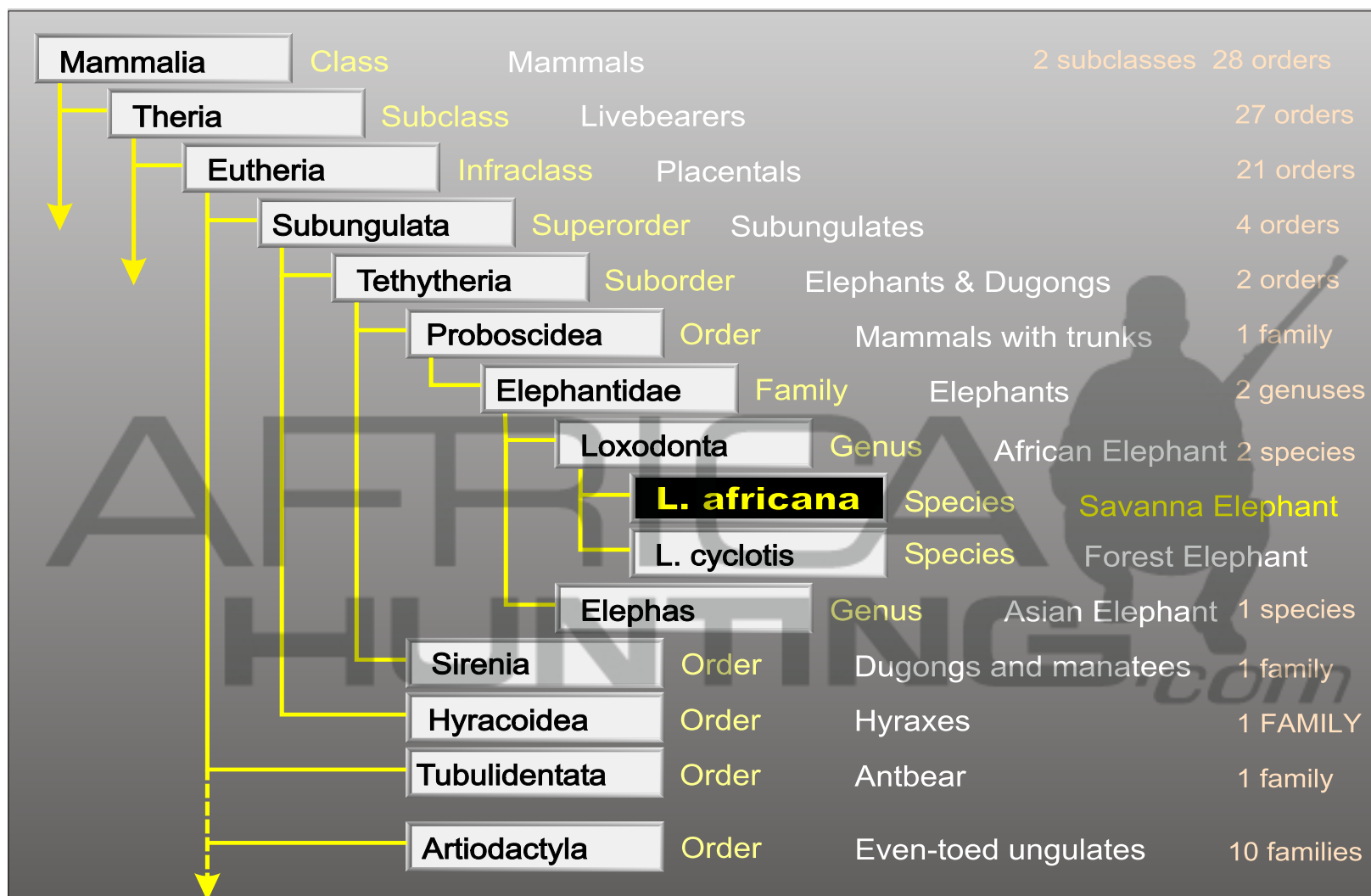


Figure 2: Taxonomy of the Subungulata

The species for which management plans have been completed under the Transboundary Mammal Project – Buffalo, Roan, Sable, Tsessebe, Waterbuck, Red Lechwe, Reedbuck and Puku – are all in the Artiodactyla

b. Physical description

The African Savanna Elephant is sufficiently well-known that little description is required. It is the largest land mammal with adult males achieving body weights greater than 7 tonnes. Parker (1979), from a detailed study of ivory, showed a western race of savanna elephants extending through Angola and northern Namibia across as far west as Matabeleland in Zimbabwe. Namibia is famous for its “Desert Elephant” and, although it has now been demonstrated that these desert-dwelling animals are part of a continuous population extending to Etosha National Park, they possess adaptations not seen in other savanna elephants – large body size being one characteristic. The largest elephant recorded (from Fenykoevi in Angola in 1955) was 4 metres high and is probably from the same race as Namibia’s north-western elephant.

The elephants is described as a ‘Pachyderm’ because of its very thick skin which may reach a thickness of 3-4cm. Although both species of African elephant have five well-formed digits on both fore and hind feet, *Loxodonta africana* displays 4 nails on the fore feet and 3 on the hind, whereas *L. cyclotis* has 5 and 4 respectively.

The name *Loxodonta* is derived from the lozenge-shaped teeth of the genus. During its lifetime a progression of six molars erupt from the posterior of the jaw and move along the mandibles, wearing out as they go, until they fall out. The succession of molars has allowed fairly accurate ageing of animals (Laws 1966, Sikes 1966, 1968).

The tusks are elongated upper incisors consisting of a unique mixture of dentine and calcium salts which exhibits a diamond pattern in section. Elephant tusks grow throughout their lifetime and typical relationships between tusk weights and age are shown in **Fig.3** (adapted from Pilgrim & Western 1986). The largest tusks on record are from Kenya and weighed 102.3 and 97kg. In the southern African region the largest recorded pair are 64.3 and 64.8 kg from the Limpopo Valley (Best & Best 1977). Namibian ivory (from the western population) has a reputation for being hard and brittle and broken tusks are a common feature of large adult males.

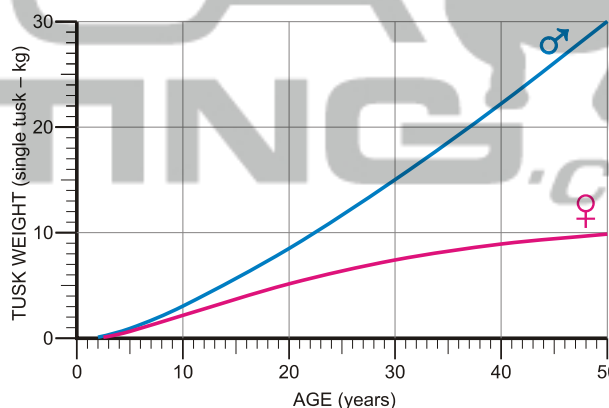


Figure 3: Tusk weights and age

Both males and females possess glands on the temporal region of the face which secrete copiously irrespective of age, sex or season (Short 1972). The discovery of ‘musth’ in African elephant is relatively recent (Moss 2000) and this discharge is one of the symptoms displayed by adult males in a musth condition. Musth is directly linked to reproductive behaviour and occurs in males over 29 years of age mainly during the rains and lasts for two-three months at a time.

Elephants are capable of communications over long distances using infrasound inaudible to the human ear (14-20Hz). Much of the communication is linked to females in oestrus but also plays a rôle in relaying alarm messages and maintaining contact when elephant groups are separated (Payne 1998, Charif *et al* 2004).

Although no subspecies of the Savanna elephant are recognised today, this has not always been the case. Shortridge (1934) recognised two subspecies: *L.a. knochenhauri* and, of relevance here, *L.a. zukowskyi* from the type locality of Qoabendus in the Kaokoveld (the ear of which is shown in **Fig.4** opposite). Shortridge notes that this is “a large elephant” but discredits Steinhardt’s claim that it reaches 4.5 metres at the shoulder. He also notes that the elephants that inhabit the Kaokoveld and south-western Angola appear to be isolated from other populations and that Wilhelm considered this subpopulation to differ from the Caprivi-Okavango elephants. Shortridge speculates that South-eastern Angola, the Caprivi, Ngamiland and north-western Zimbabwe may in fact be a single geographical area for elephants – which corresponds closely with Parker’s (1979) findings. Large tusks were not common amongst these elephants.

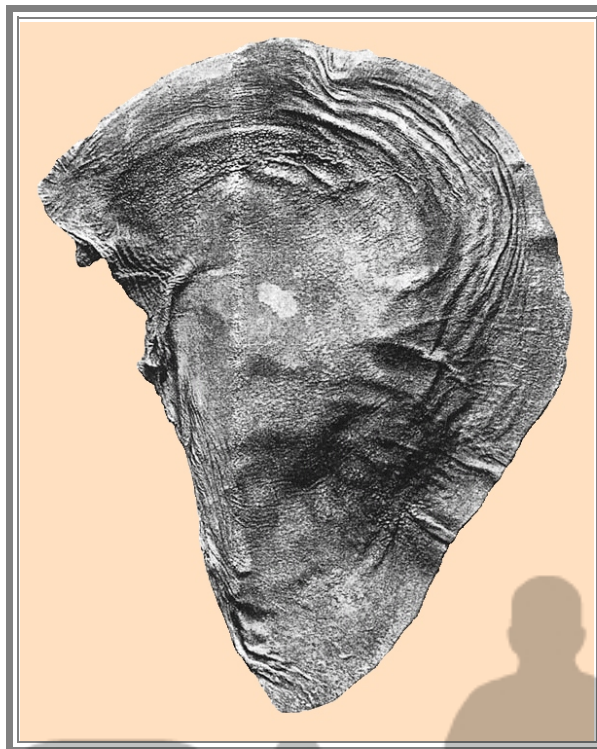


Figure 4: Ear of the Kaokoveld Elephant (*Loxodonta africana zukowskyi*)

Ansell (1974) recognised four subspecies of savanna elephant but included the Kaokoveld elephant in the main type *L.a. africana*.

Table 1. Shoulder heights for elephant

Some shoulder heights of elephants are given in **Table 1**. I have taken the body length and age data for Etosha from Lindeque (1991) and applied the formula from Chase (*et al* 2003) to derive shoulder heights for these elephants. Lindeque’s data only extends up to age classes of 30 years but, in these classes, the indications are that both males and females are at least 10% taller than the Kruger National Park elephants. Applying this ratio to the oldest animals in the population suggests that shoulder heights over 3.5 metres would be expected.

	Shoulder height (cm)	
	♂♂	♀♀
Largest: Fenykoevi - Angola 1955	400	–
Namibia: from Lindeque (1991)	>350	>300
Namibia: Best & Best (1977)	up to 350	–
Zimbabwe: Martin (1987)	up to 340	250
Africa: Macdonald (2001)	330	270
Southern Africa: Shortridge (1934)	305-320	–
Asia (<i>Elephas</i>) Macdonald (2001)	250-300	–
Forest elephant: Smithers (1983)	235	210

For interest, I include a brief note on the identification of adult male and female elephants. Field experts and authors of books on African elephants will advise that male elephants are taller than females; that they have thicker tusks; that the foreheads of adult females are pointed whereas those of males are sloping; that the back and belly of a male elephant slopes downwards towards the hind legs whereas in the profile of a female these features are more horizontal; and that the shape of the prepuce in the adult male forms an abrupt right angle with the belly whereas the vulva of a female has a triangular profile.

All of these features (**Fig.5**) are generally correct. But they are not infallible. After working with experienced field rangers for a few years immobilising elephant and after seeing numerous cases where males were mistakenly identified as females and vice versa, I realised that the conventional wisdom was not sufficient to ensure correct identification in every case.

I have found only one criterion that is invariably correct and which can be applied in every close inspection of an adult elephant. **The presence of mammary glands is limited to females only.** Although males have vestigial nipples, they lack the pronounced swelling between the forelegs. The mammary glands can be detected in all views of a female elephant (except perhaps from dead astern). The belly of an adult female dips downwards immediately behind the forelegs and the skin of the mammary gland is paler than the belly skin.

The various teams which I have worked with in the field probably made 10 mistakes in the first 50 elephants that we darted. After applying the above criterion, there were no further errors in the tranquillising of about 200 elephants.

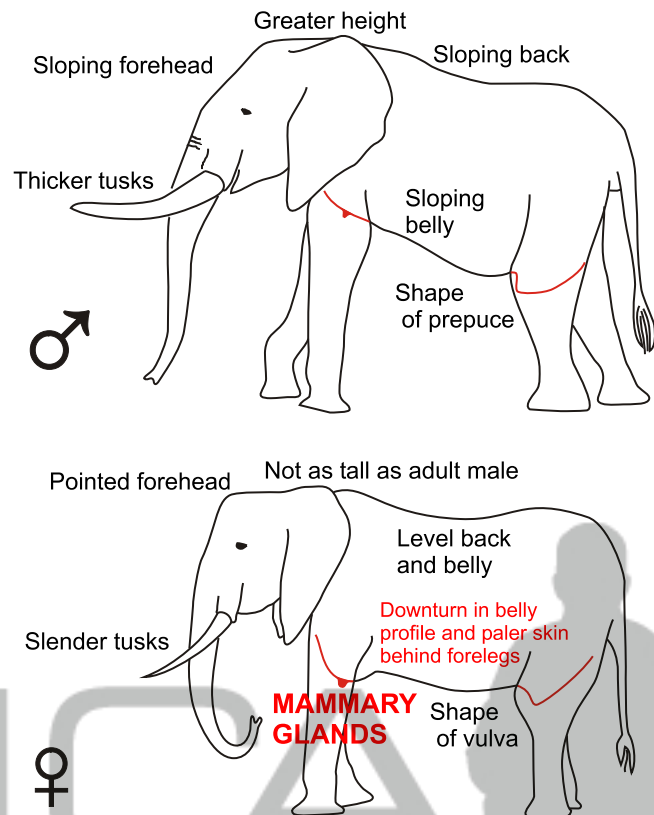


Figure 5: Identification of adult male and female elephants

c. Reproduction and Population Dynamics

The biological parameters which determine the population dynamics of elephants are summarised in **Table 2** below. Sources of data include Craig (1984, 1992), Dunham (1988), Hanks (1972), Laws (*et al* 1975), Lindeque (1988), Martin (2004) and Smithers (1983).

Table 2: Reproductive parameters for Savanna Elephant

Seasonal breeding	Most populations have a distinct breeding peak during the rainy season although births may occur in any month of the year
Gestation	22 months
Age at first conception	The median age is probably about 10 years old but in favourable conditions some females may conceive as early as 8 years of age. Laws (<i>et al</i> 1975) recorded conception being delayed until 19 years of age in a high density population in Uganda.
Age at first parturition	In populations not suffering density-dependence effects, about 50% of the 12 year-old females will produce calves and by the age of 15 all females will have produced their first calves.
Fecundity (adults)	The effect of seasonal breeding results in most elephants producing a calf every four years throughout their life after their first parturition. Fecundity may decline in the last few years before death.
Longevity	Elephants are generally assumed to live to about 60 years old. On the basis of age criteria deficiencies, Craig (1992) considered it more likely that the age of senescence was about 50 years old.
Mortality (adult females)	Other than in times of environmental stress (drought or disease), natural mortality is very low – probably less than 0.5% per annum
Mortality (adult males)	Mortality is slightly higher than in females. Young males between the ages of 20-25 years have been recorded as suffering a higher mortality than the other adults in the population.
Mortality (juveniles)	Data on calf mortality are difficult to collect. Work on elephant life tables suggests that in normal conditions juvenile mortality does not exceed 10% in the first year of life.

Martin (2000b) developed a general population model for elephants on the same basis as the population models which have been in used other species' Background Studies as part of this Trans-boundary Mammal Project (buffalo, roan, sable tsessebe, reedbuck, waterbuck, lechwe and puku). The model behaves in a manner similar to the Leslie matrix (Leslie 1984) but the calculations of births and deaths are separated into successive operations because it is designed to cycle within the row operations of a computer spreadsheet. This model is extremely detailed and permits testing of expected breeding performance and the response to various management regimes (illegal hunting, culling, capture of live animals, problem animal control and sport hunting). It includes a density dependence function and it also costs all management activities regimes and estimates the income from ivory, elephant skin and sport hunting. The model is not included in this report because of its size. However, it has been used to test various parameters pertaining to the Namibian elephant populations.

Lindeque (1988) derived average fecundities for the female elephants in Etosha National Park in 1983 and 1985 from two shot samples which included 103 and 214 females respectively. His finding was that, over their main breeding life span, the females were producing almost exactly one calf every four years (i.e. a fecundity of 0.25 including calves of both sexes). In 1983 no animals under the age of 12 years were pregnant or lactating but in 1985 one quarter of the animals in the 9-12 year old age group were pregnant. In all of the population simulations carried out in this study a mean fecundity of 0.25 has been assumed for mature animals and the age at first parturition has been spread across the age groups in the manner shown below –

Age	0-9	10	11	12	13	14	15	16 - 43	44	45	46	47	48	49	50
Fecundity	0	0.025	0.075	0.125	0.175	0.225	0.25	0.25	0.25	0.225	0.175	0.125	0.075	0.025	0

Age at death has been assumed to be 50 years. I saw no point in testing a range of fecundities because this parameter is the least likely to vary much amongst all of the Namibian elephant sub-populations. It is possible that, under the harsh arid conditions of Damaraland and the Kaoko veld fecundities may be lowered in times of nutritional stress but (a) this factor is likely to be secondary to natural mortality and, (b), the ‘desert-dwelling’ elephants are part of the same population as the Etosha elephants (Lindeque 1988).

Age-specific mortality in the model is set by means of a ‘template’. It is only necessary to specify the central mortality for the population and the curves for juvenile mortality and senescence are adjusted automatically. In the example shown below, the mortality for each age class is derived by multiplying the number in the template by the central mortality of 0.5%.

Age	1	2	3	4	5	6 - 42	43	44	45	46	47	48	49	50
Template	16	8	4	2	1	1	1	2	4	8	16	32	64	100
0.5%	8	4	2	1	0.5	0.5	0.5	1	2	4	8	16	32	50

The mortality for males in the age classes 20-25 years is doubled.

Given the above fecundities and mortalities, the rate of growth for an elephant population with a stable age distribution is slightly less than 5%. If all mortality is set to zero (apart from the animals which die at the age of 50 years), the maximum growth rate rises to 5.7%. The various recorded cases in the literature where elephant populations appear to have increased at up to 7% per annum (e.g. Hall-Martin (1980) – Addo National Park) are invariably in situations where a stable age distribution has not been achieved. Although, in theory, a fecundity of one calf every 3 years is possible such a rate is likely to be an episodic event. Synchrony of calving among females following a drought could also give the effect of a very high rate of increase for a single year. However, averaged over four years the result is no different to that which would be obtained with a fecundity of 0.25.

In **Table 3** below I examine the effect of natural mortality on an elephant population. The fecundities are as specified on the previous page and the mortality template is used in **Table 3a** (i.e. juvenile mortality increases with the central mortality). Once natural mortality exceeds the threshold at which the population can maintain itself, it is of more interest to express the decline as a ‘half-life’ i.e. the time it takes the population to halve.

Table 3. Response of an elephant population to changes in natural mortality

Table 3a. Effects of changes in overall mortality on population growth rate

Natural mortality %	0	0.25	0.5	0.75	1	1.25	1.5	2	2.25	2.5
Rate of population growth %	5.70	5.11	4.56	3.99	3.42	2.84	2.26	1.09	0.00	Decline

Half-life (years)	150	100	50	25	10	9	8	7	6	5	4	3	2	1
Natural mortality %	2.5	2.6	2.8	3.5	5.4	5.8	6.1	7.0	8.1	9.8	11.8	15.4	21.5	36.6

The effect of varying juvenile mortality independently of adult mortality is examined below. The specified mortality in the first row is for animals under one year old. Mortality is halved for each subsequent age class up to 5 years old. The adult mortality has been set at 1%.

Table 3b: Effects of changes in juvenile mortality on population growth rate

Juvenile mortality %	5	10	15	20	25	30	35	40	45	50
Rate of population growth %	4.35	3.95	3.51	3.07	2.62	2.16	1.65	1.17	0.40	-0.12

It is apparent from **Table 3b** that an elephant population can tolerate very high levels of juvenile mortality – it is only when mortality reaches 50% that the population begins to decline. The same is not true for adult female survival. A mortality of more than 2.5% causes the population to decline. These results are used later in this study to examine particular Namibian elephant subpopulations.

d. Habitats

Elephants are able to survive in a very wide range of habitats across the extremes of rainfall in Africa. Namibia provides the prime example of elephants adapted to living in desert conditions where annual rainfall is less than 150mm. Except for the most extreme desert areas, all of Namibia is suitable habitat for elephant. Even within the desert areas, elephants are able to make use of the watercourses almost as far as the coast and, following good rainfall, elephants may use areas below the 100mm and 50mm rainfall isohyets on an occasional basis (see **Fig.8**, page 19).

Parker (1984) and Parker and Graham (1989) show that maximum elephant densities increase with rainfall across Africa and, invariably, this places elephants in competition with human beings for habitats. With few exceptions, elephants are displaced by human beings. Kingdon (1971) showed that the range available to elephant in East Africa decreased by about half over the 50 year period from 1920-1970. From a situation where human populations had been islands in a sea of elephants, the transformation had taken place to make elephant populations islands in a sea of humans. Martin (*et al* 1985) adapted Parker's relationship between elephant and human densities to estimate elephant numbers in areas of Africa where no elephant surveys had been conducted but where human population densities were known.

In northern Namibia elephants and humans are competing for the same resources in a zone extending from the Cunene River in the west as far as Impalila Island at the eastern extremity of the Caprivi. The experience throughout Africa is that no amount of protection by the State can save elephants in areas into which humans wish to expand. The final outcome of this competition will depend entirely on the value (both economic and intrinsic) which the people living in the north of Namibia place on elephants and the extent to which they are able to realise that value.

In all of the previous background studies done by this author under the Transboundary Mammal Project, the habitat requirements of rare and valuable species have been investigated in some detail. However, the question to be asked in this study is not so much what elephants require from habitats as what elephants do to habitats.

The term "damage to vegetation" is resisted strongly by many elephant researchers who prefer to regard what elephants do to vegetation as "modification". However, Anderson (1973), Swanepoel & Swanepoel (1986), Lindeque (1988) and Murindagomo (1992) used the term elephant damage to describe the loss of canopy trees from woodlands.

Over the past 30 years the relationship between elephant densities and loss of trees has been quantified in many parts of southern Africa (Martin 1974, Thomson 1975, Barnes 1983 and 1985, Coulson 1992). Both Craig (1992) and Martin (1992a) independently arrived at the finding that, almost irrespective of the vegetation type, to retain more than 50% of canopy trees required elephant densities less than 0.5 per km². Trees with rapid growth rates such as *Acacia* species appear to suffer higher rates of mortality from elephants than *Brachystegia* and *Baikiaea* woodlands: however the regeneration potential is far lower for the hardwood species. O'Connell (1995) reported significant damage to many species of trees in the Caprivi including *Acacia erioloba*, *A. nigrescens*, *Terminalia sericea* and *Baphia massaiensis* and notes that *Baikiaea* was not heavily used by elephants. She remarks – "*Acacia nigrescens* specimens do not have much chance along the Kwando".

Whether the changes in vegetation wrought by elephants are harmful will remain a hotly contested point. However, the work of Cumming (*et al* 1997) showed clearly that biodiversity in the mid-Zambezi Valley in Zimbabwe had been reduced by the action of elephants. Comparisons were made of the presence or absence and, where possible, densities of a range of plant and animal species (including large mammals, small mammals, birds, bats, and insects) inside and outside State protected wildlife areas and it was found almost universally that the biodiversity in the State protected areas was lower than immediately outside them. If the aim of a conservation area is to conserve biological diversity then, in this area, they were not meeting their objective. In each of the related studies under this Trans-boundary Species Project (Martin 2002, 2003, 2004a), attention has been drawn to the possible negative impact which elephants are exerting on the other rare and valuable species which Namibia would like to conserve.

Cumming & Cumming (2003) examined the trampling effects of ungulate communities (including both wild mammals and domestic livestock). The impact of elephants was 3 times higher than that of cattle (for the same biomass of animals) and that of cattle was double that of smaller domestic livestock (sheep and goats). Cattle and elephants both had a far greater impact than any multi-species wildlife communities or small domestic stock.

The concept that elephants may reach some equilibrium with their habitats has to be discredited.. Lindeque (1988) found no evidence of density-dependent regulation in the Etosha National Park. Whilst Laws (*et al* 1975) certainly found that the high elephant densities in Bunyoro National Park were having marked effects on age at first conception and reproductive performance, there was no indication that elephants would level off at some asymptotic density – indeed they appeared to be on the brink of a major collapse at the time a major culling operation was undertaken. In Tsavo National Park, Kenya, elephants destroyed their habitats and then crashed: although it is tempting to attribute this to the severe drought at the time, the result was probably inevitable (Parker & Amin 1983). In all the large culling operations carried out in Zimbabwe between 1972 and 1987 on populations which were considered to be above the ‘carrying capacity’ for the area, there was no post-mortem evidence in any of the animals that their body condition was poor or that their reproductive capacity was lowered.

Caughley (1976) hypothesized that the relationship between elephants and their habitats was cyclic. As elephant numbers built up, trees would decline. This would be followed by a decline in the elephant population. Once elephants had been reduced to low densities, trees would begin to increase. And so the cycle would repeat itself. The hypothesis is probably correct – but it lacks a spatial dimension. Given the finite areas available to elephant in the 21st century and the relatively high human populations on the continent, it is very likely that the troughs in the cycle proposed by Caughley might result in local extinctions wherever elephants are unable to move away from their own ‘mass destruction’ of trees or wherever there are no adjacent populations to repopulate the devastated area.

Even if the option of elephant population reduction were not a highly volatile political and emotional issue, the hard facts are that there is no simple recipe for elephant management which will simultaneously maintain biological diversity and substantial populations of elephant.

e. Distribution

(1) Continental Distribution

The distribution of elephant in Africa is shown in **Fig. 6** on page 14. Perhaps the most salient feature of this distribution is its patchiness. In West Africa, elephant exist in small relict populations isolated from each other. In Eastern Africa, elephant range is rapidly being reduced to the questionable havens provided by State protected conservation areas. In Central Africa, elephants survive in the fastnesses of tropical forests in Gabon and the Congo but peripheral savanna populations (particularly in the Central African Republic) are following the course of the West Africa populations – less because their habitats have been usurped by humans and more because of uncontrolled illegal hunting. The main southern African elephant populations are in a belt extending across the northern part of the region through Angola, Namibia, Botswana, Zambia, Zimbabwe and Mozambique. The potential exists, through the development of trans-frontier conservation areas, for these subpopulations to form a single contiguous population across the continent (see Fig.7).

(2) Regional Distribution

The distribution of elephants in southern Africa is shown in **Fig.7** on page 15. The map is based on AfrESG (2002) but has been updated in some parts where more recent information has been available. Points to note about this distribution are –

- Despite the fact that the southern African elephant populations are the most intensively surveyed on the continent; there are still large areas in the region where little is known about the present range of elephant – particularly in Angola and Mozambique.
- The elephant range is not a static feature. Elephant populations are expanding rapidly and re-occupying areas from which they have been absent for many years. In the centre of the region this is fuelled by the huge Botswana and north-western Zimbabwe population which appears to be spreading into Namibia, Angola and Zambia. Over 1,000 elephants have recently moved into the Chobe-Zambezi area of the eastern Caprivi (G. Owen-Smith, pers.comm. August 2004) – an area where they have not be seen since the 1960s.

Elephant numbers are also increasing in South Africa, Mozambique and Zambia and dispersal is taking place into parts of Mozambique where elephant have been absent since the late 1970s.

- Because of this dynamic situation, it needs to be emphasized that any map of the elephant distribution is no more than a snapshot in time. It is likely to be out of date within a year and attempts to map with great accuracy may be a waste of time.

(3) Distribution of elephants in Namibia

(i) *Historical Range*

Some 300 years ago elephants occurred throughout Namibia except, perhaps, in the most extreme deserts along the coast. Even in these deserts they were able to penetrate the areas close to the sea along watercourses which supported a fringe of riparian vegetation. At that time, elephants were present from Capetown to the Cunene River. Brown (2000) notes that elephant went extinct in Namaqualand in the northern Cape before 1800. Elephants occurred in the Gondwana Canyon Park immediately north of the Orange River at the turn of the 19th century and were considered ‘common’. Shortridge (1934) thought that elephants extended as far south as the Tropic of Capricorn within Namibia 150 years ago.

Alexander (1838, page 74) refers to the Damaras hunting elephants in the Swakop River. Andersson (1856, page 407) hunted elephants in Bushmanland. Baines (1864) travelled from Walvis Bay to Lake Ngami in Botswana and his maps refer to the Elephants River, a tributary of the Nossob, rising near modern-day Windhoek.

The extensive hunting for ivory around the turn of the 20th century resulted in massive declines in the Namibian elephant population. By 1900, elephants were regarded as scarce south of Cunene. The last herd in what is now Etosha National Park was exterminated in 1881 (Fischer 1914). Hahn (1925) estimated no more than 50 elephants in Ovamboland, occurring mainly in the east. Nelson (1926) notes that there were no elephants in Namutoni (the eastern end of Etosha) but that they were distributed throughout eastern Ovamboland. “The scattered herds in the Kaokoveld visit Western Ovamboland in the wet months . . . but they are more liable to persecution. Among Ovambos, ivory is in great demand. Elephants in the northern areas are ever decreasing in numbers.” Nelson estimated there were some 200 surviving elephants in the Outjo District in 1926.

By 1934, elephants were limited to the Kaokoveld and the Caprivi, with a few vagrants in Outjo District, Ovamboland and Okavango (Shortridge 1934). According to Shortridge, the elephants in the Kaokoveld were widely distributed from the Cunene in the north to the Ugab in the south (Damaraland) and numbered from 600-1,000.

Elephants were apparently absent from and rare in the areas surrounding Etosha for about 70 years (Bigalke 1958). Several bulls and small herds first colonised the Halali and Namutoni areas in the 1950s. Boreholes were developed in the 1960s in the dry west of Etosha to attract elephants into the park and solve conflicts in the neighbouring farming areas. Although successful, there were nevertheless over 200 elephants shot on farms bordering Etosha from 1970-1988 (Lindeque 1988). Colonisation of the park took place both from the east and west and the recorded movements indicate mixing of elephants. Elephants moved freely between Etosha and the eastern Kaokoveld with significant numbers leaving the park during the wet season.

The recovery of elephants in both the north-west of Namibia and the Caprivi suffered a setback during the period when the South African defence forces were active in these areas from 1960-1989. A subpopulation of some 80 elephants living west of the 150mm rainfall isohyet in the north of the Kaokoveld was reduced to 3 animals by 1981. These surviving animals travelled south and joined a larger group of 40-50 animals on the Hoanib river. Between 1979 and 1983, Viljoen (1987, 1988) found 123 carcasses in the south of the Kaokoveld and northern Damaraland mainly along the Hoarusib and Hoanib Rivers. Loutit (*pers. comm.*) found 58 carcasses in Damaraland between 1987 and 1992 and mentions large numbers illegally killed in the northern Kaokoveld near Ehombo and in western Ovamboland in the vicinity of Ombarundu. Owen-Smith (1968) estimated some 600-800 elephants in the north-west of Namibia; by the late 1980s this number had been reduced to about 250 animals. Similar illegal hunting took place in the Caprivi (Schlettwein *et al* 1991) but, because of the large Botswana population, the impact of the excesses was relatively minor.

Elephants continued to be killed after the SADF ceased operations. The last surviving elephants on the Cunene (13 animals which drank as far west as the river mouth) were killed by Angolans in 1990. Almost certainly elephants have been killed in Angola along the Kavango and Kwando Rivers immediately north of the Caprivi.

The pressure on elephants in the north-west of Namibia may have played a rôle in the rapid increase of the resident Etosha population. The estimate for Etosha in the dry season of 1967 was 500 animals; by 1983 this number increased to 2,800 (Lindeque 1988). Over 30 years the situation changed from a small number of vagrants present during wet season to a resident population numbering about 2,000 with a further 1,000 elephants present in the dry season only. Despite this substantial resident population, the Etosha elephant should still be seen as part of a larger population occurring through north-west Namibia.



Figure 6: Distribution of elephants in Africa

Source: *African Elephant Status Report 2002*,
African Elephant Specialist Group of the IUCN Species Survival Commission

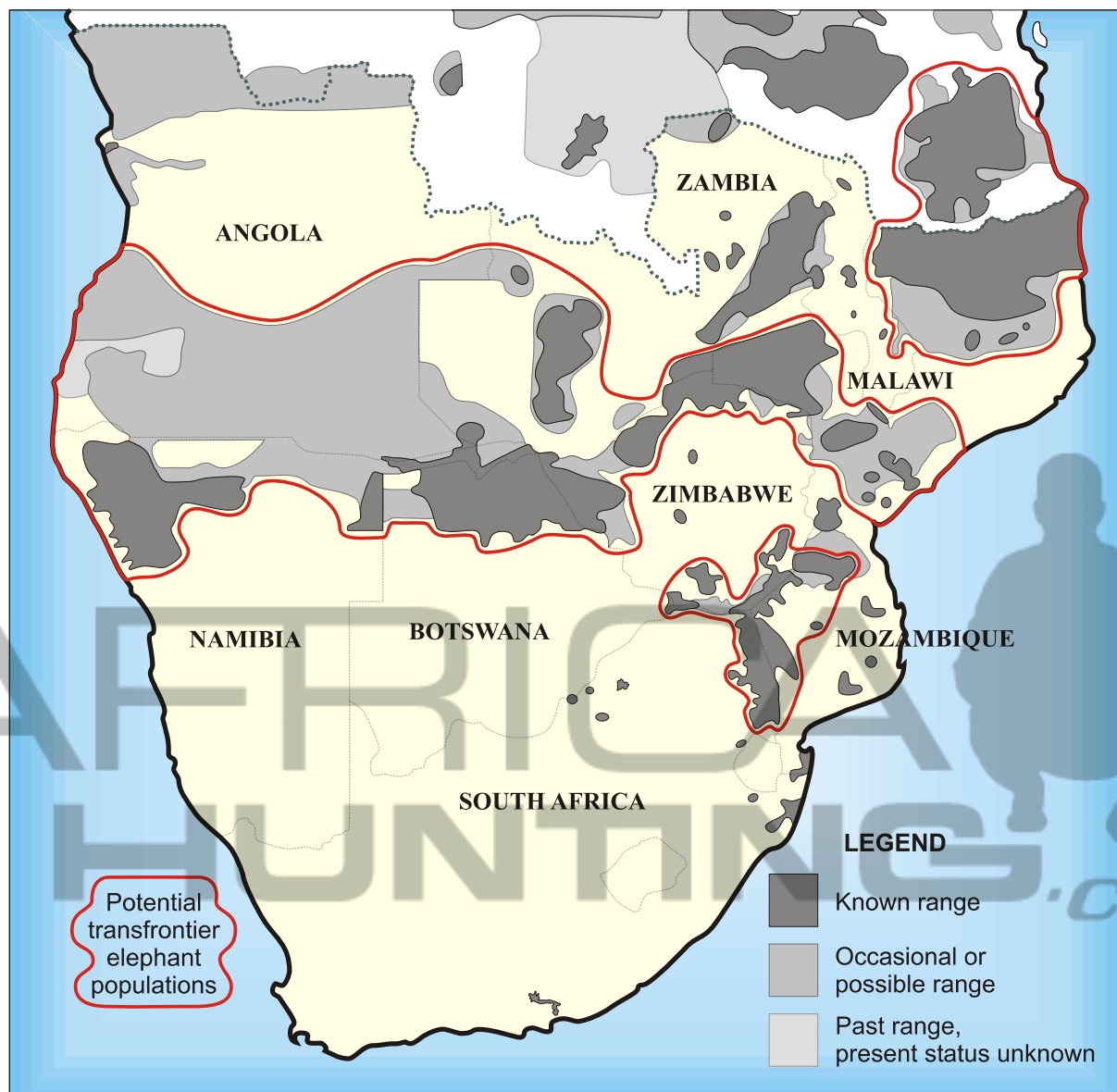


Figure 7: Distribution of Elephant in Southern Africa

Updated from *African Elephant Status Report 2002*

African Elephant Specialist Group of the IUCN Species Survival Commission

(ii) **Current Range** (Fig.8, page 19)

The present range of elephant in Namibia can be considered in two parts – the north-western and the north-eastern populations. These populations are not isolated from each other: the area shown as ‘occasional range’ in **Fig.8** links the two. Almost certainly there are sporadic movements of elephants between the two permanent ranges – although it would be unlikely for animals in the extreme west of the north-west range and the extreme east of the north-east range ever to be involved in these movements.

The north-western range appears to be expanding at the moment. Elephants are being seen as far south as the Ugab River and in all of the river catchments which flow westwards to the Atlantic Ocean in the north (Loutit, Leggatt, Owen-Smith, pers.comm.). As yet, the extreme north-western part of the potential range (the watersheds of rivers such as the Otjinjange which flow into the Cunene) has not been re-colonised although elephants were present in this area up until 1990. Malan Lindeque (pers.comm.) has speculated that, because all of the elephants in this area were killed, the ‘institutional memory’ of the remaining elephants in the south may not include a knowledge of the northern watersheds and the Cunene River.

West of Etosha, human populations are relatively sparse and most of the land between Etosha and the Skeleton Coast is organised into conservancies – which should augur well for the continued expansion of the elephant range. North of Etosha are some of the highest density human populations in Namibia reaching up to 100 persons/km². In Fig.8, the limit of the occasional range of elephant can be regarded as the contour line demarcating human densities greater than 1 person/25km². In this part of the north-western range conflicts between humans and elephants is intense, especially in those areas where conservancies have not been established.

The situation in the north-east is very different. A population in excess of 100,000 elephants in Botswana is resulting in significant dispersal of elephants into the Caprivi, Khaudum and Nyae Nyae conservancy. Elephants are being seen for the first time in 20 years in many parts of the eastern Caprivi from which they have been absent.¹ The West Caprivi Game Reserve (Babwata) and the Forest Reserve in eastern Caprivi have always held very few elephants because of the paucity of surface water² but, in the most recent surveys, substantial numbers were recorded. Much of the range in the Caprivi shown as ‘occasional’ in the African Elephant Specialist Group data (AfrESG 2002) should now more correctly be treated as ‘permanent’.

It would be extremely difficult if not impossible to make a distinction between elephants resident in the Caprivi and elephants dispersing seasonally from Botswana, so dynamic is the situation. Because the Caprivi is no more than a long narrow strip between Botswana, Zambia and Angola, it could be regarded simply as a transit area for elephant dispersal. This has two major implications for elephant conservation – firstly, the need for transboundary management becomes obvious and, secondly, if biodiversity is to be conserved in the Caprivi and Khaudum/Nyae Nyae areas, large numbers of elephants remaining for too long in these areas will need to be discouraged – particularly in the riparian and floodplain habitats.

1. Surveys done by Botswana in 1994 (ULG 1994) saw no elephants in Forest Reserve or Eastern Floodplains.
2. Rodwell (1995) remarked that elephants were seasonal inhabitants in these areas.

(iii) *Future range*

The elephant range in Namibia is expanding at the moment. Much of what was classified as ‘occasional range’ in AfrESG (2002) has become ‘permanent range’ and it is of interest to speculate where elephants might occur (say) 25 years from now (**Fig. 9**, page 20).

Some assumptions are necessary –

1. Elephants will be able to realise their real values in world markets for both tourism and for commodities such as ivory and skin. This would offset the negative values presently perceived by many communal land residents and private landholders.
2. The present encouraging trends in increased devolution of proprietary rights over wildlife to private and communal landholders continues. This would create the incentive for increased investment in wildlife-based land use by individuals and groups. As long as elephants are viewed as State ‘property’ and their use is regulated by the State, this assumption will not be satisfied.

Given that these conditions are met, the stage would be set for a significant shift in the balance between wildlife and agriculture as competing land uses. Already significant areas of communal and private land outside the parks are under wildlife management³ and these areas are the key to future elephant range expansion. Given the present encouraging trends, it would be reasonable to expect that –

- In the extreme north-west, elephants should sooner or later occupy the northern-most rivers (Sehomib, Nadas, Munutum and Engo) and the drainage basins of the Cunene river (where they occurred in the recent past);
- The southern limit of this range is presently the Ugab River but there are no obstacles preventing range expansion as far south as the Swakop river where they occurred in the 19th century (Alexander 1838);
- The large block of private farms south of Etosha would become far more tolerant towards elephants (several hundred elephants have been shot as ‘problem animals’ on this land over the past thirty years) and would welcome them as part of their wildlife species mix;
- In the communal lands north of Etosha, elephants would expand up to the limit where human densities exceed 25 persons per km²;
- East of Etosha, the present tenuous linkages between Namibia’s eastern and western elephant subpopulations should become greatly strengthened, taking in the small relict population in Mangetti game reserve.
- With the recent rapid expansion of elephants in Khaudum and Nyae Nyae conservancy, there is no reason why the elephant range along the eastern boundary of Namibia might not expand southwards to the 22° line of latitude.

3. The communal land conservancies shown in Fig.8 include both established and emerging conservancies. The private land under wildlife management is approximate – at the scale of the map, it is not possible to show the detailed mosaic of registered wildlife properties and the mapped areas are inclusive.

- The short distance between Khaudum and Mahango national parks is being traversed by elephants at the moment and should soon become a permanent feature of the range.
- From the results of the most recent elephant surveys (September 2004), the entire Caprivi (other than the densely populated area around Katima Mulilo) can probably be regarded as permanent elephant range.

It is important that range expansion should take place. Elephants are already having a marked impact on habitats in the Caprivi, Khaudum and Nyae Nyae conservancy. If these populations remain confined to their present areas, vegetation damage will escalate. A proactive policy approach from the Namibian government (which ignores external influences espousing the ‘protect to conserve’ philosophy) could produce the desired result.

(iv) *Transboundary elephant range*

The range of elephants in countries neighbouring Namibia is shown in **Fig.10** (page 21). Between latitudes 16 - 22° South the overall range for elephants now extends from Skeleton Coast in the west of Namibia to the mid-Zambezi Valley in eastern Zimbabwe (and, indeed, beyond it into Mozambique). Within this range are areas of elephant concentration (DG 2004, Fig.8) reaching densities in excess of 1 elephant/km² in many places.

Various land tenure categories including State Protected Wildlife Areas, Forest Reserves, communal land, private land, community based and private land conservation areas are shown on the map. For the most part, the elephant range is secure under the systems of wildlife-based land use which are now in place over large areas of the region. This bodes well for the expansion of elephant populations, increase of elephant genetic diversity and the development of transfrontier conservation areas.

It is immediately apparent from **Fig.10** that the most vulnerable part of this otherwise encouraging scenario is in north-eastern Botswana. The narrowest and most constricted part of the regional elephant range over two thousand kilometres from east to west is the isthmus in the Caprivi Strip in the vicinity of Mahango National Park. The presence of cattle populations in the north-eastern corner of Botswana is a conflicting and lower-valued land use which threatens the larger development of the wildlife potential of an entire region. The bottlenecks caused by inappropriately positioned veterinary control fences not only result in local destruction of biological diversity through elephant concentrations but also hamper the positive aspects of restoring the original fauna of the region through wildlife dispersal.

Kruger (1984) referred to the Caprivi as an “outrage to geography and all common sense” and Fisch (1999) remarks – “As it is, this unnatural appendage linked to the rest of Namibian territory by a handle only twenty miles wide, will continue to cause a great deal of administrative and technical difficulties for the government in Windhoek.”. A hundred years after its creation, the geography of the Caprivi remains problematic. Visions of a ‘Four Corners’ Trans-Frontier Conservation Area will remain unfulfilled until neighbouring countries cooperate to create the conditions for compatible and high valued land uses in this part of the region.



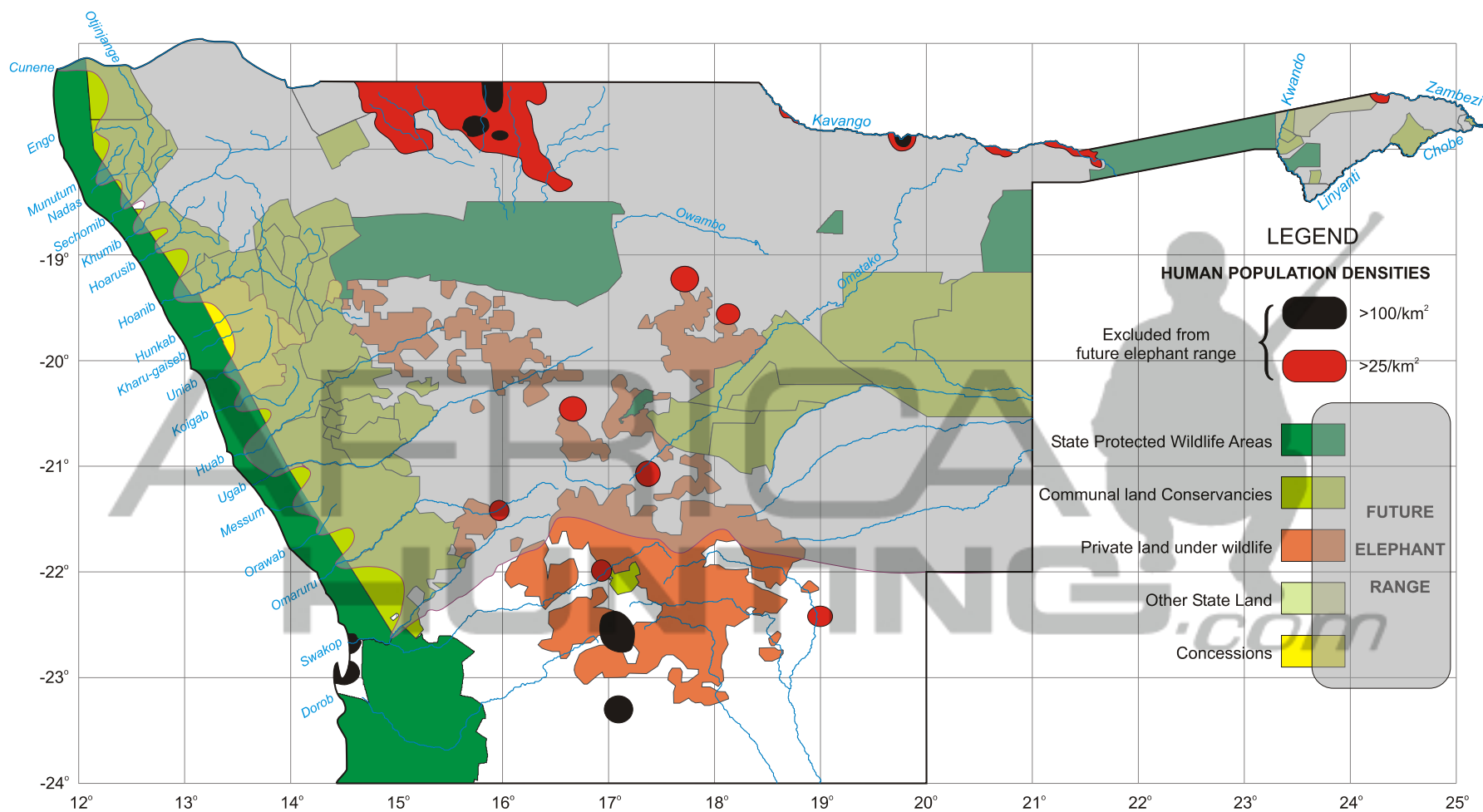


Figure 9. The future range of elephants in Namibia ?

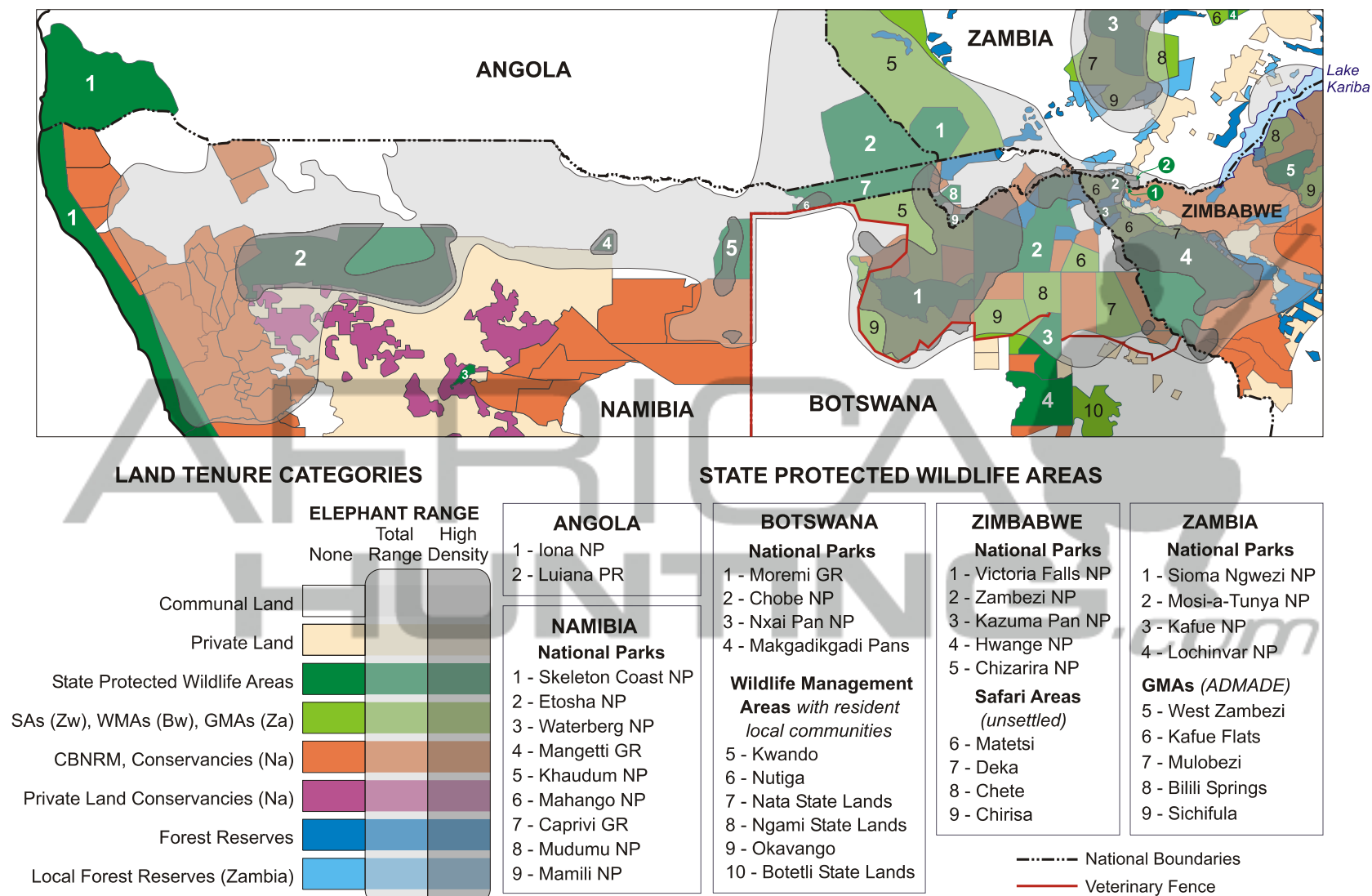


Figure 10: The transboundary range of elephants in relation to the Namibian population

f. Numbers

(1) Namibia

An examination of the permanent range of elephant (**Fig.8**, page 19) indicates subpopulations in the east and the west of northern Namibia. The separation is not so rigid as to create genetically isolated subpopulations since the ‘occasional’ range of elephant links the two and there is a small resident population of about 20 animals within the ‘occasional’ range in Mangetti Game Reserve.

Each of these subpopulations can be subdivided into two parts (which have been surveyed as separate areas over the past thirty years) –

Western Namibia: (i) Etosha National Park

(ii) the North-West (Kaokoveld, Damaraland)

Eastern Namibia: (iii) Khaudum National Park and Nyae Nyae Conservancy

(iv) the Caprivi (including East and West Caprivi)

The survey data for each of these areas are presented in **Appendix 1** (page 71) and the data for each area are discussed and interpreted briefly below. Elephants on private land in Namibia and the overall totals for Namibia follow the above four subsections.

(i) Etosha National Park (**Fig.12**, page 25)

The first elephants (in recent times) appeared in Etosha in the 1950s. The population increased fairly rapidly after 1966 reaching 2,800 animals by 1983. This increase exceeds any growth possible from natural reproduction⁴ and it must be presumed that it was due to an influx of animals from areas outside Etosha. This would have coincided with the period of intensive illegal hunting by the South African Defence Forces in the north-west (1975-1983) and the hunting pressure may have contributed to the immigration into the park. Since 1983 the Etosha population has fluctuated between 500-2,500 animals.

(ii) The North-West [Kaokoveld, Damaraland] (**Fig.12**, page 25)

In the 1950s and 1960s there were more elephants in the north-west than in Etosha National Park (**Appendix 1**). The build-up of elephants in Etosha after 1970 coincides with the period of illegal hunting by South African Defence Forces in the north-west. Viljoen (1987,1988) documented over 100 elephant carcasses in the north-west between 1980-1983 and Loutit (2004) recorded a further 58 carcasses after 1987. Owen-Smith (2002) asserts that less than 70 elephants survived in the western areas by 1982 but this claim is at variance with a number of surveys between 1976 and 1982 which showed at least 200 elephants. However, the population remained depressed as a result of hunting during this period and, significantly, the Etosha population increased sharply. From 1986-2004 the north-west population has increased from some 300 animals to about 800 – a rate which is marginally higher than might be expected from the intrinsic growth rate and requires no assumption that the population has been augmented from Etosha. The combined population is shown as a dashed line in **Fig.12**.

4. At a growth rate of 4.56% (see section on reproduction), it would have required 614 elephants in 1950 or 1,253 elephants in 1966 to attain a population of 2,800 elephants in 1983.

Lindeque (1988) has pointed out that a single regional population occupies Etosha and the North-west and that movements in and out of the park take place continuously. Perhaps the only topic for speculation is the rate and extent of such movements.

Recognising the fairly wide confidence limits on surveys, it is nevertheless surprising to find no inverse relationship between estimates in years when surveys were carried out both inside and outside the park. It might be expected that in years when Etosha showed a relatively ‘low’ population a higher than usual estimate would be obtained outside the park.

In **Appendix 2** the Etosha population has been modelled in an attempt to resolve the relationship between numbers, mortality, immigration and emigration over the period 1971-2004.⁵ The performance of the population is consistent with one which has a central mortality⁶ of slightly more than 1% resulting in an intrinsic growth rate of 3.3%. The schedule of overall mortality, immigration and emigration which follows from this is shown in **Fig.13** (page 26).

The model results indicate that the population increased rapidly between 1971 and 1983 to its highest recorded level of 2,800 animals – mainly as a result of immigration although the mortality between 1971 and 1979 was lower than expected. This period coincided with a heavy hunting pressure outside the park and with a surplus in the cumulative rainfall.⁷ In 1980 mortality shifted to being higher than expected (mainly as a result of anthrax) but this negative effect was not sufficient to stop population increase.

After 1983 the population declined sharply due to a combination of factors of which the emigration of almost 1,000 animals in 1985 had the greatest effect. Two culling operations removed 570 animals from the population⁸ and mortality remained higher than expected up until 1990. In 1983, the cumulative rainfall switched to a deficit mode and the illegal hunting pressure outside the park was greatly reduced. These two factors may have resulted in the 1985 emigration referred to above.

Apart from a brief increase to a level of 2,000 animals in 1987 caused by the presumed immigration of some 600 animals, the population declined to 1,188 animals in 1995. The mortality during this period was not sufficient to have caused the decline and it must be attributed to a sequence of small emigrations between 1988 and 1995, none of which were statistically significant in isolation but which in concert reduced the population by some 800 animals.

After 1995 the population increased – again at a rate exceeding the intrinsic growth rate. Although this coincided with a period of lower than expected mortality, the increase must be attributed to immigration from 1996-1998. From 1999-2004 the population has fluctuated around 2,300 animals.

5. The collection of elephant mortality data in Etosha dates back to 1971 (Lindeque 1988).

6. Central mortality is defined here as the age specific mortality affecting all animals between the ages of 5-45 years (see discussion on page 7).

7. The cumulative surpluses and deficits in rainfall are the integral of all deviations from the mean.

8. 220 elephants were culled in 1983 and a further 350 in 1985.

All of the foregoing assumes that there are no great errors or fundamental flaws in the model given in **Appendix 2**. The author draws attention to the analytic techniques used in this model as they produce startlingly unique results for the relationships pertaining in the population amongst mortality, immigration and emigration. Given that there may be some validity in the model, several conclusions about the Etosha elephant population can be drawn.

- (1) The findings of Lindeque (1988, p235-238: *Conclusions*) are corroborated from the model. Certain increases and declines cannot be explained through any mechanism other than immigration or emigration.
- (2) Mortality, even at the peaks of anthrax epidemics, has not been high enough to cause substantial declines or even to regulate the population.
- (3) The application of confidence intervals to the model data (**Appendix 2**) suggests that only a few of the postulated instances of migration are likely to be statistically significant when the survey results from one year to the next are compared. The corollary to this is that, whilst immigration and emigration do occur, the major migrations involving more than 50% of the population are episodic events which occur only once in every 10 years. Most migrations (if they occur) involve a small fraction of the population. According to the model about 80% of all annual immigrations and emigrations involve less than 20% of the population and more than 50% of these involve less than 10% of the population (**Fig.11** opposite).
- (4) The cumulative surpluses and deficits in rainfall over the period concerned do not provide consistent evidence of a close relationship either with migration or mortality. The increase in the population up until 1983 coincides with a period of rainfall surplus. The sharp decline in the population after 1983 coincided with the transition from a cumulative rainfall surplus to a deficit. The higher than expected mortalities from 1983-1992 occurred during the period the rainfall was in deficit mode. However, thereafter the relationship falls apart. Despite being in a continued rainfall deficit regime after 1995, the population increased and mortalities were less than expected.
- (5) An unexpected outcome of the modelling process was the derivation of a unique value for the Finding Factor for elephant carcasses (**Appendix 2**). According to the model 53% of all elephant deaths in Etosha are recorded.

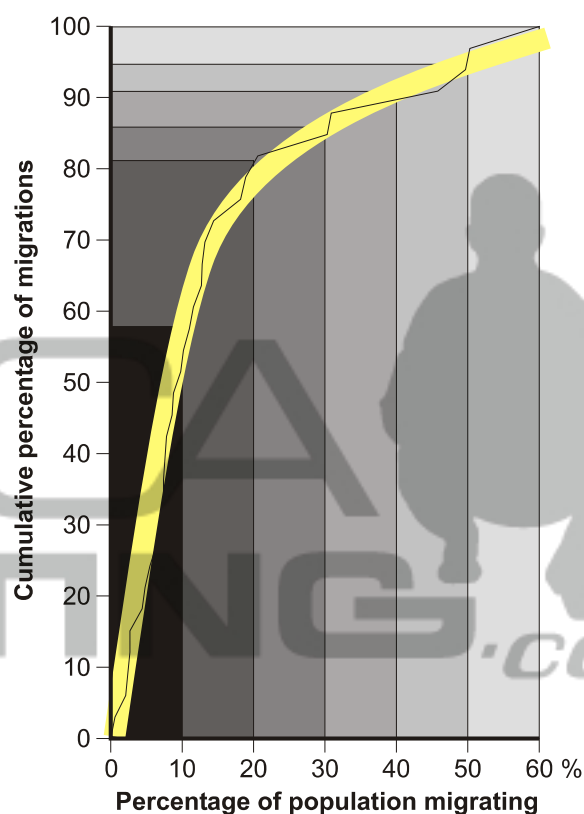


Figure 11: Etosha migrations

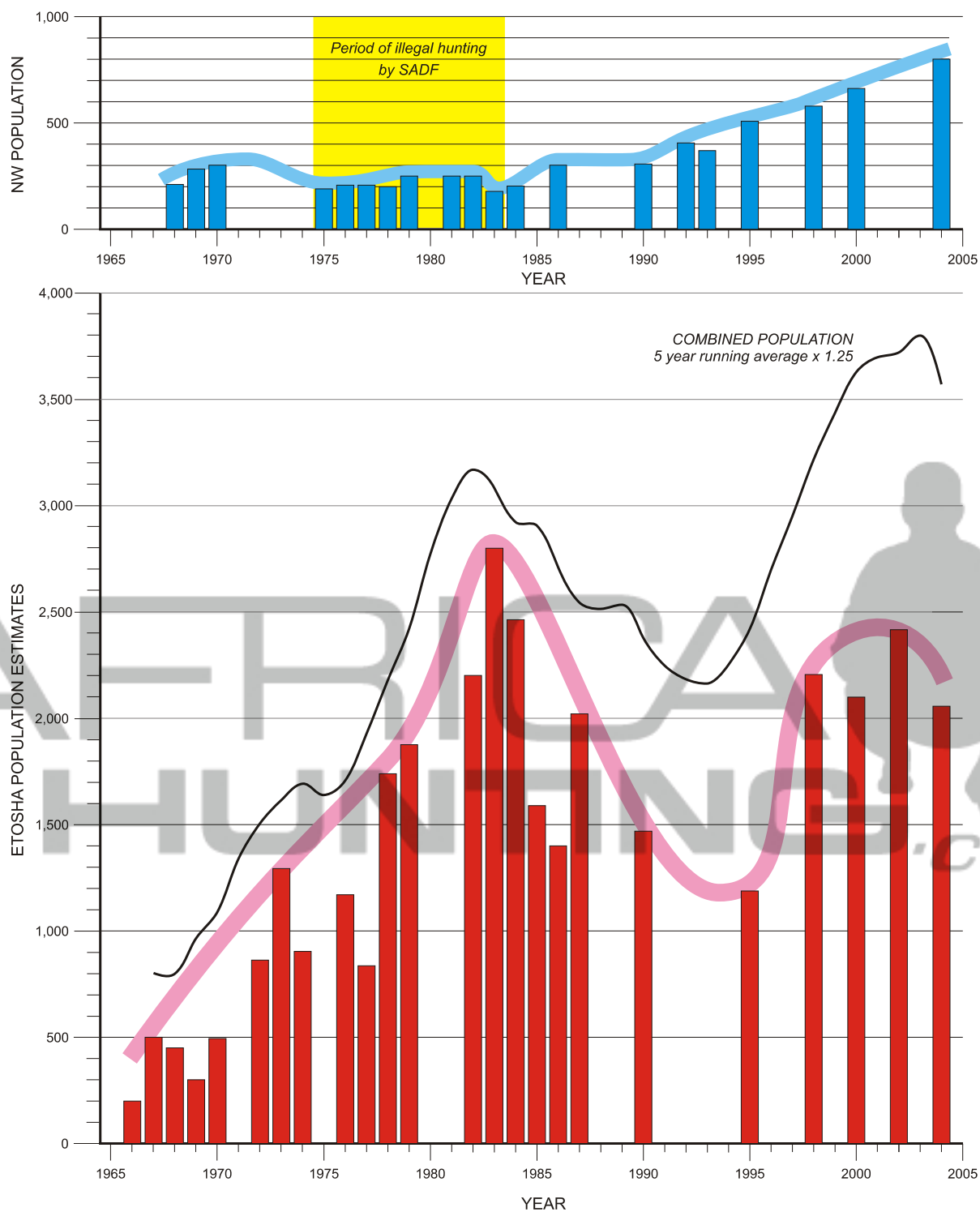


Figure 12: Elephant population estimates for Etosha and the North-west

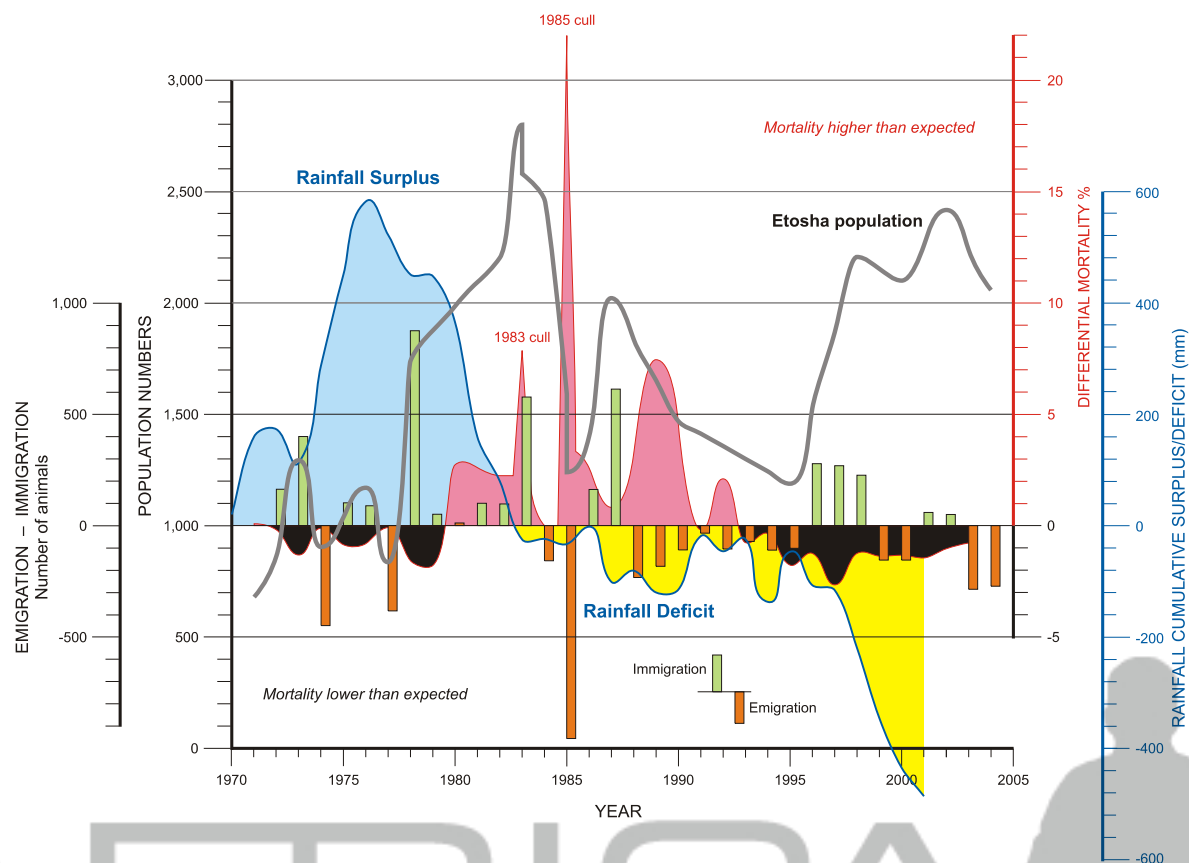


Figure 13: Etosha elephant population: Influence of mortality, rainfall and migration

KAMANJAB RAINFALL DATA					Average				
YEAR	Annual Total	Seasonal Total	Direct Addition	Zero Mean	YEAR	Annual Total	Seasonal Total	Direct Addition	Zero Mean
1961	263.00				1983	126.60	172.1	461	-25
1962	205.50	218.0	-60	-546	1984	284.30	280.3	464	-23
1963	569.00	548.0	211	-275	1985	285.00	267.0	453	-33
1964	180.10	241.4	175	-311	1986	301.50	313.5	489	3
1965	278.50	268.2	165	-321	1987	223.00	174.0	385	-101
1966	543.20	536.2	424	-62	1988	342.50	297.0	405	-81
1967	468.00	308.5	455	-31	1989	115.50	239.5	367	-120
1968	213.20	348.7	526	40	1990	311.00	282.0	371	-115
1969	282.50	317.0	565	79	1991	484.50	373.5	467	-19
1970	205.50	218.5	506	20	1992	147.00	251.0	440	-46
1971	446.00	417.5	646	160	1993	344.50	299.0	462	-24
1972	256.50	290.5	659	173	1994	100.50	165.0	349	-137
1973	259.50	218.0	599	113	1995	462.00	461.5	533	47
1974	515.00	452.5	774	288	1996	116.00	123.5	379	-107
1975	355.50	441.5	938	452	1997	309.20	268.6	370	-116
1976	386.50	407.5	1068	582	1998	116.70	174.3	267	-220
1977	233.90	217.9	1008	522	1999	248.00	151.0	140	-346
1978	203.80	206.2	937	451	2000	129.00	189.0	51	-435
1979	309.20	274.8	934	448	2001	187.20	226.2	0	-486
1980	166.40	194.4	851	365	2002	Data not available for 2002 onwards			
1981	43.50	71.5	645	159	Total		11,104	19,444	0.0
1982	273.00	199.0	566	80	Years		40		
					Average	277.595		Offset	486.109

(iii) Khaudum National Park and Nyae Nyae Conservancy (Fig.14, page 28)

The earliest surveys of Khaudum were in the mid-1970s when numbers were less than 100 animals. The data of DSS (2002a) are slightly confusing in that survey areas the north-east (excluding the Caprivi) have changed since the first surveys. As the elephant population has increased so larger and larger areas have been included in each survey. Although this section is titled “Khaudum National Park and Nyae Nyae Conservancy” the data in **Appendix 2** should be taken to include all elephants in the eastern part of Kavango and Otjozondupa provinces.

The most recent surveys estimate the eastern Kavango population (including Khaudum) at slightly less than 4,000 animals (Kolberg 2004) and the eastern Otjozondupa population at almost 1,000 animals (Stander 2004). Numbers such as these could not have been achieved through normal population growth. The model shown on page 75 shows that a starting population of 80 animals in 1977 would have reached less than 300 animals by 2005 growing at a rate of about 5%.

An exercise has been carried out on the same page in **Appendix 2** to find the amount of immigration needed to best fit the population estimates. It has been assumed that the population grows at 4.56% (page 7) and that all the population estimates need to be increased by 25% to approximate the true numbers in the population. The initial population in 1975, the initial immigration and rate of change of immigration have been simultaneously iterated to obtain the best fit. This is obtained with a starting population of zero in 1975, an initial immigration of 34 animals and in each year after 1975 the immigration increases by 7.14%. This implies an annual immigration in the year 2004 of 251 animals.

The data and the model population are shown in **Fig.14** on the next page.

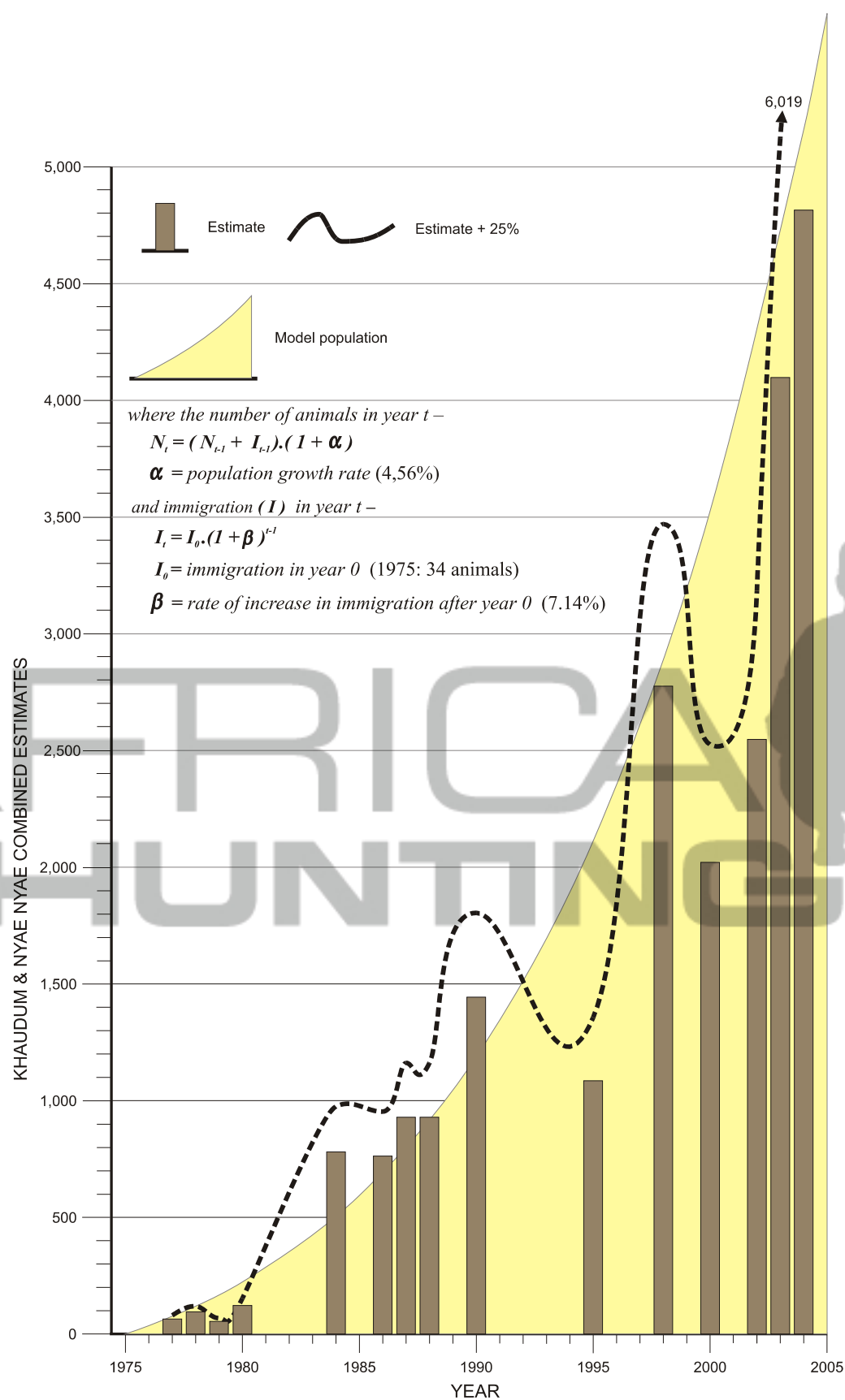


Figure 14: Elephant population estimates for Khaudum and Nyae Nyae

(iv) The Caprivi (Fig.15, page 30)

The estimates for the Caprivi population are given in **Appendix 2** together with alternative population models for the period 1977-2004. A feature of the data is the number of years with incomplete surveys – making it difficult to develop robust population models.

Despite the ‘noisy’ nature of the data, the best fit to the series of estimates is a scenario where the population declined from 1977 to 1989, a major immigration of animals took place in 1990 and, since then, the population has increased at normal growth rates to reach its current levels.

The most recent estimate for the population is 8,726 animals (Kolberg 2004). In 2003, Griffin & Chase (2004) estimated the population at 5,740 animals and, taking these two estimates in isolation, it would appear that some substantial recent immigration has occurred.

(v) Private Land

Some 600 elephants occur on private land in Namibia (**Table 4** below). Of these, most are found within the area shown as ‘permanent elephant range’ in **Fig.8** (page 19). Less than 100 occur outside this range on isolated properties from Windhoek northwards to Etosha. The presence of these elephants adds some credence to the speculative section on the “Future Range” of elephants in Namibia (page 17 and **Fig.9**) – already there are elephants in place south of the present permanent range.

Table 4. Elephants on private land in Namibia

Within ‘Permanent’ elephant range				Outside ‘Permanent’ elephant range			
Farm Name	No.	X-coord	Y-coord	Farm Name	No.	X-coord	Y-coord
Blydskap-oos	25	14.8434	-19.8550	Eden	20	18.8200	-19.5830
Didau	2	17.2812	-19.2390	Epako Game Lodge	5	15.9828	-21.2173
Eensaamheid	50	14.9178	-19.7809	Erindi	14	16.3821	-21.4314
Groot Weerlig	60	15.0229	-20.0422	Okambara	5	18.1680	-22.6120
Hirabis Sud	40	15.0860	-19.7474	Okonjati	15	16.4429	-20.9786
Khairros	15	15.1249	-19.8387	Okoronyama	4	16.0900	-21.3173
Klein Westfalen	7	15.1497	-19.7360	Okosongoro	5	16.0992	-21.1259
Kleinbegin	2	17.1281	-18.8295	Ongombeanavita	3	16.6002	-21.5652
Krenzhof	100	14.8715	-20.0337	Tweekoppies	3	16.6950	-20.6300
Lusthof	35	15.1331	-19.6789	Waldeck	2	17.1998	-22.7750
Olifantsdood	20	14.9468	-19.8535				
Paderborn	40	14.9344	-19.9107				
Safari	20	15.0691	-19.8435				
Sebra	30	14.9753	-19.9827				
Uries Ekango	40	15.0082	-19.7306				
Vryheid Wes	15	14.7950	-19.7889				
Total 501				Total 76			

Data from Peter Erb, DSS

*These data are not included in the next section
on overall elephant numbers in Namibia*

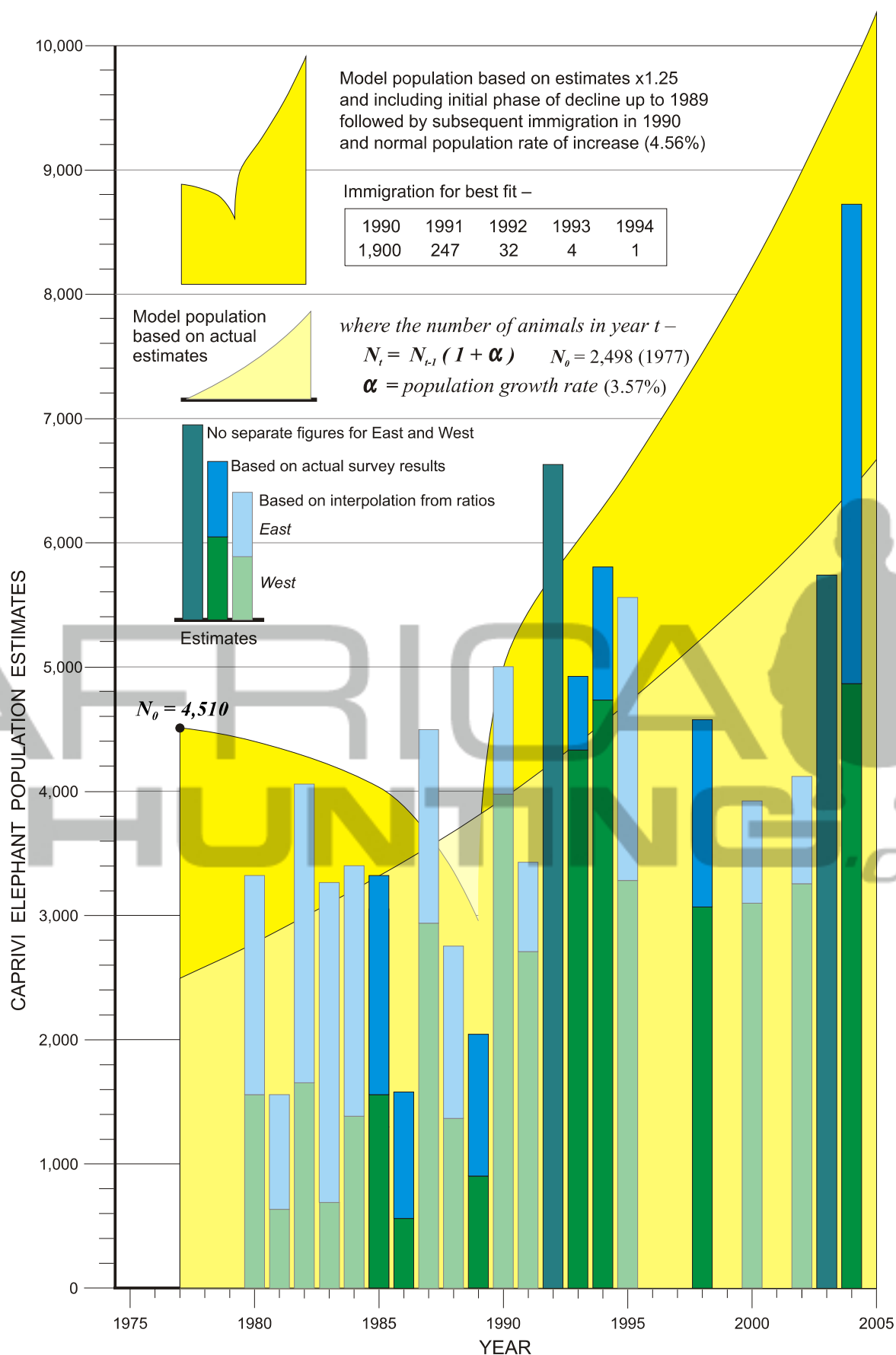


Figure 15: Elephant population estimates for the Caprivi

(vi) Overall Numbers – Namibia (**Fig.16**, page 32)

The population estimates from the preceding four sections are summarised in the table and figure on page 26. The most recent surveys (Kolberg 2004) place the national population at 16,397 animals.

There are only three occasions since 1966 when surveys have been conducted in all four of the subpopulation areas in the same year. A simple population growth model gives a best fit for these three data points (1986, 1998, 2004) with a starting population of 827 in 1966 growing at a rate of 8.173% per year. Since this exceeds the maximum intrinsic growth rate of an elephant population, it must be presumed that immigration has taken place and, in the models done for the Caprivi and Khaudum/Nyae Nyae in the previous subsections, it has already been found that the inclusion of a significant degree of immigration is necessary to obtain a reasonable fit to the estimates.

To improve the model, three additional estimates have been added to those referred to above by including interpolated values for the Caprivi in 1984, 1990 and 1995, when partial surveys were done and a minimum of speculation is demanded. A number of models were investigated before the 'best fit model' described below was obtained. An inspection of the first four estimates (1984, 1986, 1990 and 1995) suggests that very little change took place in the population during this period and that immigration only took effect after 1995. In order to establish a starting population for the model, the initial iterations were limited to these four data points and, assuming a population growth rate of 4% (being a compromise between the best fit value of 3.3% for Etosha and the assumed 4.6% for the north-east), an initial population 2,770 animals in 1966 was established.

Using all 6 estimates, iterations were then performed to obtain the optimum values for the year in which immigration began, the number of animals immigrating in that year and the rate of change of immigration in the following years. A best fit was obtained with an initial immigration of 194 animals in 1996 followed by immigration increasing at a rate of 23% for every year thereafter. The model profile is shown in **Fig.16** on the next page. Were immigration to continue at this rate, the Namibian elephant population would exceed 18,000 elephants in the year 2005.

This model must be treated with caution: it has already been established from the individual subpopulation models preceding this overall analysis that each subpopulation has a different history and displays different characteristics. Therefore any attempt to model the overall population is at best a compromise of these characteristics. However, if there is any validity in the finding that a process of substantial immigration is underway at the moment, then this must become one of the primary challenges for Namibia's elephant management plan.

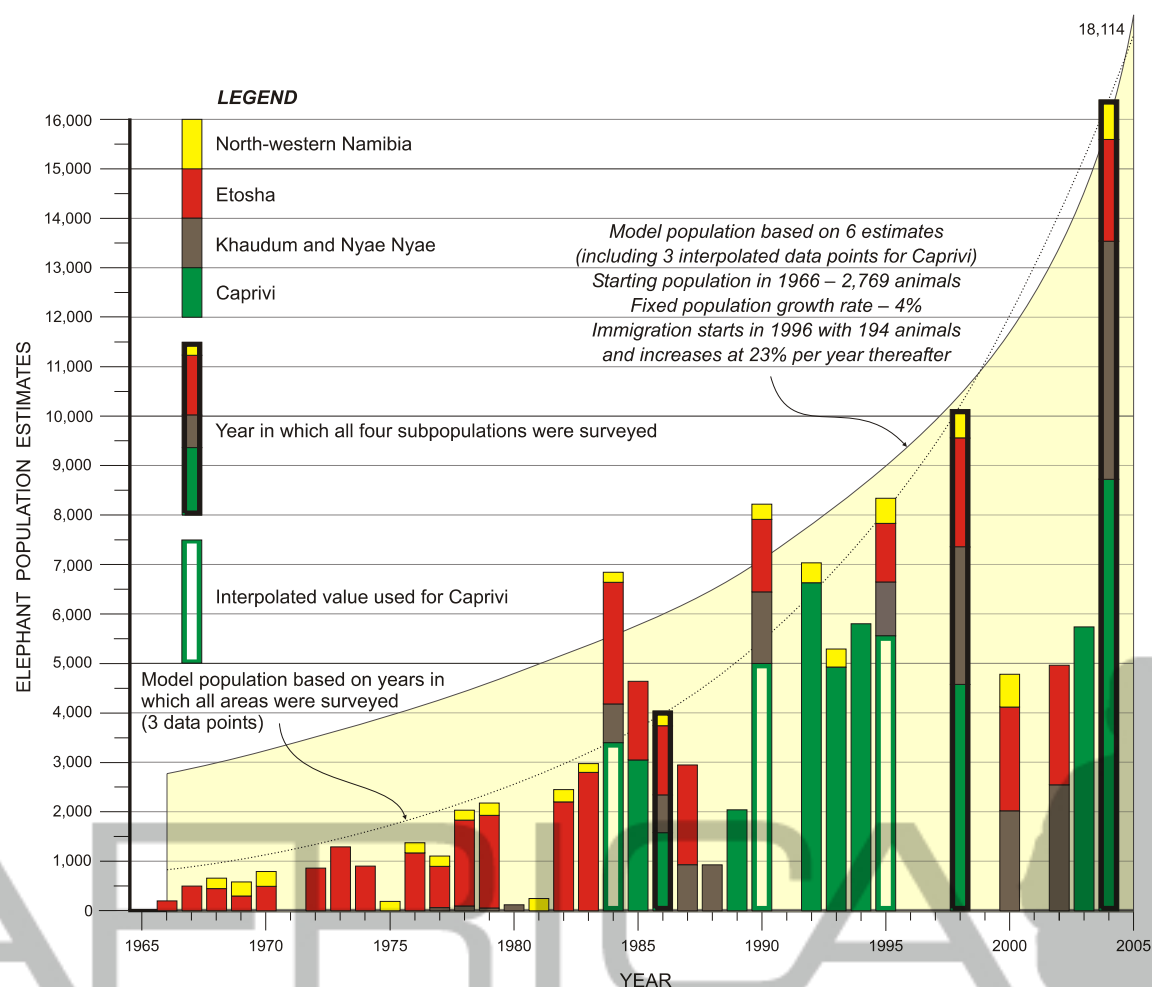


Figure 16: Elephant population estimates for Namibia

Year	Etosha	North-West	Khaudum & Nyae Nyae	Caprivi	Full Counts	Year	Etosha	North-West	Khaudum & Nyae Nyae	Caprivi	Full Counts
1966	200					1986	1,400	301	762	1,578	4,041
1967	500					1987	2,021		929		
1968	450	211				1988			929		
1969	300	283				1989				2,043	
1970	494	300				1990	1,469	307	1,443	<i>5,002</i>	8,221
1971						1991					
1972	863					1992		406		6,630	
1973	1,293					1993		370		4,924	
1974	904					1994				5,805	
1975		190				1995	1,188	508	1,085	<i>5,559</i>	8,340
1976	1,170	207				1996					
1977	836	207		64		1997					
1978	1,739	200		95		1998	2,206	579	2,782	4,576	10,143
1979	1,876	250		54		1999					
1980				122		2000	2,100	662	2,021		
1981		250				2001					
1982	2,202	250				2002	2,417		2,548		
1983	2,800	178				2003				5,740	
1984	2,464	203	780	<i>3,399</i>	6,846	2004	2,057	800	4,815	8,725	16,397
1985	1,590			3,051		2005					

Bold – Year in which all areas were surveyed

Italics – Interpolated Caprivi values

(2) Neighbouring countries(i) Botswana

Estimates for the northern Botswana elephant population are shown in the table opposite and in **Fig.17** below. In 2003 the population was estimated at 123,000 animals (Chase & Griffin 2003). A crude best-fit model for the population suggests that it reached its present level by increasing at a rate of 6.6% from a population of about 8,000 animals in 1960.

This apparent growth rate raises interesting questions. If immigration into the population is ruled out the question arises whether an elephant population is capable of such a growth rate. With a fecundity of 0.25 and a central mortality of zero, an elephant population with a stable age structure is only capable of increasing at a rate of 5.7%, according to the population model used in this study (page 8). Increasing fecundity to 0.33 (i.e. adult females produce one calf every 3 years) with a central mortality of 0.25 (which is about as low as one might reasonably hypothesize) still does not result in a growth rate as high as 6.6%.

If survey techniques had improved over the time span of the estimates this would provide one possible explanation. However, this seems unlikely: from 1993 onwards the standardised techniques of ULG (1995) have been used in all surveys. A model with a starting population of 47,600 animals in 1987 gives a best fit for the years from 1993 onwards with a growth rate of 6.6%.

Botswana elephants

1960 Population	7,884
Rate of growth %	6.625

Year	Estimate	Model
1987	51,000	47,512
1988	41,000	50,659
1989	60,000	54,015
1990	50,000	57,594
1991	65,000	61,410
1992	69,000	65,478
1993	77,000	69,816
1994	56,000	74,441
1995	80,000	79,373
1996	78,000	84,631
1997	100,000	90,238
1998		96,216
1999	107,000	102,591
2000	121,000	109,387
2001	117,000	116,634
2002		124,361
2003	123,000	132,600
2004		141,385
2005		150,752

Dry season estimates rounded to nearest 1,000 animals

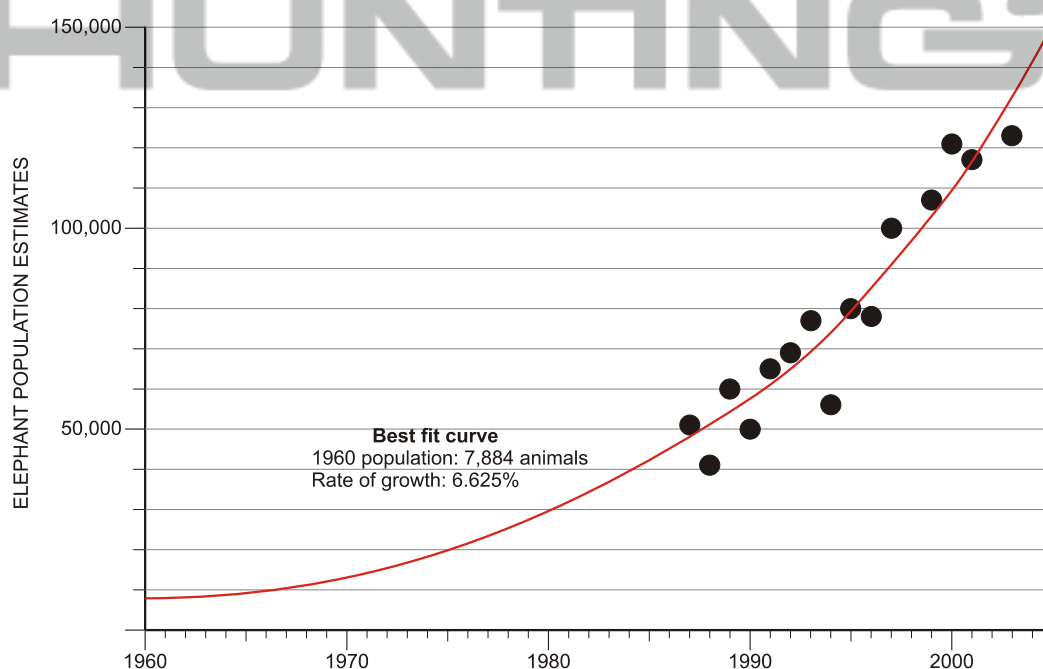


Figure 17: Botswana elephant population estimates

Data adapted from DG (2004)

If immigration were responsible for the high growth rate it would have had to come from Zimbabwe – the Zambian and Angolan populations were already depressed by 1987. Whilst this is theoretically possible, it is unlikely. Martin (1992b) showed that immigration from Botswana was necessary to explain the high growth rates of the Zimbabwe population from 1980-1991.

A growth rate of 6.6% can be achieved with a skewed age structure for the population in combination with a reduced central mortality and a slightly increased fecundity.⁹ Using the population model of Martin (2000b), a skewed age structure was produced by overhunting the adult male segment of the age pyramid so that there were very few males older than 30 years in the population. With fecundity set at 0.28 (i.e. some 12% higher than normal) and central mortality reduced to 0.1 % (which implies one natural death per year for every 1,000 animals between the ages of 5 and 45 years), when the hunting quota is reduced to a sustainable level the population growth rate immediately rises to a level of 6.6% and decreases slowly over about 20 years as the population assumes a stable age distribution.

This is the most plausible explanation for the history of population estimates. There is evidence to suggest that prior to the inception of sustainable quotas in the 1990s, the northern Botswana population had suffered a long history of overhunting for trophy males both from citizen hunting and international sport hunting. The absence of large trophy animals in the population has been noted by numerous observers (P. Becker, *pers.comm.*, G.F.T. Child, *pers.comm.*, I.S.C. Parker, *pers. comm.*).

If the population curve is projected to the year 2005, a population over 150,000 animals is predicted. However, the number resident in Botswana is likely to be less than this. Firstly, the population growth rate should by now have decreased to under 5% as a result of achieving a stable age structure. Secondly, there is evidence of emigration from the population (Chase & Griffin 2004, Chase *et al* 2004, G. Owen-Smith *pers.comm.* and population models for Caprivi and Khaudum in this report).

(ii) Zimbabwe

The north-western elephant population in Zimbabwe has a record of standardised sample surveys dating back to 1980. As the elephant population has expanded into forest reserves, communal lands and private farms in the last 15 years, the survey area has increased slightly. However, it is unlikely that because the new areas were not surveyed in the 1980s that the earlier estimates were incomplete: 20 years ago there were very few elephants outside Hwange National Park and the Matetsi Safari Area. Unfortunately, the rigorous annual survey schedule which was carried out up until 1995 has broken down and there have been no surveys since 2001.

The population estimates are presented in **Appendix 3** and **Fig.18** on the next page. Taking into account major culling operations in the 1980s, two alternative methods of modelling the population both yield the result that the population is increasing at a rate similar to the Botswana elephant population (more than 6.5% per annum). The explanation for this high rate of increase is likely to be the same as for Botswana – only with a highly skewed age distribution are such growth rates possible.

9. Calef (1988) detected the unusually high growth of the northern Botswana elephant population but failed to recognise the importance of a stable age structure in the population and attributed the growth rate mainly to a very high fecundity.

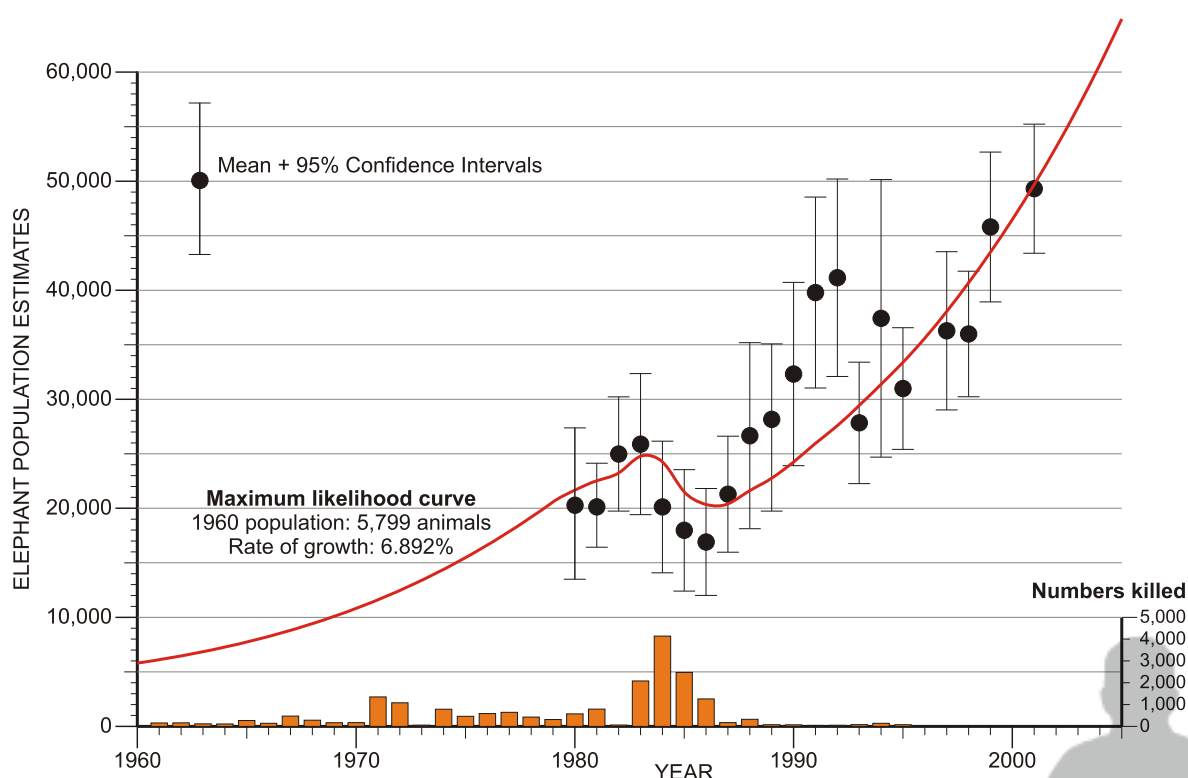


Figure 18: Estimates for the north-western elephant population in Zimbabwe

The north-western elephant population suffered a high level of problem animal control for perhaps 30 years prior to 1980 (D.H.M. Cumming *pers.comm.*). This could well have been responsible for a population with a low number of adult males and the necessary skewed age structure to produce the high growth rates demonstrated by the population. From 1980 onwards there was an increasing trend towards wildlife becoming the predominant form of land use in Matabeleland North and this allowed the expansion of the elephant population into Forest Areas, communal lands and commercial farms. At the same time, sustainable quotas for elephant sport hunting were being set. These two factors acting together are likely to have produced the apparently high growth rates.¹⁰

The combined effect of these two very large elephant populations (northern Botswana: 150,000 animals; north-western Zimbabwe: 50,000 animals) has major implications for the management of elephants in north-eastern Namibia.

10. It is important to note that a high population growth rate does not necessarily mean any increase in the annual production of elephant calves. Without a stable age distribution, it is simply an arithmetic artefact caused by dividing the same crop of calves by a smaller adult population.

(iii) Zambia

Elephant populations throughout Zambia were severely depleted by a wave of illegal hunting which began in the late 1970s. Between 1981 and 1985 Zambia may have lost 100,000 elephants (Martin 1986). Despite a hunting ban in 1981 and the listing of the Zambian elephant population on Appendix I of CITES, elephants continued to decline in most parts of Zambia. AfrESG (1998) estimated the population as 15,873 animals ('definite' estimate). The south-west corner of Zambia was not exempt from this holocaust.

Chase (*et al* 2004) carried out a survey of Sioma Ngwezi National Park and its immediate environs and estimated 1,212 elephants, of which the majority were in the national park (1,099). The authors remark that the population does not appear to have increased since the last survey which estimated 1,187 elephants in 1991 (Tembo 1995). They attribute the *status quo* to high levels of illegal hunting, human settlement along the Kwando River which is preventing Botswana's dispersing elephants from reaching Sioma Ngwezi and to veterinary fences also constraining movements.

DG (2004, Fig.8) shows a discontinuous elephant range in south-western Zambia with no links between Sioma Ngwezi and the nearby Kafue National Park. Recently large numbers of elephant are being seen along the Zambezi from Livingstone westwards to the point where the borders of Botswana, Namibia, Zambia and Zimbabwe meet.

(iv) Angola

The elephant population in Angola was heavily hunted during the UNITA occupation of southern Angola after independence in the 1970s and, although the civil war has ceased, wildlife law enforcement continues to be problem due a lack of manpower and resources.

Chase & Griffin (2004) surveyed the Luiana Partial Reserve in the south-east corner of Angola and estimated 372 elephants. Most of the animals were within 50km of the Namibian border and away from human settlements. Radio tracking studies have shown movements of elephants from Botswana into the area despite the presence of landmines. The authors stress the importance of the Luiana Partial Reserve as a dispersal area for the irrupting elephant population in Botswana.

The status of elephants in Iona National Park is uncertain. They were present here in the 1970s but there are no recent reports which confirm their presence or absence.

g. Behaviour

Few large mammal research topics have received as much attention as elephant behaviour. The social organisation of elephants has been well covered by Douglas-Hamilton (1972), Moss (1976, 2000) and Poole (1996). Male territoriality and musth have been researched in depth by Poole (1982, 1986, 1987, 1989). The aspects of behaviour included here are those which are directly relevant to elephant management in Namibia.

(i) Habitat modification

This subject was discussed at some length in subsection **d. Habitats** (page 9) with the conclusion that the maintenance of a significant canopy cover of mature trees is not possible with high density elephant populations. Of late various authors have attempted to minimise the consequences of this, asserting that the impact on biological diversity is minimal or localised (Owen-Smith 2005, du Toit 2005). Pervading the publications on this topic is a tacit assumption that all management decisions relating to elephant are based simply on whether or not biological diversity is being conserved and consideration of the wider socio-political and aesthetic issues tends to be ignored. Perhaps conservation of biological diversity *per se* is not the fundamental issue. More important may be the type of landscapes we wish to create and the rôle we would like elephants to play in a multispecies land use system where sustainable development is the key issue.

(ii) Elephant movements, dispersal and home ranges

Owen-Smith (2005) notes that true dispersal involves the abandonment of previous home ranges and the occupation of new areas. Much of what is taking place in the regional elephant range (**Fig.10**, page 21) may not fully satisfy this definition in the short term. Movements out of Botswana are still largely seasonal and it may take many years before new ranges in the Caprivi, Angola and Zambia are permanently colonised. Within Namibia, a similar situation pertains in the north-west and north-central areas.

In a radiotracking study carried out from October 1987 - May 1988, Lindeque & Lindeque (1991) found seasonal home ranges of 5,800-8,700km² amongst the population of 1,000-2,000 elephants in Etosha. Elephants from Etosha moved almost to the Angola border and elephants in Kaokoveld moved across previous bioclimatic demarcations of populations. This study raised questions about the validity of earlier classifications of elephant subpopulations in north-west Namibia. Viljoen (1987, 1988, 1989) classified the Kaokoveld elephants into 3 distinct populations, 2 of which were reportedly in contact with or were part of the Etosha population. Viljoen maintained that the western population ('desert elephant') was restricted to an area west of the 150mm isohyet and never left this bioclimatic zone. This paper disagreed. Some 30-50% of the Etosha elephant population were spending 3-5 months/year outside the park.

Rodwell (1991) used radio collars to establish that the majority of elephants in the Caprivi were seasonal inhabitants. The commonest movement pattern was residency during dry season and movement out of the Caprivi during wet season. One herd went from Mudumu through densely settled areas along Kwando to Sioma Ngwesi in Zambia in the wet season. Movements north into Angola were of very limited duration – probably due to the poor security situation. Whenever elephants were in the Caprivi, they used a small range and therefore placed enormous pressure on the vegetation. An elephant bull in Mahango used a dry season home range of 575km² and a wet season range of 5,606km². In Etosha home ranges varied from 2,851-18,681km². Rodwell concluded that Namibian elephants display some of the largest home ranges in Africa.

The spatial distribution of Namibian elephant is very much determined by the availability of suitable cover and surface water and the large home ranges are a result of the arid environment. This has major portents for management both within Namibia and across national boundaries. No single protected area is a self-contained range for elephants. Large areas co-managed by the relevant landholders and occupiers will be necessary to provide viable ranges, to distribute the pressure of elephants on habitats and to allow for population increase and expansion. The patterns of seasonal movement provide strong reasons for transboundary cooperation on elephant management especially with Botswana.

The vision statement developed under the ongoing UNDP/GEF assisted project in Namibia (UNDP 2005) provides for co-operation between stakeholders to achieve this far-sighted concept. Linkages would be established under a co-management system which would both secure and increase the available range for elephant.

(iii) Human-elephant conflict

Elephants destroy crops, damage water installations, compete with cattle at water points (and occasionally kill cattle) and are a physical threat to humans.

The Caprivi has the highest incidence of conflicts between humans and elephants in Namibia and the largest number of incidents occurs on the Kwando River frontage (O'Connell 1995a). Elephant damage to crops from 1995-2000 for the whole Kwando River region was estimated at about N\$20,000 per year (O'Connell-Rodwell *et al* 2000). Although this may seem financially trivial, it has devastating effects on household livelihoods.

Recent data from the Annual Audit database (Event Book) monitoring system of the Caprivi Conservancies (NNF 2004) indicate an escalation in incidents involving elephants (see table opposite).

The benefits which communities are receiving from elephants on their land are small. The number of elephants hunted as trophies and problem animals is very low (less than 10 over the time period of the table) and does not come close to compensating communities or individuals for their losses.

This situation is a potential 'time bomb'. With all conservancies being in a fledgling stage, there is a 'wait-and-see' attitude amongst their members. The recent rapid increase in the numbers of elephant in the Caprivi is probably due to a temporary tolerance of elephants while the conservancies are in their formative stage. But these communities will be evaluating whether a commitment to wildlife as a land use is worthwhile and, unless elephants contribute a great deal more to livelihoods, the present forbearance is likely to disappear.

Table 5: Elephant incidents in Caprivi

Conservancies	2001		2002		2003	
	I	D	I	D	I	D
East Caprivi						
Impalila	2		12	29	12	23
Kasika	3	19	0		3	33
Kwando	159		227		111	515
Mashi	41		116	162	28	59
Mayuni			162	229	55	269
Salambala	18	17	18		34	42
Wuparo	3	16	40	19	10	44
Totals	226	52	575	439	253	985
West Caprivi						
Lianshulu					20	43
Lusese					0	0
Malengalenga					25	48
Nakobolelwa					5	5
Totals					50	96

I - Number of incidents involving elephant

D - Number of instances of crop damage

h. Limiting Factors

Namibian wildlife legislation requires the preparation of management plans for species which are rare or valuable. Elephants are not rare in Namibia but they are potentially valuable. All of the previous management plans¹¹ prepared under the Transboundary Mammal Project of the Ministry of Environment and Tourism have listed, in the conventional manner, ecological factors which are preventing increases in numbers of species whose populations are lower than desired. The situation is completely different in the case of elephants.

Elephant numbers are not lower than desired – they already exceed what many would consider desirable for the available habitats. A cursory look at the modifications to vegetation in large parts of the elephant range in northern Botswana (DG 2004, page 7) might cause Namibians to want to prevent similar changes. **At present no factor is preventing an increase in numbers of elephants.** Elephant populations might increase faster with the addition of more waterpoints (for example, in the multiple use zone of Babwata), with the removal of veterinary fences¹² or with less competition from cattle¹³ but, even with these constraints in place, the information presented in this report suggests that elephant are increasing at a rate close to the maximum possible.

Namibia's short-term problem is to accommodate the increase in elephants which is happening at the moment. It is not the long-term problem. In the long term elephants have a propensity to eat themselves (and other species) out of house and home no matter how great the range available to them – a process which culminates in population crashes. Some would argue that this is 'natural' and that no management is necessary. Such arguments tend to put elephant conservation in a vacuum and ignore the alternative options for accommodating elephants within larger sustainable development systems.

Technically, there are no good reasons why more land in Namibia should not be available to elephants. Brown (2004) and Martin (2004b) have pointed out that, given land capability in the arid situation of Namibia, the highest valued land uses over most of the country are those based on management of natural resources (**Fig.19**, page 40). Moreover, the full potential is far from being realised at present due to national and international policy constraints which place wildlife at a competitive disadvantage with land use based on exotic species. Were subsidies to be removed from the domestic livestock industry and were it possible for elephant to play their full economic rôle in land use systems, it could reasonably be expected that large additional areas of land would be converted to wildlife management – for example, most of the northern Kavango and Owambo provinces and the Eastern Caprivi. **This would remove the short-term limiting factor of providing additional range for elephant.**

-
11. Plans have been prepared for buffalo, roan, sable, tsessebe, reedbuck, waterbuck, lechwe and puku.
 12. For example, removal of the international boundary fence along the southern boundary of Babwata and along the eastern boundary of Khardum and Nyae Nyae would greatly facilitate east-west linkages in the regional elephant range.
 13. In a study of the Caprivi, Schlettwein (*et al* 1991) saw the greatest threat to large wild herbivores as the extreme grazing pressure exerted by 96,000 head of cattle – a number which the authors expected to rise to 260,000 by 2000.

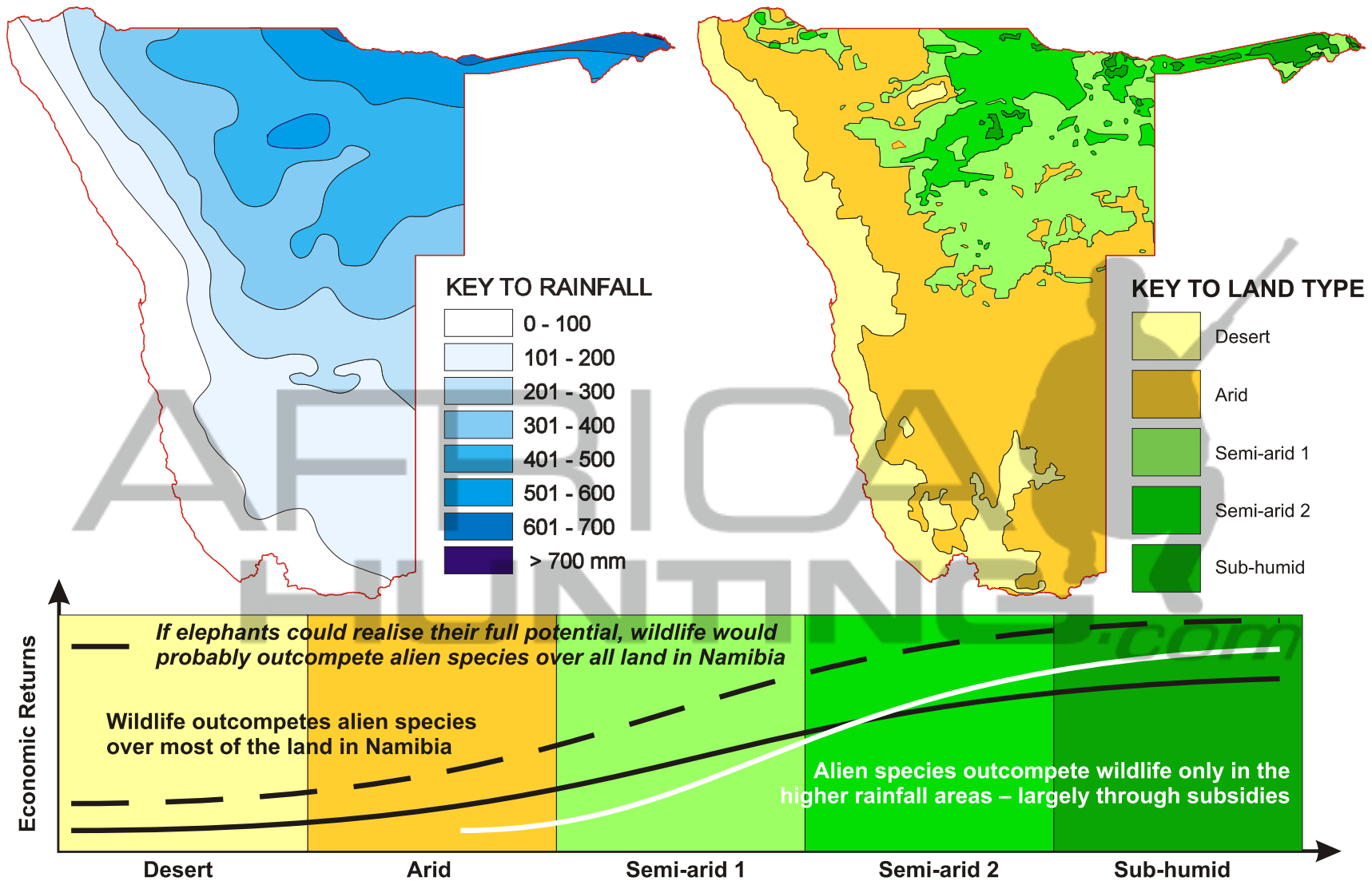


Figure 19: Land capability and economic returns from land use in Namibia

The technical arguments for greater areas of Namibia to be put over to natural resource management will not, on their own, bring about the needed changes to remove this limiting factor for elephants. It will require a high level political commitment and the correct suite of incentives to induce landholders (both communal and private) to convert to a land use based primarily on wildlife. The high level political commitment is already in place. In a speech delivered on 3rd February 2004, His Excellency the President, Dr Sam Nujoma, made the visionary statement that wildlife would be restored throughout the north of Namibia, that ownership of wildlife would be conferred on local peoples and that the economy would be transformed by diversification based on wildlife uses . . .

. . . a dream where the animals returned, the forests were restored and the people were no longer poor and hungry. The return of animals to the land could benefit the people if the animals once again belonged to them . . .

Already the trends amongst commercial farmers and conservancies are extremely positive and Namibia's record of an expanding wildlife industry over the past 10-20 years is impressive.¹⁴ To maintain the momentum requires a greater devolution of authority for wildlife management, the development of co-management institutions and, in the specific case of elephant, an ability to realise far greater returns from the species. Perhaps the greatest danger that the vision will not be fulfilled lies in a possible perversion of the intent of policy during the course of putting it into practice (Corbett and Jones 2000).

There is a corollary to this optimistic vision for the future. Failure to implement the necessary devolutionary measures will not simply result in the *status quo* being maintained. Since the 1970s, elephant populations have collapsed in an apparently inexorable process across Africa.¹⁵ The monotonous, repetitive nature of the phenomenon has caused depression amongst conservationists – but resulted in few cold-blooded analyses of the underlying causes. Invariably it has happened in countries where the State asserts that it owns all wildlife and attempts to regulate all wildlife use. Murphree (2000) describes this 'Big Government' syndrome as one where –

- the State's "authoritative reach exceeds its implementational grasp";
- extended bureaucracies are incapable of linking inputs and outputs; and
- the incentives for individuals lie largely in the enhancement of their own powers.

Degeneration into State corruption appears inevitably to accompany centralised governance (Martin 2003a). Parker (2004) documents the influence of corruption on the ivory trade in Kenya and the changes which took place in the national wildlife agency to facilitate this. Namibia may feel it is exempt from the process but the events which took place during the era of the South African Defence Force in the late 1970s and early 1980s should stand as a salutary reminder. There would seem to be only one antidote to the malaise and that is the creation of powerful, self-governing wildlife constituencies at the local level.

14. In 2004, there were more than 40 registered and emerging conservancies with 150,000 members managing wildlife over an area of 100,000 square kilometres in the areas where elephant populations are expanding.

15. AfrESG (1998) and Martin (1986) document the decline of elephant populations in various countries since the 1970s. Amongst the more spectacular population crashes have been those in Kenya, Tanzania, Uganda and Zambia.

2. SIGNIFICANCE OF THE SPECIES

a. Conservation Significance

The population of savanna elephants in Africa was thought to be around 3 million animals in the 1970s although this number is little more than an informed guess. Martin (1986) estimated the population at about 1.2 million. In the late 1980s it was claimed that the population had crashed to some 300,000 animals (ITRG 1989) but the estimates of elephant numbers were incomplete and speculations where no survey data existed may have suffered a lack of impartiality. In 1998, the population was estimated at over 500,000 elephants (African Elephant Database, AfrESG 1998).¹⁶ More than half of the current African population is in southern Africa and more than half of this number occurs in Botswana (DG 2004).

The African elephant was listed on Appendix I of CITES¹⁷ at the 7th Meeting of the Conference of the Parties held in Lausanne in 1989. In his concluding remarks at the end of the session on elephants, the Director-General of IUCN (Dr Martin Holdgate) stated that the meeting could be pleased that it had concluded its business but that “it should not be pleased with the intellectual rigour which had gone into its deliberations”. At the 10th CITES meeting in Harare in 1997 the elephant populations of Botswana, Namibia and Zimbabwe were transferred to Appendix II which, in theory, enables these countries to trade in ivory and elephant products. In practice, numerous obstacles have been placed in the way of trade.

More recently, the African elephant has been classified as *Endangered* in the latest IUCN Red Data Book. This classification was based less on the actual numbers of elephant and more on the fact that the population was fragmented and had suffered recent catastrophic declines in some countries. It is of interest that the new criteria used for the classification were very similar to those submitted originally by Botswana, Malawi, Namibia, Zambia and Zimbabwe to the 8th CITES COP Meeting as criteria for amendments to the Appendices of CITES¹⁸ which, with modifications, were adopted at the next CITES meeting in Fort Lauderdale, Florida.

This draft proposal was part of the conceptual evolution of the southern African countries thoughts about the CITES treaty. In the text of the draft resolution (para.35) it is stated that –

The “perfect” system would be one which notes the biological status of species but treats matters of trade entirely independently of this status . . .

The management measures required to enhance the status of any species may include placing a commercial value on the species regardless of its conservation status. Sustainable use is possible from very small populations and may provide the incentives and funds needed for successful conservation. Namibia could carry a larger elephant population over a larger range if it disregarded the confusion between the biological status of the species and the measures need for its enhancement. A first step towards this would be the removal of the ‘Protected Species’ designation for elephants under Namibian wildlife legislation.

16. The sum of “Definite”, “Probable” and “Possible” estimates is 519,461 animals.

17. Convention on International Trade in Endangered Species of Wild Fauna and Flora

18. Draft resolution Doc.A1.3 submitted pursuant to Conf.4.6 at the Eighth Meeting of the Conference of the Parties held in Kyoto, Japan 2-13 March 1992. The draft criteria were based upon a system proposed by Mace and Lande (1991).

b. Economic Significance

Elephants are capable of a major financial and economic contribution to the wildlife industry in Namibia. This contribution could come through any or all of the following uses of elephant –

- (i) Non-hunting tourism;
- (ii) International sport hunting for trophies;
- (iii) Culling (with byproducts of ivory, skin and meat)

These three uses are not mutually exclusive. A potential conflict could arise in any given area between the non-consumptive and the consumptive uses but with judicious planning, zoning and timing the conflicts can be minimised. Culling is usually an episodic event lasting for only a few days in the year and it can be carried out well away from the areas used by non-hunting tourists. Sport hunting can be done in areas not used for game viewing or immediately outside the boundaries of protected areas. Each of the uses is discussed below.

(i) Non-hunting tourism

The marginal contribution of elephants to game-viewing tourism is difficult to assess. In making recommendations for the management of elephant in northern Botswana, DG (2004) does not attempt it. Martin (1993) estimated the financial returns from high-quality ecotourism in selected savanna localities with wildlife populations close to carrying capacity at about US\$25/ha. It would not be unreasonable to attribute 20% of this value to elephants, i.e. about US\$5/ha. However, whilst non-consumptive tourism in prime localities will give by far the greatest economic returns possible from wildlife (Barnes 2001), only a limited amount of land in any country is suitable for high quality game-viewing tourism and these high levels of financial return are not generally applicable over large tracts of land.

The value may be even higher in areas which have a local overabundance of elephant – however, the sustainability of such a land use is questionable. The initial effect of a high density of elephant in any park is that it will attract tourists.¹⁹ However, if overpopulation is allowed to persist, eventually the large trees will disappear from the park, other animal species will decline, biodiversity will be affected and the aesthetic appearance of the park will suffer. In the extreme case desertification and soil erosion will result and this, in turn, may lead to a crash in the elephant population. At this stage the attraction of the protected area for tourism will be reduced.

In the long term, it is doubtful whether there is any proportionate increase in tourism with increasing densities of elephants above some baseline. In southern African savannas, elephants at a density of 1/km² may be the threshold above which additional numbers produce diminishing tourism returns. In areas such as the arid north-west of Namibia elephant densities will be far lower and the present population of some 1,000 elephants in about 60,000km² of the Kaokoveld and Damaraland may provide sufficient attraction for tourists to visit the area. The returns from tourism would probably not increase greatly with more elephants since there are other attractions beyond ‘desert elephants’ which cause tourists to visit the area.

19. The Chobe River riverfront in Botswana and the Main Camp area in Hwange National Park in Zimbabwe are examples of this.

The land use values given for wildlife management under non-hunting tourism may appear high. They are not. I conclude this section with two examples from Martin (2000a) for a property of about 3,000 hectares near the Victoria Falls in Zimbabwe. Before the tourism industry in Zimbabwe collapsed for political reasons, the expected gross return from this property from 24 half-day visitors paying US\$125 each for an eco-tourism experience was US\$876,000 per year or some US\$300/hectare.

In addition to normal eco-tourism, an operation using twelve domesticated elephants belonging to the Elephant Company (Pvt) Ltd was carried out on the property. Each elephant carried an average of 3 tourists each paying US\$100 every morning and every afternoon of the year on bush walks lasting about 3 hours using an area of about 500 hectares. The gross return from this operation was some US\$2,600,000 per year or over US\$5,000 per hectare. Taking into account agents' fees, running costs and capital repayments, the net annual earnings were in excess of US\$0.5 million per year – a land use return of over US\$1,000 per hectare. This is the highest land use value for wildlife which I have encountered anywhere in Africa and it is attributable entirely to elephant. The owners of the property sought a unique theme for their future wildlife development and, for interest, I include the final recommendations from the consultancy . . .

Elephants as the Theme

This option includes all the desirable aspects of high quality eco-tourism but adds an aspect which is unique. Tourists who undertake the elephant back-rides presently on offer report afterwards that this has generally been the most outstanding of their experiences at the Victoria Falls. More than the actual ride on elephants, they say that the most rewarding part of the experience has been the close contact which they have enjoyed with the animals.

At present, the range of activities on offer featuring domesticated elephants are extremely limited – they amount to no more than a short ride on the elephants and a few moments spent in contact with elephants while they are feeding. The same is true for the other companies at Victoria Falls which also offer elephant rides. The activities surrounding domesticated elephants could be greatly expanded from this to a far fuller experience with elephants, including being able to walk with them, watch them feeding, swim with them, touch them and at the same time be provided with a great deal of information about their natural biology – including the past history of elephant on the property and the record of damage to the vegetation.

The domesticated elephant could be integrated with the tourist accommodation on the property and coordinated with the guests' recreational activities. Elephants could be available to paying guests for rides or walks accompanying the elephant. Without their saddles, there is nothing to distinguish domesticated elephants from wild elephants – other than the fact that they are safe to be near. This could prove a major drawcard and form the unique theme which would differentiate this property from all others in the tourism industry at the Victoria Falls.

(ii) International sport hunting

It is assumed that only male elephants would be hunted (see discussion on hunting female elephants in **Management**, page 58). Sustainable quotas for male elephant trophy hunting are given on page 58 and in **Appendix 5** (page 93). The expected financial returns from safari hunting are calculated in **Appendix 4** (page 88).

With a trophy male quota of 0.5% of an elephant population of 1,000 animals in an area of 1,000km², the net financial return should be of the order of US\$117,000 which is equivalent to a land use value of US\$1.17/ha (N\$7.25/ha). If no other management were being undertaken, this value would remain true for one year only: an elephant population increasing at 4.56% would yield an increasing quota of trophies starting at 5 in the first year and rising to 42 after 50 years.

These values were derived for a typical savanna elephant population growing at 4.56% per annum. Tests were carried out on a population with a lower growth rate²⁰ of around 3% as might be expected for the north-western elephant population. The sustainable quota levels do not change markedly – if anything a slightly higher quota is possible from the slower growing population (around 0.6% of the total population). This would imply a quota of 5 elephants for the north-western population which is estimated as about 800 animals.

As a land use return, a value of US\$1.17 does not appear unduly high. Barnes & de Jager (1995) found net land use values of US\$1.62 for southern sheep/wildlife farms, US\$1.08 - US\$4.86 for northern cattle/wildlife farms (depending on the size of the management unit) and US\$2.43-US\$7.03 for northern non-hunting tourism operations on private land (also depending on the size of the management unit). All of these were values earned without elephants. The addition of trophy elephant hunting to the first two systems would result in increases in the net returns from land from 24-108% depending on the system to which elephant were added. It could also be expected that there would also be an increase in non-hunting tourism values if elephants were present.

For the same land categories, Barnes & de Jager (1995) found that the 'net value added' in economic terms to the land use values listed above was in all cases more than double the financial value and it would be reasonable to expect that this relationship would hold true for the enhanced income obtaining by adding elephants to the species mix.

The Event Book data from conservancies on communal land (NNF 2004) suggest that levels of exploitation of elephant for sport hunting in the Caprivi and eastern Kavango and Otjozondzupa provinces are well below the sustainable offtake levels and could be significantly increased for the benefit of local peoples.

Elephant are one of the few species for which the value-added benefits of sport hunting do not exceed the actual commodity values of the products from the hunted animals – assuming that markets are operating normally so that the values of ivory and elephant skin can be fully realised. In the table on page 89, the commodity value of elephant products from the animals hunted is slightly higher than the return from sport hunting (US\$1.22/ha versus US\$1.17/ha).

20. The model results derived in **Appendix 2** for the Etosha population were used.

(iii) Culling

The distinction needs to be made between ‘cropping’ – a deliberate exploitation of elephants for their products (ivory, skin and meat) and ‘culling’ – a management operation designed to reduce elephant densities for conservation reasons. The two differ in their effects: cropping can be practised so that all age classes in the population are equally harvested whereas culling focuses on the removal of entire elephant herds because this has the greatest effect in reducing population growth for the least offtake of animals. Both practices result in products with financial value.

In **Appendix 4** (page 88) a comprehensive management programme is analysed under which elephants are culled to keep their numbers constant and, at the same time, trophy hunting of males takes place. Elephant calves between the ages of 2-8 years are captured and sold to approved buyers rather than killed. Because of the skewing of the population age structure caused by removing a preponderance of females, the sustainable trophy hunting quota can be doubled. This does not, however, result in more hunting trophies than would be obtained from an elephant population which is managed solely for sport hunting: in the latter case, because the population continues to increase, trophy quotas can be increased over the years. When the population is being culled to keep numbers constant, the sport hunting quota remains the same in every year.

The net income from culling a population of 1,000 elephant (which would normally grow at a rate of 4.56% per annum) at a level of 3% to maintain a constant density of 1/km² would be about US\$60,000 per year. Male trophy hunting from the same population would yield an additional US\$273,000 per year, giving a total net income of US\$333,000 annually. The land use value of this income is substantial: US\$3.33 (N\$20.7) per hectare.

In the recently completed project to strengthen protected areas in Namibia (UNDP 2005), the required budget for all of the protected areas in the north-east of Namibia was estimated as N\$26 million. If the State protected areas in the north-east which have elephant populations (a total of 14,097km² including the Caprivi Forest Reserve) were managed according to this system, the expected income would be some N\$29 million. **This would more than meet the entire State conservation costs for the north-east.**²¹

Under such a management regime, the increase in income which would be enjoyed by conservancies in the north-east would also be substantial. It should more than offset the costs which elephant are presently causing through crop raiding and other damage.

There are strong arguments for avoiding a management regime which attempts to hold an elephant population at a constant level. These are discussed in the section on management. The point to be established here is that with the rapidly increasing elephant populations in the north-east, there is sufficient scope for innovative management which would produce high financial and economic returns.

21. This is a somewhat simplified calculation. Unless the State conducted its own elephant hunting safaris, a large proportion of the income from trophy hunting would accrue to safari operators. Much of the estimated income from elephant products would not be immediately realisable because of CITES. It is assumed that Babwata and the Forest Reserve elephant populations are at a high enough elephant density to be managed in this manner. However, given the estimate for the whole of the north-east in this report (about 14,000 elephants), the management programme could be arranged to secure the required income sustainably.

c. CITES matters

This section is concluded with a brief discussion on CITES matters affecting elephant. The calculations in this study of the financial values involving ivory and elephant skin have been done under the assumption that global markets for these products are operating normally – which is not the case. Although the Namibian elephant population is listed on Appendix II of CITES and, under the Articles of the Convention, trade in ivory and other elephant products should be possible with a minimum of bureaucratic interference, “*the Conference of the Parties has . . . adopted increasingly complex requirements for trade in elephant products that have all but ensured that such trade does not take place*” (MET 2004).

In a sense, these constraints which go beyond the provisions of the original Articles of the treaty are *ultra vires* – they impose conditions beyond those which were in place at the time a Party acceded to the treaty. However, there is little that any individual Party can do about it if such ‘annotations’ are adopted by a majority vote. Under the provisions of paragraph 1 of Article XXIII, a Party may enter a reservation against an annotation such as that which affects trade in elephant specimens but such a reservation must be entered within 90 days of the listing of a species on Appendix I or II or the transfer of a species between Appendices – a procedure which was not followed after the Namibian elephant population was transferred to Appendix II in 1997. The proliferation of annotations which go beyond the provisions of the Articles is a clear indicator that the original Treaty is deficient.

This leaves Namibia with three options. The first is to accept the *status quo*. The second is to proceed with trade in elephant products disregarding the annotation. The third is to denounce the treaty.

The perspectives included in Namibia’s submission to the 13th CITES meeting to amend the annotation affecting Namibian elephants (MET 2004) are extremely powerful. They provide cogent reasons why the constraints on trade are acting against conservation in Namibia. The presentation ‘*Elephants and People*’ which was distributed to all CITES Parties (Martin 2004b) reiterates Namibia’s determination to oppose measures imposed externally which act detrimentally on local people and national development aspirations. Namibia should reject the first option.

If Namibia were able to find willing partners to trade in ivory and other elephant products and followed the procedures of Article IV for trade in specimens of species included in Appendix II, there is very little that the CITES Parties or the Secretariat could do about it.²² It requires only that an export permit is issued which meets the conditions that the Namibian Scientific Authority advises that the export will not be detrimental to the survival of the species and that the Namibian Management Authority is satisfied that the specimen was obtained in conformity with the laws of Namibia. There are no conditions for importing Party to satisfy. If Namibia were to pursue this option, there should be nothing clandestine about the action. In the end it will serve the same purpose as the last option.

22. This advice is from the respected leader of the CITES delegation of the Depositary Government (Switzerland).

Namibia has considered withdrawing from CITES. This is perhaps the most powerful way Namibia could express its frustrations with the treaty and, if it is accompanied by a strong statement from the highest political level, it should cause many CITES Parties to take notice. When a country denounces CITES because it believes the treaty is acting against conservation, it will attract world wide publicity.

It is unlikely that Namibia would be able to remain outside CITES for very long: there will be a succession of representatives from the most powerful nations of the world and the CITES Secretariat beating a path to the door of the Minister of the Environment. Pressures on Namibia will be considerable, ranging from intense cajolery to direct threats affecting the delivery of international assistance. International NGOs will inflame the global media to cast Namibia in the worst light possible and it will be essential that the Namibian authorities ensure that their arguments are consistent and watertight. The best strategy may be one of total surprise. A comprehensive statement should be released at the time the denunciation is submitted to the Depositary Government and the Namibian authorities should enter into a minimum of public debate following this.

When Namibia is forced to re-accede to the Treaty, it will do so under an enhanced status. Its proposals for amendments of annotations should find ready acceptance.



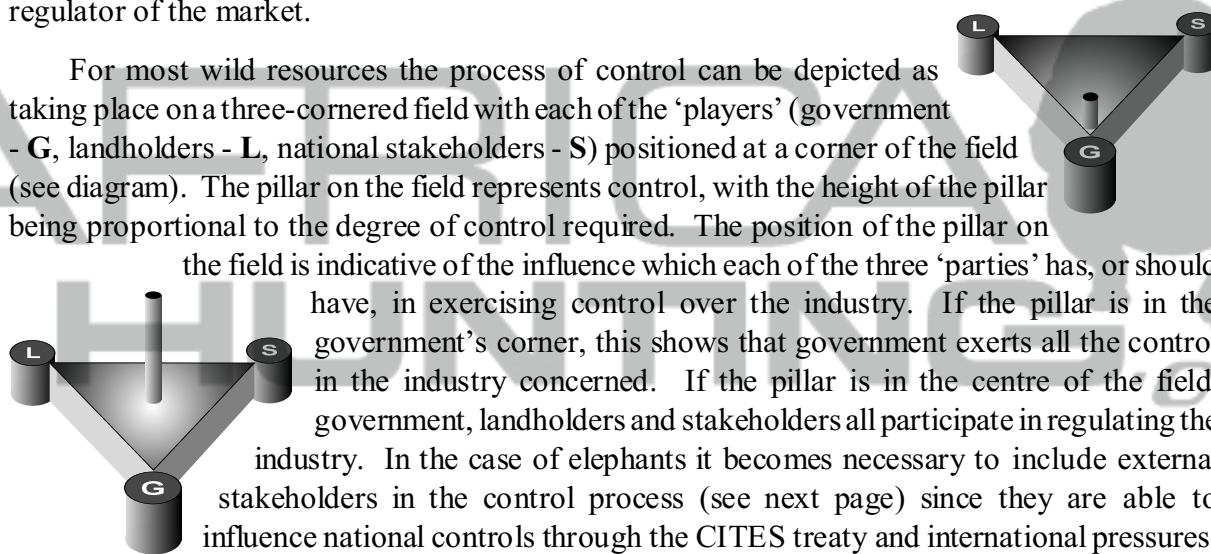
3. STAKEHOLDING

a. Stakeholders

It is convenient to consider four categories of stakeholders in relation to the demand for consumptive or non-consumptive use of wild resources: **government (G)**, **landholders (L)** which include people living in communal lands and those owning private property, **national stakeholders (S)** who are not resident in the area under consideration and **external stakeholders (E)** who live outside the country (Martin 1999a). In most cases, the demand from external stakeholders can be translated into a local demand emanating from landholders or stakeholders to take advantage of an outside market. Occasionally, the demand from external stakeholders is in direct competition with local demands as is the case with the troubling issue of elephants.

Some might choose not to view the State as being part of the demand for resources, preferring to view the government as some sort of impartial mediator and regulator of a wildlife industry carried out by landholders and other stakeholders. However, in the financial analysis in this report it is apparent that the government is as much part of the group of users as are the others and, indeed, may often be in competition with landholders and national stakeholders. The justification for the State to have an automatic mandate to exercise the controls needed in the wildlife industry can be queried, since it is attempting to be both a ‘player’ in the market and the regulator of the market.

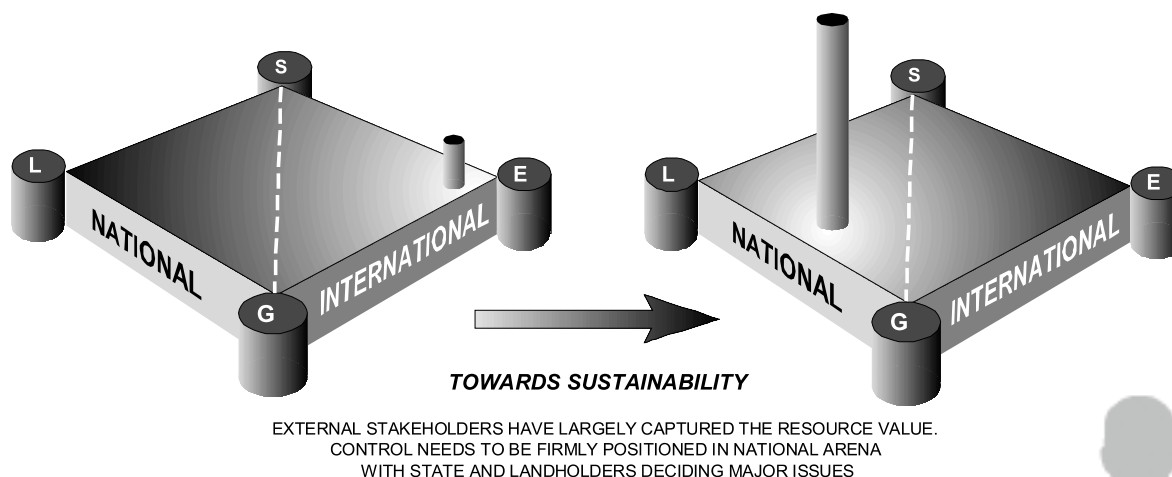
For most wild resources the process of control can be depicted as taking place on a three-cornered field with each of the ‘players’ (government - G, landholders - L, national stakeholders - S) positioned at a corner of the field (see diagram). The pillar on the field represents control, with the height of the pillar being proportional to the degree of control required. The position of the pillar on the field is indicative of the influence which each of the three ‘parties’ has, or should have, in exercising control over the industry. If the pillar is in the government’s corner, this shows that government exerts all the control in the industry concerned. If the pillar is in the centre of the field, government, landholders and stakeholders all participate in regulating the industry. In the case of elephants it becomes necessary to include external stakeholders in the control process (see next page) since they are able to influence national controls through the CITES treaty and international pressures.



These stakeholders all place a demand on elephants –

- (1) **Government** seeks revenue from tourism, sale of live animals, ivory, skins and sport hunting to maintain its protected areas;
- (2) **Landholders** (communal land and private properties with elephant) may seek income from trophy hunting, ivory, skin and meat from elephants on their lands or may be the victims of elephant depredations which affect their livelihoods;
- (3) **National stakeholders** include safari operators who seek elephants for trophy hunting on all categories of land, tourism companies and the broad body of the national public concerned over elephant conservation;
- (4) **External stakeholders** include NGOs who use the elephant as a flagship for fund-raising and a large international public demanding non-consumptive uses for elephant.

The most important control needed for elephants is protection against illegal hunting and this can only be achieved at the national level. The ‘protection’ afforded by banning commercial trade in elephant products at the global level is illusory. In the diagram below it is suggested that nations need to recapture the control of their elephants from external stakeholders. Within the nation, control of elephants needs to be achieved primarily by government and landholders with other stakeholders having some input.



b. Stakeholder Institutions – Present and Future

Namibia continues to make huge progress in the development of conservancies in communal land. There are now more than 40 registered and emerging conservancies with 150,000 members managing wildlife over an area of 100,000 square kilometres in the areas where elephant populations are expanding in Namibia (Martin 2004b). The wildlife range on commercial farmland in the north of the country is increasing – particularly in areas where it hoped that the elephant range can be expanded (see page 29). These very positive developments are recognised in the vision statement of UNDP (2005) and are seen as a way to link protected areas across the country and to provide a continuous range for elephants across the north of Namibia.

This has come about through enlightened policies and legislation which empower landholders to manage wildlife both on commercial farms and in communal lands. However, it is important that the momentum continues: further evolution of policy is needed to allow new co-management institutions for larger areas to emerge. The present mosaic of parks, conservancies and commercial farms provide a sound and essential foundation for the scaling up of institutions (Murphree 2000) and, as they stand, partnerships can be entered into amongst neighbours. But there is a difference between partnerships and full co-management institutions.

The needs of elephant provide the vehicle for co-management. No tract of land in Namibia is large enough to be a self-contained management unit for elephant. This is illustrated by the dilemma currently faced in setting quotas for sport hunting of elephants in the conservancies in the north-west of the country where a low density elephant population occurs over a range spanning many conservancies. The authorities would like to be able to allocate a minimum of one trophy bull elephant to each conservancy but this exceeds the sustainable offtake of about 5 animals per year (page 45). Various options present themselves: for example, conservancies might be allocated a trophy bull every second year or two conservancies might share the income from a single trophy. This type of approach is limited in its breadth of concept.

Two steps are needed. The first is the development of an umbrella institution in the north-west for managing elephants at the appropriate scale. Ruitenbeek & Cartier (2001) would have it that such a co-management institution cannot simply ‘be imposed on a group of innocent bystanders. It is something that should emerge naturally from a complex bio-economic system.’ Given this constraint, the second step creates the conditions for emergence – the State must hand the quota setting over to the stakeholders. This should result in the rapid formation of the appropriate institution within the ranks of the relevant conservancies. Here, too, there is scope for applying another principle – *no institution should be larger than the problem it is trying to solve* (Martin 1999b). The new institution should include only those stakeholders on whose land elephants occur.

The State could validly argue that the range of the north-western elephant population extends into Etosha and Skeleton Coast national parks and that, therefore, it cannot simply hand the setting of quotas over to a local institution. This is correct. The State must be part of the institution formed to manage elephants in the north-west. But its new rôle is very different from the ‘Command-and-control’ function it has hitherto displayed. The position of the ‘control pillar’ should be where it is shown on the playing field depicted on the previous page. To use another metaphor, the operating point on the management continuum defined by Ruitenbeek & Cartier (2001) should be close to the *laissez faire* end of the spectrum.

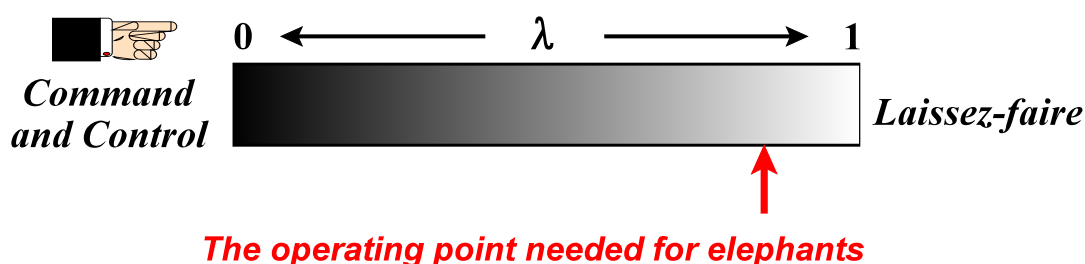
The Management Continuum

In a typical co-management regime
with government and local people sharing responsibilities –

$\lambda = 0$ when all of the authority is centralised

$\lambda = 1$ when all of the authority is localised

Values between 0 and 1 imply a degree of sharing



The elephant problem in the north-east of Namibia is different but the same principles apply. The Caprivi is the focus for conflict between wildlife management and people, domestic livestock and cultivation. Conservancy development in the Caprivi is less advanced than in many of the north-western areas and the institutions are more fragile because of a larger choice of land use options than in the extreme arid areas. It has already been emphasized in this report (page 41) that, whilst developments in conservancies appear promising, tolerance of elephants is finely balanced and it would require little in the way of disincentives for the entire edifice to collapse.

Members of conservancies and those who are not in established conservancies in the Caprivi receive little in the way of benefits from elephants. They do, however, suffer substantial losses (see page 38). Farmers are not free to defend their livelihoods from elephant depredations and the current arrangements for control of problem elephants are too tardy to be effective. O'Connell (1995a) found an extremely hostile attitude towards wildlife amongst the Caprivi peoples and the inception of conservancy projects did little to ameliorate this attitude.

The national parks in the Caprivi are small (Mahango, Mamili and Mudumu) and very much at the mercy of the land use surrounding them. The desirability of co-operation with conservancies and surrounding communal lands has been emphasized in all of the previous studies in this series and Martin (2004a) stated that successful conservation of the wetland grazers was unlikely to be achieved without co-management institutions for the full extent of the floodplain habitats in the Caprivi. A key difference between the institutions needed in the Caprivi and those in the north-west is that they would have include stakeholders who are not formed into conservancies. The same institutions could serve the management requirements for elephants. Unlike the other species in the Caprivi for which management plans have been prepared, elephant are not rare or endangered and, indeed, they are a threat to those species which are.

Co-management presents a new challenge and, given the impressive record of development of the wildlife industry and the positive spirit of co-operation amongst the State, NGOs and private sector towards larger goals, there is no reason why Namibia should not lead the way in southern Africa in developing these new forms of institutions.

c. Towards Trans-Boundary Institutions

Using the background studies and recommendations which have emanated from the Transboundary Mammal Project of the Ministry of Environment and Tourism (Martin 2002, 2003b, 2004a), Namibia has taken the initiative of establishing cross-boundary links with Botswana on species management issues. Meetings were held in 2002 and 2003 to discuss buffalo, roan, sable and tsessebe management. In each of studies referred to, the same recommendation for a permanent technical forum for future discussion has been put forward (Fig.20, page 79) and the discussion on this institution is not repeated in this report.

The 'exploding' elephant populations of Botswana and north-western Zimbabwe were referred to on page 35. The combined total of these two populations exceeds 200,000 elephants and emigration from them is having a substantial impact on all neighbouring countries. Decisions made by Botswana and Zimbabwe about whether to reduce elephant numbers are now a matter of regional significance and a meeting of SADC Ministers is to be held at the end of April 2005 to discuss the matter.²³ This represents the highest form of institution on trans-boundary issues and clearly the Ministers will wish to be well informed on the numbers, trends and distribution of elephants as well as the human/elephant conflicts which are now escalating.

23. The meeting is being convened by WWF Regional Office and will be preceded by a meeting of technical experts at the same venue to brief ministers on the issues.

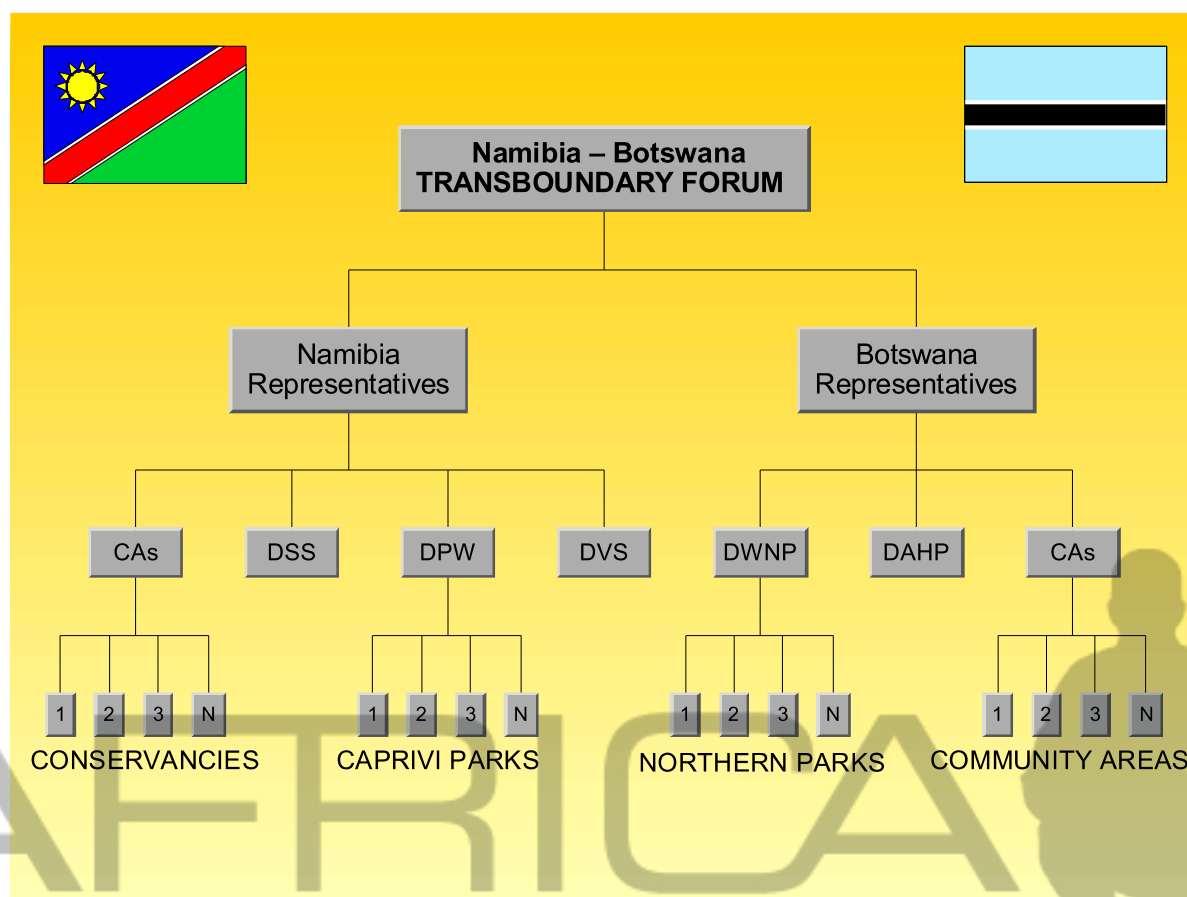


Figure 20: A Notional Institution for Botswana-Namibia Management of Shared Wildlife Species Populations

Key to Acronyms used in the diagram – see *text* for a fuller explanation of the structure

Namibia: CAs – Conservancies Association
 DSS – Directorate of Scientific Services
 DPW – Directorate of Parks and Wildlife
 DVS – Directorate of Veterinary Services

Botswana: DWNP -- Department of Wildlife and National Parks
 DAHP – Department of Animal Health and Production
 CAs – Community Areas Association

4. MANAGEMENT

In the discussion on limiting factors (page 39), the point was made that there are no limiting factors preventing elephant increase at the moment and that numbers of elephants may already have exceeded desirable levels in some areas. In all management plans prepared in this series (Martin 2002, 2003b, 2004a) elephant have been identified as a possible threat to other species. The potential impact of the large elephant population in the north-east of Namibia (some 15,000 animals) on buffalo, roan, sable and tsessebe populations was considered significant. Elephants may also be affecting floodplain habitats of reedbuck, waterbuck, lechwe and puku. Their trampling of grass swards both reduces cover and affects the grassland structure in a manner which may render it less acceptable to other species. As grazers themselves, the elephants may be in direct competition with other species.

In the short term an increase in range is needed both to accommodate the burgeoning elephant population but also as part of a transition towards higher valued forms of land use. The measures needed to achieve this fall largely outside the scope of management issues. To shift the balance between agriculture and wildlife as the primary forms of land use requires greater devolution of proprietorship to landholders, removal of agricultural subsidies and the removal of constraints which prevent wildlife from realising its full economic value. These issues have been discussed in previous sections of the report.

No matter how much range is made available to elephant, in the long term the problem of overabundance will raise its ugly head. In the north-west of Namibia elephant populations have considerable latitude for increasing their range and the situation may not require management interventions for many years. However, in the north-east escalating levels of conflict between humans and elephants suggest that the time for action has already been reached. The problem is apparently intractable: the Caprivi, Khaudum and Nyae Nyae lie on the periphery of the largest elephant population in Africa. Management interventions carried out in isolation in Namibia will not affect the core elephant population from whence the problems emanate.

If the Namibian authorities were to embark upon a determined effort to maintain relatively low elephant densities in the Caprivi, a new management question arises. Just how low should such densities be? The debate on elephant densities and biodiversity in southern Africa rages on without scientific consensus. Perhaps the flaw in the reasoning process is the narrow assumption that the only justification to intervene in 'natural' processes is when it can be incontrovertibly established that elephants are affecting biodiversity. I submit that we are dealing with a far more complex system and that it is not amenable to simple reductionist analysis of threshold densities and impacts on biodiversity. For better or for worse, we are now in the business of managing wild ecosystems and aesthetic and socio-economic considerations are as important as 'pure' conservation issues.

Perhaps the worst mistake that could be made would be to attempt to hold the elephant population of the north-east at some constant level (or, conversely, to attempt to maintain a constant harvest from it). Such a "Command-and-control" approach (Holling & Meffe 1996) is likely to have adverse effects on the resilience of ecosystems.

Walker (1989) observes –

The most complex and desirable ecosystems that we wish to conserve are markedly unstable (non-constant), and achieving our conservation goals depends on their remaining that way. It is the continued instability of these systems which allows for the coexistence of their many species Unfortunately, conservation management is often intuitively opposed to this."

Owen-Smith (1989) points out the conservation dilemma which this imposes on African ecosystem managers. Frequently, large mammal populations increase in numbers to the point where they are destroying their habitats and reducing biological diversity: at the same time, attempts to regulate such populations at constant levels hold equal conservation dangers in the long term. Successfully holding a population at a selected "carrying capacity" entails a stasis which may be unfavourable for certain other species in the ecosystem, reduces resilience and ends up in the pathology defined by Holling (1993) –

In many cases of renewable resource management, success in managing a target variable for a sustained production of food or fibre leads to an ultimate pathology of more brittle and vulnerable ecosystems, more rigid and unresponsive management agencies and more dependent societies ..."

This is the quandary faced by Namibia in managing the elephants of the north-east. Elephant populations may be in excess of sustainable limits but population reductions should not be programmed in such a way as to create the conditions described above.. Quoting further from Holling (1993) –

... there seems to be something inherently wrong with that conclusion [that all exploitation leads to pathologically brittle and vulnerable ecosystems], implying, as it does, that the only solution is a radical return of humanity to being "children of nature". . . . if we examine that pathology over a longer and larger span, examples appear where external and internal crises, amplified by the pathology, trigger a sudden lurch in understanding, a redesign and expansion of policy, and a return of flexibility and innovation."

This all points towards a need for imaginative and innovative management. Perhaps we should begin with the premise that, in Africa, the option of zero use is not a reality. Elephants will be harvested illegally and unsustainably if facile attempts are made to debar their use (page 41). As there are clearly no scientific recipes which avoid all the pitfalls described above, perhaps the time has come to move into a realm of adaptive co-management in complex systems (Ruitenbeek & Cartier 2001). **The individuals who are most affected by elephants are those living in the north-east: perhaps they should be deciding how elephants should be managed** – backed up, in a spirit of co-management, with whatever technical advice they seek.

A decision to enter into an experiment of this nature might advance the state of knowledge of elephant management in complex systems. It would introduce an element of randomness into the system and avoid routine cropping or culling programmes which attempt to impose constancy on naturally fluctuating ecosystems. The challenge would be to make it sustainable and to do this requires an adaptive management approach (Holling 1976, Walters 1976). The only way to learn about sustainability is to exploit the resource (Hilborn & Ludwig 1993) – this is the basis of adaptive management.

There follows a discussion of separate aspects of management, much of it based on tests using the population model referred to on page 7. The results of this population modelling should be treated as the underpinning hypotheses within an adaptive management system rather than rigid prescriptions for ‘correct’ management outcomes.

a. Elephant management

(1) Illegal hunting

In examining the effects of different levels of illegal harvest it is assumed that mortality would affect both sexes and all ages equally. In practice this is not likely to be the case if the hunting is primarily for ivory: it may be true if the hunting is for meat or, for example, if the intent were to eradicate the elephant population. The exercise effectively simulates the impact on the population of a harvest which is spread evenly over the entire population – which could happen in a sustainable cropping programme.²⁴ The ‘doubling time’ is the number of years it would take for the population to double its numbers and the ‘halving time’ is the number of years it would take for the population to decline to half its original size at the given rate of harvest.

Illegal harvest %	0	1	2	3	4.0	4.3	4.4	4.5	5	6	7	8	9	10
Pop. growth rate %	4.56	3.52	2.47	1.43	0.36	0.01	-0.08	-0.19	-0.71	-1.72	-2.74	-3.78	-4.84	-5.62
Years	16	21	29	49	193	∞	922	371	98	40	25	18	14	12
DOUBLING TIME (years)							HALVING TIME (years)							

Using a fecundity of 0.25 and a central mortality of 0.5% (see page 79) the population grows at 4.56% with no illegal hunting. The population growth rate decreases with each increment in the illegal hunting offtake and reaches zero as the illegal offtake approaches the intrinsic growth rate of the population. At a 10% offtake the population halves in twelve years.

Illegal hunting has no effect on the setting of sport hunting quotas because the population age structure does not change shape from a stable age distribution. All that alters is the population growth rate. Even when the level of illegal hunting is unsustainable, a quota of 0.5% can be set for sport hunting. In **Appendix 5** (page 88) it is shown that 869 trophy males would be taken over 50 years from a population subject to no management offtakes or illegal hunting: when the illegal harvest is 4% the number of trophies drops to 266.

24. It is noted that Namibia does not undertake any management aimed at ‘cropping’ from elephant populations (MET 2004).

This is not particularly relevant to the present Namibian situation. Illegal killing of elephants is low – less than 0.1% of the total population (MET 2004). However, should the mood of local communities in the Caprivi change or if people in neighbouring countries decide to obtain benefits from elephants which they are not getting at the moment, it could become highly relevant.

Inexplicably, many CITES Parties seem to think that if elephants are being killed illegally, this is a sufficient reason to ban trade in ivory in the country concerned. **The opposite is needed:** if illegal hunting is taking place, even greater is the need to trade in ivory to provide the funds to combat the challenge.

(2) Population Reduction

(i) Culling

Culling entails the removal of entire elephant herds with the aim of reducing population numbers or limiting the rate of population increase (see page 46 for a distinction between culling and cropping). By removing entire herds the age structure of the female segment of the age pyramid remains unaltered and no selective pressures arise from the practice. The overall age structure of the population does become skewed in favour of males and this permits a higher percentage quota for trophy hunting (**Appendix 4**, page 91) although it does not result in a greater number of male trophies over a period of years than would be obtained from a population which is not subjected to culling.

For a population growing at 4.6% per annum, **an offtake of 3% of the total population will stabilise numbers:** a higher percentage offtake will reduce the population. This entails an offtake of about 30 animals for every 1,000 animals in the population. If culling is combined with trophy hunting an additional 10 males over the age of 30 years would also be removed annually.

The issue of culling is highly contentious and it is not intended to discuss the ethics of the practice here. The Namibia authorities could avoid being drawn into bitter debates on the subject by adopting the recommendation that the final decision should lie with local communities (page 55). Should it be decided to cull, then the ‘best practice’ is to remove the entire herd by shooting at very close range with a team of 3 experts. Herds of up to 50 animals can be killed in less than a couple of minutes and there is probably no more humane way to carry out the distasteful task.²⁵ Calves between the ages of 2 and 8 years old may be captured for sale during the exercise. The limits of how many animals can be killed in any one day are set by the logistics of how many carcasses can be processed rather than the capabilities of the culling team.

The maximum number of elephants that it is possible to remove in any year by one culling team with the attendant back-up to process carcasses is about 5,000,²⁶ assuming the operations can only be carried out during the dry season. DG (2004, p27) point out that it would require the removal of 10,000 elephants per year for 12 years to reduce Botswana’s elephant population from 123,000 animals²⁷ to 60,000 animals – a task which is not impossible.

25. The practice of darting animals with a lethal drug from a helicopter is far more protracted causing stress before the dart is fired, a slower death and inevitably an unconscious selection process (Parker 1979).

26. This was achieved in one or two years during the 1980s by Warden Clem Coetsee in Zimbabwe.

27. Current estimates for the Botswana population are about 150,000 animals.

(ii) Translocation

During the 1991-92 drought in the south-east lowveld of Zimbabwe, techniques were developed for the capture and translocation of complete elephant herds (with the possible exception of very large adult males).²⁸ These techniques have since been used to translocate elephants in Kenya and South Africa.

Many conservationists see the translocation of elephants as the antidote to culling. Where numbers are considered overabundant in one locality, elephants can be moved to start new populations or re-establish populations which have been wiped out in other areas. This is unlikely to solve overabundance in the long term. It may gain a little breathing space in some areas for a short period. Ultimately, wherever they are, elephant populations will double in numbers within 15-25 years and quickly reach densities where they become a problem again.

Translocation of elephants is expensive and the costs are only likely to be met through donor funding rather than national wildlife budgets. However, any wildlife agency seeking to reduce elephant numbers would be well advised to explore the translocation option first and use it when funds are available. The 'green' lobby is unlikely to be sympathetic to a government which embarks on culling if it has not explored all alternative options to killing surplus elephants.

(iii) Contraception

Contraception or sterilisation is an option to reduce elephant population growth rates which has been favoured in some quarters. It does not appear to be practical or desirable. Apart from being traumatic, intrusive and expensive, it runs the major risk of introducing selection pressures in elephant populations such as those that have characterised cattle breeding. The long term consequences cannot be foreseen but it might result in the genetic composition of elephants being altered in the long term with negative implications for survival. There is another aspect to the concept which would fly in the face of any local community which had successfully conserved an elephant population to the point where it was highly productive and verging on overabundant. The idea of removing its productivity rather than using it would be found difficult to understand.

(3) Sport Hunting

At the outset, it is assumed that sport hunting will be restricted to male elephants. The implications of hunting female elephants in the safari industry are discussed after the subject of male hunting quotas.

The proportion of an elephant population which can be sustainably hunted to satisfy the safari hunting industry is surprisingly low. If it is assumed that the minimum tusk weight for an elephant trophy is about 15kg (per tusk) and that elephant hunting will not be marketable below this weight, this restricts hunting to males 30 years of age and older. In a population of 10,000 elephants which is not hunted, the number of males of age 30 years and older is slightly over 800 animals

28. Clem Coetsee of Wildlife Management Services moved 560 elephants out of Gonarezhou National Park in 1992-93 including 200 to Madikwe in South Africa.

or about 8% of the population. This is not the important statistic, however. If one imagines these 800 animals as bulls in a paddock from which it is desired to take an annual offtake, the key factor is the number of 30 year-olds entering the paddock in each year. For hunting to be sustainable, this is the number which cannot be exceeded – and it is about 60 animals per year in a population of 10,000. However, if quotas were set as high as this, after a short while the only animals in the paddock would be the annual influx of 30 year old males and they would all be killed in the year in which they entered the paddock.

The maximum sustainable offtake of male hunting trophies from an elephant population is about one-half a percent of the total population. At this level, there will always be some males in the population surviving to 40 years of age. If it is desired to have a few males in the population reaching 50 years old (at which age it is assumed they will die naturally anyway), quotas have to be less than 0.3% of the total population. To some extent, the hunter is competing with Old Father Time to get a trophy before the animal expires from natural senescence.

The effects of increasing levels of hunting quotas on the age structure of an elephant population are given in **Appendix 5** (page 93) and shown in **Fig.21** (page 61). A slight selectivity for animals with larger tusks is built into the model and is explained in the Appendix. The maximum typical trophy tusk weight declines from about 30kg/tusk in the unhunted population to about 21kg/tusk when the quota is set at 0.5%.

The hunting causes the stable age structure of the population to become slightly skewed in favour of females. For a given size of population (in this case 10,000 animals), the number of males in the 29 year-old age class actually increases from the number in the unhunted population but this is purely an artefact based on the redistribution of the animals in all the age classes to fit the new population profile. The total number of males in a population of 10,000 animals decreases from 4,994 in the no-hunting situation to 4,556 when it is attempted to extract a quota of 0.8% (80 animals) from the population.

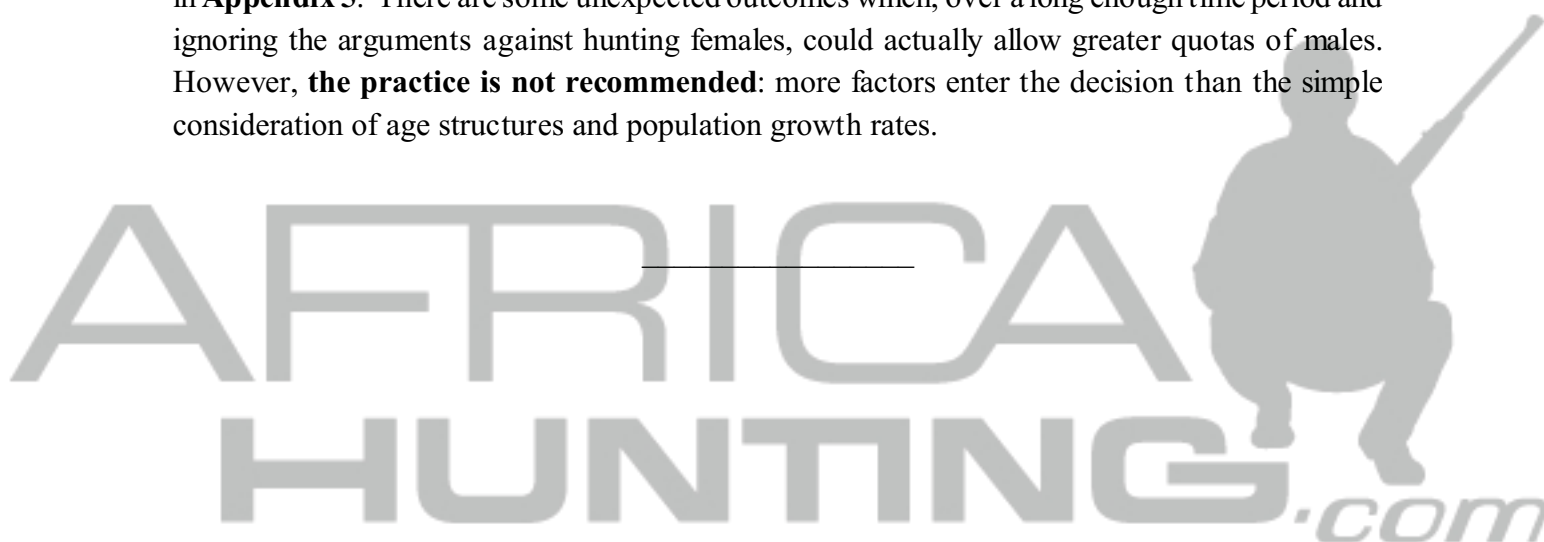
Safari operators are able to market the sport hunting of elephant females and will put pressure on the authorities to grant a quota for this purpose. The arguments against hunting females are several –

- (i) The killing of an adult female in a cow herd is socially disruptive. The knowledge of such a killing may be as traumatic for some humans as the event is for an elephant herd.²⁹
- (ii) As with males, the size of female tusks increases with age (**Fig.3**, page 3) making it likely that the matriarchs of herds will be preferentially selected. The loss of the accumulated knowledge of such older members of the population could affect elephant survival – particularly in arid environments.

29. In 1991, Katy Payne, an elephant researcher known to many Namibians, was so affected by the killing of certain elephants in Zimbabwe that “I threw myself down and sobbed out loud in grief and rage . . . Isolated by sorrow and disagreement, I stayed at home for several months . . .” (Payne 1998, *Elephant Thunder*, Chapter 13: *Slaughter in a Sacred Place*).

- (iii) Even where very modest quotas have been set for hunting cow elephant, within a few years of the inception of hunting most of the cows with large tusks will have been eliminated from the population.³⁰ Since the genes for large male trophy tusks are carried by both females and males in a population, it can be expected that this selective practice will eventually lower the quality of male trophy hunting.
- (iv) In a long tradition of sport hunting ethics, the killing of females is generally eschewed;
- (v) Elephants, rightly or wrongly, have attained the status of ‘totem’ animals and any killing of elephants upsets a large public. Sport hunting of male elephants is bad enough: many times more so is the notion of killing females – who will almost certainly be mothering offspring. This becomes a political issue through which entire elephant management programmes may be derailed simply because of the emotions aroused.

The changes in population dynamics which result from hunting female elephants are analysed in **Appendix 5**. There are some unexpected outcomes which, over a long enough time period and ignoring the arguments against hunting females, could actually allow greater quotas of males. However, **the practice is not recommended**: more factors enter the decision than the simple consideration of age structures and population growth rates.



30. The author personally observed this happen in Chirisa Safari Area in Zimbabwe in the 1980s.

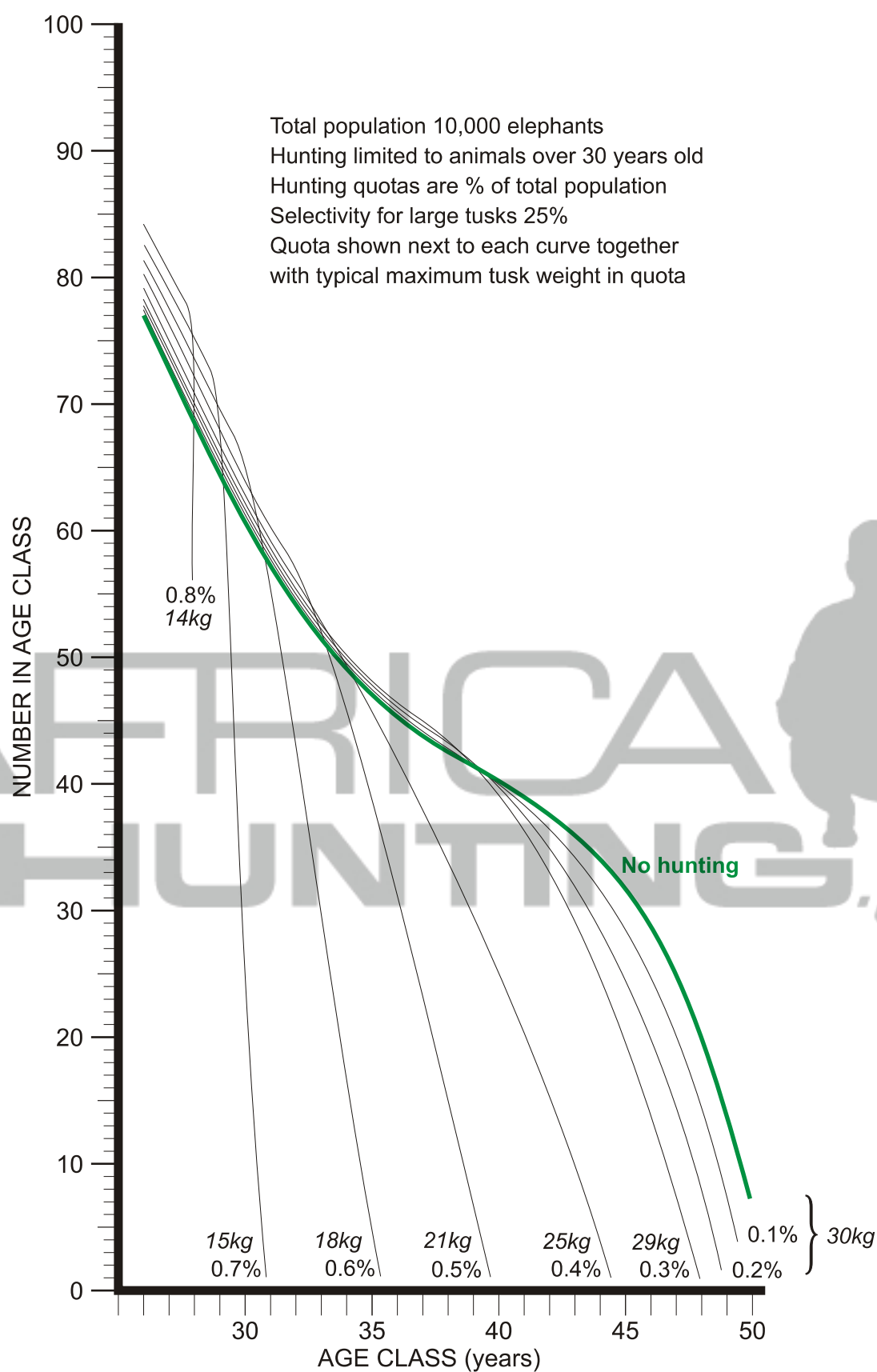


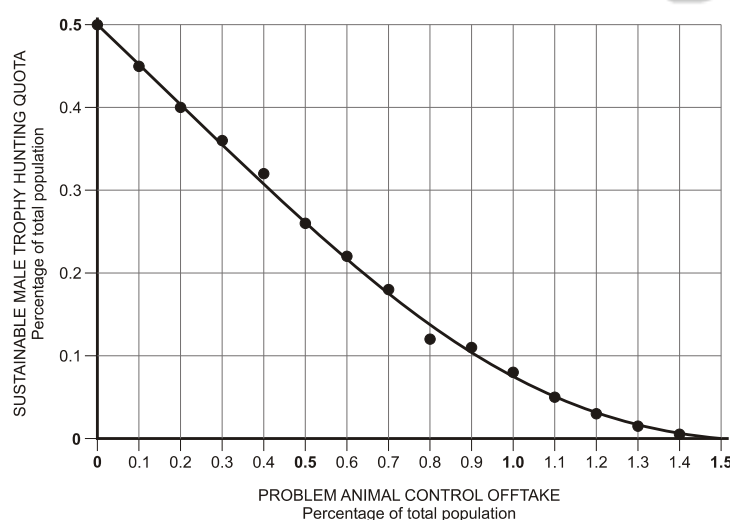
Figure 21: Effect of hunting quotas on elephant adult male age structure

(4) Problem animal control

The majority of problem animals are males which have left cow herds (i.e. from the age of 15 upwards). Although females are occasionally killed as problem animals, for the purposes of simulating the effects of problem animal control in the model it has been assumed that problem animal control (PAC) is restricted to males and that there is no selectivity for larger males. Using the same parameters in the model as for all other tests (i.e. mortality and fecundity are set so that the population growth rate is 4.56%), it was found that the maximum sustainable offtake of problem animals is about 1.5% – using the criterion that some males in the population should survive to the age of 30 years (which is the age at which trophy hunting becomes possible – **Appendix 5**). In a population with a stable age structure, about 22% of the total population consists of males 15 years and older and the annual recruitment into the 15 year age class is about 133 animals in a population of 10,000.

Problem animal control affects the quotas which can be set for male trophy hunting. The effect is not simply subtractive, i.e. if a male is shot as a problem animal this does not automatically imply that one male should be deducted from the hunting quota. The reason for this is that problem animals are drawn from a larger pool than sport hunting trophies and include animals which would be regarded as too young for sport hunting. Very often amongst the persons carrying out problem animal control there is a deliberate avoidance of shooting bulls which could be better sold as hunting trophies. The present policy for conservancies in Namibia is to make every effort to sell a ‘problem animal’ as a safari hunting trophy and only if this is not possible is the animal destroyed.³¹

The relationship between sustainable sport hunting quotas and increasing levels of problem animal control is shown in the diagram below. As for the analysis of trophy hunting quotas in **Appendix 5** (page 93), the criterion which has been used to define ‘sustainable’ is that some males must survive to the age of 39 years. In the absence of problem animal control this allows an offtake of 0.5% of the total population. When problem animal control reaches a level of about 0.5% of the total population, trophy hunting quotas must be halved to satisfy the criterion. At a PAC level of 1% the permissible sport hunting quota falls to under 0.1%, i.e. less than one animal in a population of 1,000. When the level of PAC hunting is as high as 1.2%, sport hunting must effectively cease (the quota would be 3 animals in a population of 10,000). At 1.5% no males reach the age where they could be considered sport hunting trophies.



31. Ironically, if markets were operating as they should be for ivory and elephant skin, there would be no advantage in allowing a sport hunting client to take a ‘problem animal’ (**Appendix 4**).

Cases of crop raiding comprise by far the largest number of problem animal incidents involving elephants (**Table 5**, page 38). However, elephants also destroy waterpoints and pumping equipment, compete with domestic livestock both for water and grazing (to the extent that they occasionally kill cattle) and may be a direct threat to human life.

In the assistance given by NGOs to conservancies, much effort has gone into protecting waterpoints which, particularly in the arid north-west of Namibia, are vital for human survival. Electric fencing has been used in some areas to protect both crops and water but O’Connell (1995a) concludes that cost and maintenance render this option prohibitive for a communal land farmer in the Caprivi.³² Knowing a number of case studies in Zimbabwe where electric fences have worked effectively over many years (e.g. Masoka in the Zambezi Valley), it is difficult to agree with this conclusion.

O’Connell (*ibid*) also states that “*Shooting an elephant is not a viable long term solution to solving conflicts as any elephant in the wrong place at the wrong time is potentially a problem*”. This is clearly nonsense. Eradicating elephants does solve the farmer’s problem even if it results in the lowest-valued land use triumphing. In the words of the immortal Richard Bell “*Nothing is as sustainable as extinction*”. Elephant control has been practised throughout Africa for a hundred years (Graham 1973) and, even where it does not cause cessation of crop raiding, it does provide a modicum of compensation for the affected parties. It is also the final solution for habitual offenders.

Bell (1986a) gives an extremely thorough analysis of alternatives for limiting crop damage and concludes that only electric fencing and killing of elephants have demonstrated success. More recently, experiments with chilli pepper/capsicum deterrents have shown promise – with the added benefit that these crops not only deter elephants but provide a cash income for farmers (F.V. Osborne, *pers.comm.*).³³ Bell’s final conclusion was that land use planning and selection of crop types are the most important factors determining the degree of conflict between humans and elephants. In the three preceding background studies in this series (Martin 2002, 2003b, 2004a), the lack of integrated land use planning in the Caprivi has been identified as the key cause of most of the conservation problems.

The present system for dealing with problem elephants is clearly unworkable, particularly in the Caprivi. Elephants identified as problem animals must first be offered to a hunting concessionaire. The professional hunter is not allowed to shoot after dark which means that on most occasions the offending animal will not be killed in the act of crop raiding. If he is unsuccessful in selling the animal as a trophy to a hunting client, MET staff may then destroy the animal – but only if a qualified staff member is in the area and only after permission from the Permanent Secretary.

32. O’Connor (1995a) put the cost of electric fencing at US\$1,000/km not including the cost of fence energisers. Bell (1986a) estimated the full costs of electric fencing, including maintenance at US\$300/km and Martin & Jones (2000a) estimated the same cost at US\$224/km.

33. The introduction of chilli pepper crops has started in the Caprivi and initial results are promising.

O'Connell (1995a) makes a number of recommendations to improve the situation and I deal with each of these below –

- (i) *The Secretary should devolve authority to the regional head to identify an elephant as a problem animal.* This does not go far enough. Namibia claims it has empowered communities to manage their own wildlife and this is a test case which establishes ownership of wildlife. If the killing of a problem elephant must be sanctioned by the State then, clearly, the state owns the wildlife.³⁴
- (ii) *The mandatory requirement that a professional hunter must have the first opportunity to deal with a problem elephant should be abandoned.* Agreed. From personal experience, such a system is fraught with complications. Very often the offending elephant is not a 'warrantable' trophy (Graham 1973) and the client cannot be persuaded to accept it. The delays in such a process are unacceptable. In any case, the commodity values of elephants are (or should be) at least as high as the sport hunting values (**Appendix 4**, page 89) so that, in theory, there is no advantage to be gained from trophy hunting.
- (iii) *Qualified problem animal control officers should be appoint in priority districts.* Agreed. But this should only be seen as interim measure until conservancies and local communities take responsibility for their own PAC.

The Director of Parks and Wildlife Management (Ben Beytell, *pers. comm.*) described to me the system which was in place in the Caprivi in the late 1960s and early 1970s whereby Chiefs Mamili and Moreletsatani (Salambala) had their own recognised hunters who were empowered to hunt problem animals and obtain meat for feasts. These hunters were armed with .458 and .375 rifles. A quota was issued to each chief, problem animals were reported and dealt with within 24 hours, the tusks from problem elephant were registered, sold on the chiefs' behalf and the funds were deposited into the chiefs' account for community development. Beytell said that the system worked extremely well. In certain aspects, empowerment may have taken a step backwards since the 1970s.

- (iv) *A quota system for PAC should be introduced.* This would slightly ameliorate the present extent of bureaucratic procedures surrounding problem elephant control and Beytell (above) provides the evidence that such a system has been implemented effectively in the past. It is still far from ideal and it again raises the question of wildlife ownership. **The preferred solution is the co-management one** suggested at the foot of page 55.
- (v) *An alternative might be to allow traditional authorities or local Namibian citizens to hunt problem animals.* This option is dealt with under (iii) above.

34. The same principle applies to the paying of compensation to local peoples for damage caused by elephant.

This section on management is concluded with a brief discussion of three other topics which are not related to population dynamics or modelling.

(5) Artificial water

The provision of artificial water supplies for elephant is a double-edged sword. It may allow elephants to remain throughout the year in habitats which, before the water supply, they were only able to visit seasonally. Often these habitats cannot take the impact of elephant concentrations and, invariably, heavy damage occurs close to the waterpoints. Bushmen in the Khaudum and Nyae Nyae are convinced that the development of water supplies has been responsible for the influx of elephants (Beytell *pers. comm.*) and the subsequent vegetation damage. However, national parks such as Etosha and Hwange would not exist without artificial water.

Notwithstanding the habitat changes which will result, there would seem to be merit in developing water supplies in several parts of the present elephant range in Namibia. In Babawata in the Caprivi Strip the presence of water might distribute elephants more evenly over the range and relieve pressure along the major rivers. In the north-west, additional water might reduce elephant-human conflict in parts of the range as well as accelerate the re-colonisation of large areas outside Etosha. In the Kavango province, pressures of elephant in Khaudum might be relieved with the development of water supplies in the central area – provided such water was not totally commandeered by domestic livestock and human settlement. The links between the north-western and north-eastern elephant populations might be strengthened by the provision of artificial water in the area surrounding the Mangetti and along the Omurambo Owambo.

(6) Fire

In areas with significant densities of elephant, fire becomes an important secondary factor in determining habitat change. The death of canopy trees which are partially bark-stripped or have had major limbs removed by elephants is hastened by fires (Laws *et al.* 1975) and protection of elephant-modified woodlands from fire may be important to encourage regeneration. In *Brachystegia* woodlands in Zimbabwe which were extensively modified by elephants in the 1970s and 1980s, fire is now a major factor preventing recruitment to the tree layer regardless of the present densities of elephants. Thomson (1975) documents the interaction of elephants and fire and the decline of *Brachystegia* woodlands in the Chizarira escarpment in Zimbabwe.

Mendelsohn and Roberts (1997, pages 24-25) present a compelling picture of the gravity of the fire situation in the Caprivi with burns commencing as early as April each year and continuing until December when over 60% of the vegetation has been burnt and the total count of individual fires may have exceeded 3,000. Coupled with high elephant densities, inevitably this will hasten the demise of woodlands.

In an attempt to mitigate the synergistic effect of elephants and fire on protected area habitats in Zimbabwe, firebreaks were constructed in many areas during the 1970s (e.g. the Zambezi Valley escarpment woodlands). This policy was unsuccessful, since fires invariably occurred despite the firebreaks. Several years without fires resulted in an accumulation of fuel and, when fires did occur, they were hotter and more damaging to woody regeneration than annual fires.

In 1978/79, the burning policy in elephant-modified *Brachystegia* woodlands in the Zambezi escarpment of Zimbabwe was changed to "early burning". In the early dry season, grass moisture content is low enough to allow a relatively cool fire and the early burn (May-June-July) is intended to create a patchwork of burnt and unburnt areas to achieve two objectives. The first is to prevent late dry season fires from burning large areas of woodland and the second is to encourage the maximum rate of regeneration which tends to occur in unburnt patches. This management practice has also not produced the hoped-for regeneration, mainly because early-burning programmes have not been properly implemented or maintained for long enough in any part of the Zimbabwe wildlife estate to reach significant conclusions on whether canopy woodland will return. There are ecological concerns about the early burning practice: it may reduce woodland vigour in the long term more than a regime of occasional hot fires.

Although there are some minor potential benefits from burning (e.g. reduction in bush encroachment), the overall effect of the present extreme fire regime in the Caprivi is likely to be negative. It removes the cover which is an essential element of habitats for many other animal species, it destroys grass production at a key time when animals are facing nutritional hardships and it disrupts the stability in the ecological niches of species, resulting in local movements which may be traumatic for stressed populations.

Unfortunately, there do not appear to be any simple management prescriptions which can be unconditionally recommended to mitigate the effects of fire in combination with elephants (other than keeping elephant densities at a low level). This is an area where more applied experimental research is much needed.

(7) Veterinary Fences

The influence of veterinary fences on the current elephant range both in Namibia and in the region is profound. It was pointed out (page 18) that there is a bottleneck in the vicinity of Mahango national park in the Caprivi Strip which affects the entire regional range for elephant across the central southern Africa region (**Fig.10**, page 21) – caused by the positioning of veterinary fences on the southern boundary of the Caprivi Strip and along the international border between Botswana and Namibia. The compression of elephants in this narrow isthmus has undoubtedly been responsible for the woodland destruction in Mahango.

The emigrations of elephant into Namibia which have occurred recently indicate that these fences are less than effective.³⁵ However, there should be little cause for elation over this: the fences undoubtedly impede movement of elephants up and down the Kavango River and act against the maintenance of spatial linkages between the subpopulations. The danger is that the authorities in both countries will suddenly become conscious of the *status quo*, attempt to repair the fences and, at the same time, demand that elephants are killed as problem animals.

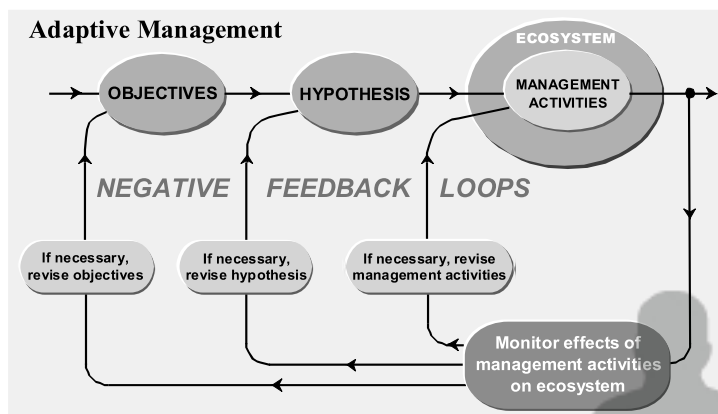
Cumming (2005) has called for the veterinary profession to re-examine its methods of disease control as the southern African region moves into trans-boundary wildlife management over very large areas. Methods of control that were developed in the 1960s and applied at national levels may no longer be appropriate at the international scale where collaborative efforts are being made between governments to move to the higher valued land uses offered by wildlife tourism.

35. The boundary fence between Khaidum and Botswana has been breached over a large section (Beytell *pers.comm.*) and the fence on southern boundary of the Caprivi is in a similar state (Booth *pers. comm.*)

b. Monitoring

The need for an adaptive management approach towards elephants was stressed at the start of this section (page 56). These recommendations need to be seen as the monitoring agenda for any co-management institutions which are developed and the techniques should be applied as much by local communities carrying out their own management as by the wildlife authorities.

What has been put forward as the expected population dynamics of elephant in response to various management treatments needs to be seen as the hypotheses in an adaptive management system. Under adaptive management, if for example an objective were set to maintain canopy tree cover at 50%, the hypothesis might be that this will be achieved at an elephant density of 0.25/km². However, the correct parameter to measure is not elephant density but recruitment of trees into a certain age class. Population reduction would continue until tree recruitment satisfied the original criterion.



The three main variables to be monitored under the management programme are the status and trends of elephants, woodlands and the interactions between humans and elephants.

(1) Elephants

The population size and distribution of elephants should continue to be monitored by aerial surveys. The standardised techniques of ULG (1995) are still probably the best method although it is as well to be aware that estimates obtained from aerial strip transects may be 25% or more lower than the true number of animals (Graham & Bell 1969).

Some frustration has been experienced in this study in attempting to model the various elephant subpopulations in Namibia by the lack of complete country surveys in most years and by the number of partial surveys carried out within subpopulations. It may be better to survey all elephant populations in Namibia simultaneously every second or third year rather than to obtain partial estimates which cannot be placed in a complete data set.

The legal offtakes from elephant populations (sport hunting trophies, problem animals destroyed and numbers culled) require to be meticulously recorded as part of long term data sets to calculate the value of elephants and which can be taken into account in population models and used to adjust quotas.

In setting quotas for sport hunting, a system based on population estimates is likely to be less robust than an adaptive management system because, firstly, the confidence intervals on population estimates are large and, secondly, the area of interest is not the total number of animals in the population but the number of adult males older than 30 years – which is only about 8% of the total population.

The key parameter to be measured is the age of trophies taken from the population. If a criterion is set that there should always be some males in the population reaching an age of 40 years, then all that is required is the ageing of all trophies from their dentition using any one of the standard methods (e.g. Laws 1966). An initial quota might be set by the crude method of applying 0.5% to the population estimate but thereafter that quota should be adjusted upwards or downwards by the age structure information available from the animals which have been killed.

Measuring illegal offtake needs to be incorporated into a system which simultaneously records law enforcement effort. The method was originally described by Bell (1986b) but has since been applied in other conservation areas (Jachmann 1998). The Annual Audit database monitoring system in Namibian conservancies ('Event Book': NNF 2004) is ideally suited to this monitoring. Aerial surveys can provide an additional check on illegal hunting if the ratio of carcasses to live animals is recorded.

(2) Habitats

A description of the habitat types present in the elephant range is essential benchmark information: the status of vegetation mapping in Namibia is up to a high standard and perhaps all that is needed in some areas is the more detailed establishment of 'witness' stands whose species composition and physical structure is accurately measured.

Methods to monitor changes to the vegetation should be quick and inexpensive. The rate of loss of canopy trees can be measured without the need for field work. Aerial photographs (at a scale of at least 1:25 000, preferably in colour) can provide a reliable data base. Plots or transects of a suitable size to include an adequate sample of canopy trees can be delineated on aerial photographs and can be repeated as needed. At least five plots per vegetation type are required and monitoring should be done every two to three years. In open woodlands, photopanoramas can be used to monitor rates of loss of canopy trees. The number of panorama points will be determined by tree density, the number of trees in the sample and the expected rate of loss and elephant densities. A minimum of 5 photopanorama points per vegetation type is recommended. The status of trees of special interest needs to be assessed by following the life history of a cohort of individually marked trees (e.g. baobabs – Swanepoel & Swanepoel 1986).

Monitoring regeneration in woodlands where extensive removal of canopy trees has occurred and where the management objective is to promote regrowth of a canopy layer is a slightly different exercise. Because mature trees tend to occur in even aged stands, when they are destroyed by elephants it cannot be expected that there will be recruits standing by to replace the lost trees within a year or two. The time lags involved before the original woodland can be restored may have to be measured in complete generation spans for trees (25-100 years). The objective of management in such a case would have to be that the conditions have been created (i.e. elephant densities have been reduced to a low enough level) to ensure that the woodland will eventually regenerate. Monitoring of a cohort of young trees over many years may be the only reliable method to establish the woodland dynamics. Very young specimens are likely to be present in abundance but the rate of attrition amongst them is likely to be high. Survival needs to be measured through a similar modelling process as that used for elephants in this study. Only when it can be established that substantial recruitment is taking place into age classes (say) older than 10 years can it be considered that regeneration is happening.

(3) Conflict between elephants and humans

The ‘Event Book’ system mentioned on the previous page is already producing the needed information on this topic for conservancies. There may be a lack of data where elephants are invading areas where there are no conservancies (e.g. parts of the eastern Caprivi).

In addition to the quantitative data on numbers of crop-raiding incidents, the extent of damage to crops and the financial value of the damage, there perhaps should be ongoing attitudinal surveys. If the frustrations of local communities are approaching the stage where they are ready to take the law into their own hands, it would be as well to know about this in advance. Equally, if communities are well satisfied with the benefits derived from elephants this can be used as a criterion to assess the success of management programmes.

c. Transboundary Issues

Most of the areas identified in the previous Transboundary Mammal Project reports where co-operation with neighbouring countries would yield benefits remain the same in this report. The overarching question arising from this study is whether Botswana will limit or reduce its northern elephant population – this affects any management plan made by Namibia.

The following are some management issues where transboundary co-operation could make a substantial difference to the conservation of the species.

(1) Population reductions

There are huge numbers of elephant distributed across central southern Africa in a continuous population from Mozambique to Namibia. The largest populations are in northern Botswana (150,000 animals) and north-western Zimbabwe (50,000 animals). Dispersion from these populations is affecting all neighbouring countries. The initiatives for transboundary conservation areas augur well for the conservation of the species and development of high-valued tourism. However, elephant numbers may be exceeding any level which adds additional value to this land use transformation and may, in fact, be prejudicing the transboundary development because of increasing conflicts with human settlements.

Neither Botswana nor Zimbabwe have given any public indication of their intended elephant management strategies and, by default, it must be assumed that they intend to make no management interventions in the near future. Because of the implications for neighbouring countries, there is a need for this issue to be discussed in a high level forum.

(2) Illegal Hunting

As elephant populations increase in the region, in the absence of any management actions by government authorities, it can be expected that illegal hunting will escalate. The lessons from elsewhere in Africa are that, notwithstanding international attempts to ban trade in ivory, elephants are still regarded as a valuable resource and they will be exploited illegally if no attempts are made to use them legally. Collaboration amongst neighbouring countries aimed at containing illegal hunting is obviously desirable but it may be addressing symptoms rather than causes.

(3) Veterinary Control Measures

Veterinary fences are constraining the natural movements of elephants and causing compression in certain areas with disastrous effects for vegetation. Over the entire elephant range in central southern Africa the bottleneck at the western end of the Caprivi Strip is having the greatest effect on elephant dispersion. Scott-Wilson (2000) put forward options to mitigate the effects of veterinary fences in northern Botswana and decisions are still awaited on these options – or an alternative solution. This cannot be seen simply as a local or national issue – it has negative ramifications for development beyond Botswana's borders.

(4) Liaison on Hunting Quotas

It is unlikely that excessive sport hunting quotas for elephant in either Namibia and Botswana would be likely to affect each other's safari hunting industry significantly because of the abundance of the resource. However, it is possible that in specific sites on either side of the international border there are good reasons to cooperate on joint hunting management. This is an area of liaison which would require little effort and could produce significant economic and conservation gains. In places on either side of the international border hunting is taking place from the same population, so that there is a strong case for developing local co-management institutions at the appropriate scale which would enable the proceeds from an overall quota to be shared proportionally amongst the participating community areas.

(5) Population Monitoring

With the geographic nature of the Caprivi it would be beneficial and cost-effective to combine elephant surveys with northern Botswana, south-eastern Angola and south-western Zambia.

Elephant Population Estimates

The following tables are contained in this Appendix –

Population Estimates for Etosha National Park

All available estimates for Etosha are tabulated together with the time of year, type of survey and source of the estimate.

Combined Estimates for Etosha and the North-Western Population (same page)

Several analytical steps have been carried out in this table –

- (1) The highest estimate for the Etosha population in each year has been carried forward from the previous table;
- (2) A 5-year moving average has been applied to the data to interpolate missing values and to smooth stochastic variation from one year to the next;
- (3) The estimates for the north-western population are tabulated (taken from the next table);
- (4) For those years in which an estimate exists for both the Etosha population and the north-western population the ratios of the two have been calculated;
- (5) These ratios clearly demonstrate trends – in the years prior to 1970, the numbers of elephant outside the park were relatively high, during the period 1975-1982 of SADF illegal activity numbers of elephant outside the park were low in comparison to those in the park and in the years after 1982 there has been as a steady increase in elephant numbers in the north-west in relation to the numbers in the park;
- (6) The missing values in the sequence of data for north western population have then been interpolated by applying the ratios calculated above for the different time periods to the 5 year average values for Etosha;
- (7) A 5 year running average has then been calculated for the north-west population;
- (8) The total of the combined populations appears in the final column.

Estimates for the North-Western Population

Using all available data, estimates have been compiled for the north-western population. In some years where surveys were limited either to Damaraland or the Kaokoveld, and estimate for the total population has been made by using the value from the year before or the year after for the missing part. The notes in each line of the table explain how each estimate has been obtained.

Estimates for Khaudum and Nyae Nyae Populations

Survey areas have altered over the period 1977-2004 and the later estimates include areas outside the national park and the conservancy. In some years where only part of the area was surveyed an overall estimate has been made by using the value from the year before or the year after for the missing part. References for all estimates are given at the foot of the table and a simple population model is included on the same page.

Estimates for East and West Caprivi Populations

Over the period in which surveys have been carried out in the Caprivi (1978-2004), the full Caprivi has been surveyed on only 9 occasions. In order to augment the available data for modelling purposes, the estimates for some years have been interpolated from the ratios between East and West Caprivi and the ratios for survey units within the East and West areas. However, in carrying out the modelling, no ‘double’ interpolations³⁶ have been used.

Some simple models for the Caprivi population are shown on page 77. These are based on an assumed starting population in 1977 and an assumed rate of growth. None of these models fit the estimates particularly well. A closer examination of the data suggests that the Caprivi population actually declined from 1977-1989 and a model for these years (on the page following the simple models) confirms that a closer fit to the estimates can be obtained by assuming an exponential decline from 1978-1989. The formula used for Phase 1 of the model is –

$$P_t = 0.01 \times P_0 \times (100 - e^{\alpha(t-t_0)})$$

where – P_t is the population in year t

P_0 is the starting population in 1977 (t_0) and

α is a constant

After 1989 the population increases at a rate which exceeds the maximum possible intrinsic growth rate for elephant populations and it is necessary to introduce some immigration into the model. In the second phase of the model (1990-2004) the starting population is that generated by the first phase of the model and a typical growth rate for elephant populations (4.56%) is assumed. Immigration begins in 1990 and both the initial immigration and the rate of change of immigration after the first year are set as variables. The best fit is obtained with a large immigration of 1,900 animals in 1990 which tails off very sharply.

The Caprivi estimates and the model results are shown in **Fig.15** in the main part of the report (page 30). It is necessary to note that the data are not particularly robust and that other interpretations of the estimates might be possible. The general impression in the field is that immigration has become very noticeable in recent years rather than in the 1990s.

36. A ‘double interpolation’ is one in which only a part of either east or west Caprivi was surveyed and to get the estimate for the whole Caprivi it is necessary firstly to scale up the estimate (say) for West Caprivi based on a part of West Caprivi and, secondly to obtain the estimate for East Caprivi by using the ratio of estimates for the two areas around that time.

Etosha Estimates

Etosha and North-Western Population

Year	Estimate	Survey	Month	Year	Highest	5 yr av	NW Pop	Ratio	NW pop reconst	5 year average	Combined population	Adjusted estimates
1966	200	CE	Mar	1966	200	200						
1967	500	C	Mar	1967	500	383		0.673	258	258	641	802
1968	450	W	Sep	1968	450	389	211	0.469	211	251	639	799
1969	300	CE	Apr	1969	300	485	283	0.943	283	288	773	966
1970	494	CE	Feb	1970	494	557	300	0.607	300	315	872	1,090
	116	C	Nov	1971	679	726		0.536	389	348	1,073	1,342
1971	124	C	Feb	1972	863	847		0.464	393	359	1,205	1,506
1972	447	C	Mar	1973	1,293	955		0.392	374	337	1,292	1,615
	547	C	Apr	1974	904	1,053		0.320	337	300	1,354	1,692
	433	C	Jun	1975	1,037	1,048	190	0.249	190	263	1,311	1,639
	419	CEW	Jul	1976	1,170	1,137	207	0.177	207	228	1,365	1,707
	863	CEW	Sep	1977	836	1,332	207	0.248	207	211	1,542	1,928
	686	CEW	Oct	1978	1,739	1,521	200	0.115	200	223	1,744	2,180
1973	292	CEW	Feb	1979	1,876	1,706	250	0.133	250	232	1,937	2,422
	477	CEW	Mar	1980	1,985	1,979		0.127	251	240	2,219	2,774
	281	CE	Apr	1981	2,093	2,191	250	0.120	250	236	2,427	3,034
	715	CW	Jun	1982	2,202	2,309	250	0.114	250	226	2,535	3,169
	1,293	Park	Sep	1983	2,800	2,161	178	0.064	178	235	2,396	2,995
1974	904	Park	Feb	1984	2,464	2,022	203	0.082	203	245	2,267	2,834
	835	Park	Jul	1985	1,244	1,986		0.149	295	265	2,251	2,814
1975				1986	1,400	1,793	301	0.215	301	301	2,094	2,617
1976	1,170	Park	Jul	1987	2,021	1,631		0.214	348	331	1,962	2,452
1977	836	Park	Mar	1988	1,837	1,676		0.212	355	333	2,009	2,511
1978	826	Park	Mar	1989	1,653	1,679		0.210	353	345	2,024	2,530
	1,298	Park	Mar	1990	1,469	1,546	307	0.209	307	357	1,903	2,378
	1,739	Park	Sep	1991	1,413	1,438		0.253	363	360	1,798	2,248
1979	1,876	Block Ct	Mar	1992	1,357	1,357	406	0.296	406	391	1,747	2,184
1980	723	W	Jun	1993	1,300	1,300	370	0.340	370	431	1,731	2,164
1981				1994	1,244	1,323		0.384	508	478	1,801	2,252
1982	2,202	Total Ct	Jul	1995	1,188	1,425	508	0.428	508	510	1,936	2,420
1983	2,800	W+Park	May	1996	1,527	1,606		0.373	598	552	2,159	2,698
	1,437	Park	Dec	1997	1,867	1,788		0.318	568	573	2,361	2,951
1984	1,158	Total Ct	May	1998	2,206	1,971	579	0.262	579	604	2,574	3,218
	2,464	Total Ct	Sep	1999	2,153	2,117		0.289	611	633	2,750	3,437
	2,081	Total Ct	Dec	2000	2,100	2,227	662	0.315	662	675	2,902	3,628
1985	1,244	Total Ct	May	2001	2,259	2,233		0.334	745	725	2,958	3,698
	1,186	Total Ct	Aug	2002	2,417	2,214		0.352	779	763	2,977	3,721
	702	Transects	Dec	2003	2,237	2,237		0.371	829	803	3,040	3,800
1986	650	Mixed	May	2004	2,057	2,057	800	0.389	800	800	2,857	3,571
	1,400	Ground	Aug	Estimates from Lindeque (1988)								
	1,200	Ground	Dec									
1987	1,500	Ground	May	Estimates from DSS (2002a)								
	2,021	Total Ct	Aug									
	1,100	Ground	Dec	Estimate from Erb (2004) - DSS								
1988												
1989												
1990	1,469	Transects	Aug	Estimate from Kolberg (2004)								
1991												
1992				Sources of estimates for North-west on following sheet								
1993												
1994				Interpolated values								
1995	1,188	Transects	Aug									
1996				In the final column, the 'Adjusted estimates' are 25% higher than the calculated values								
1997												
1998	2,206	Transects	Aug									
1999												
2000	2,100	Transects	Sep									
2001												
2002	2,417	Transects										
2003												
2004	2,057	Transects	Sep									

Estimates for the North-West Elephant Population

Year	Estimate	Source
1934	1,000	Shortridge (1934)
1968	211	E. Joubert (Supercub survey)
1969	283	E. Joubert (Supercub survey)
1970	300	G. Owen-Smith (2004)
1971		
1972		
1973		
1974		
1975	190	De Villiers (Bantu Affairs)
1976	207	Viljoen (MSc study 1976-1978)
1977	207	Viljoen (MSc study 1976-1978)
1978	200	65 (Viljoen - Western)+ 135 (DSS 2002 - Eastern)
1979	250	192 (DSS 2002 Damaraland only)+ 58 (Balance of 1982 total)
1980		
1981	250	138 (DSS 2002 Kaokoveld only)+ 112 (Balance of 1982 total)
1982	250	214 (Loutit 2004 Damaraland) + 36 (DSS 2002 Kaokoveld)
1983	178	DSS (2002a)
1984	203	54 (Owen-Smith 2004 Kaokoveld) + 159 (DSS 2002 - Damaraland 1983 estimate)
1985		
1986	301	247 (Loutit 2004 Damaraland) + 54 (Owen-Smith 2004 - Kaokoveld 1984 estimate)
1987		
1988		
1989		
1990	307	253 (Loutit 2004 Damaraland) + 54 (Owen-Smith 2004 - Kaokoveld 1984 estimate)
1991		
1992	406	Loutit (2004)
1993	370	Loutit (2004)
1994		
1995	508	Loutit (2004)
1996		
1997		
1998	579	DSS (2002a)
1999		
2000	662	DSS (2002a)
2001		
2002		
2003		
2004	800	Leggatt (pers.comm)

1975-1982 SADF illegal hunting

Estimates for Khaudum National Park and Nyae Nyae Conservancy Population

MODEL PARAMETERS									
		Average rate of growth		4.56	4.56 % / year				
		Starting population (1975)			0 animals				
		Starting immigration (1975)			34 animals				
		Rate of change of immigration			7.14 % / year				
ESTIMATES						MODEL			
						Best fit analysis			
Year	Khaudum	Nyae Nyae	Totals	Selected	Estimate x 1.25	Zero immig	Predicted	Immigration	Difference ²
1975							0	34	
1976							36	36	
1977			64	64	80	80	75	39	22
1978			95	95	119	84	120	42	1
1979			54	54	68	87	169	45	10,236
1980	0		122	122	153	91	223	48	4,999
1981						96	284	51	
1982						100	350	55	
1983						105	424	59	
1984	395	385		780	975	109	505	63	220,983
1985				762	953	114	594	68	
1986	377			929	1,161	120	692	73	67,855
1987	528			929	1,161	125	799	78	130,879
1988		401		929	1,161	131	917	83	59,528
1989						137	1,046	89	
1990	1,206	237		1,443	1,804	143	1,187	96	380,006
1991						149	1,341	102	
1992						156	1,510	110	
1993						163	1,693	118	
1994						171	1,894	126	
1995	783	302		1,085	1,356	179	2,112	135	570,978
1996						187	2,349	145	
1997						195	2,608	155	
1998	2,224	558		2,782	3,478	204	2,889	166	346,519
1999						213	3,194	178	
2000	1,266	755		2,021	2,526	223	3,526	191	999,453
2001						233	3,886	204	
2002	1,687	861		2,548	3,185	244	4,277	219	1,192,290
2003	3,184	914		4,098	5,123	255	4,701	234	177,838
2004	3,099	967	749	4,815	6,019	267	5,160	251	736,884
2005						267	5,658	269	
						Total sum of squares			4,898,470

All estimates from DSS (2002a) up to 2002 except 1998 (Craig 1998) and 2000 (Craig 2000)

2002 - Erb (2004), 2004 - Kolberg (2004)

Kavango & Jaqna*Italics – interpolated values*

Elephant Population Estimates for the Caprivi

Year	WEST CAPRIVI				Subtotals		EAST CAPRIVI				Subtotals		Total
	Mahango	W Core	Centre	E core	Sum	Sum or Survey	Mudumu	Mamili	Forest	Floodp	Sum	Sum or Survey	
1977	•	•	•	•			•	•	•	•			
1978	•	•	•	•			•	•	•	•		7	7
1979	•	•	•	•			•	•	•	•		16	16
1980	•	•	•	•		1,352	•	32	1,509	15	1,556	1,969	3,321
1981	•	•	•	410	410	634	•	•	•	•		923	1,556
1982	•	•	•	•		1,652	193	135	1,936	•	2,264	2,405	4,057
1983	53	•	•	•	53	690	539	100	1,550	•	2,189	2,575	3,265
1984	•	•	•	•		1,384	149	57	1,768	41	2,015	2,015	3,399
1985	0	1	•	•	1	1,297	310	72	1,353	19	1,754	1,754	3,051
1986	0	•	•	•	0	560	158	136	567	157	1,018	1,018	1,578
1987	169	868	•	•	1,037	2,937						1,559	4,496
1988	0	•	•	884	884	1,366	143	169	1,075	•	1,387	1,388	2,754
1989	82	92	•	728	902	902	387	179	335	240	1,141	1,141	2,043
1990	319	1,085	•	•	1,404	3,977	534	491	•	•	1,025	1,025	5,002
1991	208	•	•	•	208	2,708	•	•	•	•		719	3,427
1992	•	•	•	•			•	•	•	•			6,630
1993	298	1,209	•	2,825	4,332	4,332	405	187	•	•	592	592	4,924
1994	248	1,533	0	2,953	4,734	4,734	433	638	•	•	1,071	1,071	5,805
1995	252	•	•	•	252	3,281	821	1,457	•	•	2,278	2,278	5,559
1996	•	•	•	•			•	•	•	•			
1997	•	•	•	•			•	•	•	•			
1998	292	1,227	0	1,549	3,068	3,068	175	1,333	0	0	1,508	1,508	4,576
1999	•	•	•	•			•	•	•	•			
2000	238	•	•	•	238	3,098	•	•	•	•		823	3,921
2001	•	•	•	•			•	•	•	•			
2002	250	•	•	•	250	3,255	•	•	•	•		864	4,119
2003	•	•	•	•			•	•	•	•			5,740
2004	340	1,927	38	2,563	4,868	4,868					3,858	3,858	8,726
2005													

Ratios within West Caprivi

1989	0.09	0.10	0.00	0.81
1993	0.07	0.28	0.00	0.65
1994	0.05	0.32	0.00	0.62
1998	0.10	0.40	0.00	0.50
Av	0.08	0.28	0.00	0.65

Ratios between West & East

1985	0.43	0.57
1986	0.35	0.65
1989	0.44	0.56
Av	0.41	0.59
1990	0.80	0.20
1993	0.88	0.12
1994	0.82	0.18
1998	0.67	0.33
Av	0.79	0.21

References

DSS (2002a)
 Rodwell (et al 1995)
 ULG (1994)
 Craig (1998)
 Chase & Griffin (2004)
 Kolberg (2005)
 Sikopo (2002)

Subtotal constructed using ratios ('All available data' used in model)

Bold font indicates actual estimates ('Actual estimates' used in model)

Simple Population Models for the Caprivi

Rate of Growth – Rg (%/year)	4.56	5.19	4.56	3.57
1977 Starting population	2,200	1,944	2,097	2,498
0.001 x Difference ²	17,373	17,054	35,707	33,815

Year	DATA			ACTUAL ESTIMATES				ALL AVAILABLE DATA			
	WEST	EAST	Total	Rg fixed Model 0.001 D ²	Rg variable Model 0.001 D ²	Rg fixed Model 0.001 D ²	Rg variable Model 0.001 D ²	Rg fixed Model 0.001 D ²	Rg variable Model 0.001 D ²	Rg fixed Model 0.001 D ²	Rg variable Model 0.001 D ²
1977				2,200	1,944	2,097		2,498			
1978		7		2,300	2,045	2,193		2,587			
1979		16		2,405	2,151	2,293		2,680			
1980	1,352	1,969	3,321	2,515	2,263	2,397	853	2,775	298		
1981	634	923	1,557	2,630	2,380	2,506	901	2,874	1,735		
1982	1,652	2,405	4,057	2,749	2,504	2,621	2,063	2,977	1,167		
1983	690	2,575	3,265	2,875	2,634	2,740	275	3,083	33		
1984	1,384	2,015	3,399	3,006	2,770	2,865	285	3,193	42		
1985	1,297	1,754	3,051	3,143	2,914	2,996	3	3,307	66		
1986	560	1,018	1,578	3,286	2,918	3,065	2,212	3,132	2,416	3,425	3,413
1987	2,937	1,559	4,496	3,436		3,224		3,275	1,490	3,548	900
1988	1,366	1,387	2,753	3,593		3,392		3,425	451	3,674	849
1989	902	1,141	2,043	3,757	2,937	3,568	2,325	3,581	2,365	3,805	3,106
1990	3,977	1,025	5,002	3,928		3,753		3,744	1,582	3,941	1,125
1991	2,708	719	3,427	4,107		3,948		3,915	238	4,082	429
1992			6,630	4,294	5,455	4,153	6,138	4,093	6,434	4,228	5,771
1993	4,332	592	4,924	4,490	188	4,368	309	4,280	415	4,379	297
1994	4,734	1,071	5,805	4,695	1,232	4,595	1,465	4,475	1,768	4,535	1,613
1995	3,281	2,278	5,559	4,909		4,833		4,679	774	4,697	743
1996				5,133		5,084		4,893		4,864	
1997				5,367		5,348		5,116		5,038	
1998	3,068	1,508	4,576	5,612	1,073	5,625	1,101	5,349	598	5,218	412
1999				5,868		5,917		5,593		5,404	
2000	3,098	823	3,921	6,135		6,225		5,848	3,713	5,597	2,810
2001				6,415		6,548		6,115		5,797	
2002	3,255	864	4,119	6,708		6,887		6,393	5,173	6,004	3,553
2003			5,740	7,013	1,622	7,245	2,265	6,685	893	6,218	229
2004	4,868	3,858	8,726	7,333	1,940	7,621	1,221	6,990	3,014	6,440	5,224
2005				7,668		8,016		7,309		6,670	

A two-phase model for the Caprivi elephant population

Starting population 1977	4,510
Coefficient of exponential decline 1977-1989	0.295
Rate of growth 1990 onwards	4.56
Starting immigration 1990	1,900
Rate of change of immigration %	-87
First phase: $0.001 \times \text{Difference}^2$	8,372
$(0.001 \times \text{Difference}^2) / N$	930
Second phase: $0.001 \times \text{Difference}^2$	16,876
$(0.001 \times \text{Difference}^2) / N$	2,411

Year	ESTIMATES			TWO PHASE MODEL			
	WEST	EAST	Total	Estimate x 1.25	Model Immigration	0.001 x Diff ²	
1977					4,510		
1978		7			4,449		
1979		16			4,429		
1980	1,352	1,969	3,321	4,151	4,401		62
1981	634	923	1,557	1,946	4,363		
1982	1,652	2,405	4,057	5,071	4,313		575
1983	690	2,575	3,265	4,081	4,245		27
1984	1,384	2,015	3,399	4,249	4,154		9
1985	1,297	1,754	3,051	3,814	4,032		48
1986	560	1,018	1,578	1,973	3,868		3,595
1987	2,937	1,559	4,496	5,620	3,648		3,888
1988	1,366	1,387	2,753	3,441	3,353		8
1989	902	1,141	2,043	2,554	2,956		161
1990	3,977	1,025	5,002	6,253	4,990	1,900	
1991	2,708	719	3,427	4,284	5,465	247	
1992		6,630		8,288	5,746	32	6,458
1993	4,332	592	4,924	6,155	6,012	4	20
1994	4,734	1,071	5,805	7,256	6,287	1	939
1995	3,281	2,278	5,559	6,949	6,574	0	141
1996					6,874	0	
1997					7,187	0	
1998	3,068	1,508	4,576	5,720	7,515	0	3,221
1999					7,857	0	
2000	3,098	823	3,921	4,901	8,216	0	
2001					8,590	0	
2002	3,255	864	4,119	5,149	8,982	0	
2003			5,740	7,175	9,392	0	4,914
2004	4,868	3,858	8,726	10,908	9,820	0	1,183
2005					10,268	0	

Data shown in italics is interpolated. No double interpolations have been used in obtaining the best fit.

Etosha elephant population: mortality, immigration and emigration

Lindeque (1988) saw the Etosha population as part of a larger regional population with movements taking place both into and out of the park. It is an interesting challenge to gauge the extent and frequency of such movements.

The status of the population from one year to the next is a function of –

- (1) The intrinsic rate of growth of the population;
- (2) The mortality during the year concerned; and
- (3) The immigration into or emigration from the population during the year concerned.

Each of these parameters is discussed individually below.

(1) The intrinsic rate of growth of the population

In the modelling exercise which follows, I have assumed that this is a constant. Lindeque (1988) found a fecundity of 0.25 for adult female elephants in Etosha (i.e. one calf every four years). The mortality schedule for Etosha elephants is one of the unknowns sought from the modelling process. For a typical elephant population with a fecundity of 0.25 and an age-specific mortality of 0.5% for animals between 5-45 years the expected growth rate is 4.56% per year (see page 7). I began this analysis by assuming this growth rate and later modified it to achieve correspondence between the observed population estimates and the model.

(2) Mortality

Some clarity is needed in defining the processes involved here. A population with an intrinsic growth rate of 4.56% per annum and a central mortality of 0.5% (see diagram opposite) produces an expected number of deaths in maintaining a net annual growth of 4.56%. For any given size of population and a fecundity of 0.25 calves per year, the total mortality (%) is given fairly accurately by the formula –

$$M_{total} = M_{central} (0.91 + 2.28 M_{central}^{-0.23})$$

A population of 1,000 animals with a central mortality of 0.5% produces about 18 deaths in the course of increasing to 1,046 animals in the following year. In the model table on page 81, deaths arising in this manner are shown in the column ‘Expected deaths’.

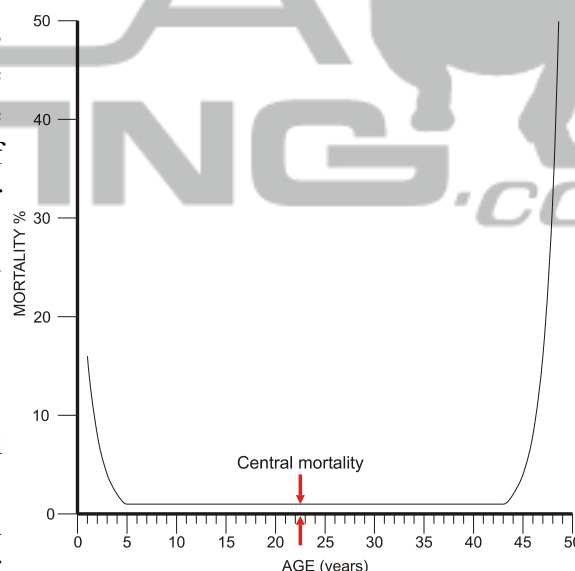


Figure 22: Definition of ‘central mortality’

Elephant deaths have been recorded at Etosha since 1971. The data shown in the model table from 1971-1987 are from Lindeque (1988) and those for 1988-2003 are from Kilian (2004). Lindeque gives grouped totals for the periods 1971-1979, 1980-1983 and 1984-1987 and the deaths have been evenly allocated over the time span involved in the table.

A further unknown enters the analysis here. No mortality collection ever captures 100% of the deaths which occur in any year and the finding factor (i.e. the proportion of total deaths recorded) is a critical value in attempting to make use of the data. In the model I have assumed it remains the same over the period 1971-2004 but this assumption may not be true. During the period when Lindeque was working on his thesis, the intensity of data collection (1983-1987) may have been higher than at other times. The finding factor is treated as one of the variables to be modelled and the values which appear in the column 'Deaths' in the model table on page 81 are simply the recorded deaths divided by the assumed finding factor.

(3) Immigration and emigration

The net migration in any given year is calculated on the assumption that each population estimate is correct with zero confidence interval (later we examine the effect of confidence intervals) and that any difference between two successive estimates which does not match what would have been expected from intrinsic growth is due to migration. In any given year –

- (a) The population from the year before is increased by the intrinsic growth rate;
- (b) The difference between the actual deaths and expected deaths is deducted from (a);
- (c) The immigration/emigration in any given year is calculated by subtracting (b) from the population in the year concerned. i.e. –

$$\text{Net migration } I_t = P_t - P_{t-1} (1 + R_g/100) + D_a - D_e$$

– where P_t is the population in year t

P_{t-1} is the population from the previous year

R_g is the intrinsic rate of growth of the population (%)

D_a is the actual number of deaths in the previous year

D_e is the expected number of deaths in the previous year

Some of the effects of this relationship may be counterintuitive. The greater the mortality in a year in which the population increases, the greater the immigration needed to achieve the next given population level. If the mortality is higher than expected in a year in which the population decreases, the less is the emigration required to match the new population level. The relationship between the finding factor, immigration and emigration for the Etosha data is shown in **Fig.23** (page 82). If the assumed finding factor is low, the true number of deaths is high and immigration must exceed emigration by a large amount in order to maintain the population. A high finding factor implies that the recorded number of deaths is close to the true number and, for the Etosha data, emigration must exceed immigration to achieve correspondence between modelled data and the population estimates.

(4) Modelling

The model population in any year is very simply obtained from the previous equation –

$$P_t = P_{t-1} (1 + R_g/100) + I_t - D_a + D_e$$

ETOSHA POPULATION MODEL					Central mortality %		1.045	Growth	1.03296	
					Rate of growth %		3.296			
					Total mortality %		3.310			
Year	MORTALITY				Finding Factor		0.548	Migration		Population with no migration
	TOTAL	Man	Natural	Anthrax	Pop Estimate	Expected deaths	Actual Deaths	Numbers	Significant Conf Intl %	Model Pop
1971	12	9	3	0	679	22	23			679
1972	14	10	4	0	863	29	27	163	23	863
1973	13	9	3	1	1,293	43	25	400	45	1,293
1974	15	10	4	1	904	30	29	-449	32	904
1975	13	9	3	1	1,037	34	25	102	11	1,037
1976	15	10	4	1	1,170	39	29	89	9	1,170
1977	14	10	3	1	836	28	27	-383	30	836
1978	15	10	4	1	1,739	58	29	875	100	1,739
1979	14	10	3	1	1,876	62	27	51	4	1,876
1980	64	12	14	38	1,985	66	123	12	2	1,985
1981	66	13	15	38	2,093	69	127	100	2	2,093
1982	65	13	14	38	2,202	73	125	97	1	2,202
1983	67	13	15	39	2,800			577	23	2,800
	220	220			2,580	85	128	0		2,580
1984	42	4	18	20	2,464	82	81	-158	84	2,464
1985	44	5	18	21	1,590			-956	37	1,590
	350	350			1,240	41	84	0		1,240
1986	44	5	18	21	1,400	46	84	162	9	1,400
1987	44	5	18	21	2,021	67	84	613	39	2,021
1988	64	1	16	47	1,837	61	123	-233	12	1,837
1989	96	4	10	82	1,653	55	184	-183	12	1,653
1990	62	2	14	46	1,469	49	119	-109	13	1,469
1991	23	3	12	8	1,413	47	44	-34	4	1,413
1992	39	0	7	32	1,357	45	75	-105	7	1,357
1993	17	3	4	10	1,300	43	33	-71	7	1,300
1994	19	1	6	12	1,244	41	36	-110	7	1,244
1995	9	0	6	3	1,188	39	17	-102	7	1,188
1996	16	3	5	8	1,527	51	31	278	24	1,527
1997	5	0	3	2	1,867	62	10	269	18	1,867
1998	23	1	9	13	2,206	73	44	226	14	2,206
1999	21	0	8	13	2,153	71	40	-155	5	2,153
2000	21	4	7	10	2,100	70	40	-155	5	2,100
2001	21	0	14	7	2,259	75	40	60	4	2,259
2002	28	1	21	6	2,417	80	54	50	2	2,417
2003	29	1	28	0	2,237	74	56	-286	10	2,237
2004					2,057	68	0	-272	10	2,057
Totals	1624	751	331	542	61,055	1,876	2,021			
%	100.0	46.2	20.4	33.4		Mortality	3.31			

1983 cull – 220 animals

1985 cull – 350 animals

Interpolated values

Immigration 4,123

Emigration -3,761

Difference 362

Population change 1971-2004 with no migration 362

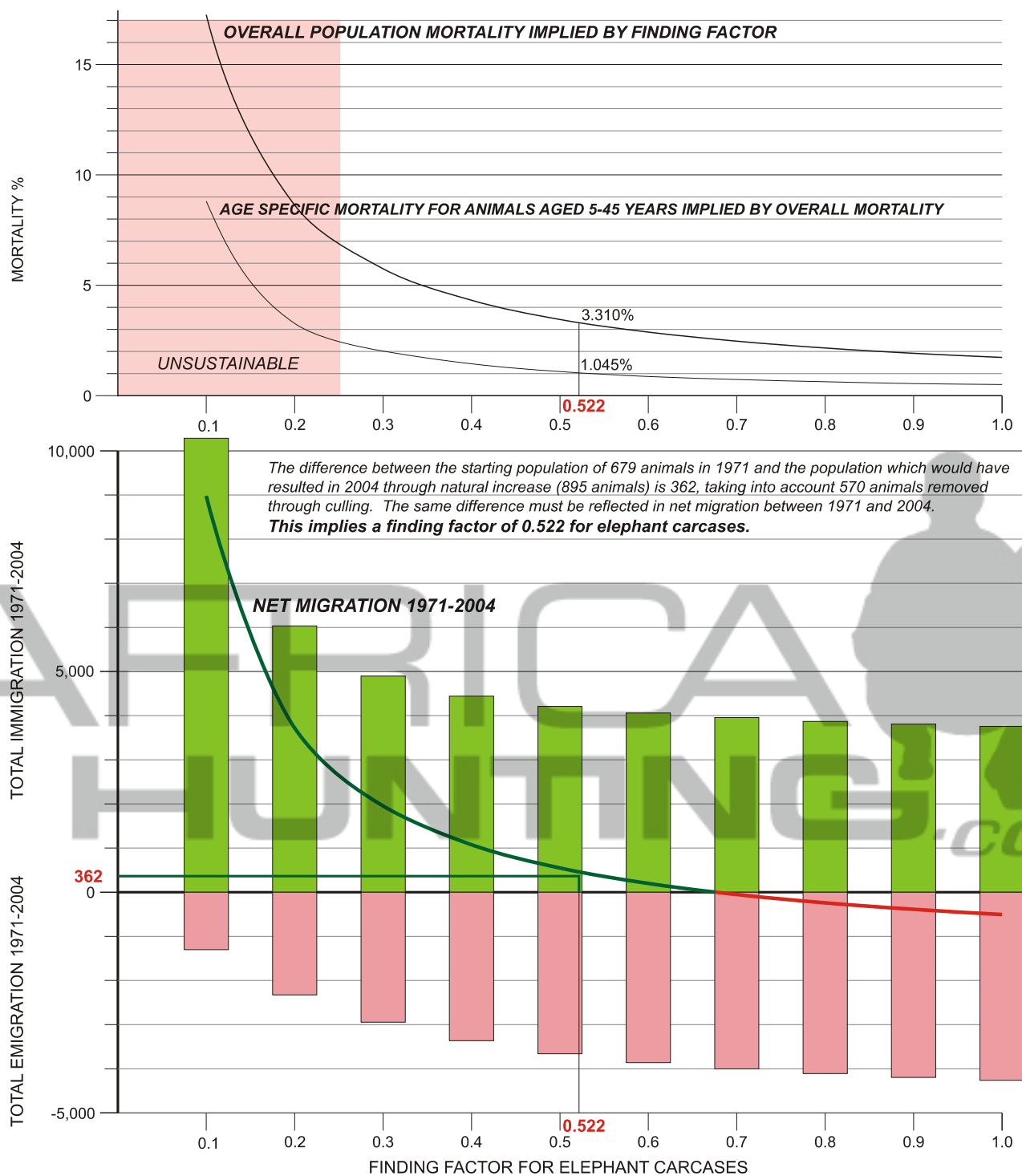


Figure 23: Etosha – Influence of assumed finding factor on mortality and migration

At first glance, there would appear to be a tautology in these relationships. The two terms involving expected and actual deaths actually cancel out, so that no matter what finding factor is specified for actual mortality, the net migration is adjusted to give the correct population estimate in each year. **The apparent tautology is the key to the model solution.**

The model is attempting the extreme. We are not sure to what extent the mortality record represents the actual deaths (i.e. we don't know the finding factor), we don't know the population growth rate (more specifically we don't know the central mortality for the population) and, finally, the immigration and emigration are a movable feast. If we set the finding factor high, we obtain relatively low mortalities and hence lower levels of immigration for years in which the population increases and higher levels of emigration for years in which the population decreases. If we set the finding factor low, we obtain relatively high mortalities and hence higher levels of immigration for years in which the population increases and lower levels of emigration for years in which the population decreases. Either way we end up with a model population which faithfully tracks the population changes year by year.

There is one additional factor that has been overlooked – the difference between the starting population in 1971 (679 animals) and the ending population which would have been obtained with no immigration or emigration. If we take a population of 679 animals in 1971 and allow it to increase at an intrinsic growth rate of (say) 3.3% assuming no immigration or emigration, its value after 23 years is 895 animals – a net change of 217 animals (see final column in the model table). When the difference between the actual and expected mortalities over the same time period is added to this, the change becomes 362 animals. **A key assumption in the model is that the net difference between the total number of animals which have immigrated into the population and the total number of animals which have left the population between 1971 and 2004 must be equal to this change.**

Only one value for the central mortality will give this result, i.e. we have a unique solution. When the central mortality is set at 1.045% (giving a population growth rate of 3.296%) the difference between immigration and emigration is equal to the change which would have taken place in the population with no migration. This result is independent of the assumed finding factor for the reason given at the top of this page.

From the relationship given on the first page of this appendix, a central mortality of 1.045% implies a total mortality of 3.31%. By adjusting the finding factor, the total mortality over the period 1971-2003 can be set to this value (see model table – 2,021 deaths between 1971 and 2003 when the finding factor is set to 0.5215). **This too is a unique solution.** And, having established the 'actual' mortalities in each year, the profile of immigration and emigration is automatically set. The Etosha population estimates and the model values for mortality and migration are shown in **Fig.24**. The 'growth history' of the population is discussed in the main body of this report and will not be duplicated here.

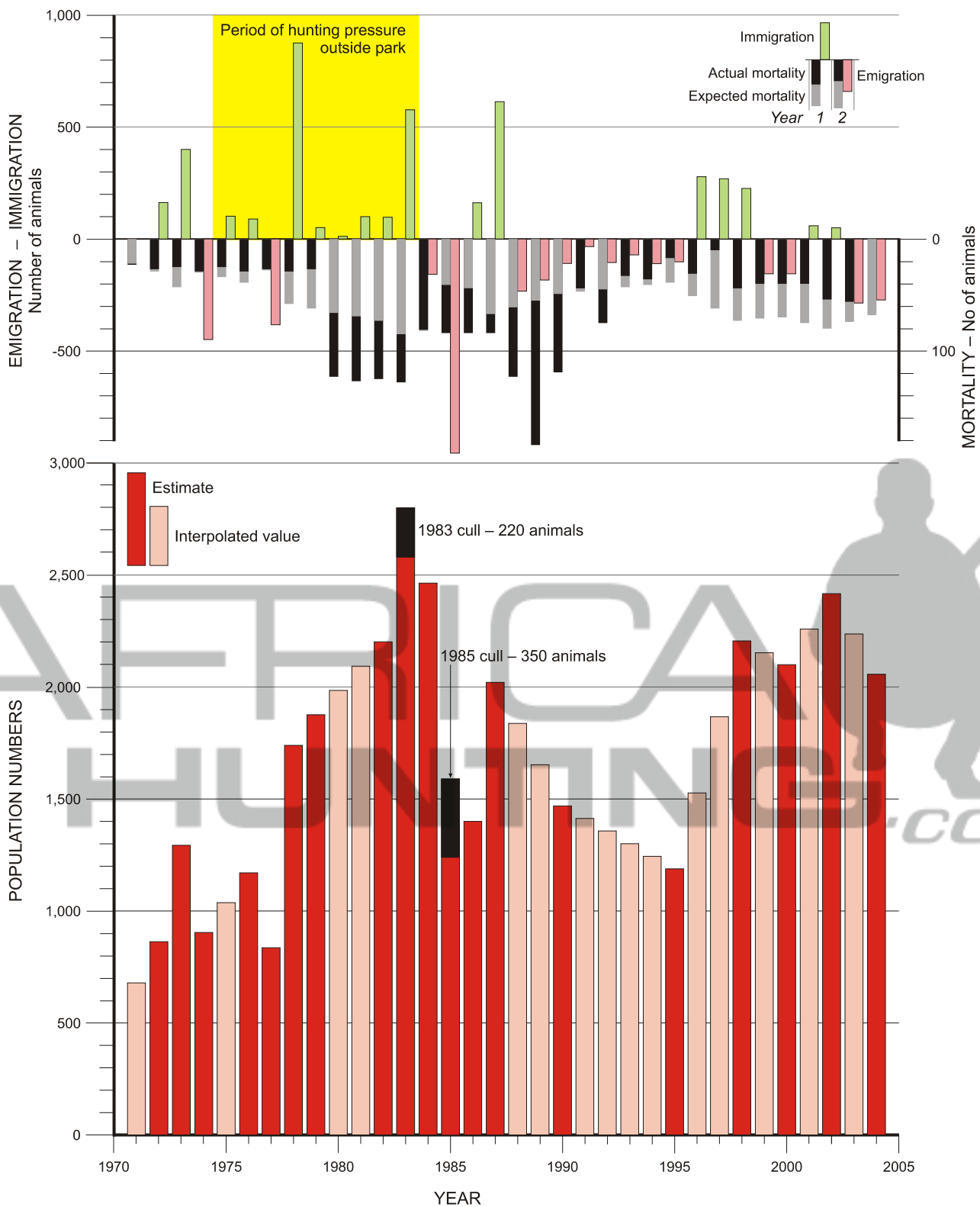


Figure 24: Etosha – Immigration, emigration and mortality

(5) The effect of confidence intervals on population estimates

So far this modelling has assumed perfect estimates. In practice, a 95% confidence interval approximately equal to \pm two standard deviations of the mean would be associated with every estimate. Each estimate for immigration or emigration predicted by the model has been tested to find the level at which it would be significant. The method used was simply to examine each estimate in relation to the preceding year and if it fell outside the value obtained by adding a specified confidence interval to the estimate for the year before (taking into account the expected population growth), it was treated as significant. The process is equivalent to postulating that if the standard deviations of two successive estimates do not overlap, the predicted migration probably occurred.

The results are shown in **Fig.25** below. The immigration of some 875 animals in 1978 is significant at the 100% level and the immigration of 400 animals in 1973 is significant at a level of 45%. Thereafter a further immigration of 613 animals in 1987 and emigrations of 956 animals in 1985, 449 in 1974 and 383 in 1977 appear significant at the level of 30%. All other estimates fall below the 30% significance level and, since few surveys produce confidence intervals better than this, *in sensu strictu* there is no basis for accepting that any population movements actually took place in these years. However, these tests are by no means exhaustive. Lindeque (1988, p236) points out that the increase from 1979-1983 exceeded the normal rate of increase for elephant populations and that the decline from 1983-1986 could not be explained in terms of recorded mortalities. A deeper consideration of the model data might show that any sequence of predicted emigrations, such as occurred between 1988 and 1995, may be highly significant over the period concerned although each successive instance does not appear significant.

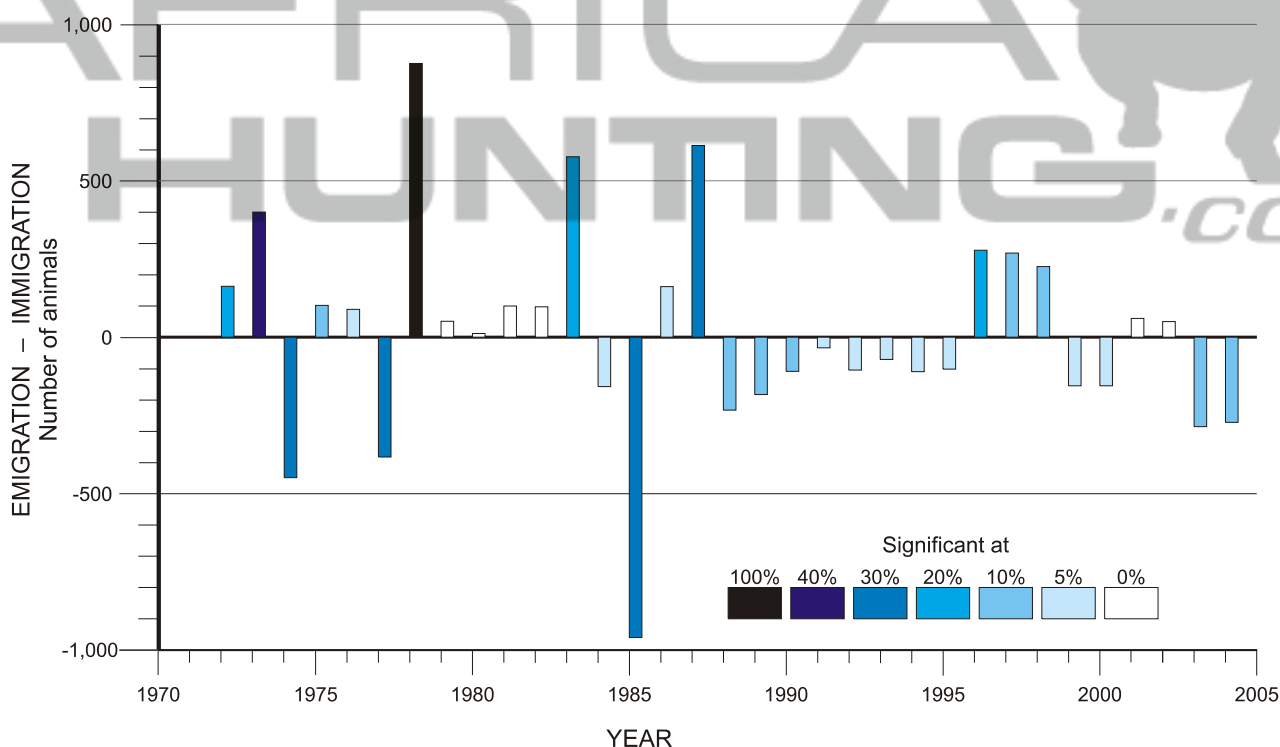


Figure 25: Etosha – Significance levels of immigration and emigration

The north-western elephant population of Zimbabwe

The population estimates for Zimbabwe since 1980 are shown in the table on the following page. Two models for the population are presented. The first is a simple growth model which takes into account the numbers of animals killed annually including the major culls of the mid-1980s. The second is a technique developed by Martin (1992b) which uses a maximum likelihood estimator to obtain the most likely growth rate for the population in combination with the starting population in 1979.

The use of maximum likelihood analysis is only possible where confidence intervals obtained from sample survey techniques can be attached to all the estimates in the data set. Such a situation pertains for the Matabeleland North population from 1980 to the present date. For any population estimate with confidence intervals, the true value of the estimate is most likely to lie midway between the upper and lower values of the confidence interval. The probability that the true value is somewhere else decreases as one moves away from the central value according to the standard shape of the normal distribution.

A model population can be constructed by specifying a starting population in a given year (1979 in the model overleaf) and a rate of growth. In each year of the model, the number of animals which were killed due to culling or problem animal control is deducted from the population for that year and the population is then increased by the specified growth rate. This results in a set of hypothetical values for the population over the time span involved. In any given year, the hypothetical value can be compared with the actual population estimate and a probability assigned, based on the confidence interval, that the model value is the specified difference away from the estimate. The formula for this probability is –

$$P_x = \frac{e^{-\frac{(x - \bar{x})^2}{2\sigma^2}}}{\sigma\sqrt{2\pi}}$$

– where x is the model prediction for the population

\bar{x} is the actual population estimate

σ is the standard deviation (obtained from the confidence interval)

The values for the probabilities obtained in this manner are very small numbers and in the analysis shown on the next page they have been multiplied by 10,000 to bring them close to unity.

The probability that all the values in the data set lie in the positions predicted by the model is the product of the probabilities for all the estimates (box labelled 'INDEX' on the next page). This is an extremely powerful estimator. It does not rely on a 'sum of squares' to ascertain the best fit to any curve but rather on a set of statistical likelihoods that the true values for all the estimates are where the model has placed them.

The best fit is obtained with a population of 20,575 animals in 1979 growing at a rate of 6.892%, taking into account the numbers of animals killed in the time period. The model curve does not pass through the 95% confidence intervals for two estimates (1991 and 1992) and it must be suspected that these are faulty. Excluding them from the analysis results in a slightly lower value for the starting population (19,911 animals) and a slightly higher growth rate (7.075%).

Matabeleland North Elephant population in Zimbabwe

Simple growth model					Maximum likelihood analysis			
Population 1979		22,384			Population 1979		20,575	
Rate of growth %		6.361			Rate of growth %		6.892	
0.001 x Sum of squares		557,389			INDEX		277.43	
Year	Estimate	Mortality	Predicted	Difference ²	95% CI	Std Dev	Predicted	Probability x 10,000
1979		314	22,384				20,575	
1980	20,444	574	23,474	9,180,129	34	3,545	21,657	1.061340
1981	20,297	794	24,357	16,479,813	19	1,967	22,536	1.060773
1982	24,981	60	25,061	6,456	21	2,675	23,241	1.206869
1983	25,888	2,083	26,592	495,168	25	3,301	24,779	1.142272
1984	20,122	4,140	26,068	35,351,102	30	3,079	24,260	0.525172
1985	17,980	2,474	23,322	28,542,295	31	2,843	21,506	0.650147
1986	16,906	1,259	22,175	27,758,904	29	2,500	20,344	0.619925
1987	21,292	173	22,246	910,341	25	2,715	20,400	1.392400
1988	26,660	324	23,477	10,130,287	32	4,351	21,622	0.468956
1989	27,411	75	24,626	7,756,430	28	3,914	22,765	0.503949
1990	32,318	71	26,113	38,506,369	26	4,285	24,254	0.158505
1991	39,788	43	27,698	146,164,247	22	4,464	25,850	0.006830
1992	41,149	51	29,414	137,703,089	22	4,617	27,586	0.011547
1993	27,841	81	31,231	11,492,804	20	2,840	29,432	1.200742
1994	37,422	141	33,132	18,407,859	34	6,489	31,374	0.398201
1995	30,985	75	35,089	16,843,568	18	2,844	33,386	0.982288
1996			37,241				35,606	
1997	36,280		39,610	11,090,628	20	3,701	38,060	0.960235
1998	35,992		42,130	37,673,424	16	2,937	40,684	0.379233
1999	45,803		44,810	986,548	15	3,504	43,487	0.915217
2000			47,660				46,485	
2001	49,310		50,692	1,909,249	12	3,018	49,688	1.311628
2002			53,916				53,113	
2003			57,346				56,773	
2004			60,994				60,686	
2005			64,873				64,869	

Financial values of elephants

1. Sport hunting

Using the ‘optimum’ quota of 0.5% established in **Appendix 5** for elephant male trophy hunting, the expected returns from an elephant population at a density of 1/km² are calculated in the table on the next page. It has been assumed that the safari operator conducting the hunting will pay one-quarter of the gross income from hunting to the landholder (government or local community) as ‘rental’ for the hunting, and that this sum includes the trophy fees for the elephants. As a land use, the net return is about US\$1.17 (N\$7.25) per hectare.

The commodity value of the elephant quota (i.e. the value of ivory, skin and meat) has been calculated at the foot of the same table and, if markets were operating for elephant products, this value is actually higher than income obtained from sport hunting – US\$1.22 (N\$7.56) per hectare.

These values would remain true for one year only: with a population growing at 4.4%,³⁷ the quota will increase continuously (see table below). After 50 years the population will have increased to more than 8,500 animals, the quota will have risen from 5 to 42 and a total of 869 males will have been hunted. The sustainability of the system is another matter altogether: sooner or later the entire population will crash.

Trophy male elephant hunting quotas over 50 years

Yr	Q	Pop	Yr	Q	Pop	Yr	Q	Pop	Yr	Q	Pop	Yr	Q	Pop
1	5	1,044	11	8	1,603	21	12	2,463	31	18	3,784	41	28	5,812
2	5	1,090	12	8	1,674	22	12	2,571	32	19	3,950	42	29	6,067
3	6	1,137	13	8	1,747	23	13	2,684	33	20	4,123	43	31	6,333
4	6	1,187	14	9	1,824	24	13	2,802	34	21	4,304	44	32	6,611
5	6	1,239	15	9	1,904	25	14	2,925	35	22	4,492	45	34	6,901
6	6	1,294	16	9	1,987	26	15	3,053	36	23	4,689	46	35	7,204
7	6	1,351	17	10	2,075	27	15	3,187	37	24	4,895	47	37	7,519
8	7	1,410	18	10	2,166	28	16	3,326	38	25	5,110	48	38	7,849
9	7	1,472	19	11	2,260	29	17	3,472	39	26	5,334	49	40	8,194
10	7	1,536	20	11	2,360	30	17	3,625	40	27	5,568	50	42	8,553

Yr = Year

Q = Trophy male quota (% total population)

Pop = Total population

37. This population would grow at 4.56% in the absence of hunting.

FINANCIAL VALUE OF ELEPHANT TROPHY MALE HUNTING

Assumed values (all figures in US\$)

Area	1,000	km ²	Exchange rate 1US\$ = N\$	6.21	
Elephant population	1,000	animals			
Hunting quota	0.5	% of total population		=	5 trophy bulls
Trophy fee US\$	10,000	charged by operator			
Daily rate US\$	1,000	charged by operator			
Minimum hunt days	14	Client charged for 14 days hunting if elephant bull included in safari			
Operating costs US\$	200	per day (Safari operator's costs)			
Operator' rental	25	% of gross income (paid to landholder – Government or community)			
Tusk weight (average)	50	kg (pair)			
Ivory value US\$	500	per kg (assumes markets operating)			
Weight of skin	100	kg dry skin/animal (assumes hunting client takes 20% of skin)			
Price of skin US\$	5	per kg (assumes markets operating)			
Body weight (adult male)	5,000	kg			
Dressing out percentage	33	% of body weight			
Meat value US\$	1	per kg (wet weight)			

Safari Operations

Trophy fees	50,000
Daily rates	70,000
Meat	8,250
Skin	2,500
Gross income	130,750
Operating costs	14,000

Net income	116,750
Net income/hectare	1.17
= N\$	7.25

Safari operator's net income

Trophy fees	50,000
Daily rates	70,000
Skin	2,500
less – Running costs	14,000
less – Rental	30,625
Operator's net income	77,875

Government or community net income

Rental	30,625
Meat	8,250
	38,875

Commodity value (assumes markets operating)

Ivory	125,000
Skin	2,500
Meat	8,250
less – Running costs	14,000
Net income	121,750
Net income/hectare	1.22
= N\$	7.56

Comprehensive population management

The same population model has been used to examine the financial implications of culling to keep an elephant population constant combined with ongoing elephant trophy male hunting. Culling entails the offtake of complete elephant herds. Assumptions and methods used in the model are as follows –

1. The management treatment is applied to a population of 1,000 animals in an area of 1,000km² (i.e. at a density of 1/km²). In the absence of any management this population would increase at a rate of 4.56% per annum (page 7). The percentage of the population to be culled is selected so that the population does not increase.
2. All males up to the age of 10 years are assumed to part of elephant herds and included in culling. The probability of a male older than 10 years being present in a herd when it is culled is set as –

$$P_a = e^{-0.015 (Age - 10)}$$

3. A computational difficulty arises with the fact that when the percentage set for the proportion of the total population to be culled (say 2%) is multiplied by the number of animals in each age class, the resulting numbers are fractional for many of the age classes. When rounded to nearest whole number the result may be zero causing the sum of the numbers to be taken from each age class to be less than the overall percentage offtake. The smaller the population, the worse is the effect and only in populations of 10,000 animals or more does the effect become minor. To overcome the problem, the following technique is used –
 - a. The total number to be culled (C_o) is calculated by applying the culling percentage to the overall population (e.g. 3% of a population of 1,000 animals would give the result that 30 animals should be culled).
 - b. A preliminary calculation is performed for each male and female age class where the percentage of the total population to be culled is applied to the number of animals in each age class and the projected offtake is summed (C_a) and compared with actual offtake desired (C_o). A ‘multiplier’ is then calculated (C_o / C_a) and the numbers to be culled in each age class are increased by this proportion. When all the new fractional values are summed, they add up exactly to the desired offtake. This still does not solve the rounding problem but it does give a total number of males (C_m) and a total number of females (C_f) to be culled taking into account the fact that most males above 10 years old will be excluded from the cull.
 - c. The numbers to be culled in each age class derived from the previous step are then rounded and the totals summed for males and females. These totals are compared with the desired offtakes (C_m and C_f) and a supplementary vector is generated using random numbers to select additional animals to be culled from male and female age classes to make the totals are correct.
 - d. Using the rounded numbers from the previous step and adding the numbers in the supplementary vector, the final age-specific offtake is calculated and deducted from the numbers in each age class of the population. The result is close to what would happen in practice: a few mature males get included in each culling operation and the individual selection from the older female age classes is determined randomly.

4. Using the above methodology, it was found that an offtake of 3% of the population is sufficient to stabilise numbers. This percentage may seem low when taken from a population which, in the absence of culling, would increase at a rate of 4.6% per annum. The explanation lies entirely in the preponderance of females in the annual offtake.

At the start of the annual culling regime the population increases slightly reaching a maximum of about 1,200 animals after 30-35 years. Thereafter it declines slowly returning to 1,000 animals after about 100 years and taking over 1,000 years to become extinct. Within any practical time span, the population is effectively regulated at 1,000 animals. Because of the inclusion of a random number component in the model no two runs are identical and, in order to derive financial values for the products from culling, average values over a run of 100 years were used.

5. It is assumed that 75% of all elephant calves between the ages of 2-8 years will be captured rather than killed. These would be sold to zoos and to approved local and regional buyers wishing to domesticate elephant or begin new wild populations.
6. The change in the age structure of the population caused by culling allows a greater percentage quota for trophy male hunting (see previous section on the effects of hunting both males and females). A quota of 1% of the total population is easily sustainable and results in some adult males surviving almost to the age at which they would die naturally (50 years).

Over any length of time, this increase in the quota does not result in a higher overall number of trophy males than the situation where the only management is a hunting quota of 0.5% being applied to a population growing at 4.56% annum. In the table shown on page 88, a total of 869 trophy bulls would be taken over 50 years from the population which is growing normally. In the population regulated by culling, the annual trophy hunting quota becomes stable (about 11 animals per annum in the first 50 years) and results in a total offtake of 586 bulls over 50 years.

7. To calculate the values of ivory, skin and meat obtained from the culling operation, the following formulae were used for males and females of specific ages –

Ivory Weight of two tusks –

$$\text{♂♂} \quad I_{\text{Age}} = 1.88 (0.1 + 0.2 (\text{Age} - 2.5)^{1.2937}) \text{ kg}$$

$$\text{♀♀} \quad I_{\text{Age}} = 1.88 (0.1 + 11 (1 - e^{-0.016 (\text{Age} - 2.5)^{1.2742}}) \text{ kg}$$

The multiplier for two tusks (1.88) is from Rodgers (*et al* 1978) and the formulae for the weight of one male and one female tusk are based on Pilgrim & Western (1986).

$$\text{Price/kg} = \text{US\$} (50 + 110 \cdot I_{\text{Age}}^{0.5})$$

Body weights

$$\text{♂♂} \quad W_{\text{Age}} = 5,200 (1 - e^{0.006 (\text{Age} + 1.5)^{1.7}}) \text{ kg}$$

$$\text{♀♀} \quad W_{\text{Age}} = 3,500 (1 - e^{0.00892 (\text{Age} + 1.5)^{1.7}}) \text{ kg}$$

Dressing out percentage = 33% (wet weight); Price/kg wet meat = **US\$1.00**

Skin weight (dry, both sexes)

$$S_{\text{Age}} = 0.373 W_{\text{Age}}^{0.67}$$

Price/kg dry skin = **US\$5**

The table below gives the results of the management programme averaged over 100 years. It is assumed that markets for all products are operating normally.

FINANCIAL VALUE OF ELEPHANT MANAGEMENT PROGRAMME

Assumed values (all figures in US\$)

Area	1,000	km ²	Exchange rate 1US\$ = N\$	6.21	
Elephant population	1,000	animals			
Trophy male quota	1.0	% of total population per year	=	10	animals
Culling quota	3.0	% of total population per year	=	30	animals
Culling cost US\$	300	per animal			
Calf capture US\$	300	per animal (2-8 years old)			
Selling price for calves US\$	1,000	per animal			
Capture success	75	% of animals 2-8 years old			
Price of skin US\$	5	per kg (assumes markets operating)			
Dressing out percentage	33	% of body weight			
Meat value US\$	1	per kg (wet weight)			

Age-specific tusk weights, ivory prices, body weights and skin weights as per formulae on previous page

Sport hunting values as per table on page 89

Sport hunting		Overall Net Income	
Gross income	305,569	Sport hunting	272,781
Operating costs	32,788	Culling	60,560
Net income	272,781	Overall Net Income	333,341
		Return/hectare	3.33
		= N\$	20.70
Culling			
Ivory	38,350		
Calf sales	14,630		
Meat	12,696		
Skin	5,768		
Gross income	71,444		
Operating costs	10,884		
Net income	60,560		

Trophy hunting quotas

The population model described in the subsection on **Reproduction and Population Dynamics** in the main body of the report has been used to test the effects of different levels of trophy male hunting quotas on the age structure of an elephant population.

Tests were carried out on a population set initially at 1,000 animals with a growth rate of 4.56% (see page 7). The population was allowed to increase to 10,000 animals (taking about 50 years) with the hunting regime in place and, when the population reached 10,000 animals, the age structure was recorded. It was assumed that the age of maximum longevity was 50 years and no animals younger than 30 years of age would be taken as trophies.³⁸ A hunting selectivity of 25% for animals with larger tusks was used in the model. The selectivity was applied as follows –

- (1) The proportion which each age class forms of the total number of huntable age classes is calculated:

$$P_a = 100 / (\text{No. of age classes}) = 100/21 = 4.76 \%$$

For zero selectivity, each age class would contribute this proportion of whatever quota was set.

- (2) The actual proportion expected to be contributed by the oldest age class (50 years) is then calculated as –

$$P_{50} = P_a + S \cdot (100 - P_a) = 4.76 + 0.25 (100 - 4.76) = 28.57 \%$$

– where S is the selectivity expressed as a fraction.

- (3) The next age class (49 years) contributes –

$$P_{49} = (100 - P_{50}) \cdot (1 + S \cdot N_R) / (N_R + 1) = (100 - 28.57) \cdot (1 + 0.25 \times 19) / 20 = 20.54 \%$$

– where N_R is the number of age classes remaining

- (4) The next age class (48 years) contributes –

$$P_{48} = (100 - P_{50} - P_{49}) \cdot (1 + S \cdot N_R) / (N_R + 1) = (100 - 49.11) \cdot (1 + 0.25 \times 18) / 19 = 14.73 \%$$

- (5) This process is continued until an expected proportion has been calculated for each of 21 age classes (the values are shown in the table on page 95). As hunting pressure is increased, it is not possible for the upper age classes to supply the number of animals demanded and so the required quota is progressively transferred to lower age classes until it has been satisfied.

Hunting quotas from zero to 0.8% of the total population were tested: a quota exceeding 0.7% of the population results in the removal of all males older than 30 years. The results are shown in the table on page 95 and in **Fig. 21** (page 61) in the main report. The ‘optimum’ quota is about 0.5% which allows some males in the population to reach an age of 40 years.

38. The average tusk weight for a 30 year old male is slightly less than 15kg (Pilgrim & Western 1986) which is too small to interest the majority of sport hunters.

Effects of hunting females in addition to males

The arguments against including females in sport hunting quotas are presented in the main report (page 59). In this section, we examine the maximum sustainable limits to female hunting quotas and the effects on the population age structure and growth rate.

Using the same population model (Martin 2000), a range of female hunting quotas was tested under the following background conditions –

- (i) A fixed quota of 0.5% of the population for male trophies was present in all tests;
- (ii) Hunting was limited to females aged 25 years and older;
- (iii) A slight selectivity (10%) for females with larger tusks was in place (calculated in the same way as for males);
- (iv) As for male hunting quotas, the female quota was applied to a starting population of 1,000 animals and the population was allowed to increase to 10,000 animals to achieve a stable age distribution. All results shown in the table overleaf were measured when the population first exceeded 10,000 animals.

With the level of selectivity chosen, female hunting quotas of up to 0.5% of the total population allow some females to reach the terminal age of 50 years old. As might be expected, the population growth rate decreases with the increase in the level of hunting and the age structure becomes skewed towards males. However, the change is very slight up to a 0.5% quota. Beyond 0.5%, the upper female age classes start to disappear and, at a quota of 1.3% of the population, no animals survive beyond 25 years old. At this level the number of animals demanded exceeds the recruitment into the 25 year old age class and is effectively unsustainable. The maximum quota which can be tolerated is 1.2% – which results in all females older than 30 years of age disappearing from the population and reduces the population growth rate to 1.56%.

The effect on the population age structure with a female hunting quota greater than 0.5% is striking. For the given number of animals (10,000), the number of males in the upper age classes increases markedly, notwithstanding the fact that males are being hunted at the level of 0.5% (the optimum quota determined from the previous analysis). When females were not being hunted, a quota of 0.5% for males results in all males 40 years and older being eliminated from the population. If, however, females are hunted at the maximum sustainable level of 1.2%, all male age classes are restored and, in a population of 10,000 animals, 16 males survive to the age of 50 years old. This result is counterintuitive but it is the outcome which must occur as the population age structure redistributes itself to accommodate the hunting pressures.

It raises the obvious question that, if hunting females causes an increase in the number of males in the older age classes, can a higher quota of trophy males be taken? The answer is, technically, “yes”. The sustainable male quota can be more than doubled when females are hunted at a level of 1.2% (see table on the next page). This is a surprising result – which effectively says **“the more females you hunt, the more trophy males you will get !”**. It is caused by managing elephants for a ‘younger’ age distribution. It is stressed that this is not a recommended management strategy – it ignores many other factors unrelated to population dynamics.

Response of the adult male age structure of a population to various levels of hunting quotas

Q – Quota (% of total population)								N – Number actually hunted								Total population 10,000								Selectivity 25%			
AGE CLASSES (years)																											
Q	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Males	N				
0.0	57	60	57	53	48	48	47	48	43	35	39	38	39	34	34	31	31	26	18	12	6	4,994	0				
0.1	61	56	57	53	51	50	48	46	44	46	40	39	31	35	32	25	24	20	14	7	2	4,971	10				
0.2	60	57	56	53	48	48	48	43	43	40	39	39	37	32	31	27	20	17	11	5	1	4,948	20				
0.3	66	60	57	48	48	48	46	48	45	40	42	34	28	25	22	17	12	7	3	1	0	4,908	30				
0.4	65	55	58	57	51	47	46	43	39	35	26	20	14	8	3	0	0	0	0	0	0	4,853	39				
0.5	68	61	59	52	46	38	29	22	14	6	0	0	0	0	0	0	0	0	0	0	0	4,760	48				
0.6	67	58	44	29	14	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,671	59				
0.7	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,574	69				
0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,556	68				
	0.02	0.03	0.04	0.06	0.10	0.14	0.21	0.31	0.45	0.65	0.94	1.34	1.91	2.70	3.81	5.37	7.53	10.55	14.73	20.54	28.57	Selectivity %					
	14.7	15.3	16.0	16.7	17.5	18.2	18.9	19.6	20.4	21.1	21.8	22.6	23.4	24.1	24.9	25.7	26.4	27.2	28.0	28.8	29.6	Tusk wt. kg					

Effects of hunting both males and females

FEMALES			MALES				
Q_f	R_g	A_f	Q_m	R_g	A_m	Population	N
0.1	4.49	50	0.5	1.51	50	10,025	50
0.2	4.41	50	0.6	1.55	50	10,025	60
0.3	4.31	50	0.7	1.67	50	10,038	70
0.4	4.17	50	0.8	1.85	46	10,167	81
0.5	4.01	50	0.9	1.98	41	10,080	91
0.6	3.76	49	1.0	2.12	36	10,200	102
0.7	3.47	45	1.1	2.24	31	10,011	110
0.8	3.17	42	1.2	2.27	29	10,144	122
0.9	2.81	39					
1.0	2.44	36					
1.1	2.03	33					
1.2	1.56	29					
1.3	1.23	24					

Female hunting: Q_f – Quota (% of total population) R_g – Rate of population growth % A_f – oldest surviving female age class

Selectivity – 10%, No females < 25 years old hunted

Fixed male hunting quota – 0.5% of total population

Male hunting: Q_m – Quota (% of total population) R_g – Rate of population growth % A_m – oldest surviving male age class

Selectivity – 25%, No males < 30 years old hunted

Fixed female hunting quota – 1.2% of total population

BIBLIOGRAPHY AND REFERENCES

Numerous people have kindly contributed to this bibliography and not all of the papers listed below have been read by the author.

Van Aarde, R.J., W. Kilian, N. Brain and W. Versfeld (2003). **Population Dynamics of Savanna Elephants in Etosha National Park, Namibia.**

AfrESG (1998). **African Elephant Data Base 1998.** Occasional Paper No.22 of the IUCN Species Survival Commission (African Elephant Specialist Group: R.F.W. Barnes, G.C. Craig, H.T. Dublin, G. Overton, W. Simons and C.R. Thouless), 250pp.

AfrESG (2002). **African Elephant Status Report 2002.** Report of the African Elephant Specialist Group, IUCN Species Survival Commission.

Alexander, Sir J.E. (1838). **An Expedition of Discovery into the Interior of Africa, through the hitherto undescribed countries of the Great Namaquas, Boschmans and Hill Damaras.** Henry Colburn, London.

Andersson C.J. (1856). **Lake Ngami; or, Explorations and Discoveries during Four Years' Wanderings in the Wilds of South Western Africa.** Second Edition, Hurst and Blackett, London.

Anderson G.D. (1973). **Vegetation composition and elephant damage in the major habitat types of the Sengwa Wildlife Research Area of Rhodesia.** MSc thesis, University of Rhodesia.

Ansell W.F.R (1974). **Order Proboscidea**, Part II, pp1-5. In: *The Mammals of Africa: an identification manual*. Eds. J. Meester and H.W. Setzer. Smithsonian Institution Press, Washington D.C.

Ashley, C. & C. LaFranchi (1997). **Livelihood strategies of rural households in Caprivi: implications for conservancies and natural resource management.** Discussion Paper No. 20, Directorate of Environmental Affairs, Ministry of Environment and Tourism, Windhoek, Namibia.

Ashley, C. & C.E. O'Connell (1998). **Can the financial benefits of wildlife outweigh the costs for Caprivi households ?** In: Barnard, P. (Ed.). *Biological Diversity in Namibia – A Country Study*. Namibian National Biodiversity Task Force, Windhoek. 268pp.

Baines, T.R. (1864). **Explorations in South-West Africa, being an account of a journey in the years of 1861 and 1862 from Walvisch Bay, on the western coast to Lake Ngami and the Victoria Falls.** Longman, Green, Longman, Roberts and Green, London.

Barnes, J.I. (1995). **The value of non-agricultural land use in some Namibian communal areas: a database for Planning.** DEA Research Discussion Paper No. 6, Directorate of Environmental Affairs, Ministry of Environment and Tourism, Windhoek, Namibia.

Barnes J.I. & J.L.V. de Jager (1995). **Economic and financial incentives for wildlife use on private land in Namibia and the implications for policy.** Research Discussion Paper Number 8, Directorate of Environmental Affairs, Ministry of Environment and Tourism, Namibia. 20pp

Barnes J.I. (2001). **Economic returns and allocation of resources in the wildlife sector of Botswana.** South African Journal of Wildlife Research 31(3&4): 141-153

Barnes R.F.W. (1983). **The elephant problem in Ruaha National Park (Tanzania).** Biol. Cons. 26: 127-148

- Barnes R.F.W. (1985). **Woodland changes in Ruaha National Park (Tanzania) between 1976 and 1982.** Afr. J. Ecol. 23: 215-221
- Bell R.H.V. (1986a). **The man-animal interface: an assessment of crop damage and wildlife control.** In: *Conservation and Wildlife Management in Africa*. Proc. Workshop sponsored by the US Peace Corps, Kasungu National Park, Malawi. Edited by R.H.V. Bell and E. McShane-Caluzi. Peace Corps, Washington, 1986.
- Bell R.H.V. (1986b). **Monitoring illegal activity and law enforcement in African conservation areas.** In: *Conservation and Wildlife Management in Africa*. Proc. Workshop sponsored by the US Peace Corps, Kasungu National Park, Malawi. Edited by R.H.V. Bell and E. McShane-Caluzi. Peace Corps, Washington, 1986.
- Best, A.A. & T.G.W. Best (1977). **Rowland Ward's Records of Big Game.** XVII Edition (Africa), Rowland Ward Publications Ltd., Sussex, England.
- Bigalke R.C. (1958). **On the present status of ungulate mammals in SWA.** Mammalia 22: 478-497. *Original not seen: in Lindeque (1988)*
- Brown, C.J. (2000). **Historic Distribution of Large Mammals in the Gondwana Canyon Park area of southern Namibia.** Unpublished report, Namibia Nature Foundation. 7pp + 1 table
- Brown, C.J. (2004). **Namibia's Conservation Paradigm: use to conserve versus protect to conserve.** Unpublished discussion paper, Namibia Nature Foundation. 4pp + 3 figures
- Brown, C. and B. Jones (1994). **A strategic community-based environmental and development plan.** Internal Report, Directorate of Environmental Affairs, Ministry of Environment and Tourism, Windhoek, Namibia: pp1-41
- Calef G.W. (1988). **Maximum rate of increase in the African elephant.** Afr. J. Ecol. 26: 323-327.
- Caughley G. (1976). **The elephant problem – an alternative hypothesis.** E.Afr.Wildl.J. 14: 265-283
- Charif, R.A., R.R. Ramey II, W. Langbauer Jr., R.B. Martin and L.M. Brown (2004). **Spatial relationships and matrilineal kinship in African elephant clans.** In press.
- Chase, M.J. & C.R.Griffin (2003). **The population status, ecology and movements of elephant populations in northern Botswana.** Final Project Year End Report to US Fish and Wildlife Service.
- Chase M.J. & C.R. Griffin (2004). **Elephant distribution and abundance in the Luiana Partial Reserve, Angola: Results of an aerial survey in January 2004.** Final Report submitted to the Angola Ministry of Urbanisation and Environment. 8 pages
- Chase M.J., C.R. Griffin & E. Mwiya (2004). **Elephant distribution and abundance in Sioma Ngwezi National Park, Zambia: Results of an aerial survey in 2004.** Final Report submitted to the Zambian Wildlife Authority. 12 pages
- Corbett, Andrew & Brian T.B. Jones (2000). **The Legal Aspects of Governance in CBNRM in Namibia.** Directorate of Environmental Affairs Research Discussion Paper Number 41, October 2000, Ministry of Environment and Tourism, Republic of Namibia. 25pp
- Coulson I.C. (1992). **Elephants and vegetation in the Sengwa Wildlife Research Area.** . Appendix 4 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp

- Craig, G.C. (1984). **Foetal mass and date of conception in African elephants: a revised formula.** S. Afr. J. Sci. 80: 512-516
- Craig G.C (1992). **Population dynamics of elephants.** Appendix 8 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp
- Craig G.C (1992). **A simple model of elephant/tree equilibrium.** Appendix 10 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp
- Craig, G.C. (1997). **The ELESMAF project.** Namibia Nature Foundation, Namibia.
- Craig, G.C. (1998). **Aerial Survey of Northern Namibia.** Survey carried out for Directorate of Scientific Services, Ministry of Environment and Tourism, Republic of Namibia.
- Craig, G.C. (2000). **Aerial Survey of North Western Namibia.** Survey carried out for Directorate of Scientific Services, Ministry of Environment and Tourism, Republic of Namibia.
- Cumming D.H.M, M.B. Fenton, I.L. Rautenbach, R.D. Taylor, G.S. Cumming, M.S. Cumming, J.M. Dunlop, G.A. Ford, M.D. Hovorka, D.S. Johnston, M. Kalcounis, Z. Mahlangu and C.V.R. Portfors (1997). **Elephants, woodlands and biodiversity in southern Africa.** S.Afr.J.Sci. 93: 231-236
- Cumming D.H.M. & G.S. Cumming (2003). **Ungulate community structure and ecological processes: body size, hoof area and trampling in African savannas.** Oecologia 134: 560-568
- Cumming, D. H. M. (2005) **Wildlife, Livestock and Food Security in the South-East Lowveld of Zimbabwe.** In: Proceedings of the Southern and East African Experts Panel on Designing Successful Conservation and Development Interventions at the Wildlife/Livestock Interface: Implications for Wildlife, Livestock, and Human Health. IUCN Occasional Paper, AHEAD (Animal Health for the Environment And Development) Forum, IUCN Vth World Parks Congress, Durban, South Africa, September 14th and 15th, 2003
- Douglas-Hamilton I.D.H. (1972). On the ecology and behaviour of the African elephant. D.Phil. Thesis, University of Oxford.
- DSS (2002a). **Aerial Survey Summary (1968 - 2001).** Compiler: Uatjavi Uanivi, Directorate of Scientific Services, Ministry of Environment and Tourism, Republic of Namibia. 54pp
- DSS (2002b). **Air Survey of Mahango National Park, October 2002.** Compiler: Uatjavi Uanivi, Directorate of Scientific Services, Ministry of Environment and Tourism, Republic of Namibia. 3pp
- Du Toit J.T (2005). **Understanding elephants as agents of heterogeneity in Kruger.** Executive Summary prepared for South African National Parks Elephant Management Workshop, March 2005.
- Dunham K.M. (1988). **Demographic changes in the Zambezi Valley elephants (*Loxodonta africana*).** J. Zool. 215: 382-388
- Ferreira S., A. Shrader, W. Killian and N. Brain (2003). **The Dynamics of Savanna Elephants in Etosha National Park, Namibia.** Progress Report January-August 2003, US Fish and Wildlife Service.
- Fisch, Maria (1999). **The Caprivi Strip during the German colonial period 1890-1914** (with a chapter on the boundary dispute up to the present). Out of Africa Publishers, Windhoek. 151pp
- Fischer A. (1914). **Menschen und tiere in Duetsch-Suedwestafrika.** Duetsche Verlag, Stuttgart. *Original not seen: in Lindeque (1988)*

- Graham A.D. & R.H.V. Bell (1969). **Factors influencing the countability of animals.** East African Agricultural Forestry Journal 24 (Special Issue): 38-43.
- Graham A.D. (1973). **The Gardeners of Eden.** George Allen and Unwin, London.
- Griffin C.R. & M.J. Chase (2004). **Elephant distribution and abundance in the Caprivi Strip: Results of an aerial survey in 2003.** Draft Final Report, January 20, 2004, submitted to the Ministry of Environment and Tourism, Namibia. 11 pages and 5 figures
- Hahn, H.S. (1925). **Big Game: Distribution in Ovamboland.** Report to the Secretary for South West Africa from the Officer in Charge of Native Affairs, Ondonga, 10th September 1925. 36pp
- Hall-Martin A.J. (1980). **Elephant survivors.** Oryx 15:355-362
- Hanks J. (1972). **Reproduction of elephant, *Loxodonta africana*, in the Luangwa Valley, Zambia.** J. Reprod. Fert. 30:13-26
- Hilborn, R. & D. Ludwig (1993). **The limits of applied ecological research.** Ecological Applications 3(4): pp550-552.
- Holling C.S. (1976). **Adaptive Environmental Assessment and Management.** John Wiley, New York.
- Holling C.S. (1993). **Investing in research for sustainability.** Ecological Applications 3(4): pp552-555.
- Holling C.S. & Gary K. Meffe (1996). **Command and Control and the Pathology of Natural Resource Management.** Conservation Biology 10(2); pp328-337
- ITRG (1989). **The ivory trade and the future of the African elephant.** Report from a group assembled by the chair of the African Elephant Specialist Group. Published in Oxford, 2 volumes, 700pp.
- Jachmann H. (1998). **Monitoring illegal wildlife use and law enforcement in African savanna rangelands.** Published by The Wildlife Resource Monitoring Unit, Lusaka. 124pp
- Jones, B. (1990). **The challenge of Caprivi.** African Wildlife 42: 94-99.
- Kilian W. (2004). **Mortality data for Etosha Elephant.** Records from the Etosha Ecological Institute, Ministry of Environment and Tourism, Namibia.
- Kingdon J. (1971). **East African Mammals.** Vol. IIB, Large Mammals. Academic Press London.
- Kruger, C.E. (1984). **A history of the Caprivi.** Unpublished manuscript, National Archives, Windhoek. In: Fisch (1999).
- Laws R.M. (1966). **Age criteria for the African elephant, *Loxodonta africana*.** E. Afr. Wildl. J. 4: 1-37
- Laws R.M., I.S.C. Parker and R.C.B. Johnstone (1975). **Elephants and their habitats: the ecology of elephants in North Bunyoro, Uganda.** Clarendon Press, Oxford.
- Leslie, P.H. (1984). **Some Further Notes on the Use of Matrices in Population Analysis.** Biometrika 35: 213-245.
- LIFE (2002). **Game Population Estimates for Nyae Nyae Conservancy, January 2002.** Annex One of an annual report on Nyae Nyae Conservancy from the WWF LIFE programme, Windhoek, Namibia
- Lindeque, M. (1988). **Population dynamics of elephants in Etosha National Park, SWA/Namibia.** PhD thesis, Univ. Stellenbosch.
- Lindeque M. (1991). **Age structure of the elephant population in the Etosha National Park, Namibia.** Madoqua 18(1): 27-32

- Lindeque, M. (1993a). **Namibia elephant conservation and management plan**. Internal report, Ministry of Environment and Tourism, Windhoek, Namibia.
- Lindeque, M. (1993b). **National policy for elephants in Namibia**. Internal report, Ministry of Environment and Tourism, Windhoek, Namibia.
- Lindeque, M. (1995). **Conservation and management of elephants in Namibia**. *Pachyderm* 19: 49-53.
- Lindeque, M. & P.M. Lindeque (1991). **Satellite tracking of elephants in north-western Namibia**. *Afr. J. Ecol.* 29: 196-206.
- Loutit, R. (2004). **Elephants in the North-West – Kunene Region (formerly Damaraland and Kaokoland)**. Written communication to the author. 4pp
- MacDonald D. (2001). **The New Encyclopedia of Mammals**. Oxford University Press, Oxford. 930pp
- Mace G.M. & R. Lande (1991). **Assessing extinction threats: towards a re-evaluation of IUCN threatened species categories**. At the time referred to in the report, this document had been submitted to *Conservation Biology* and was 'in press'.
- Martin R.B. (1974). **Structure, biomass and utilisation of vegetation in the mopane and miombo woodlands of the Sengwa Wildlife Research Area**. Certificate in Field Ecology dissertation, University of Rhodesia.
- Martin R.B. (1986). **Establishment of African ivory export quotas and associated control procedures**. Consultancy for the CITES Secretariat, 1985. In: *African Elephants, CITES and the Ivory Trade*, R.B. Martin, J.R. Caldwell and J.G. Barzdo. Publ. Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, Lausanne, Switzerland.
- Martin R.B. (1987). **Field records for immobilised elephant**. Data sheets for 210 elephants immobilised in Zimbabwe.
- Martin R.B. (1992a). **Relationship between elephant and canopy tree cover**. Appendix 9 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp
- Martin R.B. (1992b). **Maximum likelihood analysis of the elephant population estimates for Matabeleland North, Zimbabwe**. Appendix 11 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp
- Martin R.B. (1993). **Should Wildlife Pay Its Way ?** Keith Roby Memorial Address. Murdoch University, Western Australia, December 1993.
- Martin R.B. (1999a). **Commercial uses of wildlife, control systems and sustainability**. Paper presented at the Second International Wildlife Management Congress, 28 June - 2 July 1999, Gödöllő, Hungary. 44pp
- Martin R.B. (1999b). **Adaptive Management: The Only Tool for Decentralised Systems**. Paper presented at a Norway/UN Conference titled *The ecosystem approach for sustainable use of biological diversity* held in Trondheim, Norway, 6-10th September 1999. 14pp
- Martin R.B. & M.A. Jones (2000a). **Wildlife Development on Nakavango and Ursula**. Consultancy carried out for Aujan Southern Africa Developments (Pvt) Ltd., March 2000

- Martin, R.B. (2000b). **A spreadsheet model for simulation of elephant population dynamics.** Unpublished work prepared for general use by elephant managers.
- Martin, R.B. (2002). **Species Report for Southern Savanna Buffalo.** Study conducted in support of *The Transboundary Mammal Project* of the Ministry of Environment and Tourism, Namibia facilitated by The Namibia Nature Foundation and the World Wildlife Fund LIFE Programme (Living in a Finite Environment). 97pp
- Martin R.B. (2003a). **Conditions for Effective, Stable and Equitable Conservation at the National Level in Southern Africa.** Paper presented at a Workshop titled *Local Communities, Equity and Protected Areas* held from 26-28th February in Pretoria, South Africa, hosted by The Programme for Land and Agrarian Studies (PLAAS), Africa Resources Trust (ART) and IUCN. 23pp
- Martin, R.B. (2003b). **Species Report for Roan, Sable and Tsessebe.** Study conducted in support of *The Transboundary Mammal Project* of the Ministry of Environment and Tourism, Namibia, facilitated by the Namibia Nature Foundation and the World Wildlife Fund LIFE Programme (Living in a Finite Environment). 96pp
- Martin, R.B. (2004a). **The Wetland Grazers: Species Report for Reedbuck, Waterbuck, Lechwe and Puku.** Study conducted in support of *The Transboundary Mammal Project* of the Ministry of Environment and Tourism, Namibia facilitated by The Namibia Nature Foundation and the World Wildlife Fund LIFE Programme (Living in a Finite Environment). 96pp
- Martin, R.B. (2004b). **Elephants and People.** PowerPoint Presentation for global distribution on Namibian elephant policy. Ministry of Environment and Tourism, Namibia, August 2004.
- Martin R.B. (2005). **Patterns of Movement of Elephant in the Sengwa Wildlife Research Area of Zimbabwe.** Ph.D. (in preparation), University of Zimbabwe.
- Mendelsohn, John & Carole Roberts (1997). **An Environmental Profile and Atlas of Caprivi.** Directorate of Environmental Affairs, Ministry of Environment and Tourism, Republic of Namibia. 45pp
- Moss C. (1976). **Portraits in the Wild: Animal Behaviour in East Africa.** Hamish Hamilton, London.
- Moss C. (2000). **Elephant Memories.** University of Chicago Press, Chicago.
- MET (2004). **Additional perspectives on Namibia's proposal to CITES COP 13 to amend the annotation regarding the Namibian population of *Loxodonta africana*.** Supplementary document submitted to the CITES Parties at the 13th Conference of the Parties in Bangkok, Thailand, November 2004. 5pp
- Murindagomo F. (1992). **Rates of tree loss and regrowth of *Brachystegia* woodland.** Appendix 7 in *Elephant management in Zimbabwe*. Eds R.B. Martin, G.C. Craig, V.R. Booth and A.M.G. Conybeare. Department of National Parks and Wild Life Management, Zimbabwe. 124pp
- Murphree, Marshall W. (2000). **Boundaries and Borders: The Question of Scale in the Theory and Practice of Common Property Management.** Paper presented at the Eighth Biennial Conference of the International Association for the Study of Common Property (IASCP), Bloomington, Indiana, USA 31 May-4 June 2000.
- Nelson, E. (1926). **Distribution of Game in South West Africa.** Government Report from the Game Warden of Namutoni Game Reserve, 23rd March 1926.

- NNF (2004). **Annual Audit (Event book) database**. Conservancy natural resource monitoring data provided to the consultant by Simon Mayes.
- O'Connell-Rodwell, Caitlin E., Timothy Rodwell, Matthew Rice and Lynette A. Hart (2000). **Living with the modern conservation paradigm: can agricultural communities co-exist with elephants ? A five-year case study in East Caprivi, Namibia**. Biological Conservation 93: 381-391.
- O'Connell, C.E. (1995a). **East/West Caprivi Natural Resources Monitoring Project: Elephant/Human Conflicts**. Final Technical Report. Ministry of Environment and Tourism, Namibia, Namibia Nature Foundation. USAID/WWF
- O'Connell, C.E. (1995b). **Elephant/human conflicts: a management recommendation for Namibia**. Internal report, Ministry of Environment and Tourism, Windhoek, Namibia. USAID/WWF.
- Owen-Smith, G. & M. Jacobsohn (1988). **The Eastern Caprivi: a situation report May 1988**. Internal report, Endangered Wildlife Trust, Johannesburg.
- Owen-Smith, G (2002). **The satellite collaring of elephants at Purros**. Report circulated in Namibia by IRDNC, October 2002. 11pp
- Owen-Smith, N. (1989). **Megafaunal extinctions: the conservation message from 11,000 years B.P.** Conservation Biology 3(4): pp405-412.
- Owen-Smith, N. (2005). **1. Ecosystem Resources influencing elephant populations. 2. Vegetation consequences for biodiversity. 3. Biodiversity. 4. Surface water**. Executive Summaries prepared for South African National Parks Elephant Management Workshop, March 2005.
- Parker I.S.C. (1979). **The ivory trade**. Consultant report for U.S. Fish and Wildlife Service. - 6 vols.
- Parker I.S.C. (1984). **Rainfall, Geology, Elephants and Men**. In the *Extinction Alternative*: Proceedings of an International Symposium, Endangered Wildlife Trust, Johannesburg: 137-177
- Parker I.S.C. & M. Amin (1983). **Ivory Crisis**. Chatto and Windus, London.
- Parker I.S.C & A.D. Graham (1989). **Men, elephants and competition**. Symp. Zool. Soc. Lond. 61:241-252
- Parker I.S.C (2004). **What I tell you three times is true: conservation, ivory, history and politics**. Librario Publishing Ltd., Kinloss, Scotland. 414pp
- Payne K. (1998). **Silent Thunder in the Presence of Elephants**. Simon and Schuster, New York.
- Pilgrim T. & D. Western (1986). **Inferring hunting patterns on African elephants from tusks in the international ivory trade**. Journal of Applied Ecology 23: 503-514.
- Poole J.H. (1982). **Musth and male-male competition in the African elephant**. PhD thesis. University of Cambridge.
- Poole J.H. (1987). **Rutting behaviour in African elephants: the phenomenon of musth**. Behavior 102:283-316.
- Poole J.H. (1989). **Announcing intent: the aggressive state of musth in African elephants**. Animal Behaviour 37:140-152.
- Poole J.H. (1996). **Kenya's initiatives in elephant fertility regulation and population control techniques**. Pachyderm 16:62-65.

- Poole J.H. (1996). **Coming of Age with Elephants**. Hyperion Press, New York; Hodder & Stoughton, London.
- Poole J.H. (1997). **Elephants**. Colin Baxter Photography, Grantown-on-Spey, Scotland.
- Poole J.H. (1998). **An exploration of a commonality between ourselves and elephants**. Special Issue, *Etica and Animal* 9: 85-100.
- Poole J.H. & C.J. Moss (1988). **Musth in the African elephant *Loxodonta africana***. *Nature* 292: 830-831.
- Poole J.H., K.B. Payne, W.B. Langbauer Jr, and C.J. Moss (1988). **The social contexts of some very low frequency calls of African elephants**. *Behavioural Ecology and Sociobiology* 22: 385-392.
- Poole J.H. & A.P. Dobson (1992). **Ivory: Why the ban must stay !** *Conservation Biology* 6:149-151
- Rodgers W.A., J.D. Lobo & W.J. Mapunda (1978). **Elephant control and legal ivory exploitation in Tanganyika from 1920-1977**. In: Parker (1979). Typescript 31pp
- Rodwell, Timothy (1995). **Caprivi Elephant Monitoring Project**. Draft Final Report (Oct 1992- Oct 1995). Ministry of Environment and Tourism, Windhoek, Namibia. USAID/WWF.
- Rodwell, T.C., J. Tagg and M. Grobler (1995). **Wildlife Resources in the Caprivi, Namibia: Results of an Aerial Census in 1994 and Comparisons with past Surveys**. Research Discussion Paper No. 9, Ministry of Environment and Tourism, Republic of Namibia. 29pp
- Ruitenbeek, Jack & Cynthia Cartier (2001). **The Invisible Wand: Adaptive Co-management as an Emergent Strategy in Complex Bio-Economic Systems**. Occasional Paper No.34, Centre for International Forestry Research, Bogor, Indonesia. 47pp
- Schlettwein C.H.G., R.E. Simmons, A. MacDonald and H.J.W. Grobler (1991). **Flora, fauna and conservation of East Caprivi wetlands**. *Madoqua* 17(2): 67-76.
- Scott Wilson (2000). **Environmental Assessment of Veterinary Fences in Ngamiland** – Summary Report. Consultants' Report to the Government of Botswana, Scott Wilson Resource Consultants in association with The Environment and Development Group (EDG). 106pp
- Short R.V. (1972). **Species differences**. In: *Reproduction in mammals: 4. Reproductive patterns*. Eds. C.R. Austin and R.v. Short, Cambridge University Press.
- Shortridge G.C. (1934). **The Mammals of South West Africa**. Vol I & II. William Heineman Ltd., London.
- Sikes S.K. (1966). **The African elephant, *Loxodonta africana*: a field method for the estimation of age**. *J. Zool. (Lond.)* 150: 279-295.
- Sikes S.K. (1968). **The African elephant, *Loxodonta africana*: a field method for the estimation of age**. *J. Zool. (Lond.)* 154: 235-248.
- Smithers, Reay H.N. (1983). **The Mammals of the Southern African Subregion**. University of Pretoria, Pretoria, RSA. 736pp
- Stander, 'Flip' (2004). **Aerial survey of the Nyae Nyae conservancy**. Report to World Wildlife Fund LIFE Programme (Living in a Finite Environment) and the Ministry of Environment and Tourism, Windhoek, Namibia

- Swanepoel C.M. & S.M. Swanepoel (1986). **Baobab damage by elephant in the middle Zambezi Valley, Zimbabwe.** Afr.J.Ecol. 24: 129-132.
- Tembo A. (1995). **A survey of large mammals in Sioma Ngwezi Park, Zambia.** African Journal of Ecology 33: 173-174.
- Thomson P.J. (1975). **The role of elephants, fire and other agents in the decline of a *Brachystegia boehmii* woodland.** J. S.A. Wildl. Mgmt. Assoc. 5(1): 11-18
- ULG (1994). **Aerial Census of Animals in the Caprivi Strip, Namibia, Dry Season 1994.** Consultants' Report to the Department of Wildlife and National Parks, Botswana. 21pp
- ULG (1995). **Final Report – Aerial Surveys.** Consultants' Report to the Department of Wildlife and National Parks, Botswana. ULG Consultants, Birmingham Road, Saltisford. Warwick CV34 4TT, England. 59pp
- UNDP (2005). **Strengthening the System of National Protected Areas.** Project of the Ministry of Environment & Tourism, Namibia, in preparation with the support of UNDP and the GEF (Oct 2004-Feb 2005). Three subprojects: 1: *Economic Analysis and Feasibility Study for Parks Financing*; 2: *Capacity Assessment for Parks Management in Conservation at Individual, Institutional & Systemic Levels* and 3: *Conservation Needs Assessment*.
- Viljoen P.J. (1987). **Status and past and present distribution of elephants in the Kaokoveld, South West Africa/Namibia.** S.Afr.J.Zool. 22, 247-257.
- Viljoen P.J. (1988). **The Ecology of the Desert-dwelling Elephants *Loxodonta africana* (Blumenbach 1797) of the western Damaraland and Kaokoland.** PhD thesis, University of Pretoria, South Africa.
- Viljoen P.J. (1989). **Spatial distribution and movements of elephants (*Loxodonta africana*) in the northern Namib Desert region of the Kaokoveld, South West Africa/Namibia.** J.Zool (Lon) 219: 1-9
- Viljoen P.J. & J. Du P. Bothma (1990). **Daily movements of desert-dwelling elephants in the northern Namib Desert.** S.Afr. Wildl. Res. 20: 69-72.
- Walker, Brian (1989): **Diversity and stability in ecosystem conservation.** In: *Conservation for the 21st Century*. Eds. D. Western and M. Pearl, Oxford University Press.
- Walters, C.J. (1986). **Adaptive Management of Renewable Resources.** McGraw-Hill, New York.
-