TRANSBOUNDARY SPECIES PROJECT

Background Study

HIPPOPOTAMUS

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The Transboundary Mammal Project

of the

Ministry of Environment and Tourism, Namibia

facilitated by

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CONTENTS

List of Appendices

List of Figures

List of Tables

PREFACE

This fifth background study in the Transboundary Mammal Project series has taken as much time as each of its predecessors despite hopes that it could have been wrapped up within a month. 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 of what is a most unusual large mammal.

There is more than one reason why the study has taken so long. In June I developed a population model for hippo using reproductive parameters given by a respected group of scientists in the mid-1960s and carried out a range of tests on the expected population responses to various management treatments. Quite by chance in mid-July I came upon several other papers written in the 1980s which discredited this earlier work and found myself forced to repeat the entire population modelling process. The present working environment in Zimbabwe is not conducive to productivity: in one week I managed less than 24 hours work because of electricity power cuts, fuel queues and a collapsing telephone system. And, lastly, I remain my own worst enemy when it comes to fast and slick consultancy work: if I find an academically challenging avenue for exploration I may end up spending days teasing out the answers to questions which probably have little impact on the final outcome.

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 benefited 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 study. In particular, I thank Chris Brown of the Namibia Nature Foundation, who continues to provide me with the space to explore interesting concepts and whose enthusiasm, support, drive and organising ability has resulted in the study coming to fruition. From the Ministry of Environment and Tourism I thank Malan and Pauline Lindeque (both for their professional opinions and personal hospitality), Ben Beytell (who spared time for me when he should have been recuperating from a medical operation), Mike Griffin (who I can always rely on for the historical record and larger conservation context), Peter Erb (who responds instantaneously to requests for information), John Barnes (whose economic studies have been quoted in each of these reports), Joe Tagg (who sees considerable value in hippo as producers of *sjamboks*) and Uatjavi Uanivi (who has always helped with survey data). I am indebted to John Mendelsohn whose outstanding Namibian Atlas data base has been central to all these studies and who always allows me to waste an hour of his time when visiting Windhoek. Mr Schumann (the retired Director of the Namibian Scientific Society) has assisted me on each of these studies with rich historical material despite not yet having seen any one of the finished reports. Without Flip Stander's excellent survey of the Caprivi hippo this study would have been entirely superficial and Simon Mayes at NNF has supplemented the survey data with numerous other valuable items.

1. BIOLOGICAL INFORMATION

a. Taxonomy (from MacDonald 2001)

The hippopotamus (*Hippopotamus amphibius* Linnaeus 1758) 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 100 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 southern landmass Gondwana became isolated from the northern continent at this time and the Atlantogenata (the Afro-Arabian group including the Afrotheria and Xenarthrans) evolved separately from the northern group of the Laurasiatheria, the Glires and the Euarchonta. These last two groups diverged from the Laurasiatheria in the mid-Cretaceous period. Further divergences took place amongst the Laurasiatheria before the end of the Cretaceous era, the first being the separation of pangolins and carnivores followed by the Perissodactyla (odd-toed ungulates) and bats. The progenitors of the modern Artiodactyla (even-toed ungulates) separated from the Cetacea (whales and dolphins) before the start of the Paleocene.

Within the Artiodactyla order, the suborders Tylopoda (camels and llamas) and Ruminantia (ruminants) separated from the suborder Suina during the mid-Eocene (34-55 million years ago), followed by the Suidae (pigs) and Tayassuidae (peccaries). The earliest recognisable hippo forebears date back to the Miocene (Smithers 1983) and it may have been that *Hippopotamus* and *Hexaprotodon* (the Pygmy Hippo – a separate genus) diverged at that time. No subspecies of *Hippopotamus* are currently recognised although Lydekker (1915) listed five and Ansell (1972) listed four.

The full taxonomy of the Hippopotamidae family is shown in **Fig.2** on the next page.

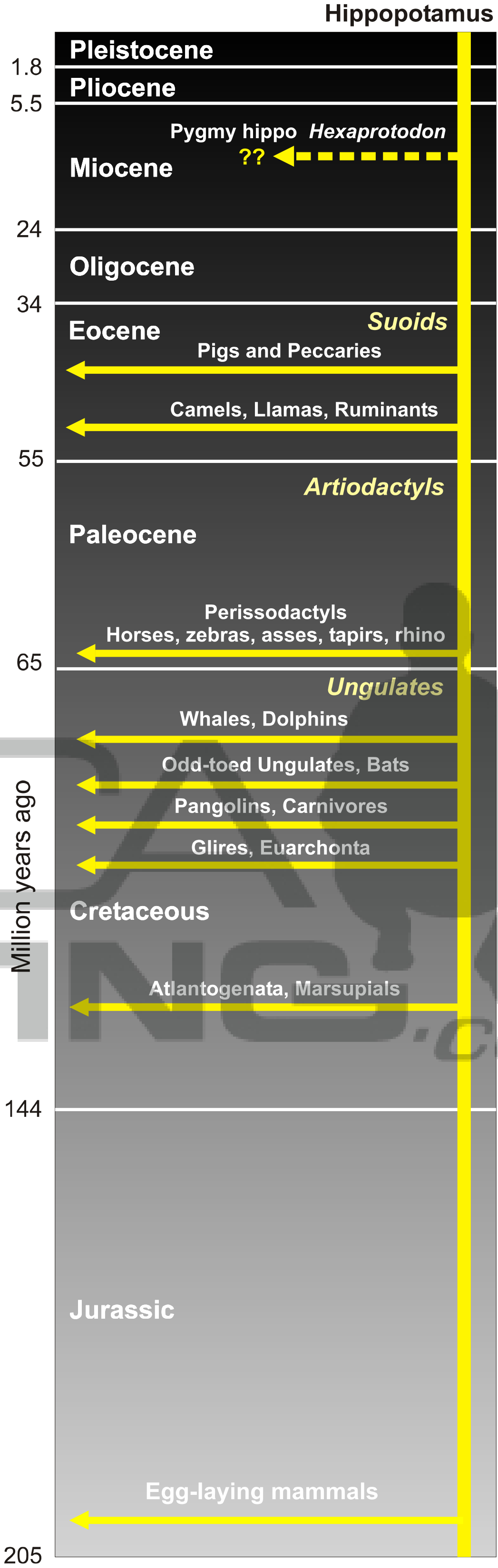


Figure 1: Evolution of Hippos

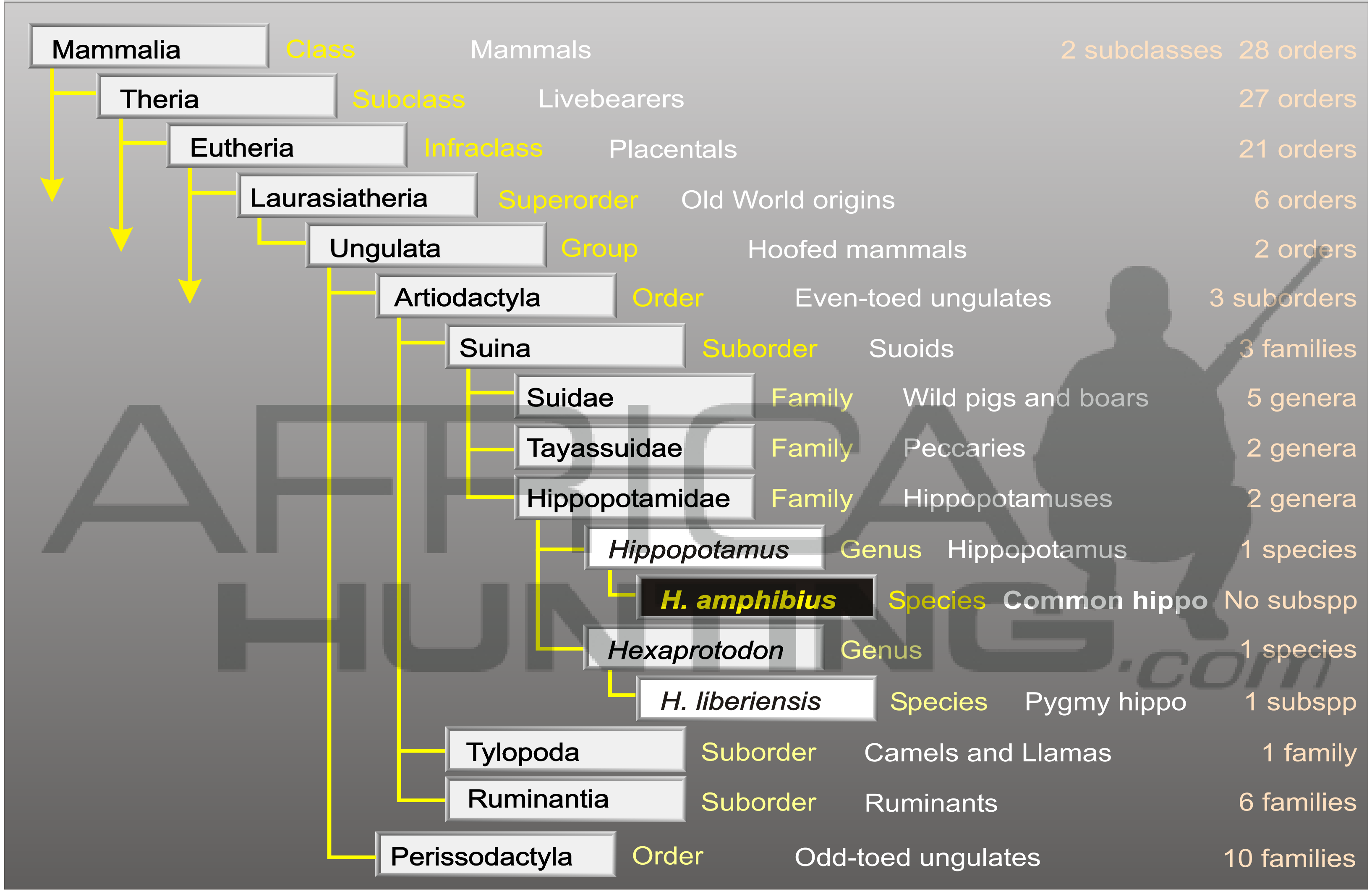


Figure 2: Taxonomy of the Artiodactyla

Other Artiodactyls for which management plans have been completed under the Transboundary Mammal Project are Buffalo, Roan, Sable, Tsessebe, Waterbuck, Red Lechwe, Reedbuck and Puku

b. Physical description

The common hippopotamus has a barrel-shaped body, smooth hairless skin and short stout legs. It is amongst the largest mammals with males achieving body weights greater than 2,500kg (Parker 2005). The tail is abbreviated and flattened with a sparse fringe of bristles at the tip.

The head is broad and massive with the eyes, ears and nostrils (which can be closed) on top of the skull – an adaptation to spending most of the time semi-submerged in water. The skin has a unique structure which causes a high rate of water loss when exposed to the air – a further reason for remaining in water during the day. The colour of the body skin is greyish-black with a pink tinge; the skin around the eyes and ears is pinkish-yellow and the gape of the mouth is flesh-coloured.

The alimentary canal of the hippo is able to break down the tough cellulose which makes up a large part of its diet. The stomach consists of 4 chambers which function like those of ruminants with micro-organisms fermenting and producing enzymes which break down cellulose (Arman & Field 1973). Hippos do not ‘chew the cud’ and are known as ‘pseudoruminants’. An ‘average’ hippo requires about 150kg of food (28 kg dry plant matter) daily (Pienaar *et al* 1966) which, although it may seem high, is less than 1.5% of their body weight and about half of that consumed by animals such as a white rhino.

The dentition of hippo is fully described by Laws (1968). The canines and incisors are enormously enlarged with the former being used exclusively for fighting and the latter primarily for digging. The lower canines are long and kept very sharp by continuous vertical wear against the short upper canines. There is considerable sexual dimorphism in the canine and incisor growth and the large protuberances on the front of the upper jaws of male hippo can be used to determine the sex of adult hippo when in water (Parker *pers.comm.*). Unlike the elephant, where a progression of six molars erupt from the posterior of the jaw and move along the mandible during the animal’s lifetime, hippo molars are not replaced and only the premolars, canines and incisors go through an early deciduous stage. Laws (*ibid*) developed age criteria for hippo from the dentition and these are given in **Appendix 1** (page 51).

Using the data of Pienaar (*et al* 1966) of body lengths and total weight and the data of Laws (1968) of age and body length, a relationship has been developed in this study which allows body weight to be predicted from the age of male and female hippo (**Appendix 2**, page 54 and **Fig.3** below). This relationship is required to predict the potential meat production from a hippo population.

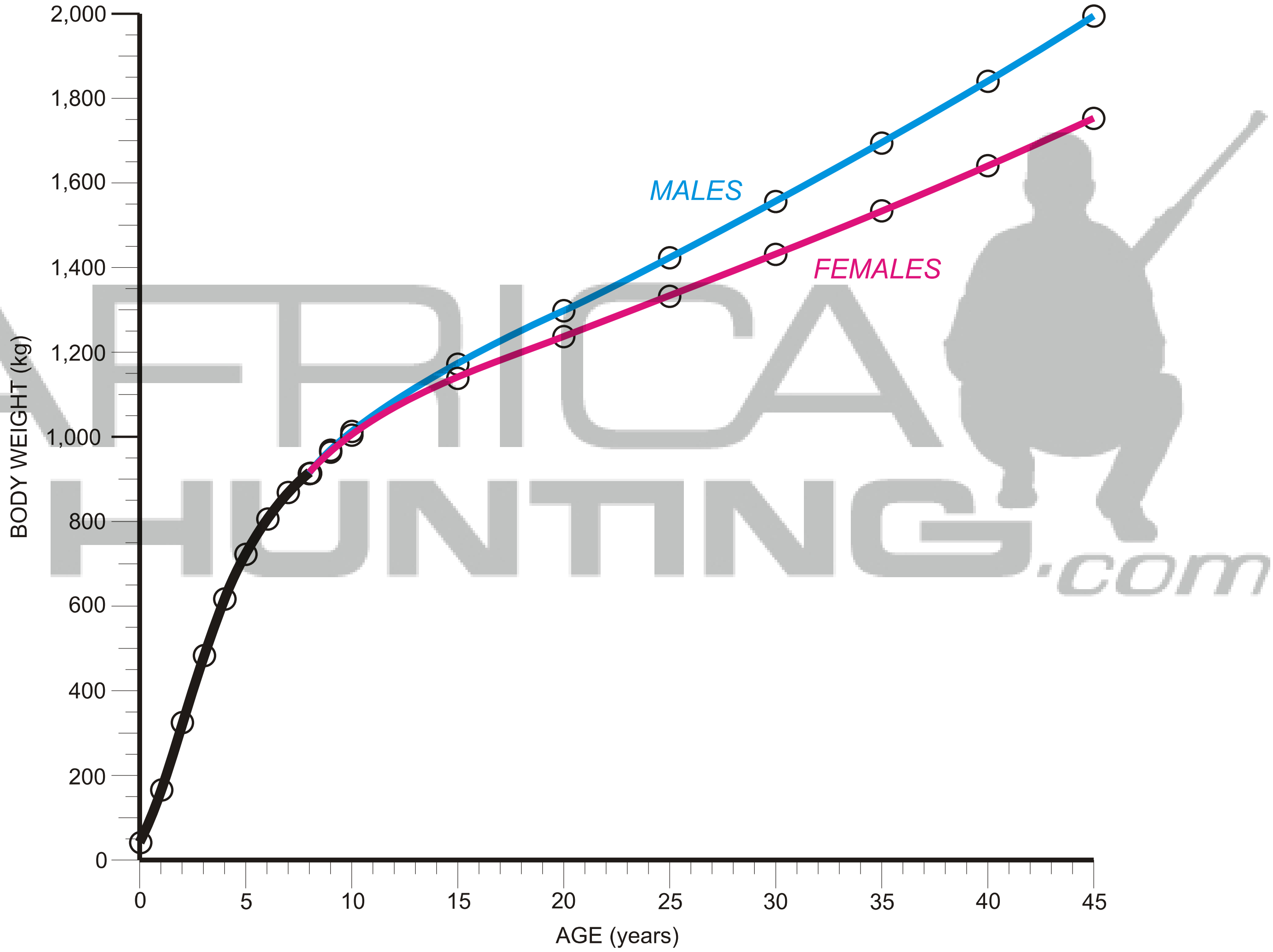


Figure 3: **Relationship between hippopotamus body weight and age**

c. Reproduction and Population Dynamics

The biological parameters which determine the population dynamics of hippo are summarised in **Table 1** below.

Table 1: Reproductive Parameters for Hippopotamus

Seasonal breeding	Most populations breed throughout the year. Pienaar (*et al* 1966) describe seasonal breeding of hippo in Kruger National park from December to July with a distinct breeding peak from March to June. Also in Kruger, Smuts & Whyte (1981) found the majority of births in 1974-75 occurred between October and March. Laws & Clough (1966) suggested breeding is correlated with rainfall.
Gestation	7½ - 8 months (225-257 days) (Pienaar *et al* 1966 and Smithers 1983)
Age at first conception and first parturition	Pienaar (*et al* 1966) and Smithers (1983) stated that the majority of hippo conceive in their third or fourth year and produce their first calves in the fourth year. Smithers may have been quoting Pienaar *et al*. However, Sayer & Rakha (1974) and Smuts & Whyte (1981) cast doubt on the ages assigned to Pienaar *et al*'s specimens. Smuts & Whyte suggest that if Laws' (1968) age criteria were applied to Pienaar *et al*'s data it would transpire that cows mature in their seventh year and calve in their eighth. Laws and Clough (1966) found the mean age at puberty for females in Queen Elizabeth National Park to be 9 years with a range from 7-15 years. Smuts and Whyte point out that the data of Laws & Clough suggest a range from 3-17 years. Sayer & Rakha found the mean age at maturity for a hippo population in the Luangwa Valley (1965-1970) to be 13 years with a range from 6-20 years. Smuts & Whyte found the mean age at maturity for hippo in Kruger (1974-75) to be 9-10 years. Hippo in captivity have produced calves at 3 years old. Clearly age at first parturition is extremely variable depending on nutritional stress and must treated as a regulating factor.
Fecundity (adults)	Although Pienaar (*et al* 1966) state firmly that mature hippo females produce a calf every three years (i.e. a fecundity of 0.33), Smuts & Whyte (1981) found a mean calving interval of 21.8 months in the same population (i.e. a fecundity of 0.55) and state that Laws & Clough's (1966) data indicate a calving interval of 32.5 months (i.e. less than 3 years). Hippos remain fertile throughout their life although fecundity appears to decrease by about 10% beyond the age of 30 years (Smuts & Whyte 1981).
Longevity	Laws (1968) gives the average terminal age of hippos as 45 years with a few individuals possibly reaching 48 years (see **Appendix 1**).
Mortality	Laws (1968) postulates 45% for calves in their first year of life (which seems very high), 15% for year 2, 4% from years 3-30, 4-16% from years 31-35, 16-26% from years 35-40 and 26-49% from year 41 onwards. Pienaar (*et al* 1966) give 16.6% for the first year of life stating that "5 out of every 6 newborn calves survive the first critical year". In both of these study populations were considered overabundant. Both Laws and Pienaar *et al* suggest that mortality is higher for adult males than adult females and this has been catered for in the population model developed for this study by adjusting the nominal value for male mortality upwards by 5% and female mortality downwards by 5% from the age of 10 years onwards (based on Pienaar *et al*'s ratio of adult males to adult females). The effects of various levels of mortality are examined using the population model.

The population model for hippo used in this study is similar to that for elephants (Martin 2005). The model behaves like the Leslie matrix (Leslie 1984) but the calculations of births and deaths are separated into successive operations designed to cycle within the row operations of a computer spreadsheet. The model permits testing of expected breeding performance and the response to various management activities (problem animal control, sport hunting and harvesting). It also costs all management activities and estimates the potential income from sustainable use of the population. The model is not included in this report because of its size but it has been used to test the population dynamics of hippo.

It is clear from the wide range in all of the key reproductive parameters that the hippopotamus is an extremely 'plastic' species. Age at first parturition varies from 3 years to as late as 20 years; calving intervals may be from less than 2 years to over 3 years; mortality for newborn animals may be as high as 45%; central mortality may be over 4%. If Laws' figures for mortality are used, the rate of growth of a hippo population is 1.55%. If Pienaar *et al*'s value for juvenile mortality (16%) is substituted for Laws' (45%) and mortality for two-year olds is set at 8%, the population grows at 5.35%. All of this presents a quandary for modelling because at least three main variables need to be explored and, finally, values of these variables need to be selected to apply to the Namibian hippo population.

The approach which has been adopted is as follows –

(1) Fecundity: Since the Namibian hippo population is at far lower densities than any of the populations on which studies have been carried out and there is no reason to suppose that it is under any environmental stress, a mean calving interval of 2 years has been selected – (i.e. a fecundity of 0.5) which is slightly lower than that of 0.55 found by Smuts & Whyte (1981) in the Kruger National Park.

(2) Age at first parturition: Although Both Sayer and Rakha (1974) and Smuts & Whyte (1981) found the mean age at maturity to be over 9 years, even in these dense populations animals as young as 3 years old were conceiving – suggesting that non-zero fecundities need to be assigned from 3 years old in increasing values until full reproductive capacity is achieved (in Kruger National Park this was at 11 years of age (Smuts & Whyte 1981)). This requires a curve-shaping algorithm which will permit asymmetry either side of the mean age at sexual maturity (**Fig.4**). Smuts and Whyte (1981) found a slight decline in fecundity after 25 years of age and the model fecundity profile has been shaped to provide this.

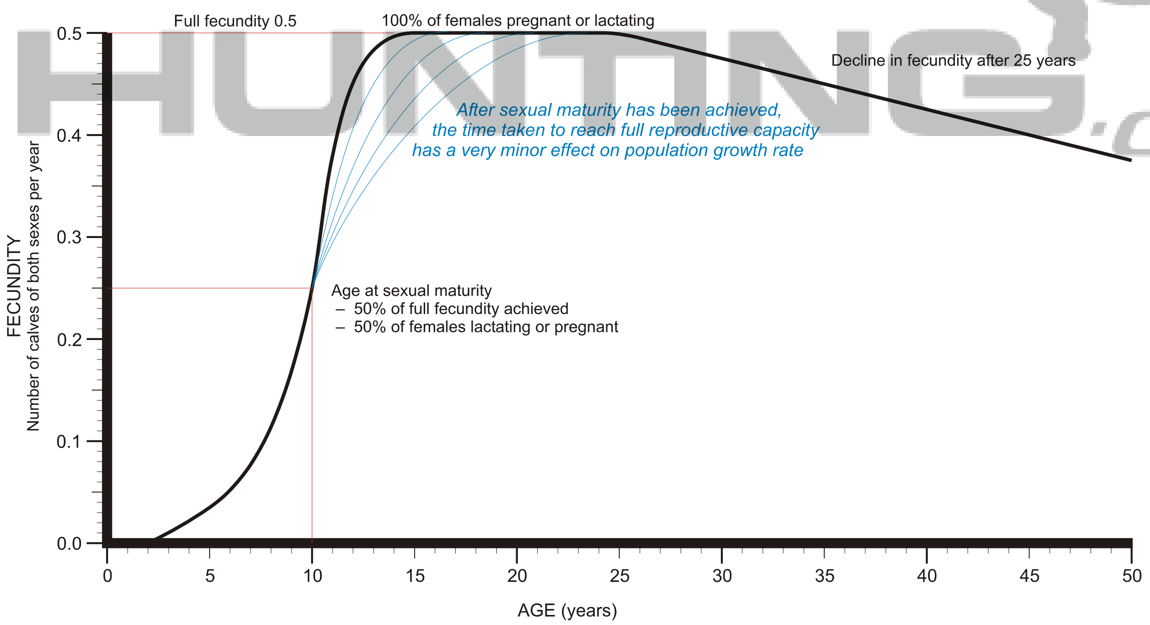


Figure 4: **Shaping the fecundity profile**

Mortality: The mortalities postulated by Laws (1968) have been adopted initially, other than in the first year of life where the value of 16% (Pienaar *et al* 1966) has been substituted for Laws' value of 45% (see **Table 1** on previous page).

Tests have been carried out to examine the sensitivity of the population to mortality, age at sexual maturity and age at full reproductive capacity.

Mortality 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 (mortality for years 3-30 shown as pale grey shading in the table below) 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 4%.

Age	1	2	3 - 30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
Template	4	2	1	1.17	1.38	1.62	1.90	2.23	2.61	3.06	3.60	4.22	4.95	5.81	6.82	8.00	9.39	11.02
4%	16.0	8.0	4.0	4.7	5.5	6.5	7.6	8.9	10.4	12.2	14.4	16.9	19.8	23.2	27.3	32.0	37.6	44.1

These mortalities are then adjusted for animals above 10 years of age by increasing the male mortalities by 5% and reducing the female mortalities by 5%.

In **Table 2** below and **Fig.4** on the next page I examine the effect of variations in central mortality (M_C) and juvenile mortality (the shaded columns in the table above) on the rate of growth of a hippo population. The fecundity of adult females is set at 0.5, age at sexual maturity at 9 years and age at full reproductive capacity at 11 years are (using Smuts & Whyte 1981). To obtain the maximum rate of growth for any given central mortality, the mortality for year 1 (M_1) and year 2 (M_2) is set equal to M_C. For first year mortalities of 10% upwards, M_2 has been set at half of M_1 except where M_C is higher than M_1 where it has been set at the value of M_C (e.g when M_C is 7%, M_1 is set at 10% and M_2 is set at 7%). The additional data points in the first two columns follow the sequence $M_C = 1$, $M_2 = 2$, $M_1 = 4$ and $M_C = 2$, $M_2 = 4$, $M_1 = 8$.

Table 2. Response of a hippo population to changes in juvenile and central mortality

CALF MORTALITY %		CENTRAL MORTALITY %									
M_1	M_2	1	2	3	4	5	6	7	8	9	10
1	1	9.76									
2	2		8.58								
3	3			7.41							
4	2 & 4	9.49			6.26						
5	5					5.10					
6	6						3.95				
7	7							2.81			
8	4 & 8		8.03						1.66		
9	9									0.52	
10	5 & Col	8.87	7.82	6.79	5.77	4.75	3.67	2.60	1.52		
20	10	7.80	6.74	5.71	4.69	3.67	2.66	1.65	0.65		
30	15	6.67	5.61	4.57	3.54	2.53	1.52	0.52			
40	20	5.48	4.40	3.35	2.32	1.31	0.31				
50	25	4.19	3.09	2.03	1.00						
60	30	2.77	1.65	0.58							
70	35	1.17	0.00								
80	40										

The area shaded in green in the table and highlighted in the figure below is the likely operating area which pertains for hippo populations in Namibia. All of the hippo populations on which the quoted studies have been carried out were considered overabundant and under stress: there is reasonable justification for reducing central mortality to 3% and setting M_1 and M_2 at 12% and 6 % respectively.

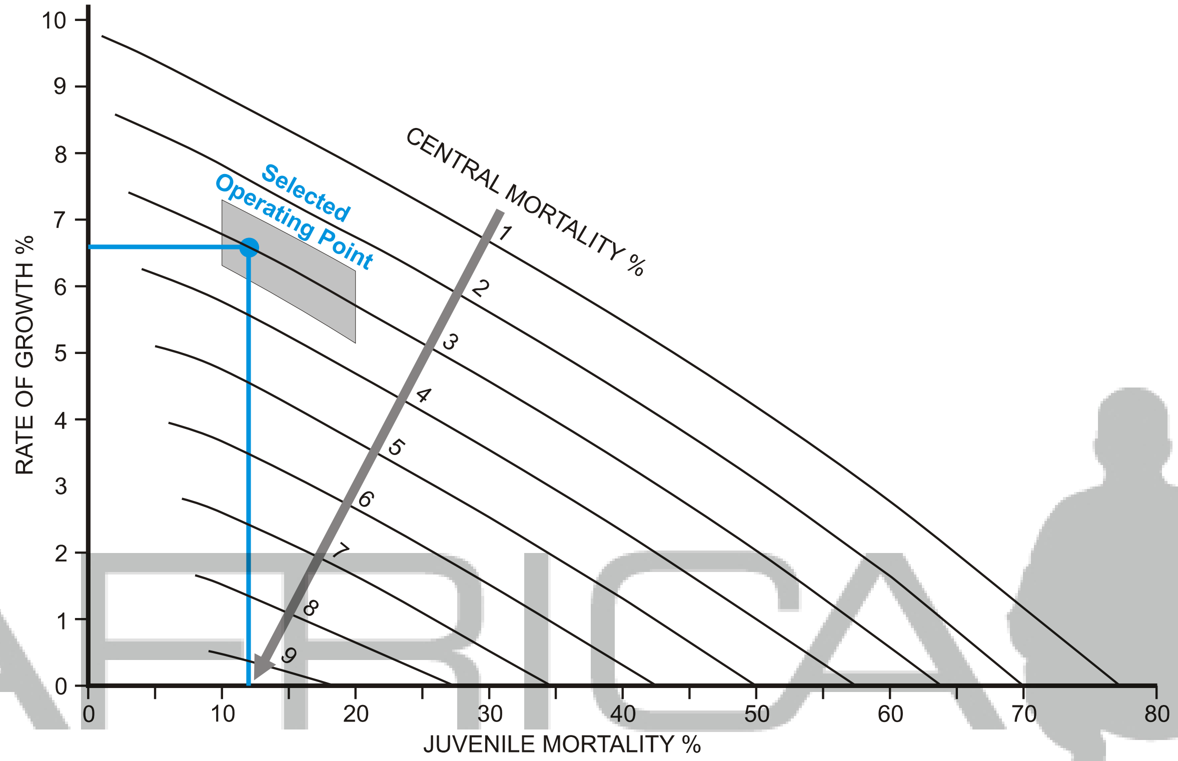


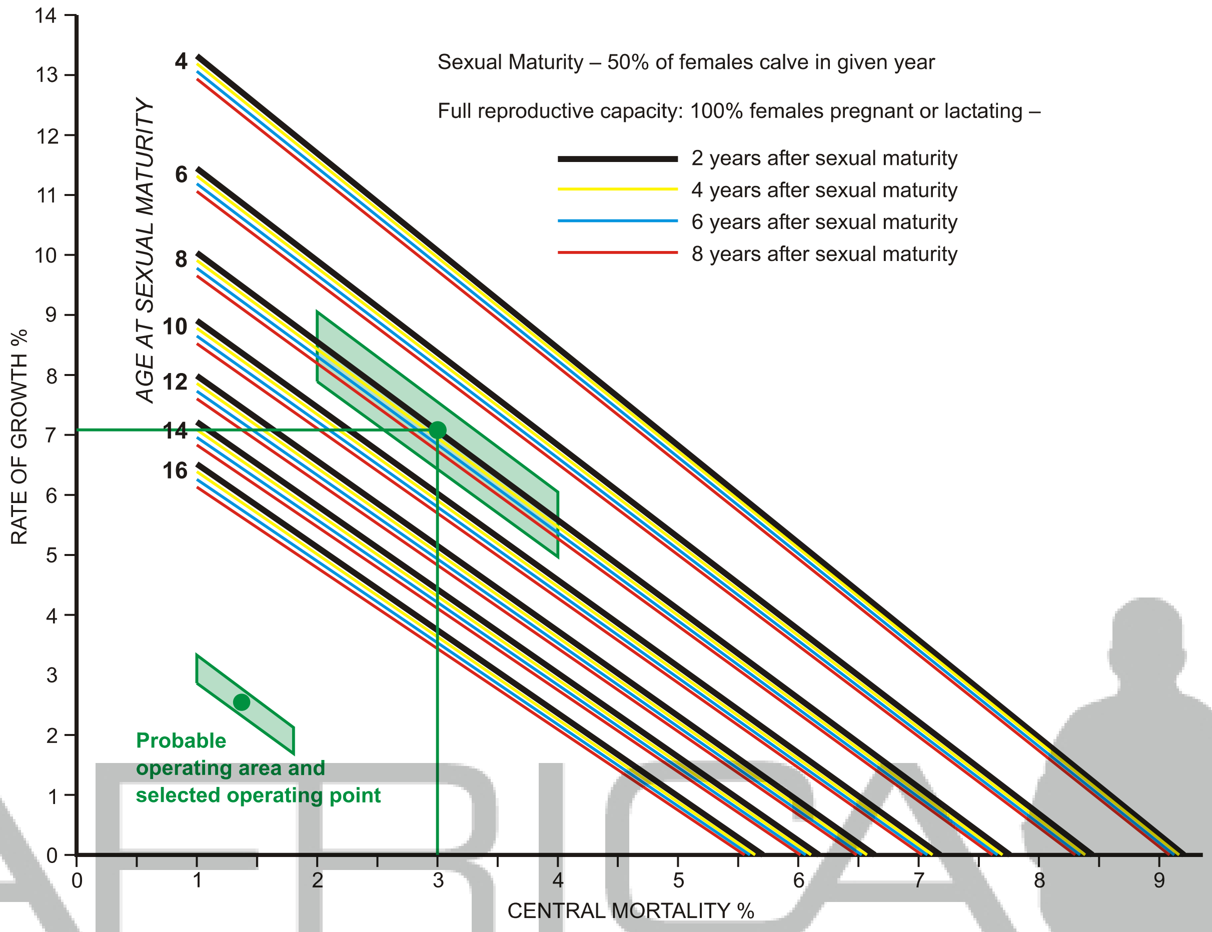
Figure 5: Effects of central and juvenile mortality on rate of growth of a hippo population

As with elephant populations, a hippo population is far more sensitive to variations in central mortality than juvenile mortality. It can tolerate high levels of juvenile mortality (e.g. over 60% for a population with a central mortality of 3%). The same is not true for adult female survival. A mortality of more than 9% causes the population to decline regardless of juvenile mortality.

<u>Age at sexual maturity and full reproductive capacity</u> For modelling purposes, age at sexual maturity is defined as the age at which 50% of the females will be either pregnant or lactating (i.e. they have already given birth) and age at full reproductive capacity is the age at which <u>all</u> females are pregnant or lactating. Because of the extreme variability in both of these parameters which is possible in hippo populations, I have assumed that a small proportion of females will calve as young as 3 years of age whatever the mean age at sexual maturity and that the age at which full reproductive capacity is attained may be anything from 2 years to 8 years after achieving sexual maturity. Because central mortality has the greatest effect on the growth rate of hippo populations, tests have been carried out over a range of 1-9% for central mortality. In all cases, mortality in the first year of life has been assumed to be four times the value of central mortality and, in the second year, twice the value of central mortality.

Table 3: Effect of age at sexual maturity and full reproductive capacity on growth rates

AGE		CENTRAL MORTALITY %								
Sexual maturity	Full reproduction	1	2	3	4	5	6	7	8	9
4	6	13.32	11.71	10.10	8.49	6.87	5.25	3.62	1.98	0.34
	8	13.16	11.56	9.95	8.35	6.74	5.12	3.50	1.87	0.24
	10	13.11	11.51	9.91	8.31	6.70	5.08	3.46	1.83	0.21
	12	13.10	11.50	9.90	8.29	6.69	5.07			
6	8	11.41	9.88	8.36	6.84	5.31	3.77	2.23	0.68	
	10	11.29	9.77	8.25	6.73	5.20	3.67	2.13	0.59	
	12	11.25	9.74	8.22	6.70	5.17	3.64	2.11	0.56	
	14	11.24	9.73	8.21	6.69	5.16				
8	10	9.98	8.51	7.04	5.57	4.10	2.62	1.13	0.00	
	12	9.89	8.42	6.95	5.49	4.01	2.54	1.06		
	14	9.86	8.39	6.93	5.46	3.99	2.52			
	16	9.85	8.38	6.92	5.45					
10	12	8.86	7.42	5.99	4.56	3.12	1.68	0.25		
	14	8.79	7.35	5.92	4.49	3.05	1.62	0.19		
	16	8.77	7.33	5.89	4.46	3.03				
	18	8.76	7.32	5.89	4.46					
12	14	7.95	6.53	5.12	3.71	2.30	0.89			
	16	7.89	6.47	5.06	3.65	2.24	0.84			
	18	7.87	6.45	5.04	3.63	2.22				
	20	7.86	6.44	5.03	3.62					
14	16	7.18	5.77	4.37	2.98	1.59	0.23			
	18	7.13	5.71	4.32	2.93	1.54	0.18			
	20	7.11	5.70	4.30	2.91	1.52				
	22	7.10			2.90					
16	18	6.51	5.10	3.71	2.33	0.96	0.00			
	20	6.46	5.05	3.66	2.28	0.91				
	22	6.45	5.03	3.65	2.27	0.90				
Mortality Year 1	%	2	4	6	8	10	12	14	16	18
Mortality Year 2	%	4	8	9	16	20	24	28	32	36



Mortality Year 1	2	4	6	8	10	12	14	16	18
Mortality Year 2	4	8	9	16	20	24	28	32	36

Figure 6: **Population response to age at sexual maturity and full reproductive capacity**

It is immediately apparent from **Table 3** and **Fig.6** that age at sexual maturity has a far greater effect on the rate of growth of a hippo population than does age at full reproduction. In other words, once half of the females in a population are producing calves, it makes little difference to the population growth rate how long after that the remainder start calving (noting of course that, whatever the time span, it is nevertheless an increasing proportion – **Fig.4**).

Whilst it is tempting to think of hippo populations as having similar population dynamics to elephants, it would be erroneous to do so. The short gestation period (8 months versus 22 months for elephants), the high fecundity (one calf every 2 years versus 4 years for elephants) and the wide range of possible ages at first parturition (4-12 years versus 10-12 years for elephants) make hippo populations capable of much higher growth rates and productivity. These tests indicate that with low central mortalities and early ages for sexual maturity hippo populations are theoretically capable of growth rates in excess of 10% per annum.

Smuts & Whyte (1981) describe the reproductive strategy of the hippo as one well adapted to the semi-arid environments of Africa. When resources become limiting, populations are able to maintain stable populations by delayed sexual maturity and fecundity and so adjust to the carrying capacity of the environment: equally, populations are capable of rapid increase when resources become abundant. This finding has important implications for hippo management. It should be possible to maintain a hippo population in a highly productive state by harvesting: the corollary is that by <u>not harvesting</u> the population is unlikely to increase greatly – its own homeostatic mechanisms will come into play to limit population growth.

There remains the need to choose parameters for the Namibian hippo populations. The selected values are shown in **Table 4** below and are what might be reasonably expected for the Caprivi – which is the only area where hippo are likely to be exploited. These values result in a population growth rate of 7.13% and will be used to examine the response of the population to various management treatments.

Table 4: Selected reproductive parameters for the Namibian hippo populations

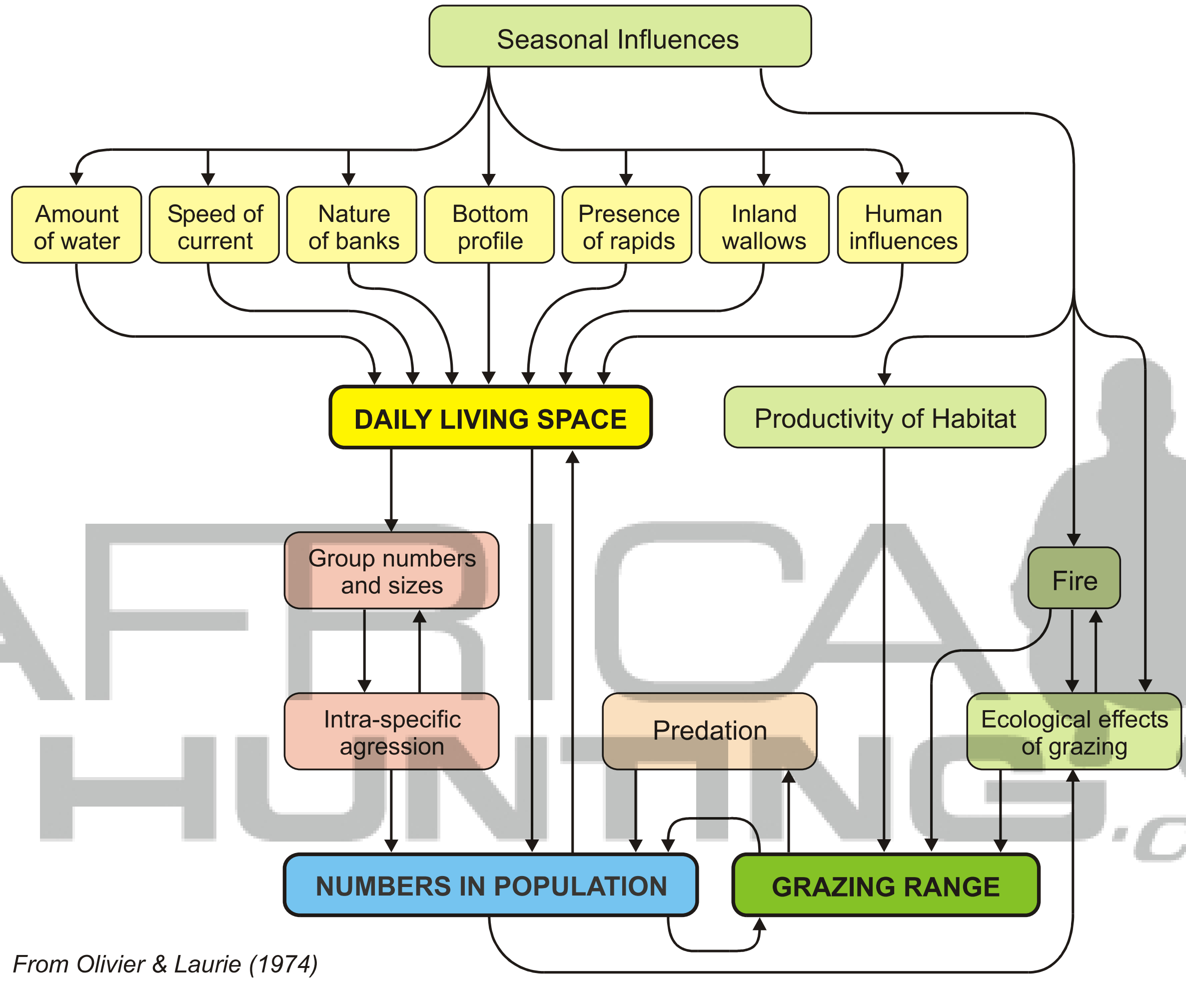
Longevity	50 years
Age at sexual maturity	8 years
Age at full reproductive capacity	10 years
Fecundity	0.5 calves/female/year
Central mortality	3%
Juvenile mortality (first year)	12%
Mortality (second year)	6%

Detailed fecundity and mortality schedules are given below

AGE	1	2	3	4	5	6	7	8	9	10
Fecundity	0	0	0.0217	0.0354	0.0577	0.0940	0.1533	**0.25**	0.3484	**0.5**
♂ mortality	12.00	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.15
♀ mortality	12.00	6.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	2.85
AGE	11	12	13	14	15	16	17	18	19	20
Fecundity	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
♂ mortality	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15
♀ mortality	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
AGE	21	22	23	24	25	26	27	28	29	30
Fecundity	0.5	0.5	0.5	0.5	0.5	0.495	0.490	0.485	0.480	0.475
♂ mortality	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15
♀ mortality	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85	2.85
AGE	31	32	33	34	35	36	37	38	39	40
Fecundity	0.470	0.465	0.460	0.455	0.450	0.445	0.440	0.435	0.430	0.425
♂ mortality	3.70	4.34	5.09	5.97	7.01	8.23	9.65	11.33	13.30	15.60
♀ mortality	3.34	3.92	4.61	5.40	6.34	7.44	8.73	10.25	12.03	14.12
AGE	41	42	43	44	45	46	47	48	49	50
Fecundity	0.420	0.415	0.410	0.405	0.400	0.395	0.390	0.385	0.380	0.375
♂ mortality	18.31	21.49	25.21	29.59	34.72	40.75	47.82	56.11	65.85	77.26
♀ mortality	16.57	19.44	22.81	26.77	31.42	36.87	43.26	50.77	59.58	69.92

d. Habitats

Hippo have a primary requirement to satisfy the aquatic conditions which provide their "daily living space" and, only after that, is the nature of their preferred pastures important. Olivier & Laurie (1974) give the relationship between hippos' daily living space and their grazing range in the form of a diagram (**Fig.7** below).



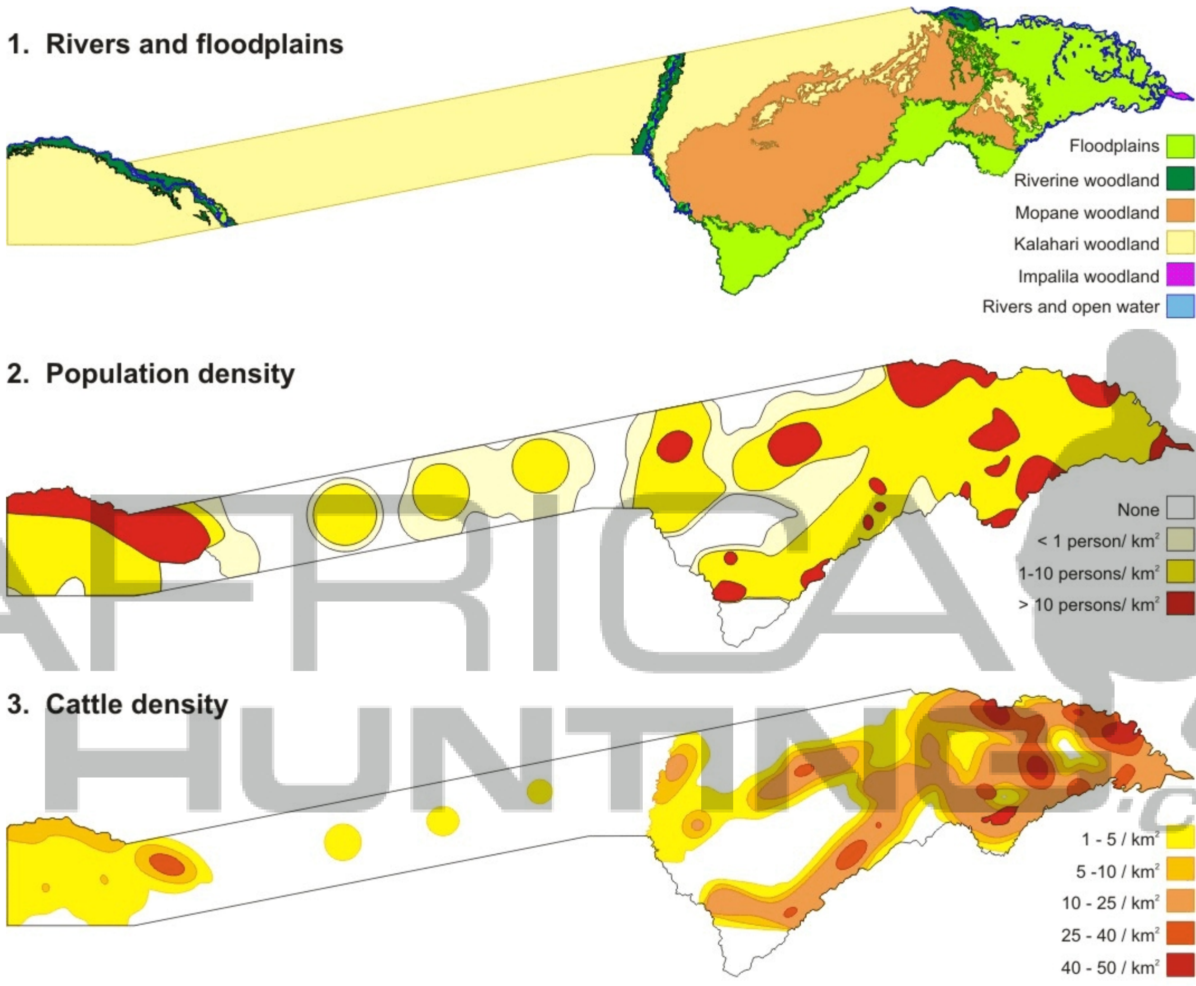
From Olivier & Laurie (1974)

Figure 7: **Daily living space, population numbers and grazing range**

A number of factors combine in creating the ideal daily living space (see figure). Where available, hippo select open stretches of permanent water with submerged sandbanks or gently shelving beaches where they can rest during the day with their back and heads just out of the water and their young can suckle without swimming. They prefer slack and relatively shallow water but like to have sufficient deep water nearby in which they can totally submerge. The daily movements between water and the grazing range result in trampling and erosion to river banks. When an exit point from a river becomes unusable due to erosion, hippo will begin another nearby and, over a number of years, this process can reshape rivers.

The significance of the relationship between daily living space and grazing range is that simple comparisons of hippo densities or attempts to assess carrying capacity are invalid without an understanding of the constraints affecting the daily living space of each population.

In the Caprivi, the influence of human activities on the daily living space of hippo is a highly significant factor (**Fig.8** below). Hippos, humans and their livestock are competing for the same resources along river margins. Mendelsohn & Roberts (1997) refer to overgrazing by cattle in most of the Eastern Caprivi vegetation types. The final outcome of this competition will depend largely on the value (both economic and intrinsic) which the people living in northern Namibia place on hippos and the extent to which they are able to realise that value.



All maps are based on *An environmental profile and atlas of Caprivi* (Mendelsohn & Roberts 1997)

Figure 8: **Vegetation, human and cattle densities in the Caprivi**

With sufficient grazing available, hippo tend to remain close to rivers. However, drought, arid conditions or competition with humans may cause hippo to seek resources some distance from their daily living space. In the Serengeti hippo tend to remain within 1.5km of the Mara River (Olivier & Laurie 1974); in Kruger National Park hippo are found up to about 5km from the Letaba River (Pienaar *et al* 1966); up to 7km in the Queen Elizabeth National Park (now Ruwenzori National Park) (Field 1970); and up to 10km in Murchison Falls (Ian Parker, *pers. comm.*). The largest recorded distances are up to 30km (Fuente 1970, in Smithers 1983). Grazing pressure tends to decrease with distance from water (Lock 1972).

The food of hippos is almost entirely grass and sedges and Scotcher (*et al* 1978) recorded some 61 monocotyledonous species (**Appendix 3**, page 57). Small amounts of dicotyledonous plants are ingested but this is more likely to be by accident than intent and is a result of their feeding style. Hippo feed by clamping plants between their lips and using a sweep of the head to detach them from the ground. This tends to preclude selective grazing in diverse habitats.

The hippopotamus selects the plant community that best satisfies its feeding requirements – pure grassland, woodland or variations thereof, whilst thickets and dense forests are not preferred. Hippo might be termed an 'area selective' grazer based on the extent to which plant communities occurring within the same grazing environs are used. Although Bere (1959) described hippos as selective grazers in Queen Elizabeth National Park, Uganda, this selectivity was achieved more by feeding in monocultural patches rather than by individual plant selection.

Hippo food preferences change seasonally with an emphasis on those plant communities which offer a continuous dispersion of grasses. The factors determining palatability or acceptability of plants to a grazing animal are complex and it seems that the different stages of growth of herbage play a key rôle in the hippo diet. Hippo may be largely unselective as far as species are concerned but they show a preference for areas which offer freshly sprouting, highly nutritious forage which is relatively high in protein and low in fibre and they avoid dry stemmy material which is low in protein and high in fibre.

Numerous authors refer to the phenomenon of hippo 'lawns' – patches where the continuous grazing of hippos results in a short, productive green grass cover. A number of the floodplain vegetation types in the Eastern Caprivi are characterised by extensive *Cynodon dactylon* 'lawns' (Mendelsohn & Roberts 1997).[1]

Olivier & Laurie (1974) put forward the idea of a cycle in the relationship between hippos and their grazing pastures (**Fig.9** next page). Areas which are intensely grazed by hippos tend to exclude fire; as a result of this woody regeneration happens; grass becomes protected against hippo grazing by the woody regrowth; the hippo grazing pressure in such areas is reduced; the grass becomes long and flammable; fires occur; the woody regrowth is set back before the plants can develop into large fire-resistant trees; the grass becomes available to hippos; grazing intensity increases and the cycle repeats itself.

Thornton (1971) monitored the effects of the removal of the entire hippo population from the Mweya Peninsula in Queen Elizabeth National Park over a period of 4 years. The most significant effects were changes in the physiognomic structure of the pasture; changes in grass species composition with large increases in *Sporobolus pyramidalis* and *Chloris gayana* linked with a decline in *Chrysochloa orientalis* (a low-growing grass species) and the build-up of large amounts of plant litter which had the beneficial effect of protecting the eroded hard-pan soils against rainfall run-off. After four years the original grass climax species (*Themeda triandra* and *Heteropogon contortus*) had still not recovered to their former levels but were increasing.

1. The Bukalo-Liambesi floodplains, Dry Mamili grassland, Liambesi-Linyanti grassland, Okavango-Kwando grassland, Zambesi floodplain grassland, and the Gunkwe *mulapos*.

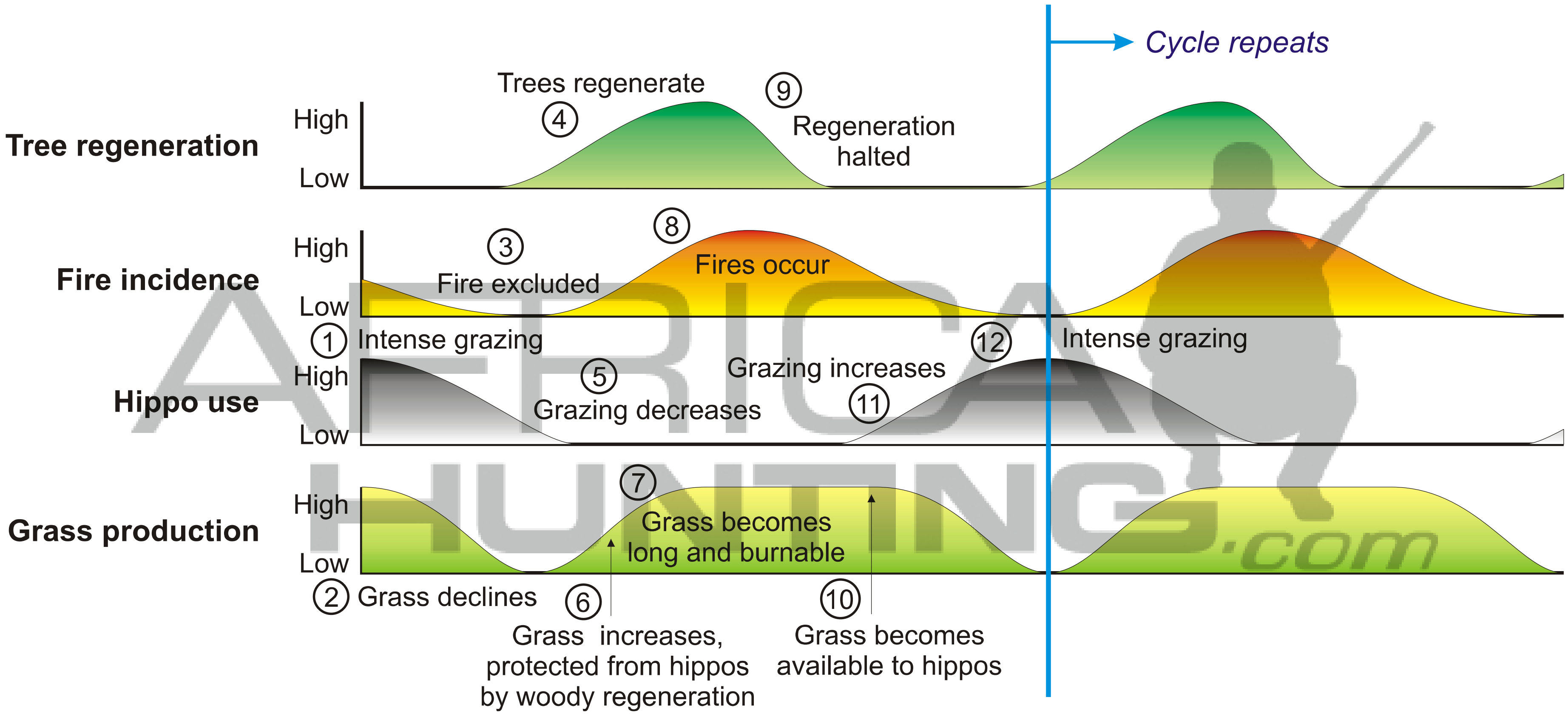


Figure 9: Cycles in the use of habitat by hippo

e. Numbers and Distribution

(1) Africa

Historically, the common hippopotamus occupied an extensive range in Africa and was considered abundant. The present distribution of hippo is shown in **Fig.10** on the next page. Although the species still occurs widely throughout the continent its dispersion is patchy and uneven. HSG (1993, *S.K. Eltringham* – pp43-54) estimated the total population of Africa at about 157,000 animals of which 7,000 occurred in West Africa, 70,000 in East Africa and 80,000 in Southern Africa.[2] These estimates were based on questionnaires and information for several countries was unavailable, including Angola. The most recent estimates of HSG (2004) differ very little from this (**Appendix 4**, page 61) and place the continental population between 130,000 and 155,000. Except for the Zambian population which appears to be increasing, hippo are stable or declining in all of the 36 countries included in the census.

In West Africa, hippos exist in small relict populations isolated from each other and are most abundant in estuarine habitats and the lower reaches of rivers, with a few occurring in the sea. The largest numbers are in Guinea, Guinea Bissau and Senegal (~7,000). The group of countries comprising Ivory Coast, Ghana, Togo, Benin and Burkina Faso have perhaps 2,000 hippos, Nigeria and Niger a further 500 and Cameroun, Central Africa Republic, Equatorial Guinea, Gabon and the Congo are unlikely to contain more than 2,500 altogether.

In East Africa, surveys have been carried out in a number of countries. Estimates for the Selous Game Reserve in Tanzania were 15,483 in 1986, 24,169 in 1989 and 20,589 in 1990 (Games 1990). Several thousand hippo occur elsewhere in Tanzania. In Uganda the main concentrations are in Queen Elizabeth(Ruwenzori) and Murchison Falls national parks. In the early 1950s the Queen Elizabeth park population numbered 21,000 but this was reduced to some 14,000 through culling. The population was further reduced by heavy illegal hunting during the Idi Amin regime and was counted at about 2,000 animals in 1989. The Murchison Falls population suffered a similar fate and numbers are now similar to those in Queen Elizabeth park. The largest numbers in East Africa occurred in eastern Zaire – about 30,000 in 1993 – but HSG (2004) place their present numbers between 2,000 - 4,000. Ethiopia and Sudan may hold 10,000.

(2) Southern Africa

As stated above, southern Africa contains the largest numbers of hippopotamus on the continent – some 80 000 animals. The major part of the population lies in a belt extending across the region between latitudes 15º-25º south of the equator. The potential exists, through the development of trans-frontier conservation areas, for the subpopulations in the countries within this zone to form a single contiguous population across the continent. In the text which follows, the southern African countries are dealt with individually, beginning with two that are not spatially linked to Namibia; continuing with those that border on Namibia; and concluding with Namibia itself. Much of the information is taken from HSG (1993) and HSG (2004).

2. It is a curious reflection on current conservation values that the hippopotamus, with a continent wide population of less than 200,000 animals (HSG 1993) is classified as having a satisfactory conservation status under the IUCN Red Data Book system (‘widespread and relatively secure’) whereas the African elephant with more than 500,000 animals is listed as ‘Threatened’.

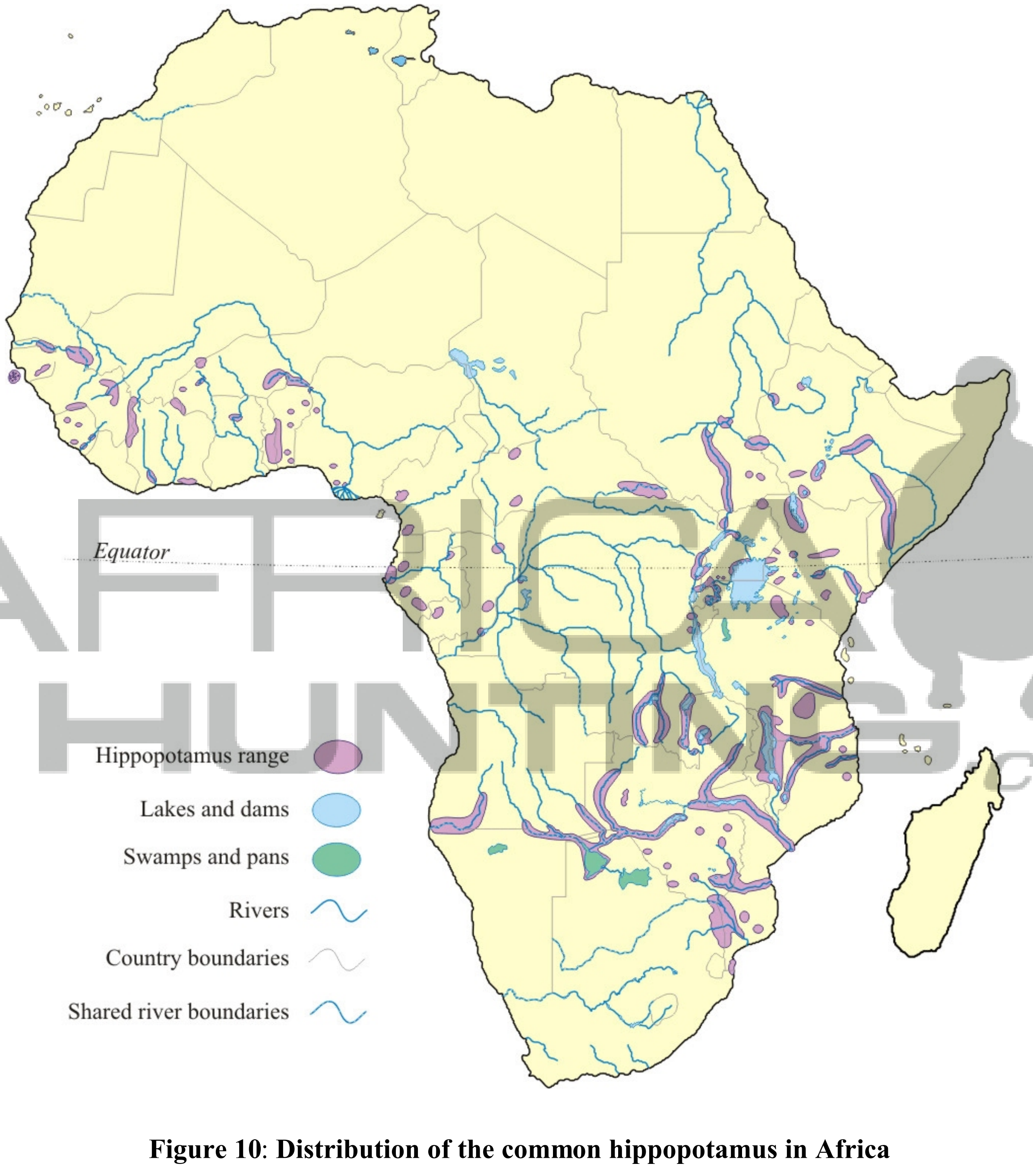


Figure 10: **Distribution of the common hippopotamus in Africa**

Re-mapped from the IUCN/SSC Hippo Specialist Group map (HSG 1993, p45)

Southern Africa *(continued)*

(i) Mozambique

Despite the civil strife in the 1980s and 1990s, a surprising number of hippopotamus appear to have survived in Mozambique. The species is still widely distributed and present on most river systems. Several State protected areas contain hippopotamus although only Gorongosa, with about 2,000, has a sizeable population. Tello (1986 in HSG 1993) estimated the total population between 16,000 and 20,500 for the country as a whole with most (10,000-12,000) in the Zambezi Wildlife Utilization Area which includes Marromeu Reserve and four safari hunting blocks. HSG (2004) now estimates the population at 18,000 animals.

(ii) Malawi

Malawi is densely populated with hippopotamus. The main concentrations are at Elephant Marsh on the lower Shire River, the southwest arm of Lake Malawi, Upper Shire River and Lake Malombe in Liwonde National Park. R.H.V. Bell estimated some 10,000 hippopotamus in the whole of Malawi in 1993.[3]

(iii) Zambia

There are probably more hippopotamus in Zambia than in any other single country. Goddard (1970) estimated the Luangwa River population at about 9,000 animals and Sayer & Rakha (1974) carried out studies on some 1,000 animals cropped from this population. R.H.V. Bell estimated the number in the Luangwa Valley to be between 20,000-25,000 in 1993. Munyenyembe (in HSG 1993) put the country-wide total at 40,000.[3] At that time they were widespread on the Kafue Flats and in Lochinvar National Park.

The hippo in the Luangwa River suffered a major anthrax outbreak in the early 1990s. The high densities of hippo provided conducive conditions for an epidemic and mortality was severe. However, the present population appears to have recovered to its former level.[4]

Of relevance to Namibia is the hippo population in the south-west of Zambia. HSG (1993) show hippo as being present along the Zambezi as far north as point where the river enters Angola. M. Eustace (*pers.comm.*) confirms their presence in moderate numbers in Sioma-Ngwezi and Liuwa Plains national parks and along the portion of the Zambezi linking these parks. In a survey of the Caprivi last year, Stander (2004) counted only 17 hippo on the Zambezi upstream of the Chobe confluence and it would seem that the dense settlement along the river coupled with illegal hunting does not provide favourable conditions for a large hippo population.

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3. HSG (2004) has not altered this estimate.

4. Cropping of hippo in the Luangwa has continued up to the present date. The author observed hippo meat being distributed in the 1980s and 1990s at Nyamaluma where an ongoing community-based natural resource management programme is in place (Dale Lewis *pers.comm.*)

(iv) Angola

Shortridge (1934) presents a conflicting narrative of hippo abundance in Angola with some reports suggesting hippo were 'disappearing more rapidly than any other game in Angola' and others stating that hippo were numerous in the south-east on the Kwando, Quito and Luiana rivers (Wilhelm 1931). Both HSG (1993 and 2004) were unable to obtain data in compiling their status report but quote Sydney (1965) as stating hippo were widespread throughout Angola and numerous on the Cunene, Cubango, Cuando, Cuanza, Longa, and Zambezi Rivers.

Beytell (*pers.comm.*) states that UNITA annihilated most of the hippo along the Okavango River in the Angolan civil war (1980s and 1990s). Chase & Griffin (2004), in carrying out a survey for elephants in the Luiana Partial Reserve, recorded sightings of other species but do not mention hippo amongst these.

(v) Botswana

Except in the north of the country, most of Botswana is too dry for hippopotamus (like Namibia). Hippo occur in the Okavango Delta and in the Chobe/Linyanti River system. A few (18+) exist on the Limpopo river in the east.[5]

In 1993, C.A. Spinage put the total population in northern Botswana at 1,600 in the wet season and 500 in the dry. ULG (1995) estimated the total hippo population of Botswana at 2,859 in 1994 (mean of wet and dry seasons) with fairly wide 95% confidence intervals (1,816 - 3,902). The authors are careful to point that standard sample survey techniques are unsuitable for counting hippos. From an examination of previous surveys, they concluded that hippo were declining in northern Botswana at an alarming rate of 33% per annum.

Stander (2004) counted 1,123 hippo in Mamili National Park and on the Kwando and Chobe-Linyanti rivers of which only those counted on the portion of the Kwando inside the Caprivi (Babwata East) could be considered as belonging exclusively to Namibia (159 animals).[6]

(vi) Zimbabwe

Hippo are found on most of the large rivers (the Zambezi, Sabi, Lundi and Limpopo) and also occur in smaller rivers and darns where there is permanent water. Some wander over long distances providing isolated records. "The only estimate for the country-wide total is that made by R. B. Martin on the basis of some limited counts, which have revealed some dense populations e.g. 2,000 on a 50 km section of the Zambezi. His estimate is 6,900, of which 5,530 occur in national parks or reserves, 1,020 on communal lands and 350 elsewhere" (HSG 1993).

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5. ULG (1995) confirm the presence of hippo on the Limpopo although none were counted within their aerial survey transects.

6. In 1994, Rodwell (*et al* 1995) counted 220 hippo in this same stratum in the course of a transect survey which was not designed specifically to count hippo. Their estimate for Mamili was 472 animals (versus 560 counted by Stander in 2004). They saw no hippo in Mudumu where Stander (2004) counted 34 animals.

(vii) South Africa

Shortridge (1934) gives an intriguing narrative of the original distribution and disappearance of hippo in South Africa . . .

In 1652 hippo occurred in the swamp which is now Church Square in Capetown and were common on the Cape Flats. They were still abundant around Capetown in the 1700s and were recorded in the Gamtoos and Krom Rivers near Humansdorp, the Fish and Sunday Rivers east of Port Elizabeth and the Kei River at the extreme of the eastern Cape. In the 1800s they were plentiful on the Orange River upstream of the Seekoei River near Colesberg and in the Berg River north of Capetown. Burchell noted their presence at the junction of the Vaal and Orange Rivers in 1811. Harris recorded them on the Molopo River near Mafeking and on the upper Limpopo River in Pretoria district in1838. They were also present in all the Natal Rivers.

The chronicle then changes to one of elimination. A single hippo remained in the Fish River in 1853, hippo were shot in the Keiskama River in 1854, the last hippo was shot in the Buffalo River (East London) in 1862, the last hippo was shot in the Berg River in 1874, the last hippo was shot in the Umsimvubu River (Port St. Johns) in 1890, a number of hippo were shot in the Umtata River mouth from 1893-1895, hippo were exterminated in Sea Cow lake in 1898, the last hippo disappeared from the lower Orange River after 1925 and the famous 'Huberta' was killed on the Keiskama River near Peddie in 1931.[7]

Hippopotamus are now confined to the northeast of the country, mainly in the Transvaal and the northern tip of Natal. The largest numbers are in the Kruger National Park in perennial rivers, dams and pools on seasonal rivers. The total counted in the park in 1989 was 2,761 with 2,575 in rivers and 191 in dams and pools. R.H. Taylor estimated about 1,500 for Natal and Kwazulu in 1986, with the largest concentration (595) being on Lake St Lucia. HSG (2004) give the current hippo population in South Africa as between 3,000 and 5,000.

The disappearance of hippo from the lower Orange River in the early part of the 20th century (see page 22) is of direct relevance to this transboundary mammal project. As part of the initiative taking place at the moment to link Ais Ais National Park in Namibia with the Richtersveld in South Africa and to include large tracts of private land under wildlife (e.g. Gondwana Canyon Park), the re-introduction of hippo to the lower Orange could have the status of a 'flagship' conservation project.

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7. In 1928, 'Huberta' left St. Lucia in Zululand and undertook a trek of 1,600km around South Africa. At various times she settled in the Umhlanga and Umgeni Rivers near Durban, walked the beaches of Durban, then crossed 122 rivers to reach Kingwilliamstown and East London in 1931. She became a national heroine and enjoyed regular reports in the South African and international press. She was killed by three hunters on the Keiskama river in 1931 who were fined £25 each.

(3) Namibia

(i) *Historical range*

It appears that Namibia enjoyed wetter conditions two centuries ago than it does today. Hippo tusks have been found in the Kuiseb and Swakop rivers and, in 1925, local people remembered hippo in both these rivers when they retained water throughout the year and the vegetation was more luxuriant (Shortridge 1934). There may even have been hippo in the Windhoek area when there were large areas of permanent open water in the 19th century (Mike Griffin *pers.comm.*).

The present aridity of Namibia limits the potential distribution of hippo to the large perennial rivers all of which are located on the boundaries of the country. Only in the Caprivi is the annual rainfall sufficiently high to support significant numbers of hippo and, inevitably, this places them in competition with humans, agriculture and domestic livestock.

The Cunene River and Owambo

The Owambo area north of Etosha probably had more wildlife than Etosha 80 years ago and hippo occurred in the wetter habitats of the Cuvelai (Mendelsohn *et al* 2000). Moller (1899) encountered hippo in the Cunene and Calonga rivers.[8] The legendary Afrikaans 'baasjagters' hunted hippo in the Cunene and Cuvelai areas in the late 19th century (von Moltke 2003).

Hippo were present above the Ruacana Falls in 1914 and 1915. A severe drought reduced the river to a succession of pools and the majority were exterminated by a party of Angolan trekkers. At this time there was an isolated herd at the Cunene mouth and two hippo below the Ruacana Falls later to be joined by several more presumably from Angola. It was unlikely that the total number of hippo on the Kunene exceeded twenty (Hahn 1925).

Shortridge (1934) noted that a few hippo still survived in the lower Cunene and refers to a count of 14 animals in 1925. He doubted that more than a dozen hippo remained between the Ruacana Falls and the Cunene Mouth. Joubert & Mostert (1975) state that the only hippo present in the Cunene were 4-6 animals in the Swartbooisdrift area below the Ruacana Falls.

Willem van Riet (*pers.comm.*) has canoed the Cunene on several occasions and reports "During the Kunene trip of 65, we found no hippo below Epupa Falls, but lots of crocodiles. We found very few hippo, probably 20 between Ruakana and Epupa and a fair number of hippo above Ruakana. During a similar trip in the 1990s we did not see a single hippo between Ruakana and Epupa but believe there were a few left."

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8. Moller (1899) gives the following cultural anecdote relating to the Ovambo people –

"The Ovampo are divided into three social classes: the aristocracy, the fetish-men and the lower people. . . . The fetish-men or "onganga" have a very strong influence, especially among certain tribes. Their most important duty is to produce rain for the wilting crops in time of drought. Some fetish-men have a big reputation for this ability, and deputations are sent by chiefs from far away to obtain rain from some of these wizards. In the Evari tribe there are also other rain-makers apart from the ongangas. In the lagoons along the Evari River there are a number of tame hippos that the people regard as holy and treat as such, and these are considered to be great rain-makers. Fetish-men are also used to discover thieves and other criminals. The hairs of the suspected person are singed with a red-hot iron and judging from the smell that then arises, and also to some degree from simultaneous interrogation, the accused is freed or sentenced. [According to Hahn's 1925 map, the Evari tribe lived on the upper reaches of the Etaka River in Owambo]

The Okavango River upstream from the Caprivi

Hahn (1925) observed several hippo slightly north of Kuring Kuru (Nkurenkuru).

Shortridge (1934) noted that the south bank of the river was relatively heavily populated and lacked suitable habitats for hippo except for two areas which possessed some marshy habitats near Katere at the confluence with the Cuito and a reed-fringed stretch near Sambio (Shambyu) downstream from Rundu. A few 'stray' hippo were also recorded at Nkurenkuru and Bunya and some occurred between the confluence of the Omatako and the Popa Falls.

Beytell (*pers.comm.*) states that in the 1980s the area around Nkurenkuru was in pristine condition with a resident hippo population of 22 animals. As the human population built up after independence they became 'problem animals'. About 15 hippo also occurred at the Cuito-Okavango confluence. An extreme example of the adaptability of hippos was the appearance of hippo in the Aa mountains near Tsumkwe in 1974-75 during a period of good rains.

Caprivi

Hippo have always been numerous in the Caprivi. "Below the Popa Falls of the Okavango, after the river has taken its sharp bend south and begun to form the western boundary of the vast marshes of Ngamiland, hippo gradually become numerous, not only in the main stream, but among all the innumerable water-channels that intersect the impenetrable reed and papyrus swamps." (Shortridge 1934). "After the entrance of the Okavango into the 'flood district' hippo become plentiful, and one can hear them bellowing at all times of the day and night." (Wilhelm 1931). "Hippopotamus are quite numerous in the Eastern Caprivi in the Maschi [Kwando] and Zambesi Rivers" (Balme in Shortridge 1934); "They are fairly plentiful in the lower Kwando and Linyanti Swamps (Wilhelm in Shortridge 1934); "These animals are abundant in the Chobe, as also in the Zambesi, and usually congregate together in herds of from three or four to twenty members, though the old bulls are often seen alone." (Selous 1881).

Hippo were and probably still are of considerable cultural significance in the Caprivi. They were killed for the inauguration of chiefs, for their marriages and other feasts and, occasionally, for the appointment of headmen. The most prized portion of the carcase was the belly meat which was reserved for the chief (Beytell *pers.comm.*).

The Orange River

Shortridge (1934) quotes several sources confirming the presence of hippo in the lower Orange River in 1887, 1898 and 1900. From then onwards, their numbers dwindled to a few individuals and references from 1903 onwards seem to presage their extinction. By 1913, only a few isolated individuals survived near the river mouth and there were records of spoor at the confluence with the Fish River in 1915. A police report in 1925 notes a single hippo opposite Swartwater which disappeared in that same year, thought to have been shot by a farmer. This was apparently the last hippo on the Orange.

(ii) *Present numbers and distribution*

It is assumed that there are no hippo left on the Cunene below the Ruacana Falls.[9] Recent information from reliable tour guides operating in the area (through Chris Roche *pers.comm.*) is fairly conclusive that there are no hippo west of the Ruacana Falls. Even if there were, the arid conditions of the area will always limit hippo numbers to a few individuals.

The full extent of the Okavango River in Namibia appears in **Fig.11** on the next page showing the few remaining localities with hippo and the floodplains which could provide suitable habitats for hippo. Mendelsohn & Obeid (2004) mention a few hippos remaining on the 'upper' Okavango. Current reports suggest that a few hippo occur in the area around Nkurenkuru and at the Cuito/Okavango confluence. Shortridge (1934) remarked on the paucity of floodplains associated with the Okavango River in Namibia above Andara. Although the floodplains are not as extensive as, for example, on the Zambezi River, there are nevertheless numerous areas which would be suitable for hippo were it not for the fairly dense human settlement, crops and cattle along the river. The newly formed Joseph Mbambangandu conservancy near Shambyu may well attract hippo to the floodplains in that area (shown in **Fig.11**)[10].

The main hippo populations in Namibia are in the Caprivi. Stander (2004) carried out the first survey in the Caprivi specifically designed to count the numbers of animals on the Caprivi floodplains and his hippo estimates are shown below –

Kavango	Kwando	Mamili NP	Chobe/Linyanti	Zambezi	TOTAL
247	308	560	255	17	**1,387**

The survey strata included the following areas –

Kavango – Mahango NP, Babwata West and the floodplains northwards as far as the main road

Kwando – Babwata east, Kwandu, Mayuni and Mashi conservancies and Mudumu NP

Mamili – Mamili NP only

Chobe/Linyanti – the full extent of these rivers eastwards of Mamili including Salambala conservancy

Zambezi – the international boundary from Katima Mulilo to the Chobe River confluence.

The hippo populations on the floodplains along international boundaries (Kwando, Linyanti, Chobe and Zambezi rivers) are shared with neighbouring countries (Botswana and Zambia). This has significant implications for any potential hippo harvesting programmes within Namibia.

9. Staff of the Cunene River Lodge estimate 25 hippo on the Cunene (Peter Erb *pers.comm.*) but it is not certain whether any of these animals occur downstream of the Ruacana Falls.

10. The vegetation map of Joseph Mbambangandu conservancy has been done using the author'sinterpretation of the aerial photograph shown in Fig.11. It is possible that the effects of fires could have caused errors in the boundaries selected for the vegetation types.

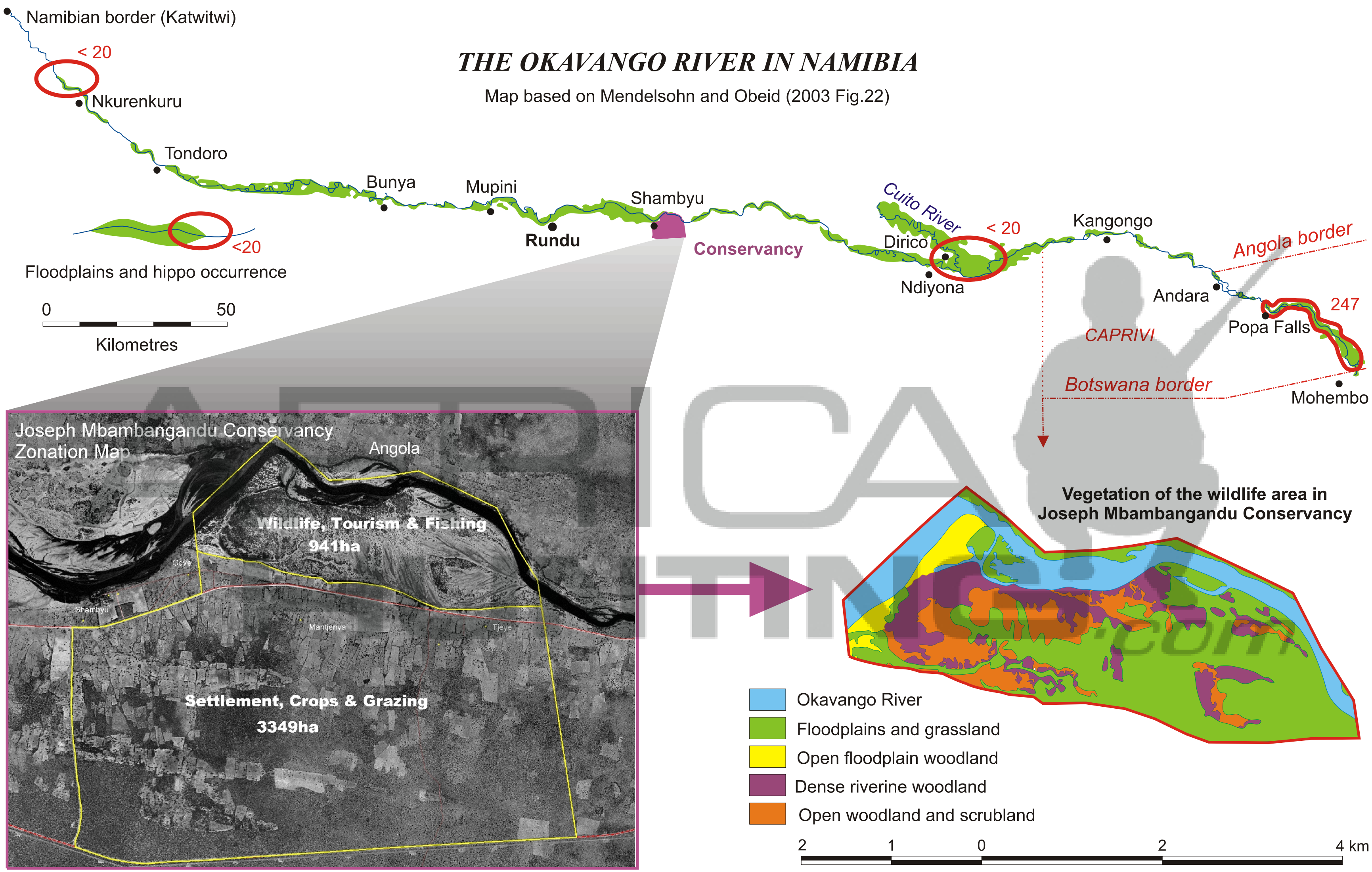


Figure 11. The Okavango River in Namibia showing the floodplains and Joseph Mbambangandu Conservancy

The estimates for hippo numbers made in the course of other air surveys since 1980 are shown together with Stander's (2004) estimates in **Appendix 5** (page 62) and **Fig.12** (next page). It is difficult to infer any trends in the population because there are no survey data which compare readily with those of Stander (2004) and because the earlier data are too sporadic to permit any meaningful analysis.

Stander's overall total for the Caprivi (1,387) and his estimate for Mamili National Park (560) are the highest yet obtained but both fall within the 95% confidence intervals of Craig's (1998) survey. Stander's estimate for Mudumu is lower than several earlier estimates and falls outside Craig's 1998 estimate. Stander's estimate for Mahango is lower than three previous estimates but falls within the confidence intervals of Craig (2000). Because of the mobility of hippo along watercourses it would be unwise to draw any conclusions about upward or downward trends in numbers.

It could be reasonably expected that some form of relationship exists between hippo population numbers and rainfall but, as stated above, the data are too scant to permit any meaningful exploration of this idea.

The distribution of hippo in relation to the different land tenure categories in the Caprivi is shown in **Fig.13** (page 27). As might have been expected, the highest numbers occur in State protected areas with more than 40% of the Caprivi total in Mamili National Park. An exception to this generality is on the Chobe River where slightly under 200 hippo were counted: in this case, the protected area is on the Botswana side of the border (Chobe National Park). Some 68 hippo counted along the Kwando River were allocated to the three conservancies (Mashi, Mayuni and Kwandu) and the number seen on the western side of the river within the Eastern Core of Babwata was significantly higher (91). However, these proportions are likely to vary as hippo move from one bank of the river to the other. The low numbers along the Zambezi and in Salambala conservancy (where there are extensive floodplains) is disappointing.

The distribution of hippo in relation to the vegetation of the Caprivi is shown in **Fig.14** (page 27). All hippo occur within the floodplains and riverine woodlands except in Mudumu where a small number occur on river banks fringed with mopane woodland. The most extensive floodplains occur along the Chobe/Linyanti and Zambezi river systems and these contain the fewest hippo: this can be attributed entirely to human population densities and cattle densities in the east of the Caprivi. The floodplains in Mamili support a relatively high density of hippo.

The distribution of hippo in relation to human population densities and cattle densities is shown in **Figs. 15** and **16** (page 28). High cattle densities generally coincide with high human populations. Whilst it is generally clear that hippo avoid areas of intense human settlement, there are some exceptions to this rule. Some 60 hippo on the Okavango occur in an area of high human and cattle densities upstream of Mahango national park and a similar number occur in the Mayuni and Kwandu conservancies under the same conditions. Immediately upstream of Mamili on the Linyanti River is an area of dense human settlement with cattle which supports 50 hippo. Hippo exclusion due the effects of high human and cattle densities is most obvious in Salambala, Impalila and Kasika conservancies and along the entire the length of the Zambezi within Namibia. An area where more hippo might be expected is on the upper reaches of the Linyanti river where there are substantial floodplains coupled with low human and cattle densities.

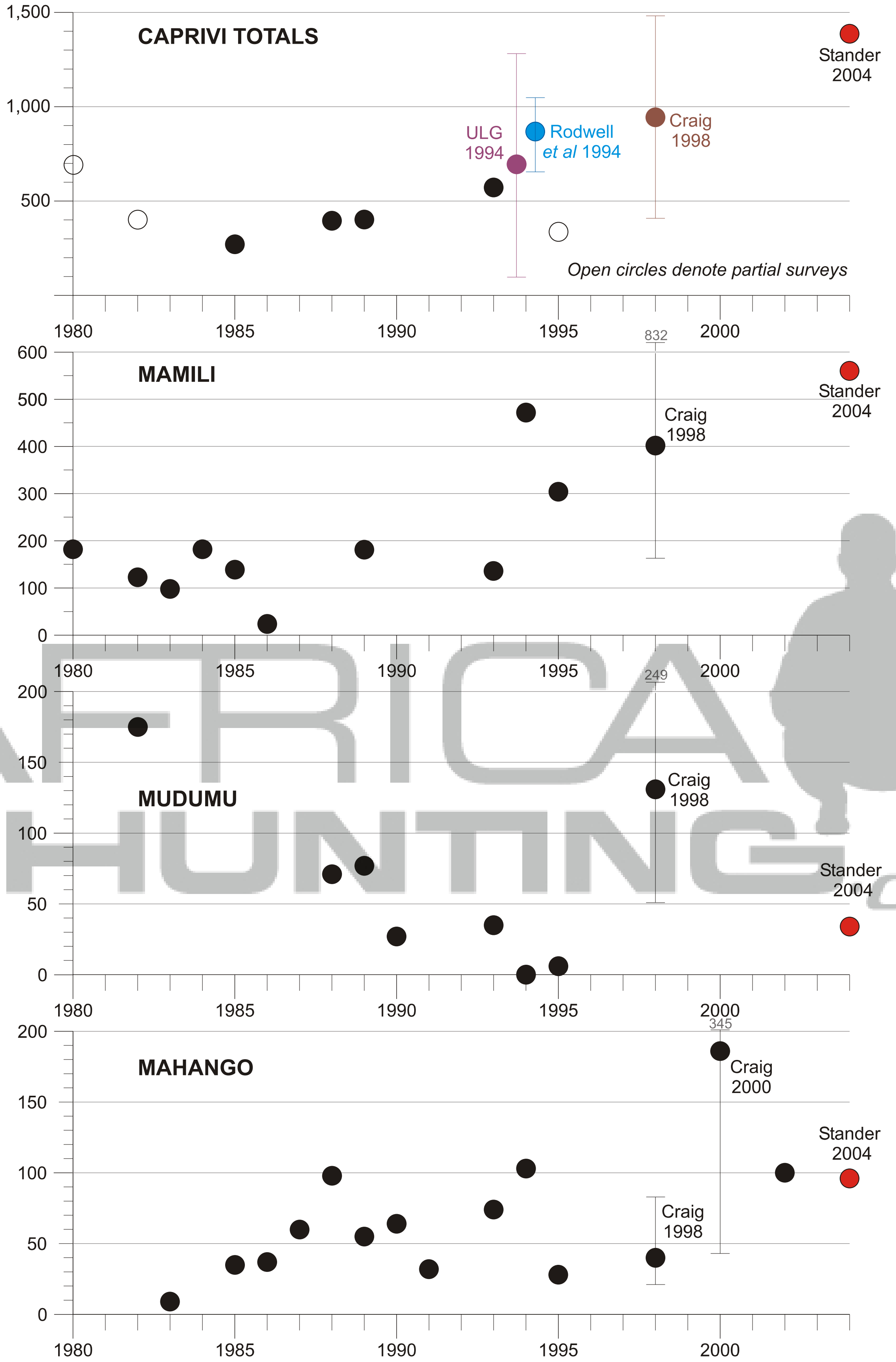


Figure 12: **Selected hippo population estimates for the Caprivi**

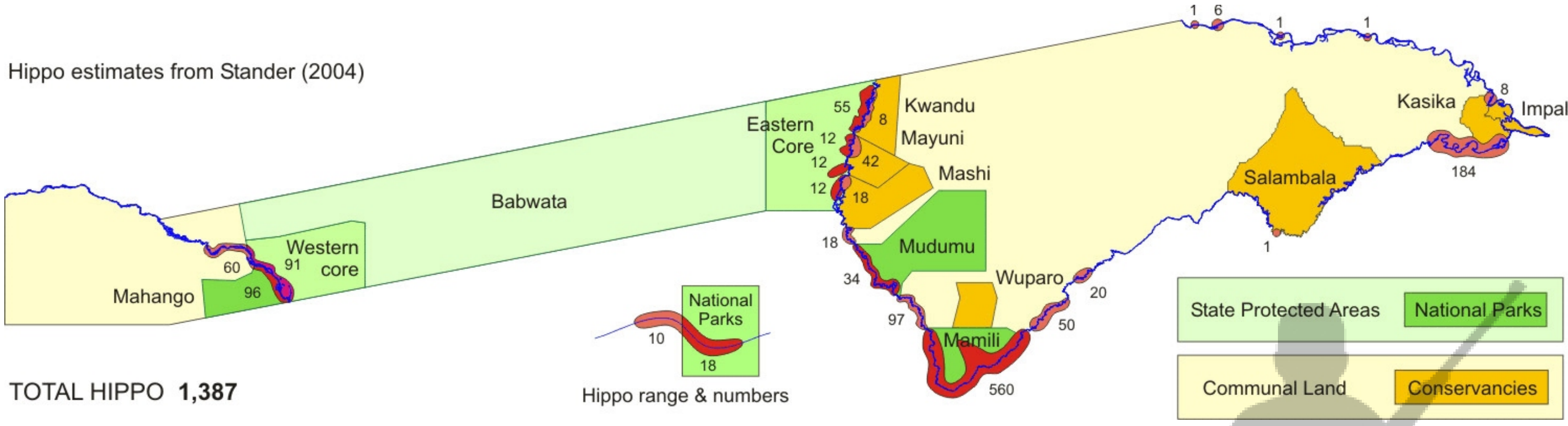


Figure 13: **The Caprivi hippo population in relation to land tenure**

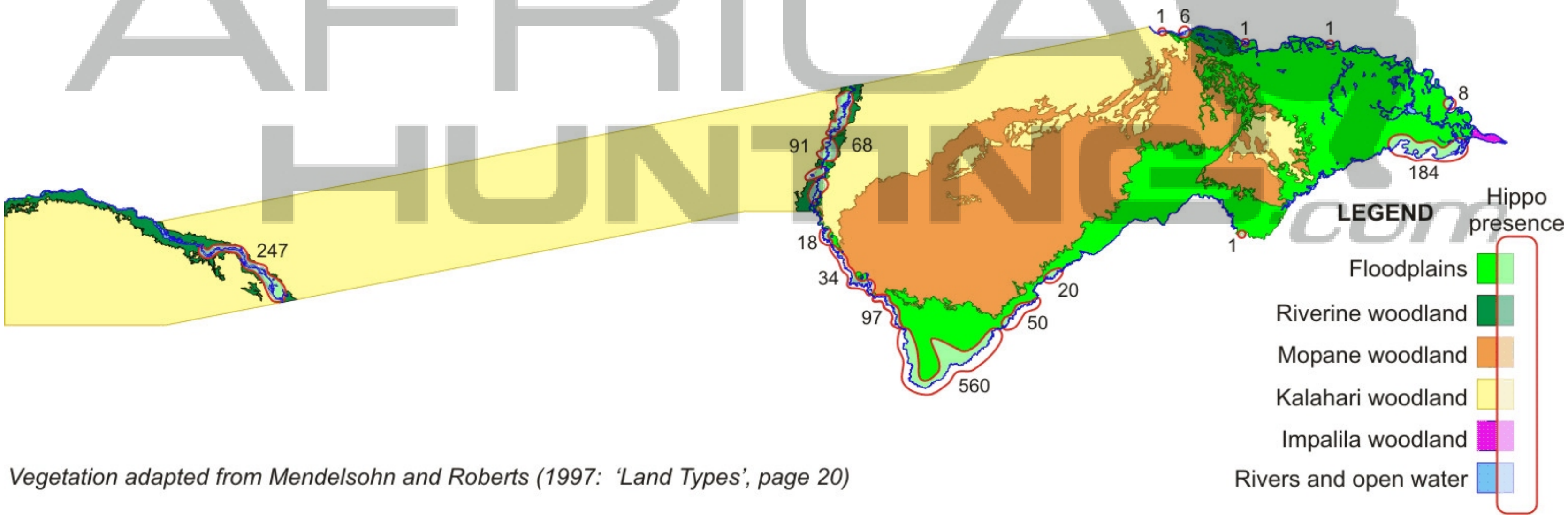


Figure 15: **The Caprivi hippo population in relation to vegetation**

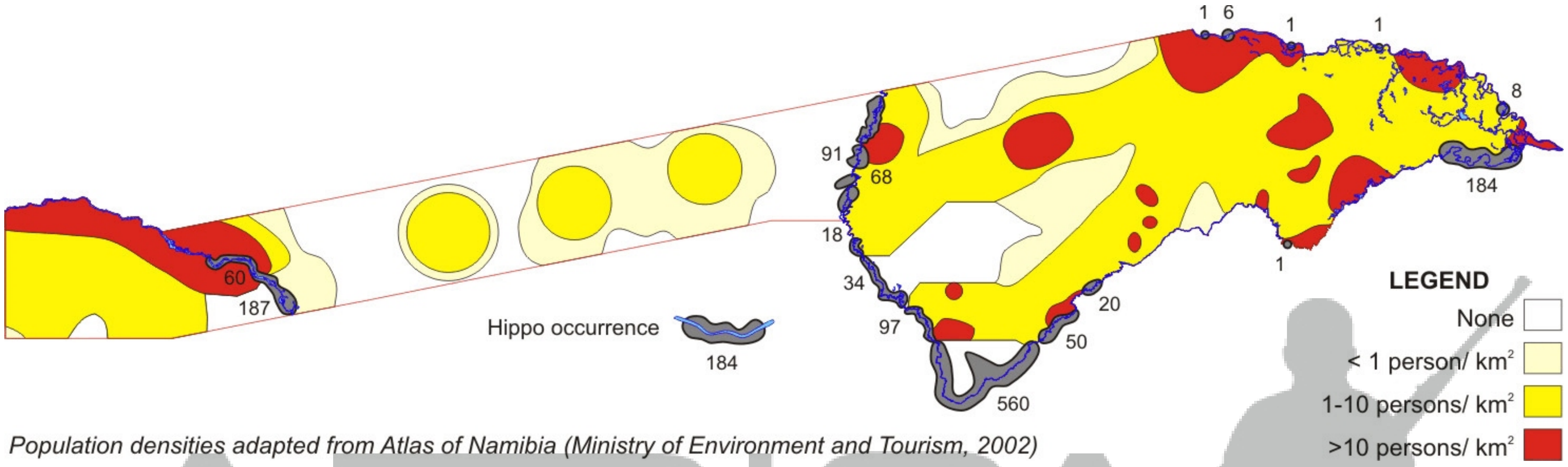


Figure 15: **The Caprivi hippo population in relation to human population densities**

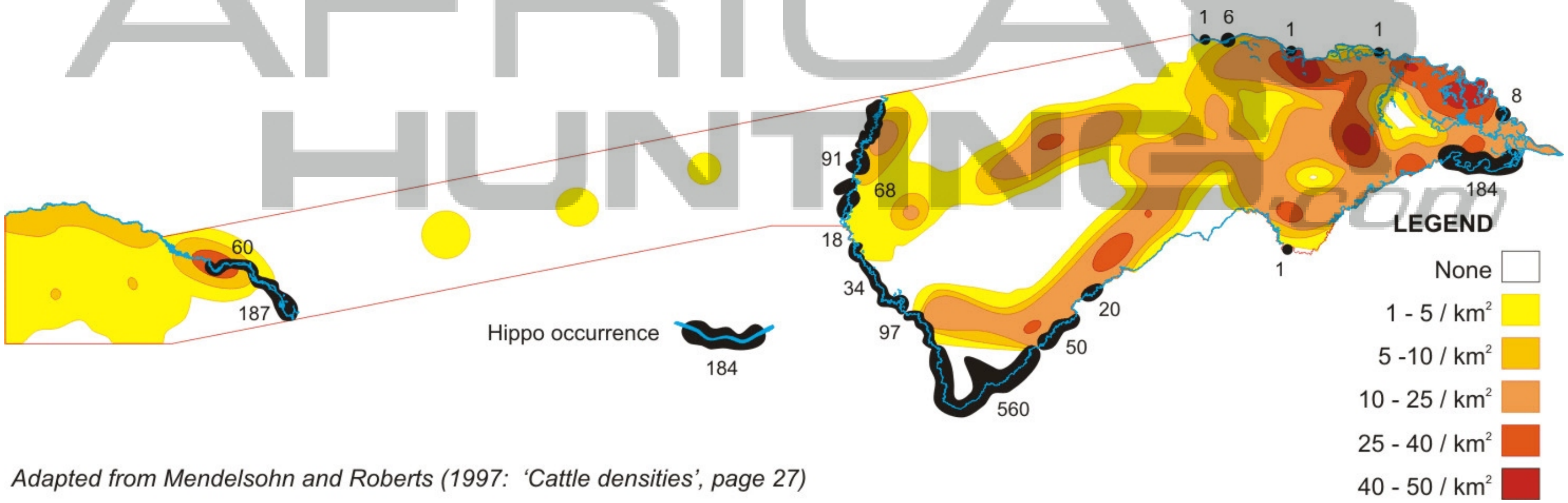


Figure 16: **The Caprivi hippo population in relation to cattle densities**

f. Behaviour

Various aspects of hippo behaviour have already been mentioned in this report including the concept of a 'living space' (page 12), feeding behaviour (page 14), hippo movements (page 13) and factors leading to homeostatic population regulation (page 11). In this section it is perhaps only necessary to reiterate those behavioural characteristics of hippo which affect management.

Hippo differ from all other species so far considered in this trans-boundary mammal project in having the dual requirement of a daily living space and a grazing range (Olivier & Laurie 1974). This affects the manner in which they use resources and survive in areas which are heavily populated by humans and where they are hunted. Their feeding behaviour is nocturnal and they are able to hide in narrow channels and impenetrable reedbeds during the day where they are relatively safe from human predation. They can remain under water for periods longer than five minutes and surface to breathe with only their nostrils appearing above the water.

It is generally considered that the hippo's nocturnal feeding behaviour arises from a need to avoid direct sunlight on their sensitive skins (HSG 1993). However, in areas where hippo are totally secure they frequently graze during the day and bask exposed to the full heat of the sun (e.g. Mana Pools on the lower Zambesi river in Zimbabwe). This would suggest that their nocturnal habits may be a survival trait arising largely from the avoidance of humans.

Hippo are capable of moving long distances in search of food and, in the extreme, to occupy new ranges. In the Caprivi, hippo move up to 90km from the Kwando river into the omurambas of the Western Caprivi during good rains (Mayes *pers.comm.*). The example of Huberta (footnote 7) illustrates the ability of hippos to cover great distances without being detected and with considerable stealth. The colonisation of artificial pans and dams in Hwange National Park, Zimbabwe, entailed hippo moving more than 100km from the Zambesi River which they achieved without being noticed *en route*. This has relevance to conservancy development in Namibia: by creating conditions which are favourable for hippo (e.g. Joseph Mbambangandu conservancy), it is likely that sooner or later they will move in to occupy the vacant niche.

Hippo group size is an extremely variable parameter. Stander (2004) found that the average group size in the Caprivi was 5 but groups as large as 45 animals were observed. Group size is most likely to be small where hippo are limited in resources or under pressure from human predation. Single adult males are a feature of hippo populations and arise from unsuccessful competition to secure females. Lone bulls frequently carry the scars and wounds of intra-specific fighting and may be dangerous to humans. It would seem logical to target such individuals in any programme of hippo exploitation.

Hippo males spread their dung by vigorous 'paddling' with their tails both on land and in water. This behaviour is thought to be a signalling function rather than a territorial display (HSG 1994). The nature of this signalling may, in many cases, be a prelude to aggression either to humans or to other hippos and is often indicative of some degree of uncertainty on the part of the animal and, hence, potentially dangerous situations (Parker *pers.comm.*).

Although hippo are predominantly grazers of wild grasses and sedges, given the opportunity they will consume maize, sugar cane, pumpkins, beans, cabbages, melons and other vegetables. Their depredations on crops planted close to river margins can be devastating and, perhaps unwittingly, they discourage illegal stream bank cultivation.

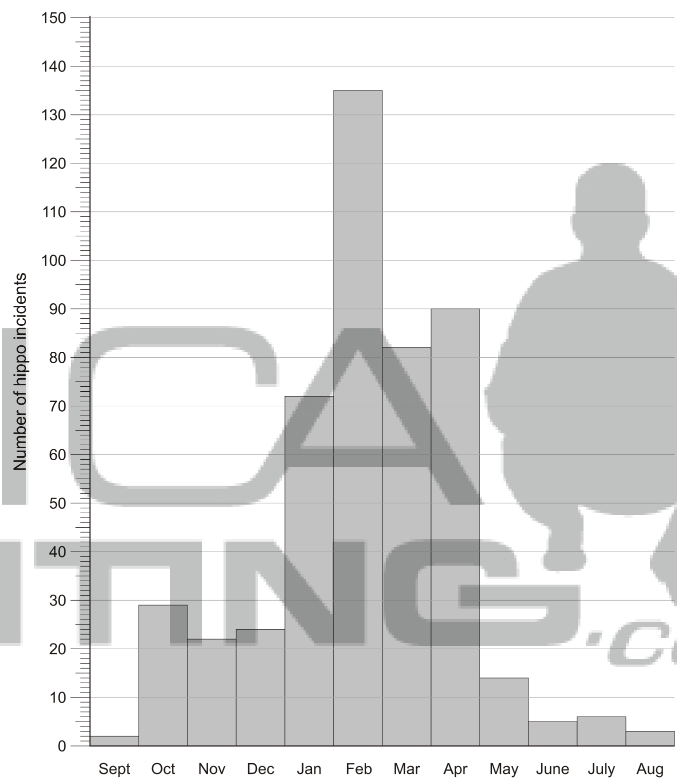
Hippo damage crops and are a physical threat to humans.[11] The data relating to hippo incidents in the Caprivi Conservancies are shown in **Table 5** and **Fig.7** below (NNF 2004, Conservancy Event Book). The greatest conflict between humans and hippos occurs on the Kwando River frontage and it is clear from **Fig.7** that the incidents reach a peak in the crop growing season. In 2003 the number of incidents involving hippo in the eastern Caprivi conservancies was 263 – which exceeds the number of incidents involving elephant (253). O'Connell-Rodwell (*et al* 2000) estimated the value of damage to crops by elephants from 1995-2000 for the whole Kwando River region at about N$20,000 per year: it might be expected that the value of hippo damage is similar. This has significant effects on household livelihoods.

Table 5: Hippo incidents in Caprivi

Conservancies	2001	2002	2003	2004
East Caprivi				
Impalila	0	6	12	27
Kasika	15	2	4	25
Kwandu	33	77	82	31
Mashi	20	16	3	18
Mayuni		16	124	17
Salambala	0	3	2	1
Wuparo	0	12	36	5
Totals	68	132	263	124
West Caprivi				
Balyerwa				8
Lianshulu			12	
Lusese			0	2
Malengalenga			2	9
Nakobolelwa			0	0
Totals			14	19

Year with no monitoring (shaded cells)

Figure 17: **Seasonal occurrence of incidents**



It cannot be inferred from the data of Table 5 that the overall number of hippo incidents is increasing (as is the case with elephant). In the Kwando conservancies (including Wuparo[12]) the number of incidents decreased from 2003 to 2004. In the extreme east of the Caprivi, despite far lower numbers of hippos, the numbers of incidents in Kasika and Impalila[13] increased in 2004.

11. Although a number of instances of direct conflict with humans are recorded in the Event Book system, it is not possible to tell the species of animal involved (e.g. elephant, crocodile or hippopotamus).

12. It is of interest that Wuparo conservancy suffers a significant number of hippo incidents. Stander (2004) does not record any hippo in Wuparo and it must be assumed that the animals originate from Mamili.

13. "Umparira is a horrid-looking place, situated in a marsh between the two rivers, suggestive of nothing but fever, ague and mosquitoes. It is a most unhealthy spot, and the graves of three English traders, who died there of the deadly malarious fever, attest the fact. It is just my idea of Eden in "Martin Chuzzlewit", and the very look of the place is almost enough to give one ague." (Selous 1881).

g. Limiting Factors

The majority of Namibia is unsuitable for hippo. Only the Caprivi has a high enough rainfall to carry a significant hippo population. It is clear that the main factors limiting hippo in the Caprivi are human settlement and competition with cattle. To this must be added the likelihood of some illegal hunting – as a result of the relatively high human densities in the Caprivi and the nature of hippo as problem animals and a potential source of meat. Conservancy development in the Caprivi will have reduced illegal hunting by Namibians to a significant extent but, with the major rivers being shared international boundaries, Zambians and Angolans have the capability of reducing the Namibian 'share' of hippo in the Zambezi and the Okavango river.

Stander (2004) estimated that there were some 1,400 hippo in the Caprivi. The question arises of how many hippo there could be if all factors were favourable to hippo population increase. A basis for making an estimate may lie in taking the present population of Mamili National Park and extrapolating to other suitable habitats in the Caprivi. Any estimate is speculative and requires a number of assumptions –

(1) The population of Mamili is close to carrying capacity;

(2) There is adequate water adjacent to all suitable habitats to meet the 'daily living space' requirement of hippos and this is not a limiting factor;

(3) The habitats which are suitable for hippo in the Caprivi are all floodplains, riverine woodlands and open water areas;

(4) The process which is underway at present whereby wildlife is valued through conservancy development will continue so that hippo are eventually able to occupy all available habitats;

(5) Numbers of cattle will decrease as wildlife becomes the primary land use; and

(6) Illegal hunting by citizens of neighbouring countries will become a minor factor through transboundary cooperation (a large assumption!).

Mendelsohn & Roberts (1997) give a detailed classification of the vegetation of the Caprivi including the area of each vegetation type and the proportions cleared for agriculture. The floodplain, riverine forest and open water areas appear in **Table 6** (following page) and these areas are reconciled with Stander's (2004) survey strata in **Appendix 6** (page 63). Were there no people or cattle in the Caprivi, approximately 4,500km^2 of suitable habitat would exist and, using the ratio derived from the hippo population of 560 animals estimated by Stander (2004) in Mamili National Park (320km^2) which is all floodplain habitat, this would give a ceiling value of about 8,000 hippo.

This does not take into account the areas within these habitat types which have been cleared for agriculture. I have taken the proportions given by Mendelsohn & Roberts in 1996 and made allowance for a further decline in the available areas as a result of human population increase since 1996 assuming this will be directly proportional to the population growth rate of 4%. The recalculated area of 'pristine' habitat amounts to 3,181km^2 (**Table 6**) which reduces the potential carrying capacity for hippo to about 5,600 animals.

Two habitats types appearing in the table are unlikely to contain hippo: the Bukalo-Liambesi grassland (120km^2) is too far from surface water and the Okavango valley fields and shrubland (133km^2) are settled and cultivated to the extent that this habitat type is unlikely ever to support more than a few hippo. Adjusting for this gives **a potential hippo population of about 5,000 animals**.

This figure will be used in later calculations to estimate the maximum financial and economic values of hippopotamus in the Caprivi.

Table 6: Habitats suitable for hippopotamus in the Caprivi

from Mendelsohn & Roberts (1997 pages 18-23)

Vegetation type	Area km2	% Cleared 1996	1996 Area remaining	% cleared 2005	2004 Area remaining
FLOODPLAINS				1.42	← *multiplier*
Bukalo-Liambezi grassland	223	32.6	150	46.4	120
Chobe grassland-hummock mosaic	294	32.7	198	46.5	157
Chobe Swamp grassland	177	37.1	111	52.8	83
Chobe wetland	73	50.4	36	71.7	21
Dry Mamili grassland	340	10.9	303	15.5	287
Kwando-Linyanti grassland	121	1.8	119	2.6	118
Liambezi-Linyanti grassland	617	32.4	417	46.1	332
Okavango-Kwando grassland	182	3.6	176	5.1	173
Wet Mamili grassland	95	0.0	95	0.0	95
Zambezi floodplain channels	64	22.4	49	31.9	43
Zambezi floodplain grassland	1,168	9.5	1,057	13.5	1,010
Zambezi transition grassland	309	8.4	283	12.0	272
Zambezi woodland	100	6.0	94	8.5	91
Totals	3,762		3,088		2,803
		Percent remaining	82		74
RIVERINE WOODLANDS					
Impalila woodland	18	22.4	14	31.9	12
Maningimanzi woodland+channels	88	7.2	81	10.2	79
Okavango valley fields+shrubland	187	20.5	149	29.2	133
Okavango/Kwando valley woodland	236	87.2	30	100.0	0
Totals	529		275		224
		Percent remaining	52		42
Open water	166	4.8	158	6.8	155
		Percent remaining	95		93
GRAND TOTAL	4,458		3,521		3,181
		Percent remaining	79		71

2. SIGNIFICANCE OF THE SPECIES

a. Conservation Significance

A crude estimate of the number of hippopotamus in Africa in 1994 was 157,000 of which 80,000 were thought to occur in southern Africa. The species "does not appear to be in any danger of extinction and there is no immediate cause for alarm over its future." (HSG 1993). The species is classified as 'Least concern' in the IUCN Red Data Book (Hilton-Taylor 2000). It was listed on Appendix II of CITES in 1995 contrary to the provisions of the criteria for listings.

Namibia holds about 1% of the African hippo population and most of the animals are in the Caprivi. The species is not under any threat in Namibia although the subpopulations on the Cunene River and upper Okavango are very small. However, given the aridity of the Cunene region and the high human population densities on the Okavango River it cannot be expected that there will ever be large subpopulations in these areas. The Caprivi population could be increased (see previous section on **Limiting Factors**) but this is dependent on wildlife in general playing a larger rôle as the primary land use in the region.

Hippo provide moderate benefits to the people of the Caprivi[14] at the same time as causing significant losses of crops. The management measures required to enhance the status of hippo may include a greater devolution of rights and responsibilities for hippo management (i.e. the conservancies should set their own quotas) combined with a coordinated harvesting programme. It was pointed out under the section on **Reproduction** (page 11) that in situations where hippo are unable to increase in number, natural regulating mechanisms tend to reduce population growth. Cropping from the population may in fact stimulate productivity.

Greater devolution of rights to manage hippo will not be possible while hippo remain designated as Specially Protected Species under Schedule 3 of the present wildlife legislation[15] and authority is denied to communal landholders under clause 37(1)(a)(ii) to kill hippo in defence of crops or property. There would appear to be no sound biological reasons for this classification and, indeed, it may be acting against conservation of the species.

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14. The Kwando River conservancies have a total quota of 10 animals of which 4 are for trophy hunting, 3 for traditional uses (see page 22) and 3 as problem animals. One hippo is allocated to Salambala for problem animal control (note that Stander (2004) counted only one hippo in the Salambala area!). A small quota has been allocated to Kasika and Impalila.

15. Nature Conservation Ordinance, No.4 of 1975.

b. Economic Significance

Outside of the Caprivi, hippo are unlikely to be important in the wildlife industry in Namibia. The absence of perennial water in the main body of the country precludes the establishment of hippo populations. The arid conditions along those rivers which are international boundaries will always limit the numbers of hippo which can survive. Hippo might make a small contribution to tourism values on the Cunene but there is some uncertainty about the permanence of hippo downstream of the Ruacana Falls. If hippo were re-introduced to the Orange River they would probably add to the value of the growing tourism industry in the arid south – where few other land uses offer any competitive advantage.

Hippo could make a significant financial and economic contribution to the wildlife industry in the Caprivi through any or all of the following uses –

(i) Harvesting for skin and meat;
(ii) International sport hunting for trophies;
(iii) Control of problem animals.

The value of hippo to non-hunting tourism in the Caprivi is difficult to assess and has not been attempted in this study. It seems doubtful that the presence or absence of hippo would greatly influence the number of visitors to the Caprivi and their rôle in this aspect of the wildlife industry is unlikely to be as important as are the consumptive uses. It would nevertheless be prudent to minimise the disturbances which arise from killing hippo for aesthetic reasons.

The highest valued use for an adult male hippo lies in the sport hunting industry. The net value of a single trophy bull is about US$8,000 including skin and meat values.[16] However, as with elephant, quotas exceeding about 0.5% of the total population result in the elimination of most of the older adult males (see **Management** page 39 and **Appendix 8** page 69). This puts an upper limit on the number of hippo which can be allocated to sport hunting and, in a population of 1,000, this limit is about 6 animals.

Based solely on size, the average gross value of a hippo carcase is about US$2,000 for trophy males, US$1,500 for problem animals and US$1,000 for harvested animals.

The financial values of a management regime based on the three activities listed above has been costed in **Appendix 7** (page 65). The management strategy is to allocate the maximum quota for sport hunting, limit the number of problem animals to the minimum and implement a hippo harvesting programme which is sustainable and which will not reduce present hippo numbers. The hippo population estimate of 1,387 animals for the Caprivi (Stander 2004) has been adjusted downwards to 900 animals to allow for population subunits which are shared with neighbouring countries.

The quotas for the three types of management are –

	Sport hunting	Problem animal control	Harvesting
Numbers	5	10	45
%	0.55	1.11	5.0

16. This assumes a trophy fee of US$5,000, two hunter days worth US$1,000/day, and skin, meat and tusks valued at US$2,400. Safari operating costs would be about US$400 for the two days allocated.

In calculating gross and net incomes for this quota of animals it is convenient to put the various stakeholders into two groups: the first group includes all safari operators engaged in hunting hippo and the second group includes the land occupiers of State protected areas, established conservancies and communal land in the Caprivi. This second group is referred to as the "**Project**". It is simple to calculate the total returns to the 'project' and to be aware that these returns have to be parcelled out amongst the various actors in the 'project' (this exercise has been done in **Table 9**, page 67). The budgets for the two stakeholder groups are calculated in **Appendix 7** (page 65) and summarised below –

All figures in United States dollars

Safari Operators

Income	
Hippo trophy fees	25,000
Daily rates	10,000
Gross income	**35,000**
Costs	
Operating costs	2,000
Rental to 'Project'	8,750
Net income	**26,250**

"The Project"

Income	
Hippo products	70,000
Operators' rental	8,750
Gross income	**78,750**
Costs	
Operating costs	5,500
Net income	**73,250**

Rental paid by the safari operators to the 'Project' is 25% of gross income and includes hippo trophy fees.

The combined net income is close to US$100,000 (N$630,000). Applying this to the area of hippo habitat in the Caprivi (3,181km^2 – **Table 6**, page 32) it translates to a land use return of US$0.31/ha (N$2/ha). If the hippo population could be increased to 'carrying capacity' (5,000 animals, page 32), the net return would rise to US$1.71/ha (N$11/ha). At this level it would amount to more than half of the potential land use value of elephant (US$3.3/ha calculated in Martin 2005). The potential combined net income from hippo and elephants is about US$5/ha and this exceeds the net land use values of US$1.08 - US$4.86 for northern cattle/wildlife farms found by Barnes & de Jager (1995). The same authors found that the 'net value added' in economic terms to the land use values was in all cases more than double the financial value and it is reasonable to expect that this would hold true for the income obtained from hippos.

The numbers of hippos (N), management quotas (Q) and distribution of income amongst the various categories of land in the Caprivi is summarised below.

	Hippos	Sport hunting		PAC		Harvesting		**TOTAL**
	N	Q	US$	Q	US$	Q	US$	**US$**
State Protected Areas	575	3	11,250	1	1,400	28	25,200	**37,850**
Conservancies	100	2	7,500	6	8,400	7	6,300	**22,200**
Communal land	223	0	0	3	4,200	10	9,000	**13,200**
Totals	**898**	**5**	**18,750**	**10**	**14,000**	**45**	**40,500**	**73,250**

3. STAKEHOLDING

This section is restricted to the stakeholders in the hippo population in the Caprivi. In due course, hippo may play a rôle in the economies of conservancies on the upper Okavango River and on the Cunene but at this stage it would be premature to enlarge the discussion.

a. Stakeholders

On the previous page the concept of two main stakeholder groups was developed for the purposes of analysing financial budgets. The group included in the '**Project**' comprised all land occupiers in the Caprivi as distinct from the group of safari operators who seek to buy the 'product' which the first group offer.

The 'Project' could be more than an artifice for the purpose of calculating budgets. Management of hippo is sufficiently lucrative that it could justify the establishment of a facility located centrally in the Caprivi to process hippo carcases efficiently so that the maximum value is obtained from the products on behalf of all the stakeholders in the 'Project'. Not only are the products from hippo valuable (see footnote 28) but the proportion of the net income which can be secured by the stakeholders is far higher than for most other species.[17] The autonomy of individual stakeholders would not be threatened by such a project and the enhanced returns might increase the incentives to conserve hippo and reduce illegal hunting.

If it were also decided to embark on a comprehensive management programme for elephant in the Caprivi, such a facility could also service the requirements of processing elephant carcases. It would provide employment and increase the economic benefits of the wildlife industry. The requirements for such a facility are listed in **Appendix 7** (page 65).

b. Stakeholder Institutions – Present and Future

Although hippo are capable of moving great distances when dispersing, for the most part they are relatively sedentary and lend themselves ideally to local management. Thus the need to develop umbrella management institutions for large areas – as is the case for elephant and most of the other species included in this Transboundary Mammal Project – is less imperative. There is a strong case for co-ordination rather than co-management amongst the Caprivi stakeholders. If a 'Project' such has been outlined in this study is implemented there will also be a need for raising awareness of the underlying principles of hippo management, the experimental nature of any management and the importance of monitoring.

A benefit of local management is that it preserves the 'principle of differential benefits' (Murphree 1994). Those conservancies and other communities who are successful in increasing or maintaining their hippo populations should deservedly gain higher benefits than others. This principle becomes increasingly important if any hippo harvesting scheme is introduced: hippo should not be seen as 'common pool' resource.

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17. The maximum value for most species lies in sport hunting where it is inevitable that safari operators will take the lion's share of the income.

The present institutions for conservancies in communal land would be adequate for the purposes of hippo management were it not for the substantial portion of the hippo population in the communal land outside conservancies. The Caprivi is the focus for conflict between wildlife management and people, domestic livestock and cultivation. Conservancy development in the Caprivi is less extensive than in the north-western areas of Namibia and the institutions are more fragile because of a larger choice of land use options than in the arid areas. Whilst developments in conservancies appear promising, tolerance of wildlife is finely balanced and it would require little in the way of disincentives for the entire edifice to collapse.

The present hippo quota allocations to conservancies in the Caprivi are substantially higher than those for elephants[18] and the benefits may be sufficient to provide tolerance for hippo. However, those people who are not in established conservancies in the Caprivi receive little in the way of benefits and they suffer substantial losses. Farmers are not free to defend their livelihoods from hippo depredations and the current arrangements for control of problem hippo are cumbersome. O'Connell (1995) found a hostile attitude towards wildlife amongst the Caprivi peoples and the inception of conservancy projects did little to ameliorate this attitude.

Unlike the other species in the Caprivi for which management plans have been prepared, hippo are not rare or endangered. There is scope for increasing the benefits from hippos for all stakeholders by introducing a harvesting programme.[19] There is a good case for devolution of hippo management to a stakeholder body within the Caprivi rather than continuing to retain it as a 'Head Office' function. This body would have to include representatives from all areas where there are resident hippo including those outside conservancies. Provided such a caucus was advised by a competent scientist and a sound monitoring programme was in place, there are good reasons for such a step. Each of the previous studies in this series has emphasized the desirability of greater devolution of authority as a prerequisite for the scaling up of institutions in the Caprivi – using the rationale of Murphree (2000) and Ruitenbeek & Cartier (2001). A substantial number of rare or valuable species in the Caprivi has now been identified which would benefit from such policy changes.

c. Towards Trans-Boundary Institutions

The case for transboundary cooperation on hippo management is perhaps stronger than for all of the other species which have been considered under the Transboundary Mammal Project. Hippo live in perennial rivers on international boundaries and some 35 % of the Caprivi hippo population estimated by Stander (2004) must be regarded as 'shared animals (**Table 9**, page 67).

The Namibian Ministry of Environment and Tourism has taken the initiative of establishing cross-boundary links with Botswana on species management issues. In each of the species studies in this series the same recommendation for a permanent technical forum has been put forward and it is not necessary to repeat it. It becomes even more relevant in the case of hippo.

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18. . . . . although the numbers of trophy hippo may be unsustainable – see page 39.

19. . . . . and, at the same time, reducing the quota of trophy hippo.

4. MANAGEMENT

The section on hippo management which follows is based largely on tests using the population model referred to on page 5. The model needs to be used with caution – hippo are one of the most unusual species encountered so far in this series of transboundary mammal studies. The adjustments which can occur in their reproductive parameters as a result of environmental conditions and management treatments are not easily predictable. The reproductive parameters which have been used in the model are based on an assumption that hippo in the Caprivi are below carrying capacity (see the discussion on limiting factors on page 31) and would therefore be capable of increasing rapidly given favourable conditions. A corollary to this is that they would be fairly resilient to sustainable exploitation. 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.

In almost all of the previous transboundary studies in this series, there has been strong advocacy for forming co-management institutions which would allow management of the target species at a scale larger than the individual park or conservancy. This is less necessary in the case of hippo. The individual units making up the Caprivi hippo population are fairly localised, discrete and sedentary: management can be applied at a local scale. There are good reasons for adjacent conservancies to co-operate with each other and neighbouring State Protected Areas on hippo management but the need is more for coordination than co-management.

The first three parts of this management section deal with sustainable quotas for sport hunting, problem animal control and harvesting. It is assumed that these will be the main forms of hippo management in the Caprivi. It has been an extremely interesting technical problem developing workable computer software programmes which accommodate the underlying assumptions for each of these different types of management and accurately simulate the population response. Having developed a fairly robust model which allows a wide range of management treatments to be simulated separately and in combination, there then arises the need to find a management strategy which optimises the mix of sport hunting, PAC and harvesting.

With Namibia's commitment to sustainable use and highest valued forms of land use, it seems justified to assume that hippopotamus will continue to be subjected to consumptive use[20] and that there are sound reasons for trying to maximise the benefits which could be derived from scientific management of the Caprivi population. This is attempted in the section on harvesting (page 42) where recommendations are made for a judicious mix of all three forms of use. The financial implications of these recommendations appear in **Appendix 7** (page 65).

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20. At present about 23 hippo are killed on quotas in the Caprivi (Table 10, page 68) as opposed to the 60 proposed in this study. A small amount of 'harvesting' takes place in the form of traditional use quotas for the Kwando conservancies.

a. Hippo management

(1) <u>Sport Hunting</u>

At the outset, it is assumed that sport hunting will be restricted to male hippo. Hunting clients seek trophies with large canines and large body size and these characteristics are limited to males. The canine teeth of a hippo begin to assume full size at about 20 years of age (approximately 2kg for the pair) and only increase slightly over the remainder of the hippo's life. The largest weights seldom exceed 3kg and, in some cases, the teeth may decrease through breakage and wear (Laws 1968). The body weight of a 20 year old hippo is about 1,250kg (**Table 8**, page 56) and hunting clients are unlikely to shoot much smaller animals.

The proportion of a hippo population which can be sustainably hunted to provide trophies is as low as that for elephant. If it is assumed that the earliest age at which hippos are likely to be taken as trophies is about 20 years of age, this restricts hunting to less than 7% of the total population. This is not the important statistic, however. In a population of 1,000 animals the annual recruitment to the 20 year old age class is about 7 animals and it is this figure which cannot be exceeded. However, if quotas were set as high as this, all males older than 20years would be removed from the population and hunting would be reduced to the annual recruitment of 20 year olds. The effects of increasing levels of hunting quotas on the age structure of a hippo population in shown in **Appendix 8** (page 69) and **Fig.18** (page 40).

The maximum sustainable offtake of male hunting trophies from a hippo population is about one-half a percent of the total population. At this level, there will always be some males in the population surviving beyond 20 years of age (see age pyramid in **Fig.19D**, page 44). A slight selectivity for older animals with larger tusks is built into the model and is explained in **Appendix 8**.

Hunting causes the stable age structure of the population to become slightly skewed in favour of females (males:females 48%:52% versus 49.9%:50.1% when there is no hunting). The number of males in the age classes below 20 years actually increases from the number in the unhunted population (see table in **Fig.18**) 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 1,000 animals decreases from 494 in the no-hunting situation to 463 when it is attempted to extract a quota of 0.9% (9 animals) from the population.

It is sound management strategy to maximise the number of hippo which can be hunted as trophy animals since this is the highest valued use for a hippo. When setting multiple quotas (i.e. sport hunting, problem animal control and harvesting), the sport hunting quota should be set first and the others adjusted to take up the balance of the sustainable offtakes.

The present trophy hunting quota in the Caprivi is 15 animals (**Table 10**, page 68) as opposed to the 5 recommended in this study. In the long term a quota as high as this is likely to result in a deficit of older males in the population.

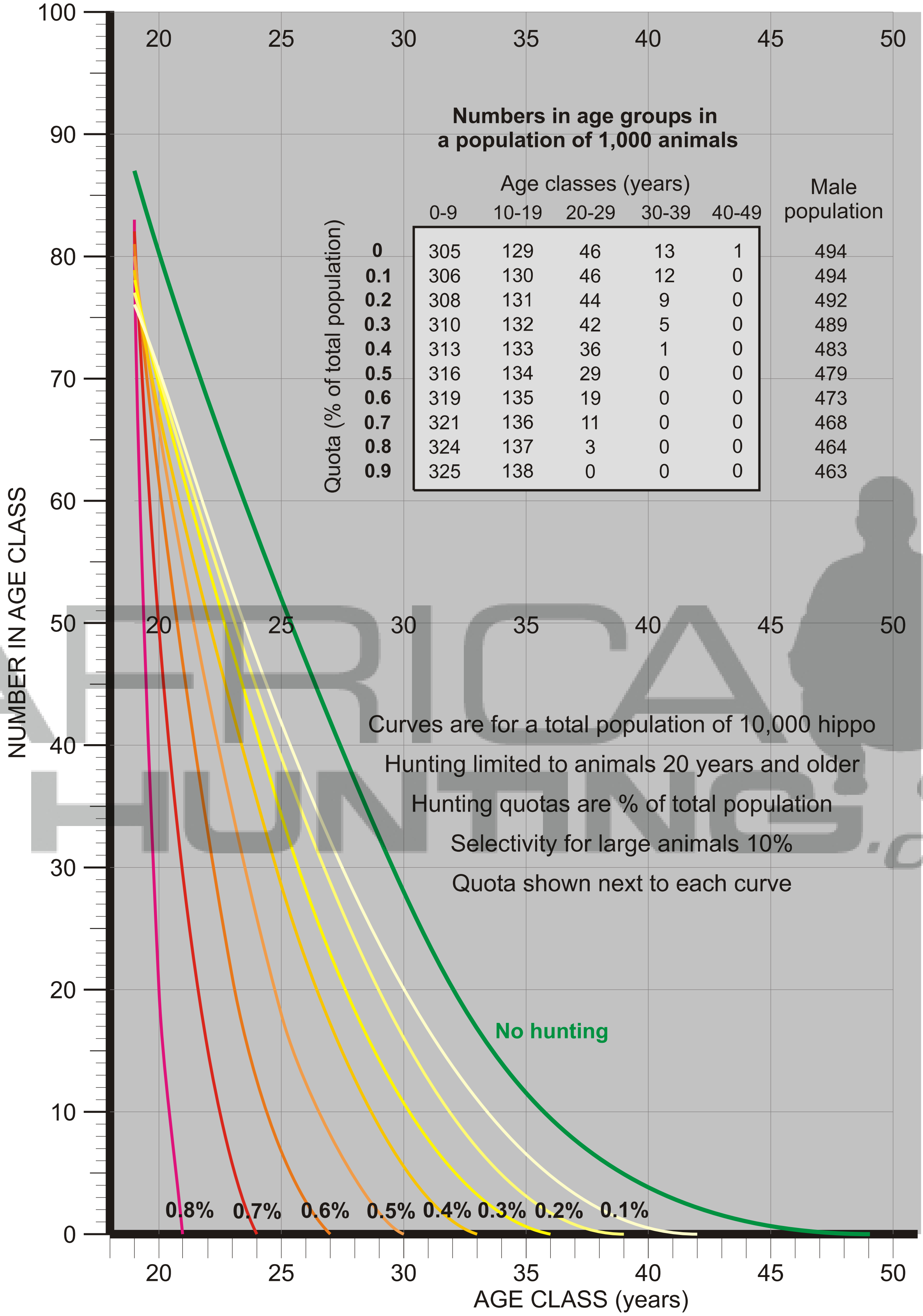

Figure 18: **Effect of increasing sport hunting quotas on population age structure**

(2) Problem animal control

For the purpose of simulating the effects of problem animal control (PAC) in the model it has been assumed that PAC is limited to animals older than 5 years and that both males and females are included without selectivity for larger animals. Using the same parameters in the model as for sport hunting tests (see page 11), it was found that the maximum sustainable offtake of problem animals is slightly under 6% of the total population (see table below). In a population with a stable age structure, about 59% of the total population consists of animals older than 5 years and the annual recruitment into the 6 year old age class is slightly less than 6% of the total population. Removing 5% of the population as problem animals has the effect of narrowing the upper part of the age pyramid and broadening the base (see **Fig. 19C**, page 44).

	PAC offtake – % of total population									
	0	0.25	0.5	0.75	1	2	3	4	5	6
Rate of growth %	7.13	6.82	6.51	6.20	5.90	4.65	3.45	2.25	1.00	Unsustainable

Initial population 1,000	PAC offtake – number of animals						
	65	70	80	90	100	150	200
% of population at start	6.5	7	8	9	10	15	20
Years to extinction	46	34	23	18	15	8	5

These relatively high offtakes of problem animals are possible only if the assumption that both males and females are hunted in equal proportions is satisfied. If it is satisfied, it has the further effect that sport hunting quotas are not affected by the level of problem animal control – provided it is sustainable (see **Fig.19E**, page 44). If the assumption is not satisfied and more males than females are killed as problem animals, then sport hunting quotas would have to be reduced to compensate for this effect.

Under a management strategy to maximise returns from a hippo population, it makes little difference whether a hippo is killed under the heading "problem animal" or "harvest" – provided the products of the hippo (meat, skin and teeth) are recovered efficiently and sold or used to maximum advantage. However, the contingency may well arise of having to deal with a problem animal (see occurrence of hippo incidents in the Caprivi – **Table 5**, page30) and this would take precedence over any harvesting programme. In the comprehensive management plan proposed under this study, a quota of 10 problem animals has been set (1% of a population of 1,000 animals) and animals should be killed only when absolutely necessary under this management 'heading'. At the end of the management year any balance left on the PAC quota can be harvested.

The present quota for problem animals in the Caprivi is 5 animals (**Table 10**, page 68) which is lower than that proposed in this study. This would partly (but not completely) compensate for the higher sport hunting quota.

(3) Harvesting

If harvesting (cropping) of hippo is to take place, it is strongly recommended that it is practised unselectively. Any cropping system which targets particular age classes will alter the age structure of the population in a manner which may produce undesirable long term effects. It has already been shown that by excluding the first five age classes from PAC the age pyramid assumes a 'bottom-heavy shape' (**Fig.19C**, page 44) and by selectively hunting large males for trophies the age pyramid becomes skewed in favour of females and has a 'bite' out of it for all the male age classes above 30 years. If any further selective pressures are introduced through harvesting it becomes increasing difficult to predict the outcomes.

For a hippo population growing at 7.13% per annum (using the characteristics defined on page 11), **offtakes of up to 7% of the total population are possible, provided the harvest is unselective** (see table below). For a population of 1,000 animals, the maximum sustainable harvest would be about 70 animals annually if there were no sport hunting or problem animal control. At this level, population growth would effectively be zero. The age structure of the harvested population is identical to that of the unharvested population (**Figs.19A & B**, page 44).

	Harvesting – % of total population										
	0	0.25	0.5	0.75	1	2	3	4	5	6	7
Rate of growth %	7.13	6.87	6.60	6.33	6.07	5.00	3.99	3.00	1.78	0.71	0

Initial population 1,000	Harvest annual offtake – fixed number of animals									
	71	75	80	90	100	120	150	200	300	500
% of population at start	7.1	7.5	8	9	10	12	15	20	30	50
Years to extinction	59	40	32	24	19	14	10	7	5	3

When harvesting is combined with problem animal control and sport hunting (see the preamble to this section, page 38), the maximum harvest must be reduced. If 5 sport hunting trophies are taken annually from the population of 1,000 animals in the Caprivi (0.5% of the total population) and if 10 animals are killed as problem animals (1% of the total population), then the maximum harvestable balance which would result in zero population growth would be about 45 animals. The age structure which results from this management regime is shown in Fig.**19F** (page 44).

To implement such a management programme in the Caprivi is not as simple as it might appear. Firstly, the Caprivi hippo population is dispersed in a number of geographically discrete subunits on the different rivers in the Caprivi. Secondly, on those river sections which are international boundaries the Namibian 'share' of the hippo population should strictly be treated as half of the estimate for any particular section – it would be provocative to neighbouring countries to treat it as more than this. Thirdly, to harvest with no bias towards any particular age class requires the application of random number techniques and some discipline. Lastly, some practicalities need to be taken into consideration in allocating quotas in conservancies.

In **Table 7** below an attempt has been made to apply the management principles. The estimates of Stander (2004) are shown in the first column and these are adjusted in the second column to take into account the population units 'shared' with neighbouring countries. Calculations of the sustainable quotas for sport hunting, problem animal control and harvesting are then made in the columns labelled '**C**'. Sport hunting quotas are calculated as 0.5% of the Namibian population values, and PAC and harvesting quotas are based on the maximum sustainable value of 5%.

Practical quotas are allocated in the columns labelled '**A**'. Sport hunting quotas have been set at the maximum, PAC quotas have been limited to minimum which might be practical in conservancies and communal land, and harvesting quotas have been set at the maximum. This results in a total annual offtake of about 60 animals from a population of 900 (6.7%) of which 5 are sport hunting trophies, 10 are problem animals and 45 are the harvesting offtake.

Table 7: A notional allocation of hippo quotas in the Caprivi

	Total Population	Namibia population	Sport Hunting		Problem Animal Control		Harvest		Total Offtake
			C	A	C	A	C	A	
Kavango	**247**	**247**	**1.2**	**1**	**12.4**	**1**	**12.4**	**12**	**14**
Mahango NP & Babwata Western Core	187	187	0.9	1	9.4		9.4	9	10
Communal land	60	60	0.3		3.0	1	3.0	3	4
Kwando	**308**	**234**	**1.2**	**2**	**11.7**	**4**	**11.7**	**12**	**18**
Babwata Eastern Core	91	91	0.5	1	4.6		4.6	4	5
Kwandu	8	8	0.0		0.4	1	0.4	1	3
Mayuni	42	42	0.2	1	2.1	1	2.1	2	3
Mashi	18	18	0.1		0.9	1	0.9	1	2
Mudumu	34	17	0.1		0.9		0.9	1	1
Communal land	115	58	0.3		2.9	1	2.9	3	4
Mamili NP	**560**	**280**	**1.4**	**1**	**14.0**	**1**	**14.0**	**14**	**16**
Chobe/Linyanti	**255**	**128**	**0.6**	**1**	**6.4**	**3**	**6.4**	**6**	**10**
Kasika & Impalila	54	27	0.1	1	1.4	1	1.4	1	3
Salambala	1	1	0.0		0.1	1	0.1	1	2
Communal land	200	100	0.5		5.0	1	5.0	4	5
Zambezi	**17**	**9**	**0.0**		**0.5**	**1**	**0.5**	**1**	**2**
Kasika & Impalila	8	4	0.0		0.2	1	0.2	1	2
Communal land	9	5	0.0		0.3		0.3		0
TOTALS	**1,387**	**898**	**4.5**	**5**	**44.9**	**10**	**44.9**	**45**	**60**

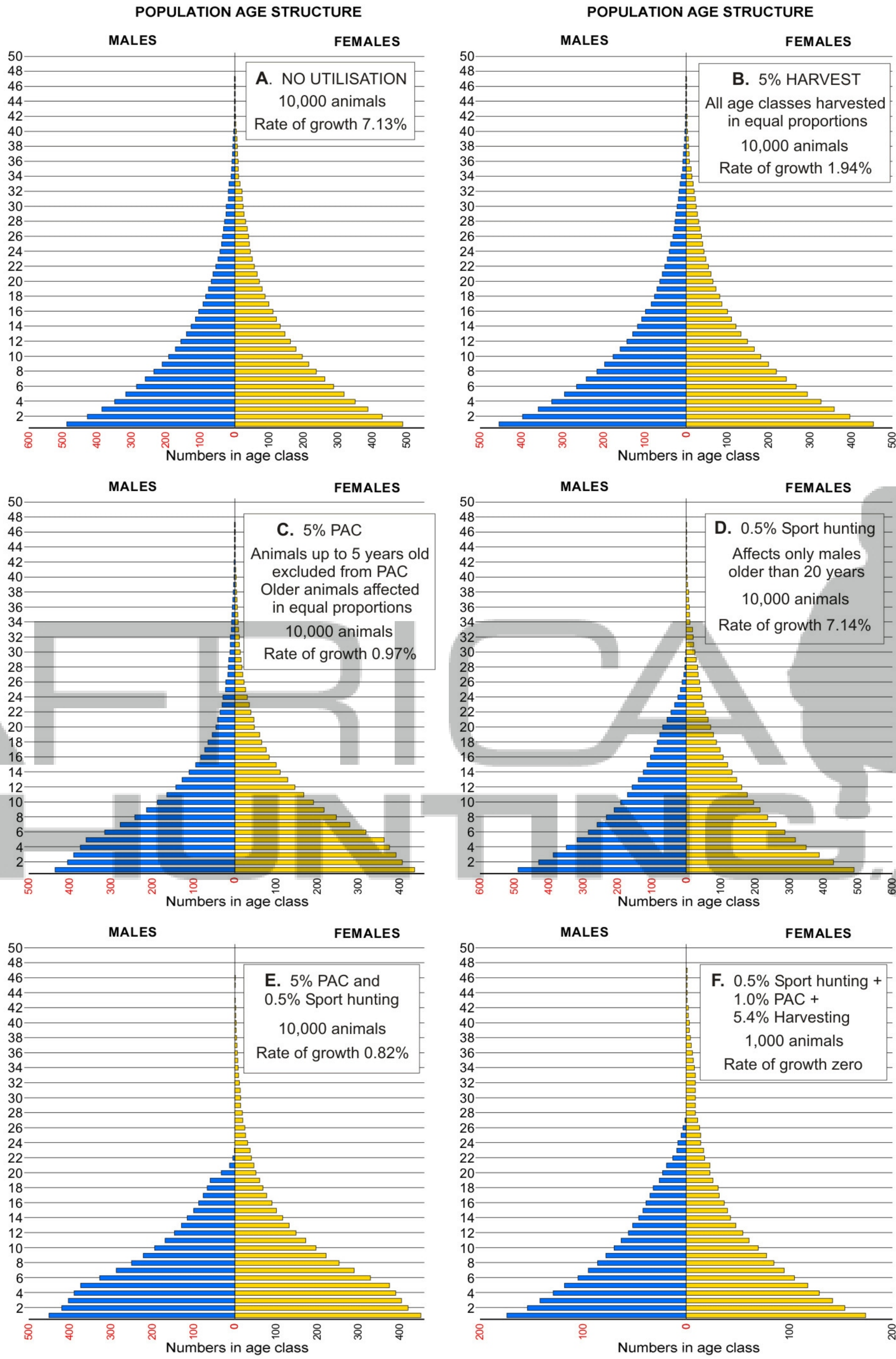

Figure 19: **Effects of various management practices on population age structures**

(4) Illegal hunting

There is unlikely to be any difference between the response of a hippo population to illegal hunting and legal harvesting if mortality affects both sexes and all ages equally. This is likely to be the case if the hunting is for meat or if the intent of the hunters were to eradicate hippo.

As with harvesting, illegal hunting should have 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% of the total population can be set for sport hunting.

Some illegal killing of hippo is taking place in the Caprivi both by Namibians and by citizens of neighbouring countries (Beytell, *pers.comm.*) but there are few data available to gauge the extent of it. Although the Namibian legislation forbids the killing of hippo to protect crops, there are instances where people take the law into their own hands and deal with hippo that threaten their livelihoods. In a recent case, notwithstanding the provisions of the legislation, a court in the Caprivi found in favour of the defendant – a precedent which throws into question the workability of the law.

Within the Caprivi, illegal hunting may be reduced by placing a greater value on hippos, devolving more authority to communities and implementing a 'project' such as that referred to on page 35. Reducing illegal hunting by citizens of neighbouring countries is more difficult since the hunters do not have to enter Namibia to obtain hippo from the 'shared' population. This problem can only be tackled by transboundary cooperation.

(5) Capture and Translocation

Translocating hippo may have application in the Caprivi as an alternative to killing persistent problem animals and may arise if it is desired to begin new hippo populations in areas which have sufficient water and pasture. One possible flagship project might be the reintroduction of hippo to the Orange River where they occurred until recent times (page 22).[21]

The direct immobilisation of hippo is difficult because of the likelihood of animals drowning. Some years ago, helicopters were used in Natal, South Africa, to drive hippos out of water and keep them out water until drugs took effect. However, the trauma associated with such operations was considerable. During the 1991-92 drought in the south-east lowveld of Zimbabwe, techniques were developed for the capture and translocation of complete groups of hippo by feeding the animals within an open boma over several weeks until they were habituated to the site. The boma door was closed when the target group was in the boma.[22]

Translocation of hippo is expensive and the costs should be sought from donor agencies rather than any local 'project' seeking financial sustainability.

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21. The translocation of hippo from the Caprivi to the Orange River is a formidable task because of the distance involved. However, an examination of Fig.10 (page 17) suggests that there are no hippo nearer to the Orange.

22. This operation is not as simple as it sounds. Firstly the boma has to be stoutly constructed to withstand the strength of large hippos. Secondly, hippo are extremely cautious animals and are very reluctant to enter enclosures. In the example given it was only because they were desperate for food that they did enter the boma. Lastly, the animals are extremely skittish and the slightest disturbance causes them to run out of the boma before the door can be closed. A successful capture can take several weeks (Clem Coetsee 1992)

(6) Habitats and fire

Probably the most important factor limiting hippo numbers in the Caprivi is competition with cattle for grazing. Increasing areas of floodplain habitat are being placed under cultivation (**Table 6**, page 32) and, in areas not cultivated, cattle grazing limits carrying capacity for hippo. This problem cannot easily be addressed through standard wildlife management techniques.

In pristine areas (e.g. Mamili National Park) there may be cyclical relationship between hippo, fire and pasture (page 15). This relationship becomes more complicated when cattle are part of the equation. Mendelsohn & 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. A close inspection of the fire occurrence mapping shows that large areas of floodplain are burnt annually towards the end of the dry season – from which the conclusion might be drawn that, if there is grass available for burning in September, the carrying capacity for grazing species has not yet been reached. In the section on limiting factors (page 31) it was hypothesized that carrying capacity for hippos in the Caprivi might be as many as 5,000 animals. Although there are parts of the floodplain habitats where 'hippo lawns' are a feature (and these clearly would not support fires), there are also large parts where surplus grazing is available.

It is doubtful whether fire has a seriously negative influence on hippo habitats and the green flush which follows burning may, in fact, favour hippo. The question then arises whether there are any active management measures which could be taken to enhance habitats for hippo (other than removing cattle and preventing the spread of cultivation which fall outside the scope of standard wildlife management practices!).

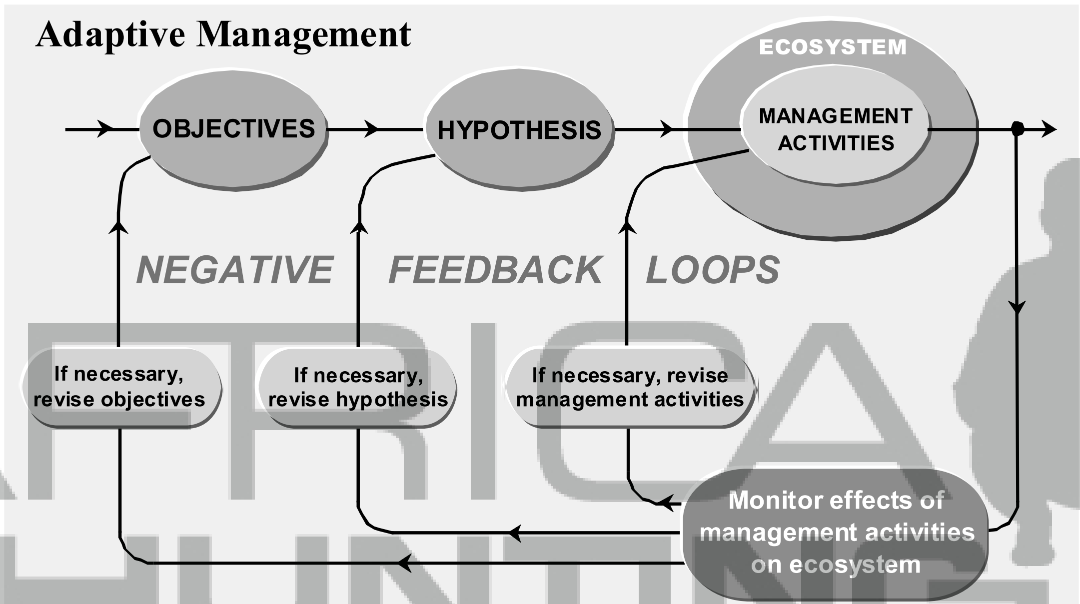
In estimating the potential carrying capacity for hippos in the Caprivi, the present population of Mamili was used as a yardstick (page 31). A valid question is whether Mamili, with some 560 hippo in 320 km^2, is not already overpopulated with hippo? Pienaar (et al 1966) considered that acceptable densities for hippo in the available habitats of Kruger National Park should not reach 1 animal/km^2 and this was used as justification for the inception of hippo culling on the Letaba River. The Caprivi is slightly moister than most of Kruger so that perhaps higher densities are possible. Comparisons with the situation in Uganda when massive culling operations were carried out in the Queen Elizabeth Park in the 1960s are probably less valid because of the higher rainfall and more fertile soils in Uganda. Hippo were at a density of more than 20/km^2 in the Mweya peninsula in the park before culling and it was generally agreed that this was an extreme case of overpopulation (Thornton 1971). Figures are not available for hippo densities in the Luangwa Valley, Zambia, prior to the inception of culling operations in the early 1970s but they probably exceeded Caprivi densities by an order of magnitude.

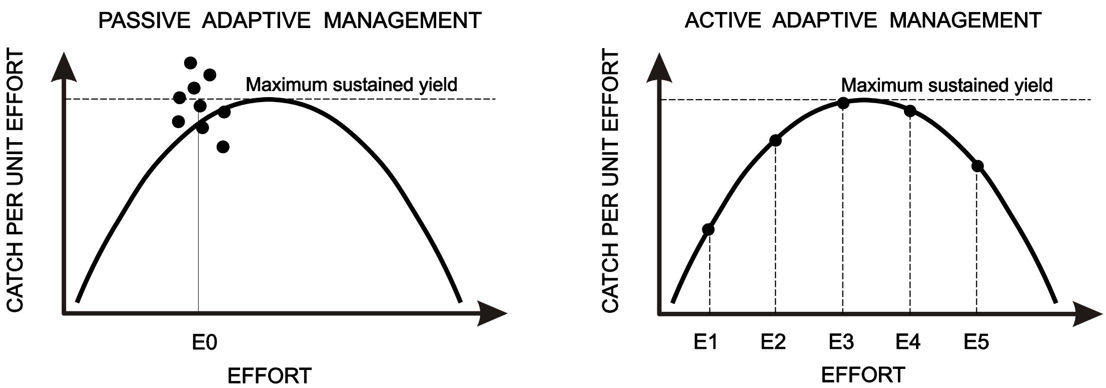
All of this points to a situation where active experimental management of hippo coupled with habitat monitoring is likely to answer more questions about the relationship between hippo and their habitats in the Caprivi than attempts to draw comparisons with other areas.

b. Monitoring

It has been emphasised throughout this study that the population dynamics of hippo are most unusual. Hippo are capable of great variation in age at first conception and inter-calving intervals and little is known about their age-specific natural (and unnatural) mortality schedules. The population response to management interventions is difficult to predict.

What has been put forward as the expected population dynamics of hippo in response to various management treatments should be seen as hypotheses in an adaptive management system (Holling 1976). Indeed, the proposed 'project' which involves harvesting, sport hunting and problem animal control should be seen as an active adaptive management research opportunity.





Under Passive Adaptive Management ("cautious fiddling") the effort is varied narrowly around some point for fear that any major change will result in system collapse. The result is that the optimum operating point is seldom detected. Under Active Adaptive Management the effort is deliberately varied over a period of time so that the population characteristic (or response to the harvest) can be defined. This may have considerable relevance to the hippo 'project'.

To understand the population dynamics of the Caprivi hippo several key parameters need to be monitored –

(1) Population numbers: Once population harvesting starts, an aerial survey such as that done last year by Stander (2004) should be carried out annually. To make comparisons from one year to the next it is worth maintaining the same strata and counting blocks.

This should be supplemented with local level counts on the ground (or in the water) in all the conservancies). Hippo are one of the few species whose numbers can be reasonably measured by direct observation. If conservancies are to be seen to be genuinely managing their wildlife then this sort of inventory is necessary and it should not be confused with Event Book monitoring. It requires one or two individuals to spend long hours with binoculars getting to know exactly what hippo are in their areas. The numbers to keep track of are fairly low: Salambala - 1; Kwandu - 8; Mashi - 18; Mayuni - 42; Kasika and Impalila ~30 (Stander 2004). This data is useful also for 'ground-truthing' aerial surveys.

This intensive ground observation is also an excellent method of monitoring illegal hunting. Apart from the likelihood of actually seeing illegal hunters, the disappearance of animals from known local populations is a good indicator that illegal hunting is taking place.

(2) Ages of all hippo killed: All lower jaws from hippo killed or dying naturally should be collected, clearly tagged[23] and transported to a central place where one person can determine the ages of the animals (**Appendix 1**, page 51). Over several years an age structure for the population[24] can be built up and, in conjunction with the population model of this study, a great deal can be inferred about the population dynamics.

This is also the most reliable method for adjusting quotas of trophy animals: the hypothesis put forward in this study is that a half-percent quota will result in a few males living beyond 30 years of age. If this is not the case, then the quota should be reduced: alternatively, if most trophies are over 30 years of age, quotas can be increased. These data also allow some inference about the age-specific natural mortality for the older males.

(3) Reproductive data: For all females killed under a harvesting programme, it is worth recording whether or not they are pregnant or lactating in order to establish both fecundity and age at first conception for the population.

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23. Each lower mandible should carry a label giving date of death, locality and category of death (e.g. natural mortality, hunting trophy, problem animal or animal harvested).

24. This is another reason for ensuring that animals are harvested randomly.

Other research questions have arisen in the course of this study. The full extent of the grazing range in the Caprivi used by hippos is far from clear (see **Appendix 6**, page 63). This can be established from the Event Book monitoring, including its seasonal variation and how it changes with episodic events (e.g. flooding).[25] This information is useful for management and for gauging the carrying capacity for hippo. It is also a valuable starting point for habitat monitoring which may or may not be needed depending on the trends in the hippo population under the management regime.

The vexatious question of the extent to which hippo along international boundaries need to be regarded as shared populations is worth investigating. A simple management approach is to assume half of the animals belong to each country but this might not be true. If conservation efforts on one side of the boundary result in larger hippo populations, this should be taken into account in any hippo exploitation. This is obviously a case-specific research question and it might form a worthwhile MSc project for a local university student.

Conflict between hippos and humans should continue to be monitored under the 'Event Book' system (NNF 2005). There may be a lack of data in areas where there are no conservancies (e.g. parts of the eastern Caprivi). If crop damage is reduced under a harvesting programme or if communities are well satisfied with the benefits derived from hippos this can be used as a criterion to assess the success of management programmes.

25. For example, if Lake Liambesi and the Zambesi Channels were to fill it might be necessary to revise the management programme drastically.

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. There are, however, some special features of hippo conservation and management that make the case for collaboration on hippo conservation and management particularly strong.

Namibia is in the unique situation that the only perennial rivers in the country all form part of international boundaries.[26] A past history of hunting by UNITA on the Cunene, Okavango and Kwando Rivers has had a significant impact on Namibia's hippo populations. With peace in Angola, it is to be hoped that co-operation on conservation and management of shared species such as hippo will result in benefits for both countries.

Hippo have not received undue conservation attention from Zambia and Zimbabwe in recent years and there is little doubt that the illegal hunting which has taken place in the Zambezi has had an effect on Namibia's hippos. This is all the more reason for Namibia to seek cross-boundary collaboration with these countries – to the extent of suggesting joint management programmes which will produce benefits for local peoples in these neighbouring countries.

The situation along the Chobe, Linyanti and Kwando Rivers is somewhat different. Illegal hunting by Botswana citizens has been minimal and there are major national parks and community-based natural resource management areas along the river frontages. Namibia needs to exercise considerable sensitivity in exploiting hippos along these rivers. There is a strong case for keeping Botswana fully informed on quotas, the assumptions made in setting them, the rationale behind any management programmes and, in general, seeking their full participation.

At the same time, Namibia should not be too hesitant in going ahead with any harvesting scheme in the Caprivi. In common law, any animal which is on the Namibian side of the river is effectively owned by Namibia and, provided that no animals are actually killed on the Botswana side of the international boundary[27] in the course of officially sanctioned hippo management programmes, no offence will have been committed.

26. The only exceptions are the short sections of the Okavango and Kwando Rivers where they cut across the Caprivi.

27. There remains to this day certain sections of the international boundary along the Chobe River between Botswana and Namibia which are still not resolved (Fisch 1999) and it would be as well not to allow the issue of harvesting hippo to cause an international incident in the contended areas.

Ageing criteria for hippopotamus

Laws (1968) derived 20 age classes for hippos based on a sample of the mandibles from 200 males and 200 females. The description for each age class shown in **Fig. 20** (page 53) is given below.

Group I: Deciduous C and I1 and I2, mm1 and mm3 protruding above bone level. Alveolus of M1 open. Mandible length 100-160 mm. Mean age – less than 6 months.

Group II: Deciduous C and I1 and I2 protruding above bone level as well as mm1-4. M1 and M2 visible in alveoli. Mandible length 182-260 mm. Mean age 6 months.

Group III: Deciduous C and I present, but roots eroded and permanent teeth showing above bone level and, in some cases, slightly erupted through the gum. Wear usually evident on all three cusps of mm4 and mm3. M1 exposed above bone and in some individuals to gum level; alveolus of M2 open. Mandible length 274-370 mm. Mean age 1 year.

Group IV: Deciduous I3 generally lost by this stage. Deciduous I1 and I2 may be lost. Permanent I1 and I2 protruding above bone and usually through gum. Permanent C erupted through gum. No wear on I or C. Increased wear on mm3 and mm4. M1 fully erupted, sometimes shows slight wear. Mandible length 318-398 mm. Mean age 3 years $\pm$ 6 months.

Group V: Both pairs of C and I show wear on occlusal surfaces. mm1 may have been lost. P2 and P3 are visible pushing out milk teeth at bone level. First cusp of M1 worn; M2 visible in alveolus, sometimes at bone level. Mandible length 368-424 mm. Mean age 3 years $\pm$ 1 year.

Group VI: C and I increasing in size. Most still have mm3 present; mm1 and mm2 usually lost in cleaned jaws; mm4 worn almost flat. M1 worn on all cusps; M2 protruding above bone level in almost all cases. Mandible length 410-466 mm. Mean age 7 years $\pm$ 1 year.

Group VII: Sex differences in C and I1 becoming apparent. mm4 worn flat. P2 and P3 usually erupted but small caps of mm2 and mm3 may still be present. M1 showing increased wear. M2 emerging from the gum in some cases, first and second cusps above bone level. Alveolus of M3 usually open. Mandible length 412-496 mm. Mean age 8 years $\pm$ 2 years.

Group VIII: P2 and P3 fully erupted, in some cases slightly worn on tips; mm4 usually present on at least one side, but P4 evident above bone level. M2 showing slight wear of first cusp in all cases, even to exposure of dentine. M3 visible in alveolus. Mandible length 454-516 mm. Mean age 11 years $\pm$ 2 years.

Group IX: P2-4 fully erupted. Greater wear on M1 but dentine not continuous between cusps; M2 shows wear on two cusps; M3 usually slightly above bone level. Mandible length 472-530 mm. Mean age 15 years $\pm$ 2 years.

Group X: Wear on M1 has progressed until exposed dentine is continuous between the two cusps in about half the specimens. M3 erupted above gum level and enamel of first cusp polished. Mandible length 462-536 mm. Mean age 17 years $\pm$ 3 years.

Group XI: Dentine continuous between cusps of M1 in nearly all cases; slight wear in first cusp of M3, third cusp at gum level. Increasing wear of P2-4. Mandible length 496-544 mm. Mean age 20 years $\pm$ 3 years.

Group XII: Appreciable wear on P2-4. Ml worn almost flat; M2 shows moderate wear; M3 first cusp worn to expose dentine, second cusp worn, third usually at gum level. Mandible length 496-558 mm. Mean age 22 years ± 3 years.

Group XIII: M1 worn flat, still with pronounced constriction between first and second cusps. M2 shows increasing wear; dentine exposed on first and second cusps of M3. Mandible length 478-550 mm. Mean age 24 years ± 3 years.

Group XIV: P2-4 usually much worn. M1 worn flat and constriction between cusps slight or absent. M2 shows moderate to heavy wear, but exposed dentine between cusps not yet joined. Third cusp of M3 worn, but not showing dentine. Mandible length 482-570 mm. Mean age 27 years ± 3 years.

Group XV: M1 either completely flat or concave, with few exceptions. Dentine continuous between first and second cusps of M2 in 50% of specimens; dentine exposed in third cusp of M3. Mandible length 506-566 mm. Mean age 30 years ± 3 years.

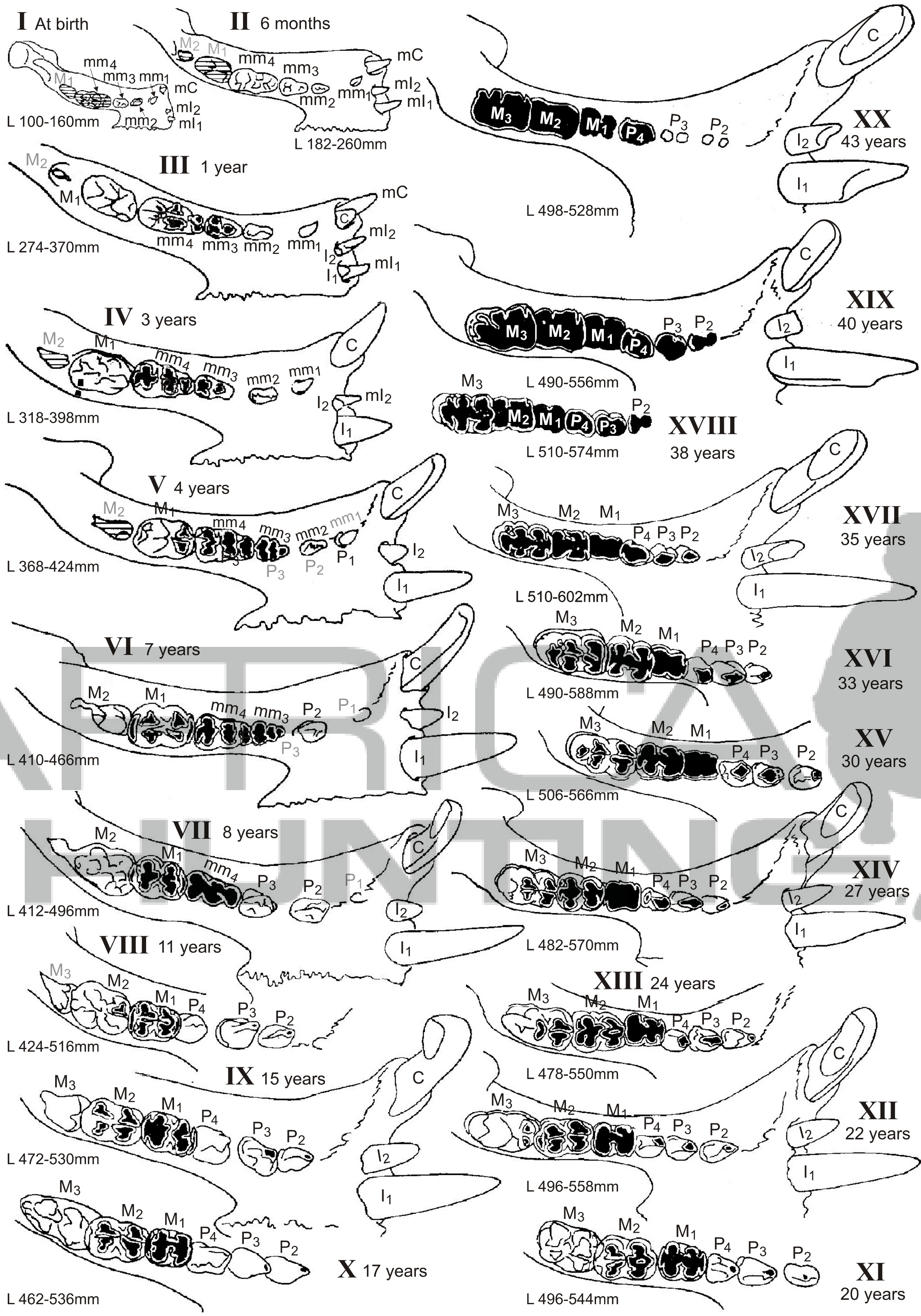
Group XVI: Dentine between cusps of M2 usually broadly continuous; main difference from previous group is in greater wear of third cusp of M3, showing large amount of dentine. Mandible length 490-588 mm. Mean age 33 years ± 3 years.

Group XVII: P2-4 worn flat. M1 worn to gum level or below; may be worn through between cusps. M2 worn flat or concave, with only slight constriction between cusps. Exposed dentine continuous between all three cusps of M3. Mandible length 510-602 mm. Mean age 35 years ± 4 years.

Group XVIII: P2-4 usually worn flat. M1 to M3 worn flat; exposed dentine of three cusps of M3 broadly joined. Mandible length 510-574 mm. Mean age 38 years ± 4 years.

Group XIX: M1 usually worn to below gum line; M2 worn concave to or below gum line; M3 completely flat with very slight constriction between dentine of cusps. Jaw feels very light for its size owing to resorption of bone, particularly in the male, in this and succeeding group. Mandible length 490-556 mm. Mean age 40 years ± 4 years.

Group XX: Usually only P3 and/or P4 present; Ml may be missing; M2 and M3 still present but worn very concave. Roots of teeth reduced by resorption to small stumps. Incisors show considerable wear. Mandible length 498-528 mm. Mean age 43years ± 5 years.



TEETH Deciduous: Incisors mI_1 mI_2 Canines mC Premolars mm_1 mm_2 mm_3 mm_4
Permanent: Incisors I_1 I_2 Canines C Premolars P_1 P_2 P_3 Molars M_1 M_2 M_3

Figure 20: The twenty age classes for hippopotamus of Laws (1968)

Relationship between Age and Body Weight for Hippopotamus

Laws (1968) gives a relationship between age and body length for hippopotamus based on a sample of 1,219 hippos (505 males and 714 females) culled in Queen Elizabeth National Park, Uganda, between 1961 and 1966. Pienaar (*et al* 1966) give body length and weight data from a sample of 104 hippo (52 males and 52 females) culled in the Letaba River in Kruger National Park in 1964. These two data sets enable the construction of a formula which predicts body weight from age.

The data of Pienaar (*et al* 1966) were examined to see if there were any reasons why male and female data could not be combined into a single data set. Although the regressions on the separate data sets for males and females yield slightly different results, an inspection of the figures suggest that there is a wide overlap between the male and female body weights for any given body length. On allometric principles it would not be expected that animals of the same species which have same body length would differ in body weight. The data were combined and a regression was used to determine the values of the constants in the relationship –

$$\textit{Body weight (kg)} = a.(\textit{Body length (cm)})^{b}$$

The regression (performed on logarithms of the data values) yielded the results of $\boldsymbol{a} = 1.49 \times 10^{-4}$ and $\boldsymbol{b} = 2.79$. Pienaar (*et al ibid*) point out that the hippo in the Letaba were in poor condition as a result of a drought which had affected Kruger National Park since 1962. Because of this, the regression constants were adjusted by inspection so that the body weights predicted by the formula were closer to the higher values in the data set rather than the central values. The final values used were $\boldsymbol{a} = 2.5 \times 10^{-4}$ and $\boldsymbol{b} = 2.70$.

Laws (1968) used von Bertalanffy's (1938) formula for predicting body length from age but notes that the derived values apply only to animals between the ages of 5 and 25 years old. Laws completes the curves for the full age span (0-50 years) by simply extrapolating graphically. von Bertalanffy's curve has the form $\boldsymbol{y = A(1 - e^{-Bt})}$ which describes a growth curve where adult animals achieve an asymptotic weight. It is not suitable for hippo where adults continuing growing throughout their life. To rectify this I have added a 'ramp' function to the formula.

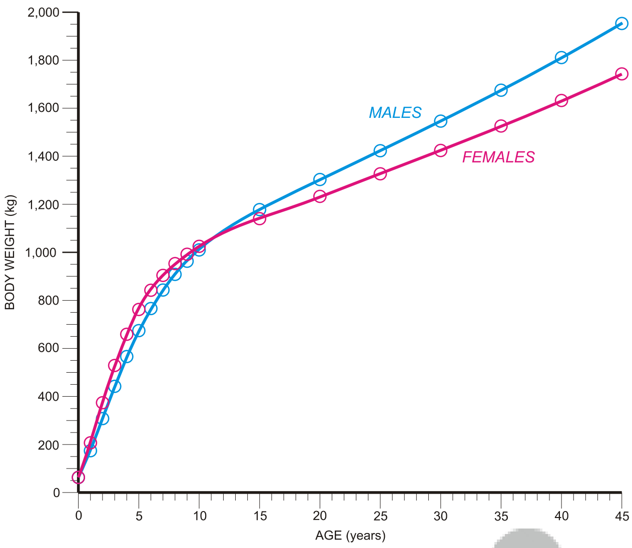
$$\textit{Body length} = A\ (1 - e^{-B(Age + C)} + D.Age)$$

Adult male hippo are heavier than females of the same age and Laws gives a separate von Bertalanffy formula for each sex. I used the values given by Laws' two formulae to generate a set of body lengths for males and females between the ages of 5 and 20 years. To these data sets I added the value of 86.11cm for the body length of hippo at birth (which is the value which gives a birth weight of 42.14kg (Smuts & Whyte 1981 p171) and the values of 360cm and 343cm as the body lengths for the oldest males and females (from Pienaar *et al*'s data).

Curves were then fitted according to the above formula by iterating the values of the above constants (***A-D***) within a spreadsheet. The results were very satisfactory and permitted a close fit between the data and the predicted values for body length.

	A	B	C	D
Males	268	0.3	1.56	7.34×10^{-4}
Females	268	0.384	1.216	6.12×10^{-4}

The analysis could have been left there but one feature of the fitted curves bothered me. When body weights are derived from the two body length formulae, female hippo up to the age of 11 years appear to be heavier than their male counterparts (see figure opposite). Both Laws' and Pienaar *et al*'s data agree that adult hippo males are heavier than female hippos of the same age and it seems unlikely that the two curves 'cross over' in the manner shown. The effect is due to the body lengths given by Laws' formulae for female hippo between the ages of 5 and 13 years and it seems likely that it is an artefact of the analytic technique. Up to a certain age, male and female hippo probably have identical body lengths and body weights and the differences only start to emerge at about 10 years old.



The data were re-analysed with the constraint that males and females must possess identical characteristics up to a certain age and only diverge thereafter. This necessitated some changes to the body length formula given on the previous page. For males to be able to grow larger than females only after the given age, the 'ramp function' must operate independently for each sex and must only come into play after the given age. The revised formula is –

$$\textbf{Body length} = A(1-e^{-B(Age + C)}) + D(Age - E)\big|_{Age > E}$$

E is the threshold age after which males and females diverge and it is determined by iteration along with the other constants. By using a logical function in the spreadsheet formula, the ramp function can suppressed for ages less than ***E***. The constants ***A, B, C*** and ***E*** are assumed to be identical for both males and females and only the slope of the ramp function (***D***) is allowed to differ between the two sexes. Iteration was performed by maintaining separate data sets for males and females and examining the combined sum of squares for the differences between observed and predicted values for both sexes simultaneously. The revised constants which come from this analysis are shown below –

	A	B	C	D	E
Males	281.4	0.347	1.054	7.49×10^{-4}	8
Females	281.4	0.347	1.054	5.87×10^{-4}	8

The body lengths and body weights corresponding to ages 0 - 45 years are shown in **Table 8** on the next page and depicted graphically in **Fig.3** on page 4.

Age	Body Length		Weight	
	Males	Females	Males	Females
years	cm	cm	kg	kg
0	86	86	42	42
1	143	143	167	167
2	184	184	327	327
3	212	212	483	483
4	233	233	617	617
5	247	247	725	725
6	257	257	807	807
7	264	264	869	869
8	269	269	915	915
9	275	274	968	964
10	280	279	1,013	1,004
11	283	282	1,051	1,037
12	287	285	1,085	1,067
13	290	288	1,116	1,092
14	293	290	1,145	1,116
15	295	292	1,172	1,138
16	298	294	1,198	1,159
17	300	296	1,223	1,179
18	302	298	1,249	1,198
19	304	299	1,274	1,218
20	307	301	1,298	1,237
21	309	303	1,323	1,256
22	311	304	1,348	1,275
23	313	306	1,373	1,294
24	315	308	1,399	1,313
25	317	309	1,424	1,332
26	319	311	1,450	1,352
27	321	313	1,476	1,371
28	324	314	1,503	1,391
29	326	316	1,529	1,411
30	328	318	1,556	1,431
31	330	319	1,583	1,451
32	332	321	1,611	1,471
33	334	323	1,639	1,492
34	336	324	1,667	1,513
35	338	326	1,695	1,534
36	340	328	1,724	1,555
37	343	329	1,753	1,576
38	345	331	1,782	1,597
39	347	333	1,811	1,619
40	349	334	1,841	1,641
41	351	336	1,872	1,663
42	353	338	1,902	1,685
43	355	339	1,933	1,707
44	357	341	1,964	1,730
45	359	343	1,995	1,753

Table 8. Age-specific body lengths and weights for hippo derived in this study

Grass and sedge species in the diet of hippopotamus

The grasses and sedges in the tables which follow are taken from the faecal analysis of Scotcher, Stewart & Breen (1978) in Ndumu Game Reserve, Natal and are presented in the four categories of use into which they grouped species. Because of the difficulty of identifying some of the smaller epidermal plant fragments down to species level, they found it necessary to group certain species together under the generic name. The species thus grouped were –

Panicum spp. – *Panicum coloratum, Eriochloa meyerana* (syn. *P.meyerianum)*

Sporobolus spp. – *Sporobolus fimbriatus, S. nitens*

Eragrostis spp. – *Eragrostis rigidior, E. heteromera*

Aristida spp. – *Aristida stipitata var.graciliflora, A. congesta congesta, A. c. barbicollis*

Digitaria spp. – *Digitaria pentzii, D. swazilandensis*

Chloris spp. *Chloris gayana, C. virgata*

Eriochloa spp. – *Eriochloa borumensis, E.* sp.

Bothriochloa spp. – *Bothriochloa glabra, B. insculpta*

Paspalum spp. – *Paspalum commersonii, P.urvillei*

Grass and sedge species recorded in the diet of hippopotamus in Kruger National Park by Brynard & Pienaar (1960) and by Pienaar, Van Wyk & Fairall (1966) are indicated by a “ ✓ ” in Column **A** and additional species not recorded by Scotcher (*et al* 1978) are given in the table which follows their list.

Grass and sedge species recorded in the diet of hippopotamus on the Mara River in Serengeti, Tanzania, by Olivier & Laurie (1974 are indicated by a “ ✓ ” in Column **B** and additional species not recorded by Scotcher (*et al* 1978) are given in the table which follows their list. Species not grazed by hippo in the Mara are listed in the last table.

In Column **C** a “ ✓ ” or an “ ✻ ”indicates that Mendelsohn & Roberts (1997) have listed the species or genus as occurring in the vegetation of the Caprivi.

Child & von Richter (1969) give a comprehensive list of grass and sedge species eaten by waterbuck, lechwe and puku on the Chobe floodplain grasslands in Botswana and these data are presented in the Background Study on the Wetland Grazers (Martin 2004a). Many of the grass species eaten by buffalo (Martin 2002, p5) and roan, sable and tsessebe (Martin 2003, p10) also occur in the diet of hippo.

(i) Species occurring abundantly in the diet

Species	A	B	C	Notes
Panicum maximum	✓	✓		
Cynodon dactylon	✓		✓	
Urochloa mosambicensis				Most preferred spp in Gonarezhou NP (Mackie 1976)
Hemarthria altissima	✓		✓	
Cyperus fastigiatus			✻	
Echinochloa pyramidalis			✓	Young plants only in diet

(ii) Species occurring commonly in the diet

Species	A	B	C	Notes
Sporobolus virginicus				Species not listed in van Oudtshoorn (1999)
Sporobolus spp.		✓		
Eragrostis superba				
Sporobolus smutsii				Species not listed in van Oudtshoorn (1999)
Eragrostis spp.			✻	
Aristida spp.			✻	
Digitaria spp.			✻	
Panicum spp.	✓	✓		
Paspalum spp.				
Chloris spp.	✓			

(iii) Species occurring uncommonly or randomly in the diet

Species	A	B	C	Notes
Schmidtia pappophoroides			✓	
Themeda triandra	✓	✓		
Setaria sphacelata				
Dactyloctenium australe			✻	
Panicum deustum				
Eustachys paspaloides				
Heteropogon contortus		✓		
Trichoneura grandiglumus				
Eragrostis cilianensis				

(iii) Species occurring uncommonly or randomly in the diet *(continued)*

Hyperthelia dissoluta			✓	
Pogonarthria squarrosa				
Eriochloa spp.	✓			
Bothriochloa spp.		✓		
Ischaemum brachyatherum				Species not listed in van Oudtshoorn (1999)
Phragmites australis	✓		✓	

(iv) Species absent from the diet but present in the Ndumu study area

Tragus berteronianus				
Oplismenus hirtellus				
Setaria chevalieri				Now *Setaria megaphylla*
Enteropogon macrostachyus				
Diplachne eleusine				
Enteropogon monostachys				
Leptochloa uniflora				*L. uniflora* var. *africanus*
Perotis patens				
Heterocarpha schiemanniania				
Tricholaena monachne				
Enneapogon cenchroides				
Digitaria gymnostachys			✻	Species not listed in van Oudtshoorn (1999)
Rhynchelytrum repens				Now *Melinis repens*
Panicum infestum				
Cenchrus ciliaris				
Triraphis schlechteri				Now *Triraphis schinzii*
Sorghum verticilliflorum				Now *Sorghum bicolor* subsp. *arundinaceum*
Dinebra retroflexa				
Diplachne fusca				
Leptochloa panicea				Species not listed in van Oudtshoorn (1999)
Phragmites mauritianus				

Additional species in hippo diet recorded in the other studies

Loudetia filifolia	●		✻	Species not recorded in van Oudtshoorn (1999)
Cyperus sexangularis	●			
Typha capensis	●			
Panicum deustum	●			
Andropogon schirensis		●	✓	
Sporobolus stapfianus		●		
Eragrostis cilianensis		●		
Eragrostis racemosa		●		
Hyparrhenia filipendula		●	✻	
Eragrostis tenuifolia		●		
Cyperus merkeri		●		

Additional species absent from the diet but present in the Serengeti study area

Loudetia kagarensis		●		Species may not occur in southern Africa
Sporobolus pellucidus		●		Species may not occur in southern Africa
Sporobolus pyramidalis		●		
Eragrostis humidicola		●		Species may not occur in southern Africa
Cymbopogon excavatus		●	✓	
Setaria sphacelata		●	✓	

Status of Common Hippopotamus in Africa 2004

Source: Hippo Specialist Subgroup of the IUCN Species Survival Commission (HSG 2004)

Country	Population	Min	Max	Trend	Status	Concern
Angola	???			Declining?	W-LD	Yes
Benin	300-500	300	500	Declining	RD-LA	No
Botswana	2,000-4,000	2,000	4,000	Declining	RD-LD	No
Burkina Faso	500-1,000	500	1,000	Declining	RD-LD	Yes
Burundi	200-300	200	300	Unknown	RD-LA	No
Cameroon	500-1,500	500	1,500	Unknown	W-LD	Yes
C.A.R.	850	850	850	Declining	RD-LA	Yes
Chad				Stable	RD	No
D.R.C.	2,000-4,000	2,000	4,000	Declining	RD-HD	No
Eq.Guinea	100	100	100	Unknown	RD-LD	No
Ethiopia	5,000	5,000	5,000	Stable	W-LA	No
Gabon	250	250	250	Declining?	W-LD	No
Gambia	40	40	40	Declining?	RD-LD	Yes
Ghana	400-500	400	500	Declining?	RD-LD	Yes
Guinea	1,000-2,000	1,000	2,000	Declining	W-LA	Yes
Guinea Bissau	1,000-2,000	1,000	2,000	Declining?	RD-LA	Yes
Ivory Coast	300-400	300	400	Declining	RD-LD	Yes
Kenya	5,000	5,000	5,000	Stable	W-LA	No
Malawi	10,000	10,000	10,000	Stable	W-LD	No
Mali	<200	150	200	Unknown	RD-LD	Yes
Mozambique	18000	18,000	18,000	Declining	W-LA	Yes
Namibia	**1500**	**1,500**	**1,500**	**Stable**	**RD-LA**	**Yes**
Niger	100	100	100	Declining	RD-LA	Yes
Nigeria	300	300	300	Declining	RD-LD	Yes
Rwanda	200-400	200	400	???	???	???
Senegal	500	500	500	Declining	RD-LA	Yes
Sierra Leone	100	100	100	Declining	RD-LD	Yes
Somalia	<50	30	50	Declining	RD-LD	Yes
South Africa	3,000-5,000	3,000	5,000	Stable	RD-LA	No
Sudan	3,000-6,000	3,000	6,000	Unknown	RD-LA	No
Swaziland				Unknown	RD-LD	Yes
Tanzania	20,000-30,000	20,000	30,000	Stable	W-LA	No
Togo	300-500	300	500	Unknown/Stable	RD-LD	No
Uganda	7,000	7,000	7,000	Declining	W-LA	Yes
Zambia	40000	40,000	40,000	Increasing	W-LA	No
Zimbabwe	7,000	7,000	7,000	Stable	RD-LA	No
Totals		130,620	154,090			

Key

Population status: W - widespread; RD - restricted distribution; LD - low density; HD - high density; LA - locally abundant

Namibian data from survey done by Stander (2004)

Hippopotamus Population Estimates for the Caprivi

Only the survey carried out by Stander (2004) has been specifically designed for counting floodplain species. The remaining data in the table below arise from a variety of types of surveys.

	WEST CAPRIVI				EAST CAPRIVI						
Year	Mahango	W Core	Bagani	Subtotals	Kwando	Mudumu	Mamili	Chobe	Zambezi	Subtotals	**Total**
1980				**0**	*479*		182	34		**695**	695
1981				**0**	122					**122**	122
1982				**0**	*84*	175	123	20		**402**	402
1983	9			**9**			98	2		**100**	109
1984				**0**			182	2		**184**	184
1985	35			**35**	89		139	8		**236**	271
1986	37			**37**	96		24			**120**	157
1987	60			**60**			79			**79**	158
1988	98			**98**	94	71		133		**298**	396
1989	55			**55**	89	77	181			**347**	402
1990	64			**64**		27	159			**186**	250
1991	32			**32**						**0**	32
1992					102						102
1993	74	76		**150**	251	35	136			**422**	572
1994		0		**0**		565		124		**689**	689
1994	103	74		**177**	220	0	472			**692**	869
1995	28			**28**		6	304			**310**	338
1996											
1997											
1998	40	55	146	**241**	170	131	402	0		**703**	944
1999											
2000	186			**186**						**0**	186
2001											
2002	100			**100**						**0**	100
2003											
2004	96	91	60	**247**	274	34	560	255	17	**1,140**	1,387

References

Rodwell (et al 1995)

ULG (1994)

Craig (1998) *Craig's estimate for the Caprivi as a whole was 946 – this difference is due simply to arithmetic rounding*

Craig (2000)

DSS (2002a)

DSS (2002b)

Stander (2004)

Floodplain areas in the Caprivi

The perceptive reader will notice that there is an apparent discrepancy between the floodplain areas calculated in **Table 6** (page 32) and the floodplain area surveyed by Stander (2004). The remaining area of floodplains (and riverine woodlands in which hippo might occur) given in Table 6 is 3,181km^2 and is based on the vegetation classification of Mendelsohn & Roberts (1997) with allowances being made for areas cleared for agriculture. The sum of all Stander's floodplain survey strata areas is 1,763km^2. This is sufficiently large a discrepancy that it has caused the author to examine in detail how it arises. The figure is important insofar as the potential hippo population in the Caprivi has been based on the total extent of floodplain habitats.

The map of Stander's survey strata has been overlayed on Mendelsohn & Roberts vegetation map to see which floodplain and riparian woodland types were not included the survey. These are summarised below. Mendelsohn's vegetation type names are given in italics –

<u>Kavango stratum</u>

The full extent of the *Okavango-Kwando valley woodland* was not included and very little of the *Okavango valley fields and shrubland* was included. In the discussion related to Table 6, the area of this latter vegetation type (133km^2) was also deducted in this report so that this does not contribute to the deficit.

<u>Kwando stratum</u>

There are no discrepancies here. If anything, Stander included some vegetation types which are not strictly floodplains and not included in Table 6 (*Mopane woodland* and *Mudumu mulapo woodland*).

<u>Mamili stratum</u>

The survey did not include all of the *Dry Mamili grassland*. This grassland extends north of the national park and it is extremely unlikely that there would have been any hippo in it during daylight hours. However, hippo do use it – as the records of problem hippo in Wuparo conservancy attest (i.e. it is valid to include the area in the available range for hippo).

<u>Linyanti-Chobe stratum</u>

The stratum was a narrow strip along the Linyanti and Chobe rivers and so did not include much of the *Liambesi-Linyanti grassland*, *Chobe Swamp grassland* and *Chobe grassland-hummock mosaic* – all of which extend some distance from the rivers. This is totally justifiable as the chances of any hippo being in these areas during daylight was probably zero. However, it is also probably reasonable to include them in the potential hippo range of Table 6 since they are reachable by hippo feeding at night.

The survey also excluded the *Bukalo-Liambesi grassland* in its entirety and it was also excluded from the areas in Table 6 on the basis that it is too far from the rivers to be used by hippo.

<u>Zambesi stratum</u>

Again because the survey stratum was limited to a few kilometres either side of the river, much of the *Zambesi floodplain grassland*, *Zambesi floodplain channels*, *Zambesi transition grassland* and *Maningimanzi channels and woodland* was not included. This, too, is completely justified – not only because it very unlikely that the areas would be used by hippo during daylight but also because these areas are heavily settled and used by cattle.

The question arises whether it is valid to include them in any assessment of the potential hippo range in the Caprivi. In the short term probably not but, if the present encouraging trends towards wildlife as a land use continue, they might within a decade or so once more carry hippo.

There do not seem to be any strong reasons to alter the assessment that the Caprivi could perhaps carry a hippo population of 5,000 animals as put forward in the section on **Limiting factors** (page 31). Sensibly, the survey by Stander concentrated on the areas where hippo rest up by day rather than where they feed at night and this factor accounts for most of the difference between the total floodplain area in the Caprivi and the survey area. Given the large number of other factors which will influence the size of the Caprivi hippo population in the coming years including the hippo's own population dynamics, the response of hippo to both legal and illegal offtakes from the population and the trend in adoption of wildlife as a primary land use, there does not seem to be much value in attempting any greater precision in estimating the final future population.

Financial values of hippos

The management quotas for hippos in the Caprivi (**Table 7**, page 43) are based on a population of 900 animals which takes into account numbers of hippo 'shared' with neighbouring countries. The quotas are –

Problem animal control: **10** animals (both sexes, animals older than 5 years, no selectivity)

Sport hunting: **5** animals (adult males)

Harvesting: **45** animals (both sexes, all age classes, no selectivity)

When these values are inserted in the population model (page 5), the population growth rate is effectively zero over a period of 100 years. The average values for hippo products which result from the stable age distribution after 100 years are given in the table below –

	Body weight kg	Dressed meat weight (35%) kg		Dry crust skin weight kg		Canine teeth (pair) kg
Trophy hunting	1,695	593	**600**	88	**90**	Taken by client
PAC	1,137	398	**400**	67	**70**	1
Harvesting	744	260	**260**	49	**50**	0.5
		Value	**USED**	*Value*	**USED**	

The values of meat and skin have been rounded to the nearest 10kg for use in the calculations which follow.

The average value of the animal products in the three categories of management is as follows –

	Dressed meat weight		Dry first crust skin weight		Canine teeth (pair)			
Prices	US$1/kg		US$15/kg		US$100/kg		**TOTAL VALUE**	
	kg	US$	kg	US$	kg	US$	US$	Rounded
Trophy hunting	600	600	90	1,350	Taken by client		1,950	**2,000**
PAC	400	400	70	1,050	1	100	1,550	**1,500**
Harvesting	260	260	50	750	0.5	50	1,060	**1,000**

Note: The price of hippo skin is approximately double that of elephant skin (Parker, *pers.comm*).[28]
The value of dry elephant skin is about US$7.5/kg (Mochaba Developments, Pvt Bag 98, Maun, Botswana).

28. Hippo skin is more valuable than elephant skin because it is a stronger leather, has a finer pattern and can also produce multiple splits (a 'split' is the process whereby a hide of sufficient thickness is passed between two rollers with a centrally placed fine and sharp band saw so that the hide emerges from the rollers as two hides). Hippo skin is sufficiently thick and solid to produce up to six splits. The top one with the epidermis has the hippo grain, while the five other splits are smooth on both sides without a pattern. The pattern is fixed by making a photographic plate of the grain on hippo hide and stamping it on to all the splits so that they resemble genuine hippo hide. Elephant hide is so loosely fibrous that the splits can be torn in two by hand and, lacking substance, they will not take a pattern. Only the elephant epidermis is tough enough to hold together.

Applying these unit financial values to the quota, the total value of hippo products is shown below.

	Quota (numbers)	Unit value (US$)	Total value (US$)
Sport hunting	5	2,000	10,000
Problem animal control	10	1,500	15,000
Harvesting	45	1,000	45,000
		Gross income US$	70,000
Operating costs @	US$100/animal	Operating costs US$	5,500
		Net income US$	**64,500**
1US$ =	N$6.3	N$	406,350

If it were decided to establish a central facility[29] for processing hippo meat and hides then the above could be regarded as gross 'project income'. The operating costs attached to such a project would include killing the hippo (ammunition, hunter time, labour and transport), labour for skinning and butchering at the facility, transport of carcases to the facility and butchered meat from the facility, replacement of equipment (knives, hooks, racks etc) and salt for curing hippo hides. An arbitrary cost of US$100/animal has been used above to provide for animals killed as problem animals or harvested. It is assumed that the safari operator would meet these costs for hippo killed as trophy animals.[30]

The final budgets are presented below. It has been assumed that safari operators conducting trophy hunting will pay one-quarter of the gross income from hunting to the 'project'as 'rental' for the hunting and that this sum includes the official trophy fees for the hippos.

Safari Operators			
Trophy fees:	5 animals @	US$5,000	25,000
Daily rates:	5 x 2 days @	US$1,000	10,000
		Gross income US$	35,000
Operating costs:	5 x 2 days @	US$200	2,000
Rental to project:	25% of gross income US$		8,750
		Net income US$	26,250

Project	
Net income from products:	64,500
Operator's rental:	8,750
Total net income:	73,250

Safari Operators plus Project		
TOTAL NET INCOME:	**US$**	**99,500**

The allocation of the returns to the individual stakeholders on whose land the hippo were killed is shown in **Table 9** on the next page. The quotas developed in this study are compared with the actual quotas for the Caprivi in **Table 10** (page 68).

29. e.g. near Kongola on the Kwando River.

30. For those carcases arising from sport hunting, it could be made condition of the hunting licence that the trophy does not include the hippo skin or meat. The hunting client wishing to obtain part or all of these products would purchase them from the 'project'.

Table 9: Allocation of net financial returns from hippo population management

All figures in United States dollars

	Hippo Numbers	Sport Hunting		PAC		Harvesting		Net Total Income
Net unit values US$			**3,750**		**1,400**		**900**	
Kavango	**247**	**1**	**3,750**	**1**	**1,400**	**12**	**10,800**	**15,950**
Mahango NP & Babwata Western Core	187	1	3,750			9	8,100	11,850
Communal land	60			1	1,400	3	2,700	4,100
Kwando	**234**	**2**	**7,500**	**4**	**5,600**	**12**	**10,800**	**23,900**
Babwata Eastern Core	91	1	3,750			4	3,600	7,350
Kwandu	8			1	1,400	1	900	2,300
Mayuni	42	1	3,750	1	1,400	2	1,800	6,950
Mashi	18			1	1,400	1	900	2,300
Mudumu	17					1	900	900
Communal land	58			1	1,400	3	2,700	4,100
Mamili NP	**280**	**1**	**3,750**	**1**	**1,400**	**14**	**12,600**	**17,750**
Chobe/Linyanti	**128**	**1**	**3,750**	**3**	**4,200**	**6**	**5,400**	**13,350**
Kasika & Impalila	27	1	3,750	1	1,400	1	900	6,050
Salambala	1			1	1,400	1	900	2,300
Communal land	100			1	1,400	4	3,600	5,000
Zambezi	**9**			**1**	**1,400**	**1**	**900**	**2,300**
Kasika & Impalila	4			1	1,400	1	900	2,300
Communal land	5							0
TOTALS	**898**	**5**	**18,750**	**10**	**14,000**	**45**	**40,500**	**73,250**

Summary

State Protected Areas	575	3	11,250	1	1,400	28	25,200	**37,850**
Conservancies	100	2	7,500	6	8,400	7	6,300	**22,200**
Communal land	223	0	0	3	4,200	10	9,000	**13,200**
Totals	**898**	**5**	**18,750**	**10**	**14,000**	**45**	**40,500**	**73,250**

Table 10: Comparison of present quotas with model quotas

Actual quotas are shown in red font (**A**)

	Hippo Numbers	Sport Hunting		PAC		Harvesting		Totals
		M	**A**	**M**	**A**	**M**	**A**	
Kavango								
Mahango NP & Babwata Western Core	187	1	4			9		4
Communal land	60			1		3		0
Subtotal	**247**	**1**	**4**	**1**	**0**	**12**	**0**	**4**
Kwando								
Babwata Eastern Core	91	1	3			4		3
Kwandu	8			1	1	1	1	6
Mayuni	42	1	4	1	1	2	1	2
Mashi	18			1	1	1	1	2
Mudumu	17					1		0
Communal land	58			1		3		0
Subtotal	**234**	**2**	**7**	**4**	**3**	**12**	**3**	**13**
Mamili NP	**280**	**1**	**2**	**1**		**14**		**2**
Chobe/Linyanti								
Kasika & Impalila	27			1	1	1		1
Salambala	1	1	2	1	1	1		3
Communal land	100			1		4		0
Subtotal	**128**	**1**	**2**	**3**	**2**	**6**	**0**	**4**
Zambezi								
Kasika & Impalila	4			1		1		0
Communal land	5							0
Subtotal	**9**	**0**	**0**	**1**	**0**	**1**	**0**	
TOTALS	**898**	**5**	**15**	**10**	**5**	**45**	**3**	**23**

Summary

State Protected Areas	575	3	9	1	0	28	0	**9**
Conservancies	100	2	6	6	5	7	3	**14**
Communal land	223	0	0	3	0	10	0	**0**
Totals	**898**	**5**	**15**	**10**	**5**	**45**	**3**	**23**

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 a hippo population.

Tests were carried out on a population set initially at 1,000 animals with a growth rate of 7.13% (see page 11). The population was allowed to increase to 10,000 animals (taking about 34 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 20 years of age would be taken as trophies. A hunting selectivity of 10% for larger animals 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:

$$P_a = 100 / (\text{No. of age classes}) = 100/31 = 3.23\ \%$$

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 –

$$P_{50} = P_a + S\ .\ (100 - P_a) = 3.23 + 0.1\ (100 - 3.23) = 12.91\ \%$$

– where S is the selectivity expressed as a fraction.

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

$$P_{49} = (100 - P_{50})\ .\ (1 + S\ .\ N_R) / (N_R + 1) = (100 - 12.91)\ .\ (1 + 0.1 \times 29)/30 = 11.32\ \%$$

– where N_R is the number of age classes remaining

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

$$P_{48} = (100 - P_{50} - P_{49})\ .\ (1 + S\ .\ N_R) / (N_R + 1) = (100 - 24.23)\ .\ (1 + 0.1 \times 28)/29 = 9.93\ \%$$

(5) This process is continued until an expected proportion has been calculated for each of 31 age classes (the values are shown in the table on the next page). 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 0.9% of the total population were tested: a quota of 0.9% of the population results in the removal of all males older than 20 years. The detailed results are shown in **Table 10** on the next page and in **Fig.18** (page 40) in the main report. The 'optimum' quota is about 0.5% which allows some males in the population to reach an age of 30 years.

Table 11. Response of the adult male age structure of a hippo population to various levels of hunting quotas

Q – Quota (% of total population) Total population 10,000 Selectivity 10% N – Number actually hunted

AGE CLASSES (years)

Q	20	21	22	23	24	25	26	27	28	29	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	70	63	59	53	46	39	36	34	32	28	27	20	18	15	13	10	9	7	6	5	3	2	2	1	1	1	1	1	0	0	0	4,959	0
0.1	71	63	59	52	44	38	37	35	32	30	26	22	21	14	13	8	6	5	4	3	2	1	0	0	0	0	0	0	0	0	0	4,941	10
0.2	69	62	57	49	46	37	35	34	30	21	19	16	13	10	8	7	6	5	4	3	2	1	0	0	0	0	0	0	0	0	0	4,901	19
0.3	69	63	59	52	43	35	31	25	21	19	14	10	10	7	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,868	29
0.4	73	64	55	45	38	30	21	16	13	10	6	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,824	39
0.5	72	59	46	37	28	18	13	8	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,778	49
0.6	66	48	35	22	12	7	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,729	59
0.7	54	31	13	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,680	69
0.8	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,637	79
0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,623	78
	0.14	0.17	0.20	0.24	0.29	0.35	0.41	0.49	0.57	0.67	0.78	0.92	1.07	1.24	1.43	1.66	1.92	2.21	2.55	2.94	3.37	3.87	4.44	5.09	5.83	6.67	7.62	8.70	9.93	11.32	12.91	Selectivity %	

BIBLIOGRAPHY AND REFERENCES

Arman, Pamela & C.R. Field (1973). **Digestion in the hippopotamus**. E.Afr.Wildl.J. 11:9-17

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

Bere R.M. (1959). **Queen Elizabeth National Park, Uganda. The hippopotamus problem and experiment**. Oryx V(3):116-124

Bertalanffy L. von (1938). **A quantitative theory of organic growth**. Hum. Biol. **10**:181-213

Brynard A.M. & U.de V. Pienaar (1960). **Annual Report of the Biologist 1958/59.** Koedoe 3: 205pp

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

Coetsee A.M. (1992). **Capture and translocation of wildlife in Gonarezhou 1992-93.** Personal diaries edited and transcribed by R.B. Martin.

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.

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: C.S. Sikopo, Directorate of Scientific Services, Ministry of Environment and Tourism, Republic of Namibia. 3pp

Field C.R. (1970). **A study of the feeding habits of the hippopotamus in the Queen Elizabeth National Park, Uganda, with some management implications**. Zool.Afr.. 5:71-86.

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

Fuente F.R. de la (1970). **World of Wildlife I. Africa. Hunters and Hunted of the Savanna**. London, Orbis. [in Smithers 1983]

Games I. (1990). **A survey of hippopotamus in the Selous Game Reserve, Tanzania**. Unpublished report to the Director of Wildlife, Tanzania. 4pp

Goddard J. (1970). **Hippopotamus population on the Luangwa river**. FAO Report, Luangwa Valley Project (in Sayer & Rakha 1974).

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

Holling C.S. (1976). **Adaptive Environmental Assessment and Management.** John Wiley, New York.

HSG (1993). **Pigs, Peccaries and Hippos**. Status survey and Conservation Action Plan. Ed. W.L.R. Oliver. Publication of the IUCN/SSC Pigs and Peccaries Specialist Group & Hippo Specialist Group, IUCN, Gland, Switzerland. 202pp

HSG (2004). **Country-by-country assessment of the status of common hippo**. Report from the web-site of the Hippo Specialist Subgroup of the IUCN/SSC Pigs, Peccaries and Hippo Specialist Group. http://moray.ml.duke.edu/projects/hippos.

Joubert, E. & P.K.N. Mostert (1975). **Distribution Patterns and Status of some Mammals in South West Africa**. Madoqua 9(1): 5-44.

Laws R.M. & G. Clough (1966). **Observations on the reproduction in the hippopotamus** (*Hippopotamus amphibius* Linn.). In: Comparative Biology of Reproduction in Mammals Symposia of the Zoological Society. No.15: 117-140. Academic Press, London.

Laws R.M. (1968). **Dentition and ageing of the hippopotamus**. E.Afr.Wildl.J. 6:19-52

Ledger H.P. (1964). **Weights of some East African mammals**. E.Afr.Wildl.J. 2:159

Leslie, P.H. (1984). **Some Further Notes on the Use of Matrices in Population Analysis**. Biometrika 35: 213-245.

Lock J.M. (1972). **The effects of hippopotamus grazing on grasslands**. J. Ecol. 60: 445-467

Lydekker, R. (1915). **Catalogue of the Ungulate Mammals in the British Museum (Natural History)**. Vol.5, British Museum, London.

MacDonald D. (2001). **The New Encyclopedia of Mammals**. Oxford University Press, Oxford. 930pp

Mackie C. (1976). **Feeding habits of the hippopotamus on the Lundie River, Rhodesia**. Arnoldia Rhod. 7(34):1-16

Martin, R.B. (2002). **Species Report for Southern Savanna Buffalo**. Study conducted for *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. (2003). **Species Report for Roan, Sable and Tsessebe**. Study conducted for *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. (2004). **The Wetland Grazers: Species Report for Reedbuck, Waterbuck, Lechwe and Puku**. Study conducted for *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. (2005). **Species Report for Elephants**. Study conducted for *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

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

Mendelsohn, John, Selma el Obeid & Carole Roberts (2000). **A profile of north-central Namibia**. Environmental Profiles Project, Directorate of Environmental Affairs, Gamsberg Macmillan Publishers, Windhoek. 79pp

Mendelsohn, John & Selma el Obeid (2004). **Okavango River – The flow of a lifeline**. Publ. RAISON (Research and Information Services of Namibia) & Struik Publishers, Capetown. 176pp

Moller P. (1899). **Journey in Africa: through Angola, Ovampoland and Damaraland**. Translation from the original Swedish edition of 1899 and annotated by Ione and Jalmar Rudner. Struik publishers, Capetown. 216pp

Moltke J. von (2003). **Jagkonings**. Protea Boekhuis, Pretoria.

Murphree M.W. (1994). **Communities as Resource Management Institutions.** Paper presented at the National Conference on Environment and Development, Maputo, Mozambique. 7-11th October 1991. Published by IIED, London. Gatekeeper Series No. SA36. 15pp.

Murphree, M. 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.

NNF (2005). **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. (1995). **East/West Caprivi Natural Resources Monitoring Project: Elephant/Human Conflicts.** Final Technical Report. Ministry of Environment and Tourism, Namibia, Namibia Nature Foundation. USAID/WWF

Olivier R.C.D. & W.A. Laurie (1974). **Habitat utilisation by hippopotamus in the Mara River**. E.Afr.Wildl.J. 12: 249-271

van Oudtshoorn F. (1999). **Guide to the grasses of southern Africa**. Briza Publications, Pretoria. 288p

Parker I.S.C. (2005). **Hippo data**. Personal e-mail communications 13 June and 11 August 2005.

Pienaar U.de V, P. Van Wyk and N. Fairall (1966). **An experimental cropping scheme of hippopotami in the Letaba River of the Kruger National Park**. Koedoe 9: 1-33

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

Sayer J.A. & A.M. Rakha (1974). **The age of puberty of the hippopotamus** (*Hippopotamus amphibius* Linn.) **in the Luangwa River in eastern Zambia**. E.Afr.Wildl.J. 12: 227-232

Scotcher J.S.B., D.R.M. Stewart & C.M. Breen (1978). **The diet of the hippopotamus in Ndumu Game Reserve, Natal, as determined by faecal analysis**. S.Afr.J.Wildl.Res. 8(1):1-11

Selous, F.C. (1881). **A Hunter's Wanderings in Africa**. Richard Bentley & Son, London.

Shortridge G.C. (1934). **The Mammals of South West Africa**. Vol I & II. William Heineman Ltd., London: 643-658.

Smithers, Reay H.N. (1983). **The Mammals of the Southern African Subregion**. University of Pretoria, Pretoria, RSA. 736pp

Smuts G.L. & I.J. Whyte (1981). **Relationships between reproduction and environment in the hippopotamus** *Hippopotamus amphibius* **in the Kruger National Park**. Koedoe 24: 169-185

Stander P. (2004). **Aerial wildlife census of the Caprivi River Systems** – a survey of water bodies and floodplains, 11-20 August 2004. Report of a survey by the Aerial Survey Unit, Wildlife Science consultants, funded by the Namibia Nature Foundation.

Sydney J. (1965). **The past and present distribution of some African ungulates**. Trans.Zool.Soc.Lond. 30: 397pp

Thornton D.D, (1971). **The effect of complete removal of hippopotamus on grassland in the Queen Elizabeth National Park, Uganda**. E.Afr.Wildl.J. 10: 47-56

Viljoen P.C. (1995). **Changes in number and distribution of hippopotamus** ***Hippopotamus amphibius*** **in the Sabie River, Kruger National Park, during the 1992 drought**. Koedoe 38(2): 115-121

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.*

Wilhelm I.H. (1931). **Flußpferdjag am oberen Capembe**. Meinerts Monats-Magazin, 1(12): 556-565