S. Jennings #16

Culling: the Zimbabwean Experience

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Introduction

In this paper, I present the following short sections:

- The underlying rationale for elephant management in Zimbabwe;
- The biological assumptions in Zimbabwe's elephant management model;
- The effects of management on the Zimbabwe elephant population;
- Ivory production and the economics of elephant management;
- Some recommendations for management.

Underlying Rationale for Elephant Management in Zimbabwe

The expression 'management' is largely a euphemism for the blunt fact of killing elephant. It does however imply that they are killed according to a plan with objectives and technical data to support decisions.

Many conservationists believe that wild animals possess all the necessary intrinsic mechanisms to limit their numbers at a level which is in balance with the environment. There should be no need for man to intervene because the 'balance of nature' does the job.

The problem is that the idea of large 'natural' areas which are untouched by the influence of man is totally false. There is virtually no part of Africa today which escapes the boundary effects imposed by the increase in human populations. This has a critical effect on one of the most important regulating mechanisms for animal populations which is emigration. In a recent paper Craig (1990) demonstrated with a simulation model that a patchy system which regulated itself satisfactorily by the dispersal of animals into 'sink areas' (areas with a carrying capacity too low for population persistence), collapsed totally when barriers were erected within the mosaic which prevented dispersal. I believe such a situation pertains on a large scale in most of Africa.

Carrying capacity

Undoubtedly, large mammals are ultimately limited by their food resources. Food production in turn is limited by rainfall and soil fertility—this effect is particularly noticeable in the semi-arid savannas of Africa. Conventionally people tend to think of growing populations following a logistic curve where they finally level off at some asymptote with zero population growth. This overlooks the violent oscillations which are possible in elephant populations and the very large lag effects which can occur due to the 'inertia' of such a large-bodied animal. *There is no recorded case I am aware of where an elephant population has increased in an orderly manner to an asymptote and remained there comfortably regulating its birth rate with its death rate.*

Long after elephant numbers have exceeded the level at which food consumption matches vegetation production, populations continue to grow. At this stage they are eating into the capital of the system in a non-sustainable manner. When the crash comes it is spectacular, as in the case of Tsavo National Park in the early 1970s when a drought resulted in the deaths of thousands of animals. Some conservationists would argue that there is nothing wrong with this. It is simply 'nature taking its way'.

This is dangerous thinking in the 1990s. There are risks that other species may go extinct as elephants destroy habitats in areas which are already ecological islands. There are far greater risks that local peoples bordering on the protected area will not accept that conservationists are entitled to treat the matter in isolation. They are likely to intervene, pointing out the abuse to the vegetation and soils—abuses which are not acceptable in Zimbabwe when perpetrated by the farmers themselves.

Too often carrying capacity is thought of in the conventional context of domestic cattle. If there are too many animals per hectare the range suffers and annual production of grasses declines. This is a fairly rapid process which can be detected within the year concerned and rectified by removing the excess animals before they cause permanent damage to the pasture. However, it is far more difficult with elephant to make such simple diagnoses.

My own view of the relationship between elephants and vegetation is as follows:

a) Firstly, it is important to recognise that elephant, where they are present, are the single most important factor which shapes the face of ecosystems. They are capable of converting woodlands to scrubland, scrubland into grassland and grassland into bare soil.

b) In typical African savannas such as those in Zimbabwe with annual rainfall around 500 millimetres, elephant have a limited impact on woodlands when their densities are less than about 0,25 per square kilometre. Canopy woodlands will persist in a slightly sparser form than in areas with no elephant.

c) At densities of between 0,25 elephants/ square kilometre and (say) one per square kilometre, woodlands become progressively more sparse. Mature trees may persist at low densities (one or two per hectare). This cannot be called an ecological problem, rather it is simply structural change.

d) In most Zimbabwean vegetation types, mature trees are likely to disappear completely when elephants are at densities greater than one per square kilometre. The trees will be replaced by scrubland or grassland, depending on edaphic factors, the exact elephant density and the fire regime. This too, may not constitute an ecological problem, although it is difficult to see how certain birds and invertebrates which live only in tree canopies will persist.

e) As densities continue to increase, a point may be reached where elephant food consumption exceeds the sustainable production of the ecosystem. Usually some episodic factor, such as a major drought, will result in a population crash of elephants, but this may not happen before irreversible changes have occurred—including the possibility of a permanent loss of topsoil through erosion. I cannot surmise with any certainty on the level at which this is likely to occur, or even whether it will occur in all cases. We have considered the risks too great to test the outcome in Zimbabwe and there seem to be very few examples of elephant populations which have been able to increase unchecked elsewhere without illegal hunter or managers taking matters into their own hands.

Before leaving this topic it is important to recognise the effects of fire in shaping the African landscape. When fire is combined with elephant pressure, woodlands tend to disappear more quickly than they would with elephant alone. Trees which are partly damaged by elephant tend to die in fires when dead branches ignite and enable the fire to spread to the healthy remainder of the tree. The increased fuel load for fires brought about by the increase of grass cover in areas where elephant have already destroyed the canopy tree cover tends to promote very hot fires which kill all potential regeneration of seedlings and saplings.

Objectives for land with elephant populations

We have enough technical information to be aware of the effects of elephant on their habitats in Zimbabwe—except perhaps for the extreme case where elephant are permitted to 'go over the top'. It is at this stage that the decision to manage elephants moves out of the technical realm and becomes one of preferences.

In state protected areas the objectives are generally set by public opinion. If the public feels strongly that they prefer to see a landscape with certain characteristics which have come to be aesthetically regarded as typical of African savannas, this is reflected in the policy statement for the park.

Almost all Zimbabwean parks have the common objective of conserving a broad spectrum of large mammals and their habitats. The emphasis is generally on maintaining entire ecosystems in a pristine state rather than favouring any single large mammal species at the expense of others. Inevitably this results in a need to manage elephant—for the reasons already discussed.

In managing national parks in Zimbabwe, the secondary income which results from elephant population reductions is not a factor which is taken into account in management decisions. Management is solely aimed at satisfying the ecological objectives of the parks.

In safari areas elephant may be validly managed for a maximum sustainable income under the objectives of the area. The highest valued use for elephant lies in sport hunting but this cannot substitute for the management needed to limit elephant populations for ecological reasons.

Zimbabwe does not manage its elephants to any predetermined density, but rather according to the result which is desired in habitat condition. This implies using the concept of adaptive management; elephant are reduced by an amount which simulation models predict will achieve the desired result and the effects are monitored. From the monitoring results, models are refined and management is improved.

The Biological Assumptions in Zimbabwe's Elephant Management Model

This section covers only those limited aspects of elephant biology which are directly relevant to elephant management and conservation and illustrates some topical research results from Zimbabwe.

Body growth and ivory production

The age/shoulder height relationship presented in Figure 1 is a simple von Bertalanfy growth curve based on data from a sample of 308 male elephant and 461 female elephant culled in the Sengwa Wildlife Research Area in Zimbabwe between 1980 and 1984. The relationships are:

MALES: $SH = 282\,(1 - e^{-0,133\,(Age + 3,24)})$cm

FEMALES: $SH = 250\,(1 - e^{-0,171\,(Age + 2,78)})$cm

Where SH = Shoulder height (centimetres)
and A = Age (years).

The asymptotic height for males may be slightly low as the sample included very few large males. Field measurements on large males under sedation show typical shoulder heights around 300 centimetres and very occasionally a large male may reach 350 centimetres.

There are local variations within Zimbabwe. Elephant from Hwange National Park in the arid west tend to be larger, with the asymptote for adult females at about 266 centimetres, and elephant from the south-east of the country are smaller (asymptote 245 centimetres). Conversely, the southeastern elephant produce larger (or longer) tusks than the short stubby ivory of Hwange.

Female elephant reach 90% of their final height within about 12 years and most have had their first calf by this age. Males are significantly larger than females of the same age from about eight years old and take longer to reach their final height.

Typical ivory growth curves for males and females are shown in Figure 2. The relationships used are as follows:

MALES: $Wt = -10,6\,(1 - e^{0,0256(Age - 2)})$kilograms

FEMALES: $Wt = -0,811 + 7,71\,(1 - e^{-0,038\,(Age)})$ kilograms

Where Wt = single tusk weight (kilograms)
and A = Age (years),
(after Pilgrim and Western, 1986).

The important points which emerge from these relationships are that males tend to produce larger tusks the longer they live, while female tusks do not increase much after the first 20 years of life. This is not because they stop growing: I have put marks onto female (and male) tusks near the lip of the animal and checked the growth at the lip line at two yearly intervals since 1982. I found that the tusks grow significantly at the lip (2 to 5 centimetres per year) but that the overall size of the tusk does not alter. Marks which were placed on tusks in 1985 have completely disappeared in 1990, indicating a very significant wear. Broken tusks are rapidly replaced; on several animals where I have noted more than half of the visible tusk broken off in any given year, I have noted that same tusk completely restored three to four years later.

There is a large variation about the mean size of tusk for any given age both in males and females. The really large tusks from males (say over 35 kilograms) tend, however, to come from very old animals. Later when I show a typical age structure for an elephant population it will be apparent how few of these can be expected.

Population dynamics

To calculate the expected growth rate of a population, it is necessary to know the age at first conception, the breeding lifetime of females, the interval between offspring, and the age-specific mortality. I will deal with each of these in turn for Zimbabwe elephant.

a) Age at first conception: When several southern African scientists criticised the population modelling section of the Ivory Trade Review Group report on elephant which was presented to the 1989 CITES Meeting, their queries included the assumed age at

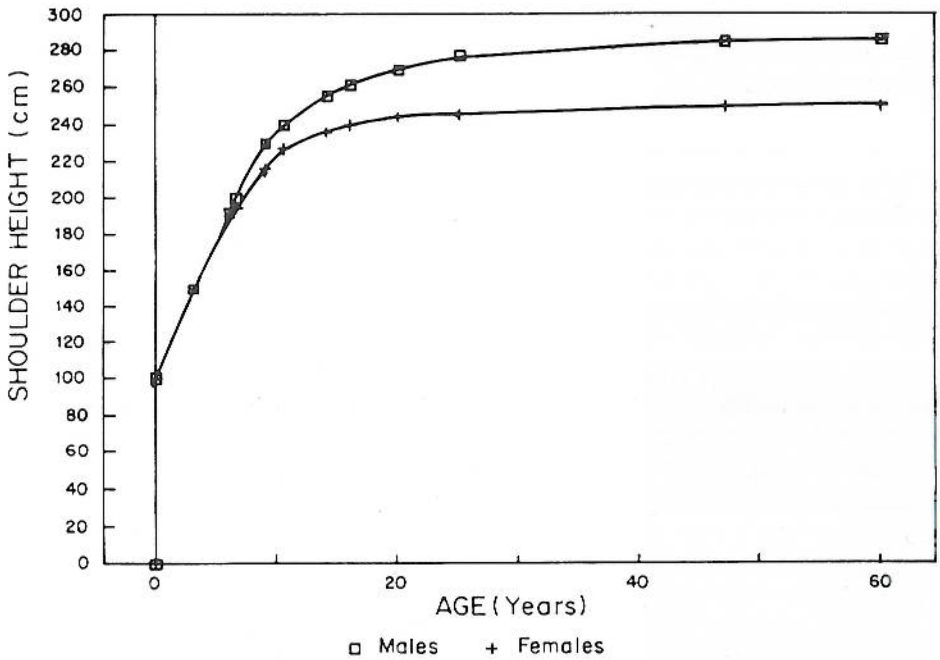


Figure 1. Elephant body growth.

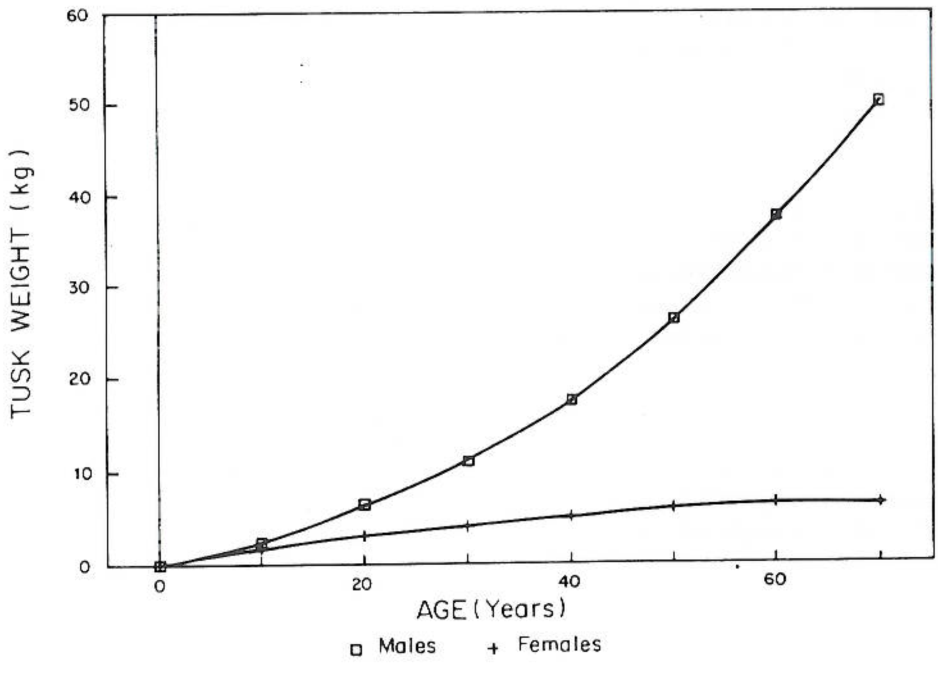


Figure 2. Elephant tusk growth.

first conception (14 years).

Since 1960 some 5,000 adult females taken on culling operations have been aged according to Laws' (1966) criteria and examined for pregnancy or the presence of uterine scars (indicating previous parturition). The mean age of first conception appears to be about 10 years, with a significant number conceiving earlier than this. Recent unpublished work in Zimbabwe by Craig suggests that Laws' age criteria may be overestimating elephant ages. This would make the age at first conception even younger.

b) Mean calving interval: The interval between calves can be found by counting the number of scars in the uterus of non-pregnant adult females, deducting the age at first conception from the age of the animal and computing the mean number of calves produced in the given time. However, compensation has to be made for increasingly inaccurate counts of the number of scars in older animals who have had many calves; scars tend to regress and to overlap each other. Perhaps the most reliable data are from animals who have recently born calves (the scars have a vivid appearance) and which have had three or fewer offspring.

In analysing the data from several thousand adult females taken on culling operations, we find little departure from a fecundity of 0,25 (one calf per adult female every four years). Occasional animals will produce a calf in three years and some in five years. Breeding in Zimbabwe tends to be seasonal so that intermediate values seldom appear.

These findings contrast sharply with the Ivory Trade Review Group assumption that the interval between calves is seven years.

c) Breeding lifetime: The typical fecundity of elephant over their lifespan is shown in Figure 3. We have found no cessation in breeding corresponding to 'menopause' even in very old animals. However the interval between calves appears to increase after about 40 years. The fecundity data in Figure 3 have been used in the modelling results shown later in this presentation.

d) Mortality: Natural mortality of elephant in Zimbabwe is very low. In the Sengwa Wildlife Research Area where elephant have been closely studied for about fifteen years, fewer than one to three adult animals are observed to die naturally out of a population of about 300 animals every year (less than 0,5%). It is usually not difficult to find all carcases of adults which die naturally; towards the end of their life they tend to leave their herds (in the case of females) and lead a highly localised solitary existence close to water.

It is extremely difficult to assess juvenile mortality. From the ratio of population cohorts in successive years where culling has taken place (taking into account the population growth rate) it would appear that mortality is unlikely to be higher than 3% in the first year of life, falling rapidly to 0,5% by three years old. Mortality may be higher than this in the elephant population in the more arid western region of Zimbabwe and there are certainly episodic 'die-offs' when water supplies fail in drought years in Hwange National Park.

The age-specific mortality shown in Figure 4 has been used in the population model discussed in the next section.

The combined effect of these parameters gives rise to a population growth rate of slightly over 5% *per annum*. Sufficient population survey data exist in Zimbabwe since 1960 to verify the prediction, taking into account culling operations (Figure 5). This implies a population doubling time of about 14 years—not 35 years as indicated in the Ivory Trade Review Group report.

At the recent CITES Meeting it was implied that Botswana and Zimbabwe count each other's elephant and claim a far larger total than actually exists. These suggestions are unjustified. We estimate that at most there is a limited traffic of one or two thousand animals across the borders in both directions and that these movements are limited to the rainy season when no management actions are being carried out.

In 1989 (at the time of the CITES Meeting) the elephant in northeastern Botswana and northwestern Zimbabwe were successfully surveyed at the same time. The results showed the highest counts yet obtained in the history of these populations; approximately 56,000 animals on the Botswana side and about 30,000 in the corresponding area of Zimbabwe. The 1990 survey carried out in Hwange

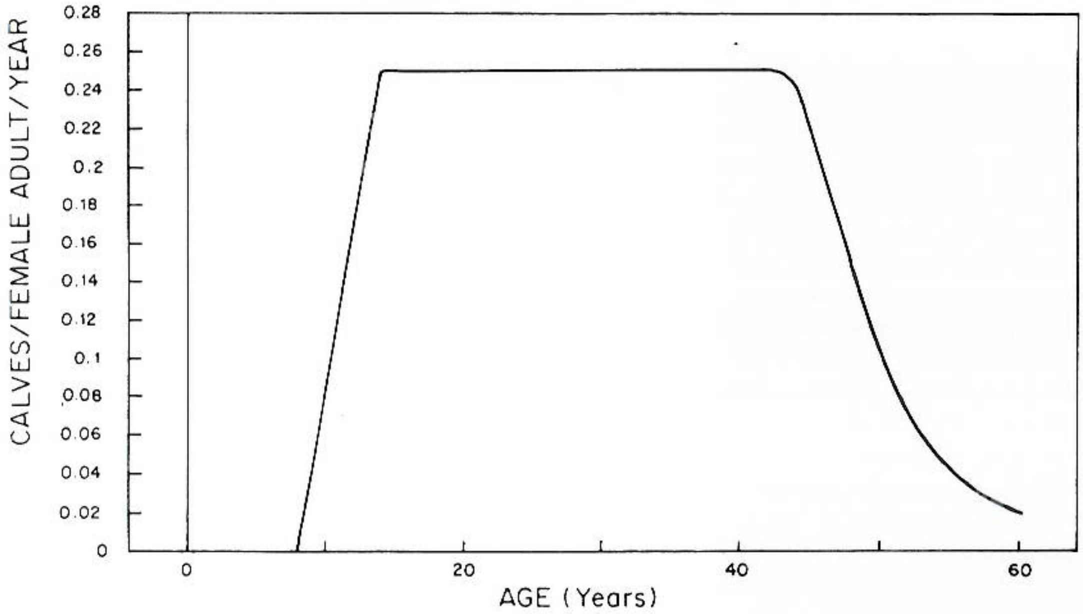


Figure 3. Elephant fecundity.

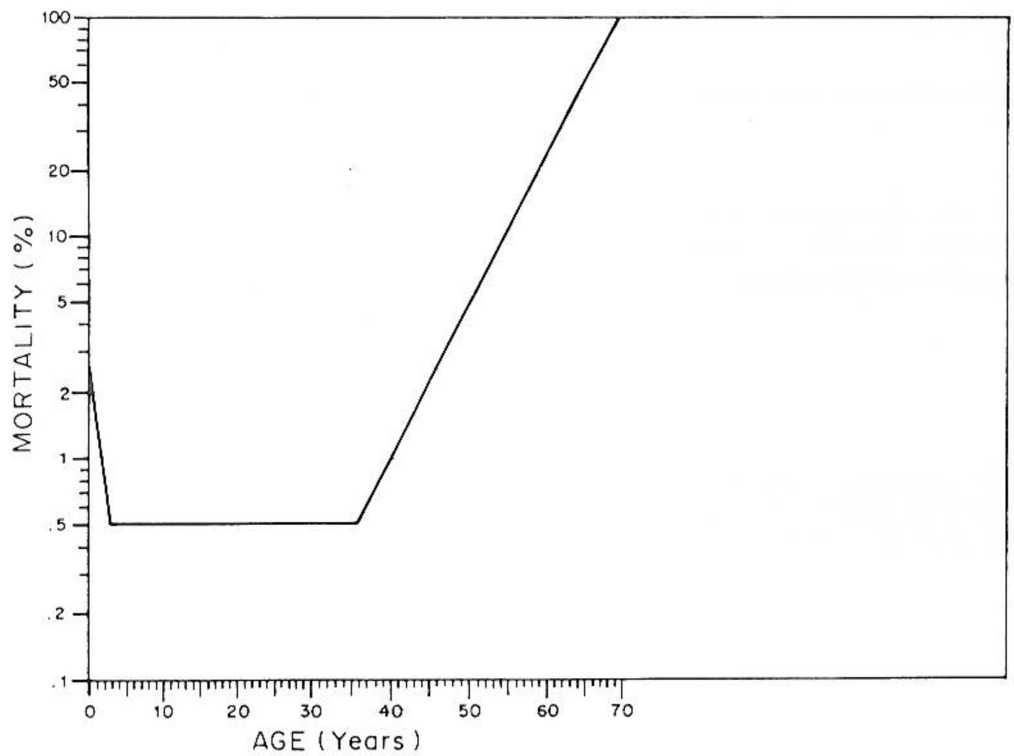


Figure 4. Elephant mortality.

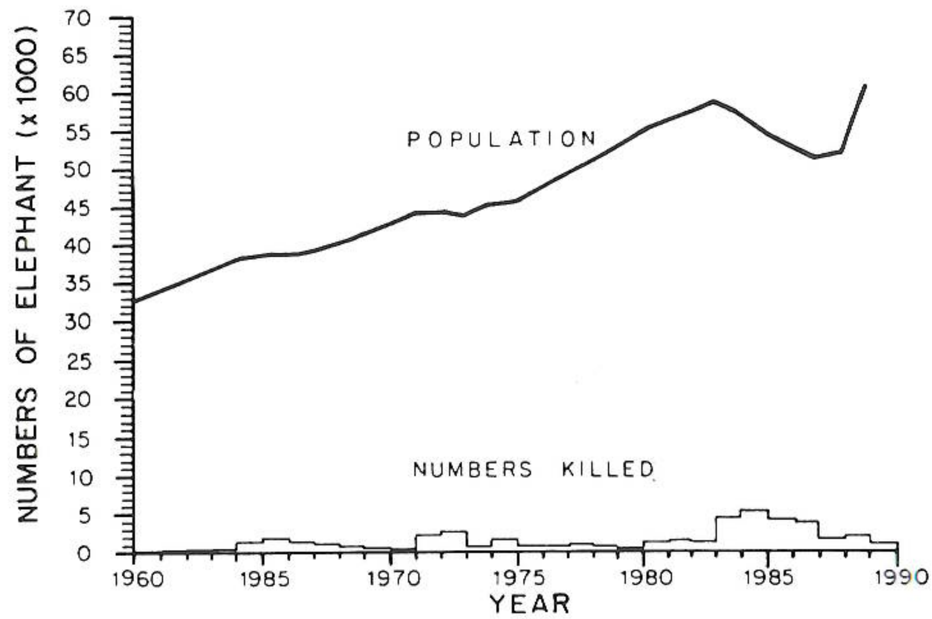


Figure 5. Elephant population growth and numbers killed 1960 to 1988

National Park and the Matetsi Complex indicates a further increase of 5%.

The stable age structure for such a population is shown in Figure 6. At a level of 10,000 animals approximately 600 calves per year are produced with an equal sex ratio. It is important to note that the proportion of this population with tusks in excess of 35 kilograms combined weight is of the order of 1%, that is 100 animals in every 10,000. The number of animals in the upper age classes is very low indeed; only 35 males out of 10,000 are expected to exceed an age of 55 years.

The Effects of Management on the Zimbabwe Elephant Population

Elephant numbers can only be reduced by removing females. In a population which increases at 5% *per annum* the recruitment to the adult male segment is less than the overall annual increment and the population would continue to increase regardless of how many adult males were killed (except in the extreme case where no males were left for breeding). This is why sport hunting cannot substitute for the culling of breeding herds.

The greatest danger in killing a large number of elephants over a long period is that of exerting a selective pressure on a portion of the population. This is an additional reason for not attempting to manage the population through an offtake of males. We use the technique of removing entire cow herds, on the assumption that this leaves the age structure undistorted (Figure 7) and causes the least trauma to the animals. If the population is capable of growing at 5% *per annum* then it requires 5% of the animals in breeding herds to be removed in order to prevent further growth. This amounts to about 4% of the total population .

One effect of removing cow herds is that adult males are excluded. This is less selective than might be expected. Males have a higher natural mortality than females, and coupled with this is the fact that males tend to be killed during problem animal control outside protected areas as a result of their tendency to raid crops. However, in a few national parks in Zimbabwe there tends to be a preponderance of large males—which is a result directly attributable to culling (Figure 7).

In Safari Areas this effect is reduced by the sport

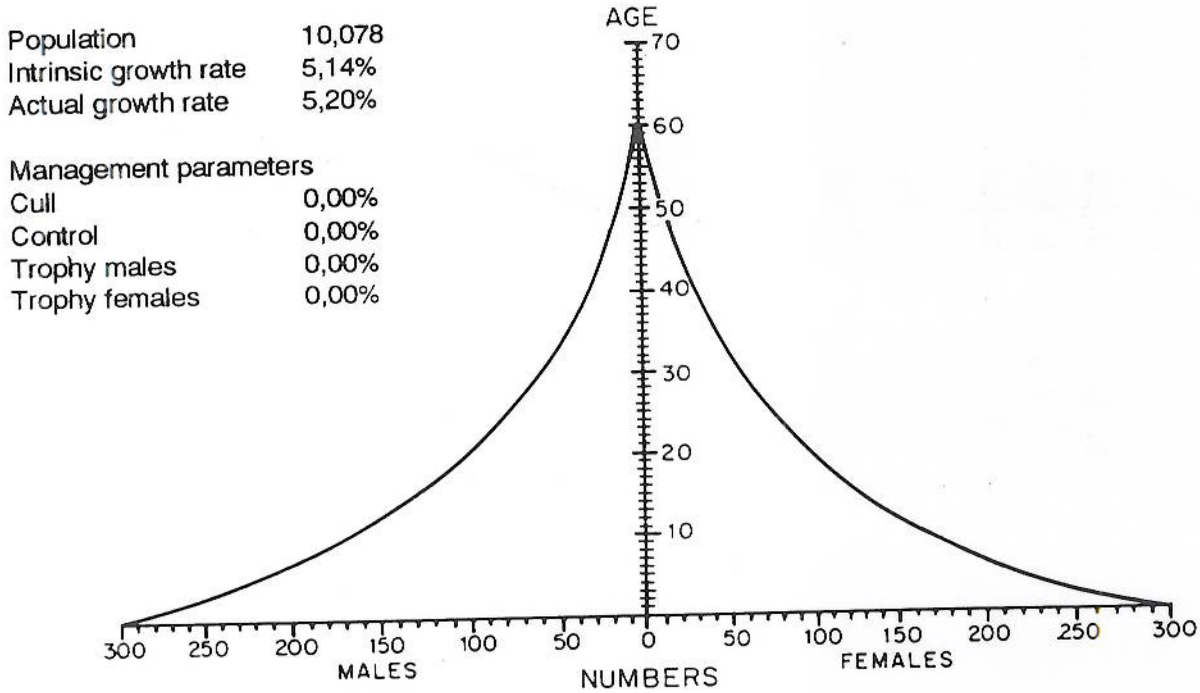


Figure 6. Structure of elephant population without utilisation.

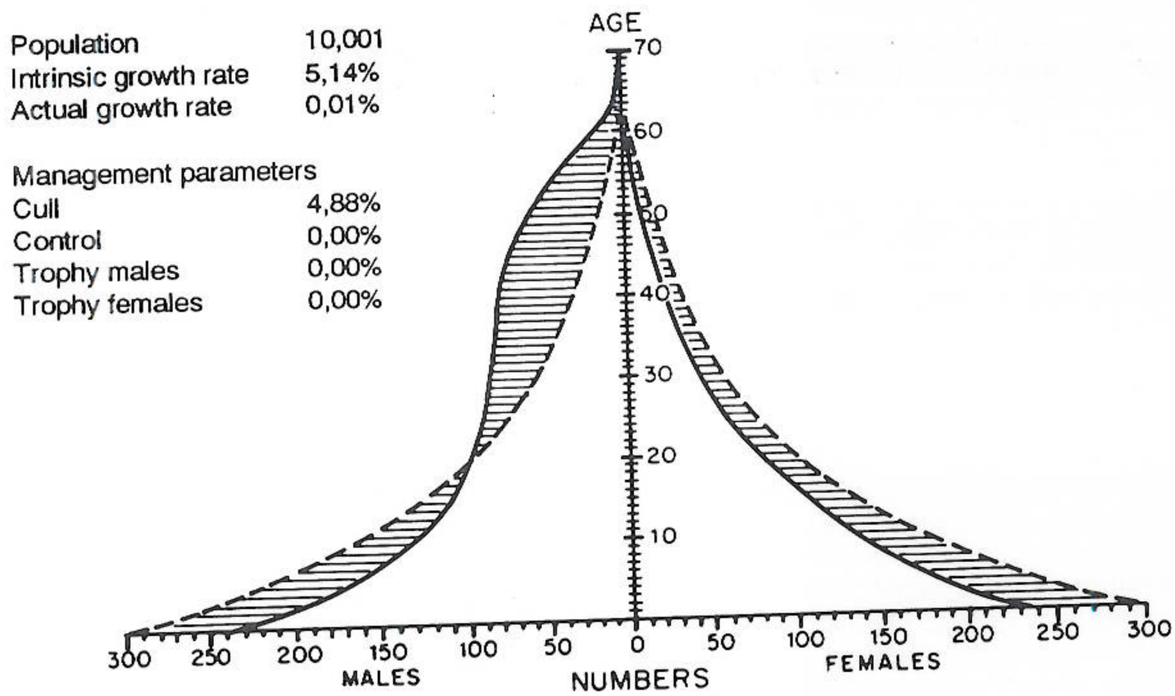


Figure 7. Structure of elephant population subjected to culling only.

hunting of a quota of males. In Figure 8 a stable, fully managed population of 10,000 animals is shown. The important features of this management are:

- The population would increase naturally at a rate of 5,1 % *per annum* in the absence of management;
- An offtake of 4,1% of the population in the form of breeding herds is sufficient to keep the population from increasing;
- An offtake of 0,2% of the population consists of adult males which are problem animals killed outside the protected area as crop raiders ('control').
- Only 0,7% of the adult males are taken as sport hunting trophies. This is the maximum percentage which, after allowing for the problem animal control is compatible with producing large tusks for the hunting market. The recruitment to the trophy hunting category is about 10 animals for every thousand. To exceed this will not necessarily threaten the population, but will result in a very low tusk weight of hunting trophies.

I was asked to talk about culling/cropping and this may be the right time to clarify the terms. In a consultant's report to CITES in 1986 I defined 'culling' as the killing of elephant for ecological reasons and 'cropping' as the killing of elephant for economic reasons. These definitions still seem appropriate. In the next section I point out that cropping is the lowest valued use for elephant.

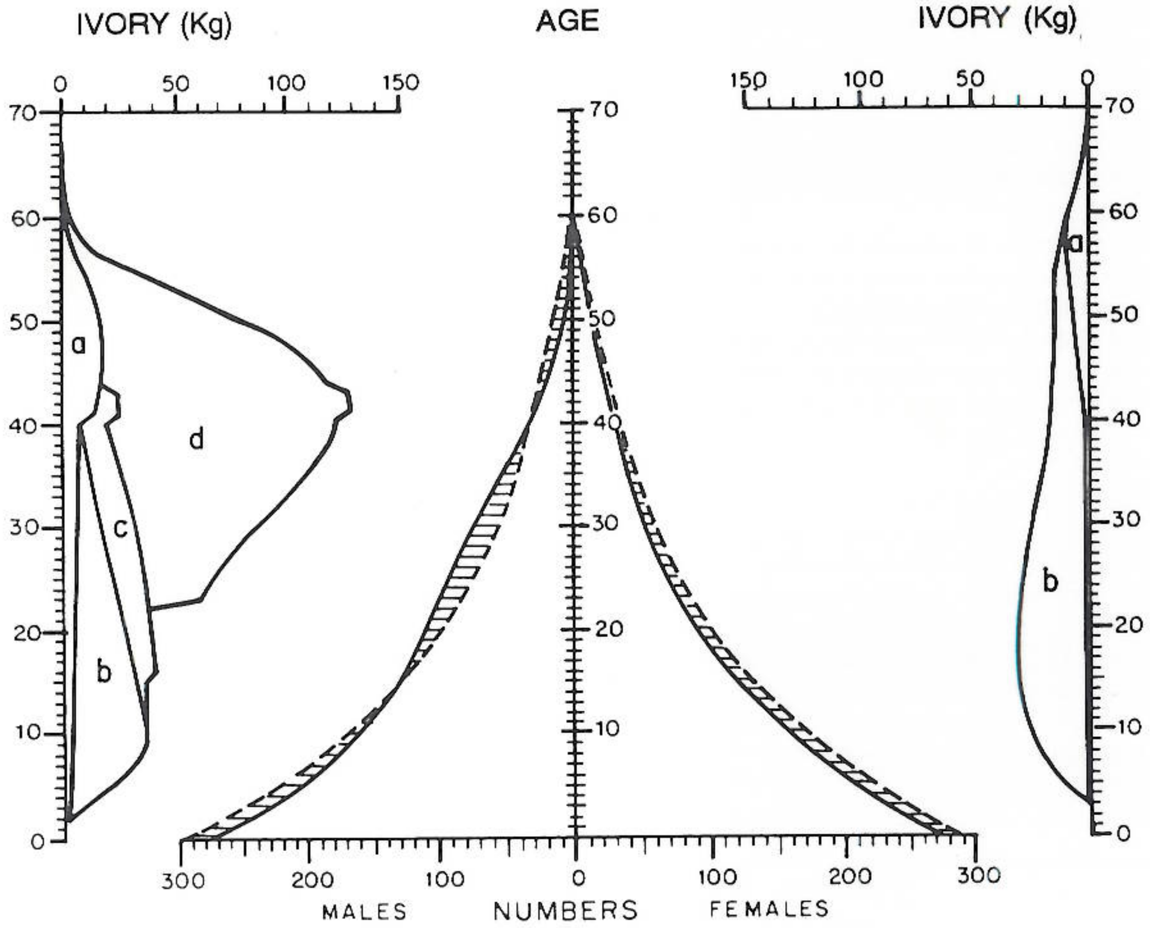
Ivory Production and the Economics of Elephant Management

In the hypothetical population of Figure 8, the ivory production is shown on either side of the age pyramid and tabled below the diagram. Points to draw attention to are:

- An unmanaged population of elephant growing at a rate of 5% *per annum* would produce some 1,35 tonnes of ivory from natural mortality in the year at which it reached a level of 10,000 animals.
- The managed population produces about five tonnes of ivory of which four tonnes come from males and one tonne from females. Contrary to statements made at the recent CITES meeting, Zimbabwe does not derive its ivory primarily from culling operations.
- The largest amount of ivory (46%) comes from 74 male trophy elephant taken in sport hunting. This ivory does not enter the commercial trade; economically it contributes far more than the value it would realise as raw ivory for sale. Typically, the average trophy elephant produces about 32 kilograms (both tusks combined) which, at pre-ban prices of about US$200.00/kilogram for this size of tusk, would be worth US$6,400. The same elephant taken by a sport hunter is worth about US$25,000.00.
- The proportions of ivory resulting from natural mortality, culling, control and sport hunting are shown in the figure. Natural mortality (closest to the axes) contributes little except in the upper age classes. However, because a significant number of males are killed by sport hunters before they die naturally, this proportion is low in the case of males. Culling affects only the immature males under about 15 years old found in cow herds and the small proportion of older males which happen to be present in cow herds on the day of culling. There is a deliberate selection in culling operations against taking cow herds when a very large male is present.
- In the example given, control hunting (problem animals) is limited to the males which have left the cow herds (over 15 years) but which are not carrying large tusks. Staff on problem animal control operations deliberately avoid trophy bulls in an attempt to leave these for sport hunting.
- Sport hunting is restricted to males and contributes by far the greatest amount of ivory (46%).

The question of whether or not to permit international sport hunting is very topical at this meeting. I point out that 74 male elephant in the sport hunting market are worth approximately US$2,5 million to the country offering them. If the same animals were 'cropped' for the value of their raw products they would be worth slightly more than US$0,5 million assuming that pre-ban ivory prices applied. Cropping produces one-fifth of the income of sport hunting and has to be regarded as poor marketing of elephant.

The above management system applied to 40,000



	Males	Females	Total
Total population	5,182	4,818	10,000
Total annual mortality (6,0%)	298	298	596
Natural mortality (0,9%)	43	50	93
Culling (4,1%)	160	248	408
Control (0,2%)	21	0	21
Sport hunting (0,7%)	74	0	74
Ivory production (kg)	3,708	1,259	4,967
Natural mortality (14,6%)	467	258	725
Culling (32,6%)	617	1,001	2,273
Control (7,1%)	351	0	351
Sport hunting (45,8%)	2,273	0	2,273
Unmanaged population ivory production	1,083	269	1,352

Figure 8. Ivory production from a managed population.

elephant would earn more than US$15 million *per annum*. Cropping might produce US$2,5 million.

The results of this simulation, which are very close to the real situation pertaining in Zimbabwe, can be used to make crude predictions of the ivory which is likely to be produced in southern Africa annually and which would be available to the raw ivory trade (Table 1). For every 10,000 animals approximately 5 tonnes of ivory are produced *per annum*. Of this 2,5 tonnes is taken by sport hunters and will not enter the ivory trade. Countries such as Botswana and Zambia which do not allow sport hunting of elephant at present might produce slightly more ivory for the trade.

Using the approximate population estimates for these countries, and assuming a maximum production of 2,5 tonnes per 10,000 elephant, the overall maximum sustainable production for the region is about 55 tonnes *per annum* at present. Since it is unlikely that any of the countries involved will be managing for such a yield, I have suggested it would be unwise to expect more than half of this amount.

As a final remark on this topic, it should be noted that total ivory production is to some extent independent of the exact management programme chosen. Ivory yield is more a function of the number of elephant in a country than it is an outcome of particular management strategies. If it is decided not to cull animals, then more animals will die as a result of control killing outside of protected areas; natural mortality will increase and provide a greater proportion of the ivory (in the extreme, elephant will starve to death and ivory will be plentiful); or, alternatively, the illegal hunters will take over management and supply of ivory.

Some Recommendations for Management

In the CITES report mentioned above, I emphasized the importance of adaptive management for elephant. Quota forms were designed to enable managers to plan their intended management and to predict ivory returns (Figures 10 a and b). I still believe that this is an essential process and that it should be extended to predicting income from the various forms of exploitation.

Most of Zimbabwe's elephant management is based on population simulation models which we hope, after many years of applying them and refining them, are close to the real biological situation. However, it is only through adaptive management—making hypotheses about the expected results of management and measuring after the treatment to see if these predictions are accurate—that management can be improved and more can be learnt about elephant populations.

Country	Approximate elephant population	Maximum potential production (tonnes)	Likely production (50% maximum) (tonnes)
Angola	20,000	5,0	2,5
Botswana	65,000	16,0	8,0
Malawi	2,000	0,5	0,2
Mocambique	20,000	5,0	2,5
Namibia	5,000	1,2	0,6
South Africa	10,000	2,5	1,3
Zambia	40,000	10,0	5,0
Zimbabwe	60,000	15,0	7,5
Totals		55,2	27,6

Table 1. Possible ivory production from southern Africa