ELEPHANT CARCASSES AND SKELETONS AS INDICATORS OF POPULATION TRENDS

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Introduction

Elephants have always posed problems to authorities, either as crop raiders, major agents of habitat change or as a potentially valuable natural resource. Decision-makers have had to consider such diverse questions as whether elephants should be culled as an ecological management policy within a park, or whether anti-poaching forces should be reinforced and the ivory trade banned to prevent their elimination. The true status of elephant populations has been confused by their apparent over-abundance in some areas and their disappearance from others. In every case where decisions must be made, knowledge is required of how many elephants there are and how their numbers are changing. The most basic requirement is a series of censuses which are accurate enough to indicate trends in numbers and densities over the years.

Unfortunately, research on elephants over the past 15 years has been very uneven. Some parks have been the subject of intensive and repeated studies, while others have been neglected. The object of elephant field surveys sponsored by the International Union for the Conservation of Nature (IUCN) has been to supplement data already available, to provide current information on particular areas where research was carried out in the past, and to census previously uncounted areas. This information, combined with a questionnaire survey, will serve as a basis to monitor the trends of key elephant populations in Africa, and by extrapolation the elephant population of the continent as a whole.

So far, 17 surveys have been carried out in Kenya, Tanzania, Uganda and Zambia supported by the World Wildlife Fund and the New York Zoological Society (WWF/NYZS), together with the national wildlife departments and national parks in each country. In addition, aerial censuses have been carried out by others in 17 other countries where African elephants are found.

The purpose of this paper is to review methods of recording dead elephants, and to discuss how carcass records can be interpreted. In addition, the usefulness of this type of information will be discussed. The methods used for elephant carcass surveys are based

on systematic counting from the air along sampling strips, as described by Norton-Griffiths (1975) and Western (1976). Although elephants are one of the least cryptic wildlife species, it is still possible for an observer. to miss not only single animals, but even whole herds. Since for these surveys observers were used of varying experience and ability, easily scannable strip widths were chosen, usually around 150 m, irrespective of terrain. These strip widths were calibrated by flying 20 to 30 times over markers on a runway and taking the average strip width seen by the observers. It has been found that more accurate strip widths are obtained by adjusting the strut markers, rather than by making adjustments using mathematical formulae.

In addition to censusing live elephants in the surveys which have been carried out, dead elephants were recorded as an indicator of mortality, often as supplementary evidence to confirm a trend. The methods suggested here for recording elephant carcasses have been developed from previous work.

Previous studies

It is a curious fact that elephant carcasses were very seldom recorded by researchers in the late 1960s, when some of the most important studies on elephant population dynamics were carried out. A reference was made to the apparent lack of dead elephants by Lamprey et al (1967), who remarked of the Serengeti that '. . . since 1961, wardens and biologists have flown for a total of over 2 000 hours over the Park and have only located eight elephant skeletons'. This observation was used to support the hypothesis that elephants had only recently arrived in the Serengeti. However, the elephant population had been on the order of 2 000 over the preceding 3 years, and it must be assumed that a natural mortality rate of 3 to 4% would have resulted in 60 to 80 skeletons a year, which had apparently largely gone unnoticed.

A single exception to the general lack of carcass observations was Graham and Laws's (1971) study in Murchison (now Kabalega) Falls National Park in Uganda. These authors were not so much concerned with measuring mortality trends through carcass observations as with identifying available quantities of ivory. In any event, they suggested some criteria for estimating carcass age since death and estimated that they had seen about 26% of all the dead elephants which were probably in the park.

No other quantitative records of elephant carcasses were made in the late 1960s. Evidently they were not considered a sensitive enough indicator of the moderate rates of elephant mortality which prevailed during that time, so no baseline was established in areas which have subsequently experienced a great increase in elephant mortality. As elephant carcasses became more abundant in the early 1970s, counting them by various methods became more widespread.

Following increased elephant mortality in Kenya's Tsavo East National Park, triggered by the 1970–71 drought, Corfield (1973) carried out a study with the objective of measuring mortality through ground and aerial carcass counts. A year later in the neighbouring Tana River District, Watson et al (1973c) recorded carcasses and commented that the observed

increase in the frequency of recent carcasses was undoubtedly caused by increased killing for ivory, resulting from a recent rise in ivory prices. According to later counts, his estimate of 900 dead elephants out of alive population of 32 000 was decidedly low. However, this count was made in the rains and it is likely that many of the dead elephants were hidden.

Subsequent aerial monitoring in Tsavo National Park and elsewhere, carried out by Cobb (1976), Leuthold (1976), the Kenya Wildlife Conservation and Management Department (WCMD), the Kenya Rangeland Ecological Monitoring Unit (KREMU) and the authors, all included counts of elephant carcasses seen within transects. Several of these studies, using somewhat different criteria, have attempted to identify carcasses that have been dead for less than a year, with the intention of estimating annual mortality. Standard methods of recording and classifying carcasses will be discussed.

Classification of carcasses

A classification system for elephant carcasses is suggested which includes four categories recognizable from the air. These are described as follows.

Category 1: fresh

This category comprises elephants which have died recently, perhaps 2 to 3 weeks previously at the most. The skin is still present, and the flesh has not yet been eaten or rotted away, but gives the body a rounded appearance. Vulture droppings may cover the skin, and surrounding area, which is often well trampled by scavengers. Carcasses only remain in this category for a short while, but their numbers can be of use to pinpoint waves of mortality which may merit investigation by management authorities.

Category 2: bones with rot patch

The second category also covers elephants which have died recently. The presence of skin and the scattering of bones are not reliable indicators of age, especially in areas where predators are dense and the rainfall is relatively high, so these have not been used as primary criteria. As Graham and Laws (1971) pointed out, a rot patch caused by the release of decomposition fluids often kills grass around a carcass and stains the surrounding soil. This is usually identifiable and lasts until the next heavy rains. The rot patch is taken as the primary criterion for this category.

Category 3: bones without rot patch

After heavy rain the rot patch is usually washed away, and grass or other vegetation may grow over it. The skin may or may not disappear, depending on rainfall and scavenger density, but the white skull and bones are often clearly visible, depending on the vegetation cover. There is no sharp distinction between this and the second category.

Category 4: old bones

After several years, the bones begin to develop cracks and pieces chip and flake off. They turn a greyish colour and become extremely cryptic. From the air, the skeletons no longer stand out as distinct entities. Twelve-year-old bones at Lake Manyara were similar in appearance to 11-year-old bones at Galatia Game Ranch which resulted from an elephant culling operation carried out by Laws and Parker in 1967 (Laws, 1969).

Factors affecting the rate of carcass breakdown

In order to attach ages to the four carcass categories, the factors affecting the rate of breakdown and visibility need to be considered. These factors will be discussed, and then the average rate of decomposition will be described for two samples of carcasses of known age from Amboseli and Manyara National Parks.

The most important factors affecting the disintegration and disappearance of carcasses were found to be rainfall, scavengers, sunlight and shade. The first two of these will be discussed.

Rainfall

An increase in rainfall generally increases the rate of carcass breakdown by softening the skin and allowing the action of invertebrate decomposers. Graham and Laws (1971) give an example from the high-rainfall area of Kabalega of a skeleton which was already grey and crumbling (i. e. category 4) after only 4 years. One 4-year-old carcass observed by the authors was classified as category 3 in 1977, yet only a year and a half later in August 1978, following heavy rains, the skin had disintegrated and the bones were almost hidden by grass. Although the carcass was at least 5 years old, the bones were uncracked since they had been sheltered from the sun during most of that period by the skin. Shaded and sheltered bones may last indefinitely (like the relics of saints), but an elephant corpse which was well shaded and sheltered would not be visible from the air.

The rapid disappearance of the skin associated with heavy rains occurred in all 20 elephant carcasses monitored in Amboseli during 1978. As the rains that year were heavy throughout Kenya, the presence of skin on any carcasses seen within the following 12 months could be used as an indicator of death since mid1978. The other effect of heavy rainfall is the increased grass growth which reduces visibility. For this reason carcass counts should only be made in the dry season, preferably after the grass has been burned.

By contrast, in an arid zone of relatively low scavenger density, such as Amboseli during recent dry years, many of the elephants which have died have dried up, with the bones held together by hardened skin. From their work on the taphonomy of carcasses in Amboseli, Behrensmeyer and Western (personal communication) estimated that large skeletons, such as elephant skeletons, could remain visible for up to 10 years.

Scavengers

If a carcass is scavenged by lions or hyenas during the first few days while the skin is soft, the skin may be partially or completely removed and bones scattered. This exposes the bones to weathering, makes it easier for them to be hidden by vegetation and renders the skeleton more difficult to see from the air than if it were a compact mass. In an area of high scavenger density, for example Seronera in the Serengeti, carcasses are rapidly dismembered. An elephant that died only 2 months previously, but was immediately attacked by scavengers, left only a skull and a few scattered bones visible from the air. In this case, there was also no visible rot patch, which suggests that most of the animal must have been eaten before it had time to decompose. In Kenya's Aberdares National Park, hyenas are abundant and scatter a carcass within days; rapid vegetation growth then renders the carcass invisible (P Snyder, personal communication).

Allocation of ages to carcass categories

The decomposition of 32 known-age carcasses in Manyara National Park and 25 in Amboseli National Park has been followed intermittently over a 3-year period. The dates of death and locations of carcasses at Amboseli were furnished by C Moss, and similar information was recorded during long-term elephant monitoring in Manyara. The population densities of scavenger species (lion and hyena) were similar in both areas.

For each carcass, the following information was recorded at each observation:

- category (1–4)
- wear stage of bones, as defined by Behrensmeyer (1978)
- scatter of bones
- presence or absence of skin
- aerial visibility of crania and other major bones
- broad vegetation type
- recent rainfall
- scavenger use
- other qualitative information.

The results of these surveys are summarized in Table 1. In Manyara, with a mean annual rainfall of 760 mm, the average age of category 1 carcasses was 7 days, for category 2 the average was 5 months, for category 3 it was 14 months, and for category 4 ages ranged from 12 to 25 months. In Amboseli, with annual rainfall averaging 300 mm, there is no record of how long carcasses remained in category 1, but for category 2 the average age was 9 months, for category 3 it was 23 months, and for category 4 the age range was from 20 to 60 months. Real age varied widely within each category and overlapped with adjoining categories. The transition from category 2 to 3 in Manyara generally occurred before the end of the first year, while in Amboseli category 2 carcasses could be older than 1 year. This pattern indicates the effect of heavier rainfall, which tends to increase the rate of carcass breakdown and disappearance.

Table 1. *Ages of carcass categories as determined from known-age carcasses in Manyara and Amboseli National Parks*

Location	Mean Annual Rainfall (mm)	Category	N	Mean Age (months)	Age Range (months)	Average wear stage	Scatter (m)	% Visible From Air	% with Skin (nearest 10%)
Manyara	760	1	4	0.12	0–0.2	0	2	100	100
		2	11	5.30	0.07–8.0	0–1	4	90	90
		3	11	14.50	10–19	1–3	10	70	30
		4	<u>6</u>	19.00	12–25+	2–5	13	50	0
			32						
Amboseli	300	1	1	0.2	–	0	2	100	100
		2	7	8.6	0.07–30	0–1	5	90	80
		3	6	23.0	20–60	1–3	9	100	20
		4	<u>11</u>	45.6	20–60	1–3	18	80	0
			25						

The proportion of carcasses in each category with skin visible was similar in the two parks. In category 1, 100% of the carcasses had skin, in category 2, 80 to 90% had skin; and in category 3, 20 to 30% had skin.
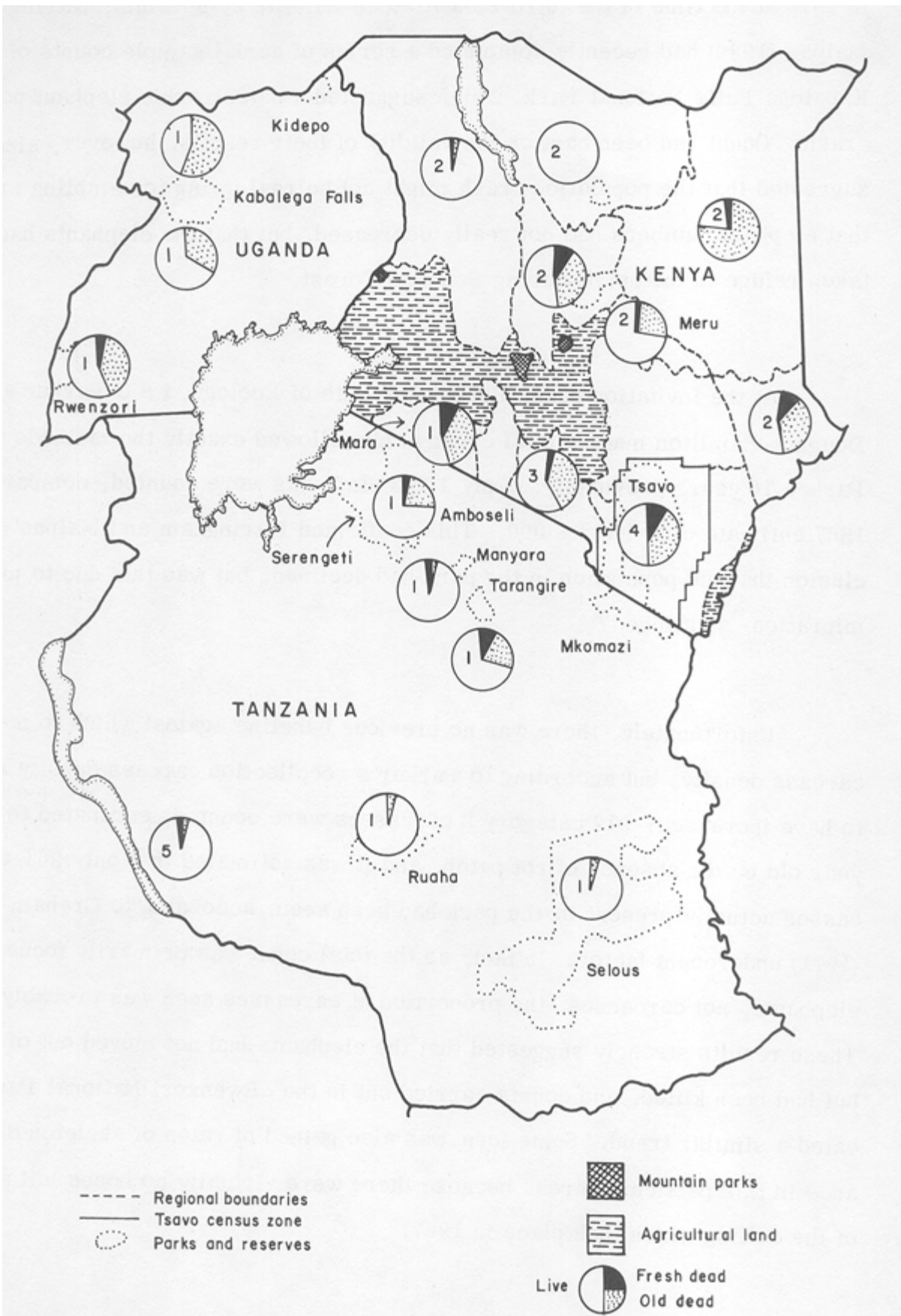
The most useful distinction is between carcasses less than and more than 1 year old. The identification of carcasses less than 1 year old gives a relative measure of annual mortality when compared with live populations, and indicates differences in mortality between areas. An absolute measure of mortality is not possible because not all carcasses are seen and some break down or disappear within less than a year.

Results from several areas indicate that the transition between categories 2 and 3 generally occurs at around 1 year after death. The results, however, also indicate the importance of considering scavenger density, average rainfall and recent short-term rainfall patterns in each area. Despite some imprecision in relating carcass categories to age, a baseline of carcass densities for different populations is now being accumulated by a number of research teams. Where monitoring flights are carried out on a regular basis, it is possible to identify trends in mortality rates.

Application of the method

Although the technique of aging elephant carcasses is new, comparative results offer some insight into recent patterns of elephant mortality in eastern Africa. The results can be presented as a ratio of dead to live animals seen during a count. The use of this ratio may to some extent even out biases due to individual observers, since a good observer is likely to see more carcasses and more live elephants than a poor observer so the ratio should not change.

Figure 1 gives a range of dead to live ratios in conditions of similar visibility. Only the ratios for the Selous, Ruaha and Manyara areas appear to represent normal mortality. The ratios for Selous and Ruaha, in particular, are likely to be accurate since they are derived from large samples. At the other end of the scale, the Tsavo, Tana, Lamu-Garissa and Samburu areas show ratios that indicate heavy mortality.

Kidepo

Kabalega Falls

UGANDA

Rwenzori

Mara

Serengeti

Amboseli

Manyara

Tarangire

TANZANIA

Ruaha

Selous

Kidepo

KENYA

Meru

Tsavo

Mkomazi

– – – Regional boundaries
—— Tsavo census zone
⬚ Parks and reserves

▨ Mountain parks

▤ Agricultural land

Live ◐ Fresh dead
Old dead

Sources: = IUCN; 2 = KREMU; 3 = D Western; 4 = WCMD; 5 = Ecosystems Ltd.

Figure 1. *Ratios of dead to live elephants in various localities of eastern Africa, 1976–77*

To illustrate the usefulness of information provided by elephant surveys using carcass data, three recent case studies will be described. The three situations and the information needed by wildlife managers and decision-makers were as follows:

- Kabalega Falls National Park, Uganda, 1976: Had most of the elephants in the park been killed or had they just left the park?
- Tsavo National Park, Kenya, 1978: Was it drought or was it poaching which caused a major elephant population crash?
- Luangwa Valley, Zambia, 1979: Were there still too many elephants in the area and should they be culled, as recommended by a UNDP/FAO report (FAO, 1973), or had they been affected by poaching, and if so to what extent?

The first question concerned the Kabalega Falls National Park, Uganda. In 1976 at the time of the third East African Wildlife Symposium, Eltringham and Malpas (1980) had recently completed a series of aerial sample counts of the Kabalega Falls National Park, which suggested a catastrophic elephant population crash. Doubt had been cast on the validity of their results, however, since it was suggested that the population crash might not be real owing to sampling errors, or that elephant numbers had not really decreased, but that the elephants had merely taken refuge in the neighbouring Budongo Forest.

At the invitation of the Uganda Institute of Ecology, I S C Parker and Douglas-Hamilton made a total count which followed exactly the methods used by Parker 10 years previously. Only 1 713 elephants were counted, compared to the 1967 estimate of at least 8 000. This confirmed Eltringham and Malpas's conclusion that the population in the park had declined, but was this due to mass migration, as alleged?

Unfortunately, there was no previous baseline against which to measure carcass density, but according to Parker's recollection carcass density appeared to have increased: 912 category 3 carcasses were counted, estimated to be over a year old by the absence of rot patch, and it was estimated that only 26% of the carcasses actually present in the park had been seen, according to Graham and Laws's (1971) undercount factor. In fact, as the total count was primarily focused on live elephants, not carcasses, the proportion of carcasses seen was probably even less. These results strongly suggested that the elephants had not moved out of the park, but had been killed, and counts carried out in the Rwenzori National Park indicated a similar trend. Some idea was also gained of rates of skeleton disappearance in this particular area, because there were virtually no bones left at the site of the culling which took place in 1967.

In Kenya's Tsavo National Park, it had been disputed whether an observed reduction in the elephant population was due to drought or poaching. In 1967 when Laws was working in Tsavo, carcasses were so few that they were not considered worth recording. However, in 1970–71 an unusually dry period resulted in the death of some 6 000

elephants, almost entirely along the Galana River in the eastern part of the park (Corfield, 1973). Over subsequent years there were shorter periods of elephant starvation, the last of which was in 1975/6 when, according to Sheldrick (1976), about 9 000 elephants probably died of all causes.

Yet mortality due to drought was not immediately apparent from aerial survey results. Successive estimates, using the same sampling techniques within the Tsavo census zone defined by Cobb (1976), are summarized in Figure 2. Cobb's series of counts during 1973–74 gave population averages close to the previous rough estimate of 35 000 (Laws, 1969). Cobb' s last count, made in November 1974, is especially interesting because for the first time he also counted all dead elephants, including skeletons which were several years old. From this count he estimated a population of 37 827 live elephants and 11 837 dead, giving a total of nearly 50 000 elephants. This figure raises the possibility that there may have been more elephants in the area in 1967 than previously estimated, and that many of the dead which Cobb recorded had been killed by the drought. Results from another count, made by Leuthold in 1975, were not significantly different from Cobb's.
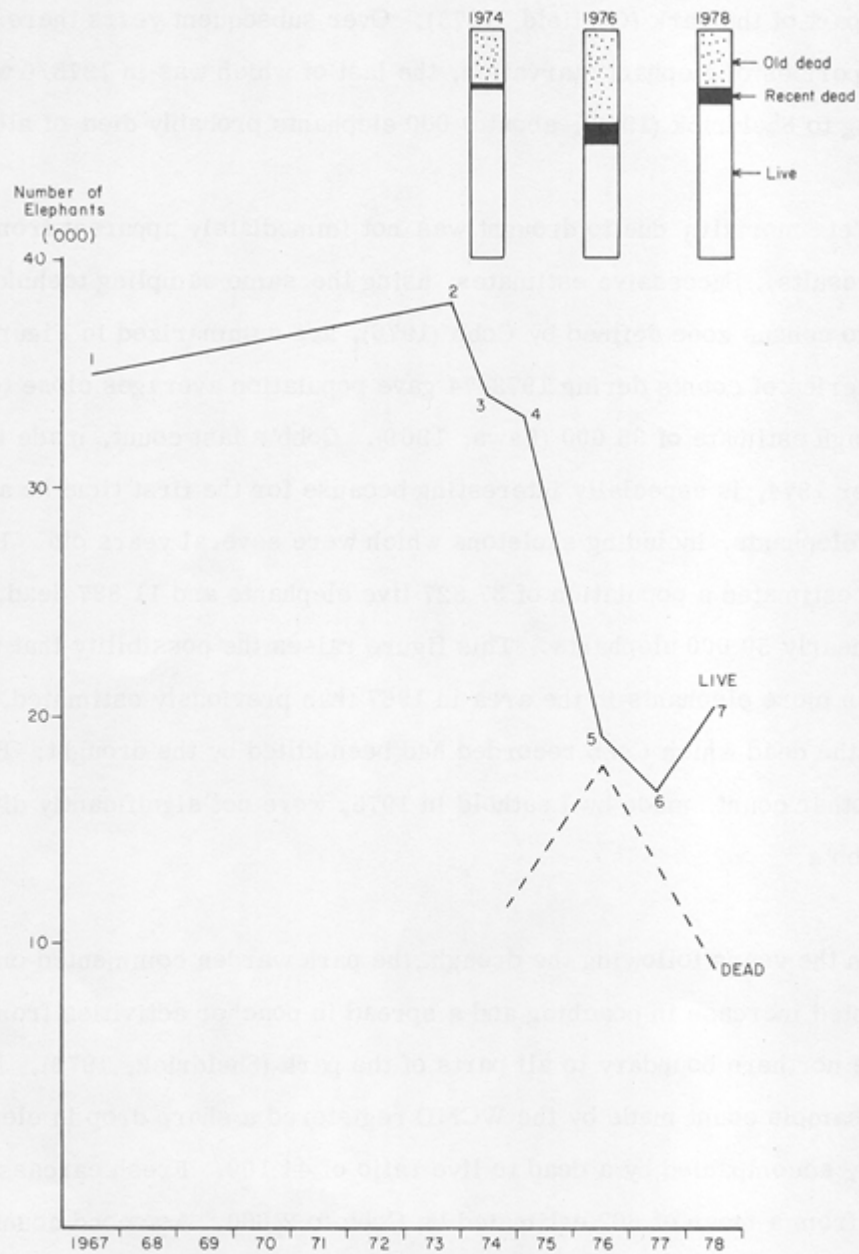
Sources: 1. Laws (1969); 2. Cobb (1976); 3. Cobb (1976, mean of five counts);
4. Leuthold (1976); 5. WCMD (mean of two counts); 6. KREMU;
7. IUCN.

Figure 2. *Elephant population estimates in the Tsavo census zone*

In the years following the drought, the park warden commented on an unprecedented increase in poaching and a spread in poacher activities from a fringe along the northern boundary to all parts of the park (Sheldrick, 1976). In June 1976, a sample count made by the WCMD registered a sharp drop in elephant numbers, accompanied by a dead to live ratio of 44:100. Fresh carcasses had increased from a mean of 602 estimated by Cobb to 2 600. A second count was made in September 1976; the average of the two counts is given in Figure 2. KREMU carried out counts in 1977 and 1978. When these results are modified to apply to the same Tsavo census zone as previous counts, minus Mkomazi, they give an average of about 19 000 live elephants, which is not significantly different from the IUCN count of nearly 20 500 made in April 1978. Visibility conditions during the IUCN survey resulted in a much lower dead elephant count because there had been heavy rains and the entire area had a thick ground cover of grass and herbs which largely concealed elephant carcasses and skeletons. The information from these aerial surveys indicates that the most substantial drop in elephant numbers occurred after 1975 and could thus only be due to poaching, not drought. This fact is of considerable concern to those responsible for managing the park.

Douglas-Hamilton et al (1979) counted live elephants and carcasses in Zambia's Luangwa Valley, including Luangwa North and Luangwa South National Parks and the Munyamadzi corridor. Their methods were similar to those of Caughley and Goddard (1975) who conducted a census in 1973. A comparison of information from the two counts is given in Table 2. Assuming that the two counts were of similar accuracy, it would appear that the population has shown an overall decline of 40% during the 6-year period. Further evidence for a decline in population, probably caused by poaching, is provided by the carcass analysis, which suggests a substantial ratio of dead to live elephants (see Figure 3). The situation in Luangwa is reminiscent of Tsavo in 1974 after the drought, but before the surge in poaching. The survey information indicates that wildlife managers in the Luangwa Valley should take measures to counteract poaching; culling programmes should not be considered until poaching can be shown to be under control.

Table 2. *Elephant population estimates in three areas of Luangwa Valley, 1973 and 1979*

Location	Area (km^2)	– total	1973 Estimates –		– total	1979 Estimates	
			density per km^2	standard error		density per km^2	standard error
North Luangwa	4 460	17 700	3.97	2 790	7 360	1.65	1 520
Munyamadzi corridor	2 400	6 700	2.79	1 430	3 350	1.39	455
South Luangwa	9 420	31 600	3.35	2 650	22 800	2.42	3 500

Total or mean	16 280	56 000	3.44		33 510	2.06	

	North Luangwa	Munyamadzi corridor	South Luangwa	Total
Decline in numbers, 1973–1979	10 340	3 350	8 800	22 400
Percent decline, 1973–1979	58%	50%	38%	40%

Sources: For 1973, Caughley and Goddard (1975); for 1979, Douglas-Hamilton et al (1979).
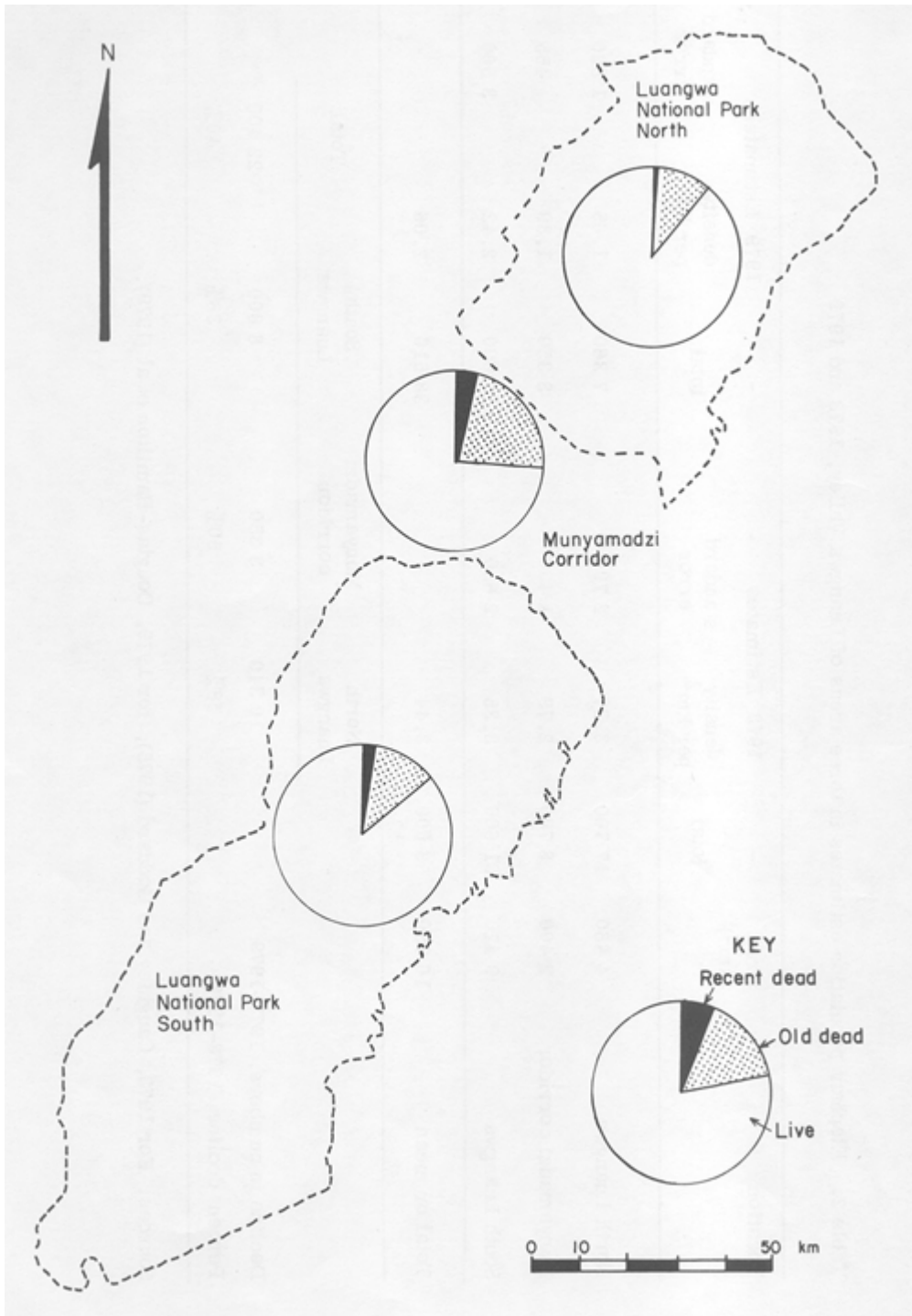
Figure 3. *Elephant live to dead ratios for Luangwa Valley census zone, October 1979*

In conclusion, the main purpose of this paper has been to stimulate comments on ways to improve the methods of counting and interpreting elephant carcass densities and to encourage those conducting elephant surveys to record carcasses in a standardized way.

This information should be important in interpreting long-term changes in elephant mortality which will help wildlife and resource managers make better decisions concerning the management of elephant populations.