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Irven O. Buss

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MANAGEMENT SUGGESTIONS FOR THE AFRICAN ELEPHANT[1]

Irven O. Buss

Abstract: A half century of experience managing deer, elk, and other herbivorous game mammals in America has shown that no known management method is more effective than scientifically controlling population numbers to carrying capacity. Unfortunately, such experience is wanting among many wildlife managers in Africa. Consequently, inadequate harvest of elephants made in Kabalega Falls and only a scientific sample obtained in Tsavo National Park has resulted in serious degradation of ranges, reduced fertility and reproduction, lower chance for survival of all age groups, particularly juveniles, lower biotic diversity, reduced flow of energy through the ecosystem, and loss of the opportunity for human utilization of the resource.

In Kruger National Park of South Africa, however, elephants have been scientifically managed for a decade, including annual harvests or "cullings." Between 1905 and 1970 elephants increased rapidly. When culling operations began in 1968, they were planned as a holding action against unrestrained increase of elephants in the park and possible immigration; by 1971 this goal was achieved. At that time the first decline in elephant numbers was noted. Expected future quotas for cropping will probably range from 200 to 400 elephants annually, unless the population drops below 7,000, at which level cropping would cease. Hopefully, this program, or a similar one, will serve as a foundation for management of elephants on many of their remaining ranges in Africa.

Introduction

The dwindling of ranges of large wild animals continues on a global front as human populations surge inexorably upward. By 1920 the pronghorn antelope (*Antilocapra americana*) was nearly eliminated from the United States. According to Allen (1962), "taking over of the Great Plains for cattle raising and agriculture resulted in the elimination of the pronghorn antelope from much of its primitive range."

A westward tide of avaricious humanity, construction of railroads, and failure of the President to sign a bill passed by the Congress in 1874 providing for the protection of the bison (buffalo) were the main causes for liquidation of the American bison (*B. bison*) from its vast original range. At one time there were possibly sixty million buffaloes in the U.S., but by 1883 nearly all of the animals were driven from their range and killed (Grinnell, 1892; Hornaday 1913).

In India, Talbot (1957) attributed human encroachment, overgrazing, and shrinking range as primary causes for the declining numbers of the Indian lion

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[1]Modified, updated, and rewritten version of "Management of big game with particular reference to elephants," Malayan Nat. J. 31(1):59-71.

(*Panthera leo*) and other wild animals. Talbot (1957:577) concluded: "Most significant is the destruction of the forests themselves."

African elephants (*Loxodonta africana*) also are victims of range depletion. An example of such range depletion was mapped by Brooks and Buss (1962), showing that the total area occupied by elephants in Uganda was reduced by 75 percent between 1929 and 1959. Subsequently, further restriction occurred which, according to Laws and Parker (1968:320), was caused almost entirely by expanding human populations and associated land use. As a result of continued range restriction, perhaps 95 percent of the elephants in Uganda lived in parks and other sanctuaries. Inside the sanctuaries they quickly reached very high densities which were fostered by (1) normal reproductive increase, (2) blocking of migration routes, and (3) harassment outside the sanctuaries combined with protection within the sanctuaries. These restricted and unnaturally dense populations almost completely destroyed their habitats and threatened the entire ecosystems in which they lived. Scientific management of these elephant populations is still one of the most important, but unfortunately also one of the most controversial, problems related to wildlife in Africa.

The remainder of this report is directed: (a) to habitat degradation caused by over-populations of elephants in parks of Africa where I have worked, (b) to problems associated with over-populations and range deterioration, and (c) to a discussion of the status of two parks in East Africa where little or no reduction was made, compared with the status in Kruger National Park of South Africa, where controlled reductions are part of a scientific management plan.

Habitat degradation and over-population

Significant changes that occurred to elephant populations and their habitats in the south part of Kabalega Falls National Park (formerly Murchison Falls National Park), including Budongo Forest and other peripheral ranges occupied by elephants, are documented by studies conducted there since 1957 (Brooks and Buss, 1962; Buechner and Dawkins, 1961; Buechner *et al*., 1963; Buss and Brooks, 1961; Buss and Savidge, 1966; Buss and Smith, 1966; Laws, 1969a; Laws and Parker, 1968; Laws *et al*., 1970; Shantz and Turner, 1958). All of these investigators agree that significant habitat deterioration occurred during this time and that over-populations of elephants was the primary cause.

Evidently the population in Kabalega remained high until 1973 during which year 14,309 elephants were counted by S. K. Eltringham and R. C. Malpas (1976). According to Norris (1977), "the real destruction" of elephants by poaching started in 1973. By 1974 the count had plunged to 6,030, then dropped to 2,246 in 1975, and apparently leveled off at 2,448 in 1976. Schaller in 1973 predicted such destructive poaching by stating (p. 242) that "the new African wardens are desk-bound, concerned with administration rather than with natural history. They lack a personal involvement with the parks, they lack the possessiveness that is the basis of dedication. And dedication is surely needed to maintain the wildlife against the constant pressure of poachers and other threats."

Regardless of the causes for this 80 percent reduction, more recent reports from Kabalega indicate that the habitat destruction referred to above is currently a problem of the past and that there is rather "rapid recolonization of grasslands by woodland and forest species." Thus there is now a clear picture of high destruction of forest and woodland habitat under conditions of over-populations of elephants, but a rather rapid regeneration of forest and woodland habitat following the conspicuous decline in elephants since 1973.

Ills of over-populations

As elephant populations escalate above carrying capacity of their ranges, there is progressive retrogression in availability of tree and shrub forage. Eventually a threshold in availability of woody forage is reached. At this stage elephants begin to consume grass in excess of their nutritional requirements, since palatability and availability primarily determine what wild elephants eat (Wing and Buss, 1970:48, 57, 66).

By 1963-64 elephants had severely over-utilized the range in the south part of Kabalega Falls National Park. Buss and Smith (1966:379) describe the situation as follows: "The elephants south of the Victoria Nile River in the [Kabalega] Falls National Park area are very crowded and compete for forage with buffaloes (Syncerus caffer) and hippopotami (Hippopotamus amphibius). In addition, the elephants are hemmed in closely by the Nile River, Lake Mobutu, two controlled hunting areas, and highways used by continually increasing numbers of hunters. Actually, the continual constriction of this elephant range appeared to approach pen conditions." These conditions of habitat degradation were reflected in the elephant's food-habits. A food habits study conducted in this area by Buss (1961) and based on stomach contents of 71 elephants examined during the dry season of 1958-59 showed that grass comprised 98% of the total food material eaten. Laws and Parker (1968) reported grass as the main component of stomachs, averaging 84 and 95 percent for two populations studied inside the park. Comprehensive food-habits studies reported by Wing and Buss (1970) for samples collected at various times in forests and savannas indicated that grass was eaten with impressive frequency (p. 61). Nevertheless, significant differences did occur between percentage (97 and 93) of grass eaten in grasslands of Kabalega National Park and percentage (64 to 68) of grass eaten in Kibale Forest Reserve (Wing and Buss, 1970:59-60).

As forest and woodland habitat deteriorated in Kabalega National Park, calves in the population decreased from about 7 or 8 percent in 1957-59 (Buechner et al., 1963:52) to approximately 6.0 to 6.5 percent in 1963-64 (Buss and Savidge, 1966:807), indicating reduced fertility and/or increased mortality. Also, Buss and Smith (1966) studied ovaries of 120 adult cows collected in 1958-64 and reported (p. 379) an average postpartum conception interval of 81.9 months (6.8 years). This is more than three times as long as the 2-year interval reported for 1947 to 1950 by Perry (1953) for the same general area. Thus these studies show that severe over-utilization of the range was associated with a significant decrease in reproduction. This view is supported by Laws et al. (1970:171), who state that the high grass content in the south part of Kabalega Park diet "is associated with a population decline involving lowered fertility and increased mortality." Sikes (1971:230) points out that "The slave trade and the ivory trade grew up hand in hand in Africa . . ." and " . . . the drastic culling of the elephant populations in those days was also somewhat advantageous to the elephant populations, by maintaining them well within the carrying capacity of the environment."

Over-utilization of range by elephants can have an important impact on numerous other animals coexisting on these ranges. Particularly notable is the impact on forest and woodland species when elephants are involved in destruction of these habitats. Some of the most common large mammals observed in the south part of Kabalega Falls National Park and peripheral ranges while elephant studies were conducted there in 1957-58 and 1963-64 included the following 13 species of herbivores: hippopotamus, buffalo, bush pig (*Potamochoerus porcus*), warthog (*Phacochoerus aethiopicus*), giant forest hog (*Hylochoerus meinertzhageni*), oribi (*Ourebia ourebi*), reedbuck (*R. redunca*), bushbuck (*Tragelaphus scriptus*), Jackson hartebeest (*Alcelaphus buselaphus*), waterbuck (*Kobus ellipsiprymnus*), Uganda kob (*Kobus kob*), and three duikers (*Sylvicapra grimmia, Cephalophus* spp.). There were also at least four common carnivores, seen both in the forest and on the nearby savanna: lion (*Panthera leo*), leopard (*P. pardus*), serval cat (*Felis serval*), and spotted hyaena (*C. crocuta*). A ratel or honey badger (*Mellivora capensis*) was seen on one occasion, at the west base of Igisi Hill. Primates were represented by five species: chimpanzee (*Pan troglodytes*), baboon (*Papio anubis*), colobus monkey (*Colubus abyssinicus*), vervet monkey (*Cercopithecus aethiops*), and Sykes monkey (*C. mitis*). Some of these animals, such as the giant forest hog, chimpanzee, and the monkeys that depend on gallery or seral-stage forest, have been extirpated from some areas. Also, two species of duikers, bushbuck, leopard, and baboon that are partly dependent on forest vegetation have decreased in abundance. A check list of birds for the area includes some 400 species, almost a quarter of them living primarily in woodland or forest habitats (Meester and Setzer, 1971). Nearly all of the animals listed above have been reported for habitats in north Bunyoro of Uganda by Laws *et al*. (1970) who give estimated population density for seven of the large mammals.

As woodlands and forests shrink under the impact of excessive elephant populations, so does the range of the many small mammals, reptiles, amphibians, and invertebrates living in these habitats. Their decline or even complete disappearance often goes unnoticed. Yet these small animals serve as prey and are thus paramount to survival of the larger animals. The onset of decline in any animal population heralds a decrease in biotic diversity, which should be maintained at the highest possible level to assure maximum secondary productivity. Although an increase in number of biotic species does not always guarantee increased total productivity, "yet such a result would be expected if the greater diversity of secondary producers represented a broader capacity to consume and convert organic matter and thereby to speed up the turnover rate within the system" (Evans, 1967:13). Considering that no two species occupy exactly the same niche, one can logically assume that greater diversity of secondary producers represents a broader capacity to consume and convert organic matter.

Problems in Tsavo National Park

Establishment of a park frequently generates an animal problem. Tsavo National Park in Kenya is no exception. As stated by Glover in 1972, "The 'elephant problem' started when Tsavo was declared a National Park in 1947. The elephants soon discovered that this vast semi-desert offered a refuge and respite from legal hunting, poaching, and ever increasing agricultural activities outside the park." With the increase of elephants in the park, however, illegal hunting, particularly by the Waliangulu and Wakamba tribes, became a major issue. Parker (1972) worked in Tsavo and comments on poaching during the period when elephants increased. "At this time it was erroneously thought that there were less than 10,000 elephant in the Tsavo system and it was stated that if illicit hunting was not suppressed elephant would be extinct (there) in less than three years."

Illegal killing of elephants increased in the 10 years after World War II. "By the mid fifties at least 1,500 to 2,000 (elephants) were being killed annually in the Tsavo National Park and the adjoining Coast Province. In 1957 the park and surrounding country was cleared of poaching gangs in a remarkably efficient paramilitary operation. During this campaign, in one small area of about 32.2 km^2 (20 square miles), 1,280 elephant skeletons were found, a tenth of which were juveniles" (Laws, 1969b).

Despite the intensive poaching operations, Tsavo's elephant population continued increasing. By 1959 the warden observed that certain trees, such as baobab, were beginning to be destroyed within the eastern part of the park (Glover, 1972). Destruction of woody vegetation continued until a crisis was reached in the 1960-61 drought period. According to Laws (1969b), "'Elephant slums' were created along the rivers, which looked like battlefields, and increasingly large areas changed from bush to grassland." By the time the drought ended, some 300 rhinoceros (Diceros bicornis) had died in the western part of the park. Their deaths "from malnutrition were attributed to elephant having consumed all the rhino's browse" (Parker, 1972). Elephants also died during the 1960-61 drought in Tsavo "but not to the extent as in the 1970-71 drought" (Sheldrick, 1972b:26).

During the succession of wet years from September 1961 until 1970, when elephant densities were increasing, replacement of woody vegetation by grassland continued. Quantitative studies by Laws (1969b:17) showed "that in 1962-67 trees and bushes were dying over large areas at the rate of six percent a year, mainly species with a lifespan of from 30 to 50 years. Baobabs which have a lifespan of several hundred years (one tree has been aged at 1,000 years) were decreasing at a rate of at least two percent a year." Exceptionally high loss occurred to Commiphora sp. and Acacia tortilis; both highly favored foods for elephants.

"From the middle of 1970 until 23rd November 1971 a very severe drought prevailed" in Tsavo National Park (Glover, 1972). The impact of the drought was indicated by Sheldrick's statement (1972a:29) that "Throughout some 12,800 km^2 (8,000 $mile^2$) of dusty bushland, more than 5,000 African elephants and about 300 black rhino weakened and died." How many elephants were living in Tsavo's 12,800 km^2 at the onset of the drought? Glover (1963) published a report on the elephant problem at Tsavo giving an estimate of 10,799 elephants for 1962. Laws (1970) began working in Tsavo during February 1967 and in a relatively short time his research team estimated "23,000 in the park with an additional 12,000 in the peripheral areas, a total of 35,000 ± 7,000." On the basis of Laws' population estimate, there were 2.9 elephants per 1.6 km^2 (1 $mile^2$), a density far above the park's carrying capacity. Laws (1970) estimated an approximate carrying capacity of "about 1.5 to 2.0 elephants per 1.6 km^2 (1 $mile^2$) for the areas studied in Tsavo before habitat change." He also stated that his estimate is higher than Glover's (1963). Considering the subsequent change in habitat caused by the drought of 1970-71 and the need for herd reduction, one elephant per 1.6 km^2 (1 $mile^2$) would be more realistic for Tsavo's dry and depleted range. In other words, by use of Laws' data, Tsavo can support about 8,000 elephants without jeopardizing the welfare of future generations of elephants and other animals sharing the trees and shrublands of the park.

Management. For Kabalega and Tsavo National Parks there is strong evidence that excessive elephant populations caused a degradation of habitat, decrease in elephant reproduction, and reduction of animals sharing woodland and forest habitats with these elephants. Yet little or no scientific management of elephants has been accomplished in these parks.

Two thousand elephants were cropped in Kabalega by Wildlife Services Ltd. in 1965-66 and 300 in Tsavo National Park. This was a good beginning, but why were cropping recommendations based on scientifically sound information pigeon-holed? The reason is that policy makers (high government officials), not biologists, are managing the elephants. These officials are keenly aware and responsive to public concern, but they do not understand ecologic function. Changing park policy, therefore, is difficult and the process just begins when a biologist submits management recommendations requiring policy revision. Public education and selling the recommendations are prerequisites of success, and unless there is complete agreement in recommendations, success should not be expected.

In Tsavo much controversy and wrangling has occurred over management practices. Scientists have advocated cropping programs to reduce the elephant herds so their forage supply and range status will be maintained without deterioration of the biota. Their recommendations are based on field investigations of elephants in Tsavo and on considerable experience studying elephants and other big mammals elsewhere in Africa.

Preservationists oppose cropping and recommend letting nature take its course. They question whether the Commiphora woodland, which was destroyed by elephants, is really the climax vegetation for the area. They suggest that the climax vegetation for the area is grass and that the vegetational conversion from open savannah to woodland and vice versa represents a natural cycle hastened by elephants. Furthermore, they believe that the developing grasses have a higher value in terms of productivity than the low-tree regime, that grass protects the soil from erosion better than trees, that grass has given rise to numerous permanent springs, and that grass has resulted in proliferation of numerous plains-loving antelopes, buffaloes, and zebras. In other words, some of the preservationists' arguments are perfectly sound, and although this group is labeled preservationist, most of them are well trained, highly experienced, deeply dedicated, and honest. Nevertheless, I believe their views will have to change. Scientific cropping programs such as the one in Kruger National Park which is discussed below and many other successful cropping programs in other parts of the world have demonstrated repeatedly that controlled harvest of the wildlife resource is by far the best management program. Elephants, like other game animals, can not be stockpiled.

During a half century of trial and error in managing America's big game (elk, moose, deer, and other herbivores) populations, no method proved more universally effective than controlled annual reduction of population numbers to the carrying capacity of big game ranges. Where such cropping programs were achieved, annual productivity was maintained at a high level and the resource was used. Equally important, protection of forage on these ranges assured high carrying capacity for other animals and resulted in high biotic diversity, an excellent goal for scientific management.

Leopold, Sowls, and Spencer (1947) published a survey of over-populated deer ranges in the United States and concluded: "Apparently deer men everywhere have found it hard to convince the average citizen, and especially the average deer hunter, that (1) delay in reduction of over-populated deer ranges means ultimate shrinkage of both the herd and the range, (2) reduction is the only remedy, nothing else works; (3) to accomplish a reduction, female deer must be killed." Obviously, over-populated deer ranges and their management in America cannot be used as a model for managing the African elephant. Nevertheless, there are similar biological responses by both American and African herbivorous game animals to population reduction that are highly relevant to management.

Biological response to population reduction. There is wide recognition and acceptance by wildlife professionals in America that reduction of excessively dense big game populations shows the same biological responses to decrease as studies have shown for other species of animals (Allen, 1962). In sparse populations, individuals grow faster, attain higher ultimate weight, and reproduce at a higher rate than in dense populations (Fig. 1).

The response relating to reproductive increase, which is particularly relevant to this report, was possibly first recognized by Malthus in 1798 (see Allee *et al*., 1949:25). More recently Errington (1945) gave impetus to this relationship by showing an inverse relationship between spring population density and summer rate of gain in populations of bobwhite quail (*Colinus virginianus*). Later, E. L. Cheatum (1947) found this response in New York's white-tailed deer (*Odocoileus virginianus*). In the northern high-density region, 78 percent of the does were pregnant, in contrast to 92 percent in the southern low-density agricultural region. Furthermore, about one in 24 of the Adirondack female fawns was pregnant during its first fall of life, but in the southern agricultural region more than one in three were pregnant.

Murie (1951) in his book on the elk (*Cervus canadensis*) of North America reports that female elk breed for the first time at an average age of 2 years and 4 months. Buechner and Swanson (1955), however, studied increased natality resulting from lowered population density among elk in southeastern Washington

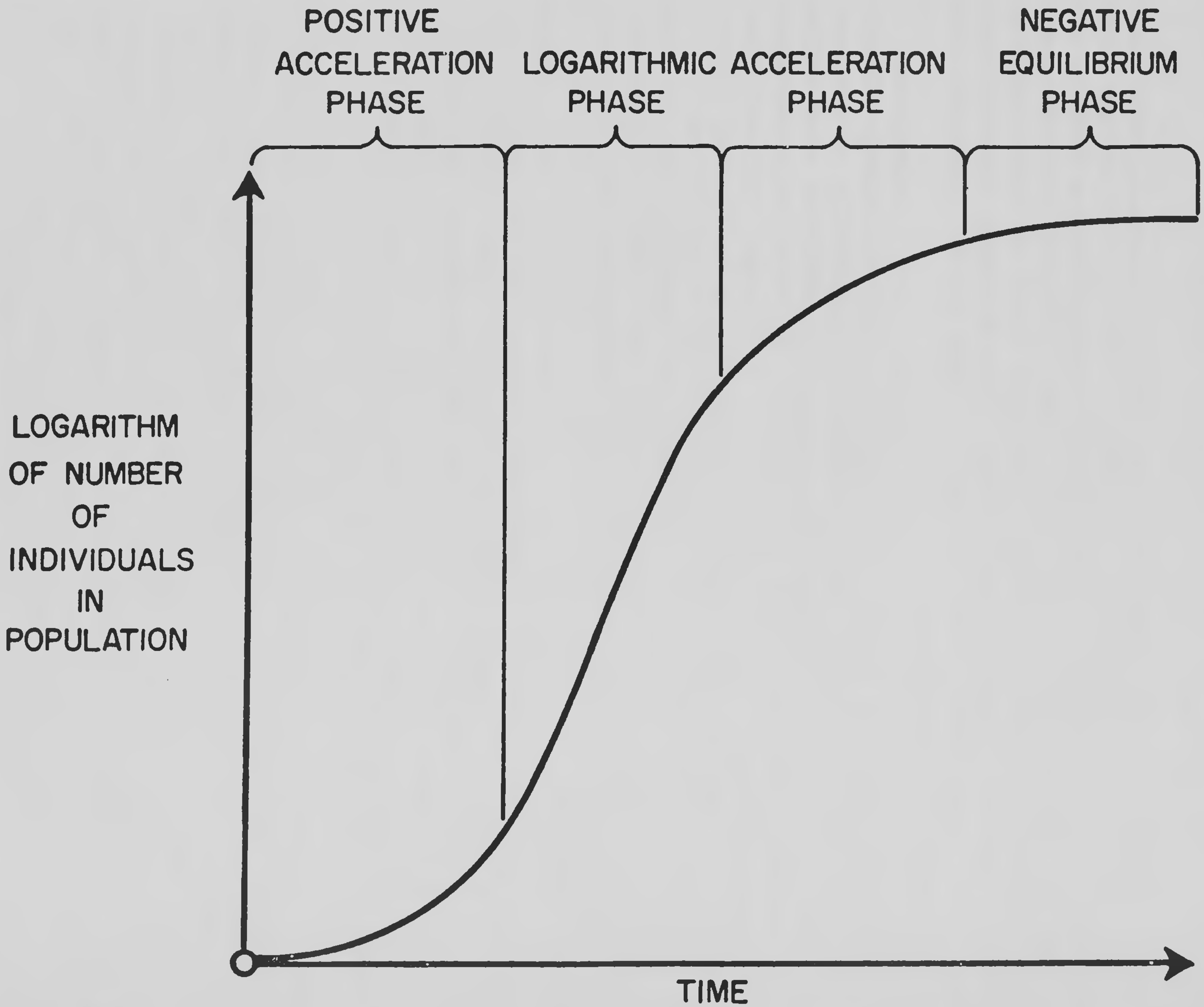

Figure 1. A typical growth curve of a population in which the logarithm of the total number of individuals is plotted against time. The absolute units of time and the total number in the population would vary from one species to another but the shape of the curve would be similar for all populations. Populations of animals, including elephants, held at the logarithmic phase reproduce at a higher rate and remain younger in age composition than populations at any other phase; they probably also grow faster and attain higher ultimate weight.

and found yearlings breeding. They concluded that "Apparently the increase in natality reflects better nutrition through greater availability of forage. . ." After studying optimum yield in deer and elk populations, Gross (1969:385) included the following statements in his summary: "Fecundity rates and the net number of young produced per unit of breeding stock declines at high densities . . ." and "Net annual production of young by the population declines as the population size continues to increase. . ."

Reproduction in the African elephant is also inversely related to population density. Information presented above from studies conducted in Kabalega Falls National Park showed that when woodland habitat was seriously reduced under pressure of high elephant density, percentage of calves in the population decreased and calving interval increased. All of the evidence associated with this change in natality suggests causative relationships very similar to those reported by Buechner and Swanson (1955) and by Gross (1969). Evidently reduced natality in the elephant population reflects inferior nutrition through reduction in availability of woody forage (Laws et al., 1970).

Some of the effects of changing population density on reproduction are illustrated graphically by the sigmoid growth curve (Fig. 1). Growth of an elephant population very probably conforms to this curve since such sigmoid or S-shaped curves are amazingly similar for populations of almost all organisms from bacteria to man. In an elephant population that is increasing in density and approaching the leveling off or equilibrium phase of growth, certain intrinsic factors slow down the population growth process by operating against reproductive potential. This slowing down process is indicated by changes in reproductive patterns and other self-regulatory or homeostatic mechanisms.

As density increases there is more competition and hence more movement by elephants for food. Consider that the first energy used from an elephant's total food intake is for body maintenance. Then, rising density associated with increasing competition would result in progressively more use of energy for body maintenance and less being available for reproduction. Change would then occur in reproductive patterns and other self-regulatory mechanisms which bring the population into equilibrium with its environment.

If environmental factors such as drought, floods, erosion, and fire reduce carrying capacity suddenly and drastically, there would be considerable delay before self-regulatory mechanisms could bring the population into equilibrium with the reduced carrying capacity. Delay in the case of elephants would be particularly prolonged as a result of the elephant's exceptional longevity, which fosters a very long population turnover period. Reduction in range available to an elephant population would further prolong the delay, during which the availability of habitat and carrying capacity would decrease. Conceivably, if habitat destruction and reduction of carrying capacity continued long enough, carrying capacity for an elephant population could drop to zero. An example of such environment destroying activity is suggested by Simon (1963) and reported by Wing and Buss (1970:63-64). The elephant's destructive ability caused Curry-Lindahl (1968:26) to state that "except for man there is no other animal in Africa that is able to alter a habitat so drastically as does the elephant." Laws (1969b:11) in discussing the influence of elephants on their environment reports that "There is good evidence for the former existence of large populations elsewhere in the Kingdom of Bunyoro. This includes reports of the large quantities of ivory that the district produced and the records of sightings of large numbers of elephants" in areas where they are no longer abundant.

Elephant management in Kruger National Park

The population history of elephants in Kruger National Park (about 19,000 km^2) is one of rapid rise in numbers. Historic information on this rise is provided by Pienaar (1972) and Van Wyk (1972) and summarized in Table 1. The rapid increase in numbers of elephants, and other big game animals, that occurred after proclamation of the Kruger National Park in 1926, is similar to the rise in elephant populations that occurred in Kabalega and Tsavo National Parks after establishment.

As the population of elephants in Kruger "exploded" and numbers of some of the other big game animals also rose to excessive levels, shortage of drinking water became apparent. Concern among officials in the research section of the park increased and management plans used elsewhere in the world were reviewed. As a consequence Dr. Pienaar and his associates concluded that "few, if any, national parks or reserves in the world today are managed as true ecological entities. The boundaries of the protected areas frequently cross. . .migration routes (leading) to seasonal grazing or breeding areas. Contact with neighboring agricultural areas or tame livestock creates problems of invasions of lands or the transmission of epidemic diseases from wild to tame animals and vice versa. The available water supplies in the reserve may be insufficient to support all the animal populations protected there under all drought conditions." Similar observations were reported by Elder and Rogers (1968) for the Luangwa Valley Game Reserve of eastern Zambia. Among their empirical observations, they stated (p. 281) that "once an elephant population has found sanctuary in a park it is essentially doomed to over-populate it." Sherry (1978:49) in south-eastern Rhodesia states that he (1975) "has shown the need for continued population control of elephants" in the Gonarezhou National Park area.

Pienaar (1972:5) continues by saying that "from the earliest times, man has been the super-predator and an integral part of the pre-historic and historic scene. With the establishment of parks and nature reserves, this influence was entirely removed. In Africa large herbivorous animals such as elephants and hippopotami in similar protected situations lost their most important natural enemy with the termination of man's influence as a predator, and their numbers speedily increased to the point where they became a threat to the survival of the undisturbed ecosystem.

After long and careful consideration of the recommendations made by Kruger's research section, the National Parks Board decided to thin out the numbers of certain animals artificially. Although "The Board's decision to control the numbers of animals unleashed a veritable storm of criticism amongst the public and through letters to the press" (Pienaar, 1972), the decision has not been rescinded, and contrary to much condemnation is indeed proving to be a

Table 1

Rise in elephant population,

Kruger National Park*

Year	Elephants counted**	Remarks
1905	10-	Between Letaba and Olifants Rivers
1912	25	Some immigration from Mocambique possible
1931	135	Park proclaimed in 1926
1946	450	Set by Col. Stevenson-Hamilton
1947	560	Estimated by Col. Sandenbergh
1954	740	Estimated by L. B. Steyn
1958	995	First estimate by newly established research section
1960	1000+	First aerial count (incomplete)
1962	1762	
1964	2374	First helicopter count
1967	6586	11.3 percent calves less than 1 yr. in age
1968	7701	Approximately 130 flying hrs., cropping initiated
1969	8312	
1970	8821	Appeared to have reached peak
1971	7916 }	
1972	7611 }	Some 1800 harvested - most ever
1973	7966	
1974	7702	
1975	7408	
1976	7275	
1977	7715	
1978	7478	

*Data through 1971 from Pienaar (1972) and Van Wyk (1972).

**Counts obtained after completion of current year's harvest - after 1958.

sound management program. Earlier a carefully planned cropping program was initiated in the Luangwa Valley and cropping operations were well done. Unfortunately outside meddling by an influential but uninformed individual quashed the project (Elder, personal communication).

Cropping of elephants in Kruger began in 1968, with nearly a thousand elephants taken in some years. When these operations began they were "planned as a holding action" against unrestrained increase of elephants and buffaloes in the Park (Pienaar, 1969:185). Evidently, this objective was achieved by 1971 when the first decline in number of elephants counted occurred (Table 1). Van Wyk (1972) discussed the decline in number of elephants and buffaloes recorded in 1971 and reported (p. 48) "that success is only now being achieved in checking the uncontrolled increase of the animals."

At the present time there are strong reasons for believing that the cropping program is a success. Perhaps of greatest importance is the observation that there is no visible evidence that elephants exceed the carrying capacity of any component of their habitat. Neither are the lesser browsing animals on the elephant ranges threatened by shortage of forage or water despite a series of droughts that culminated in the great drought of 1970. Unusually high rainfall occurred during 1972 to 1977 causing physiognomic changes in shrub vegetation (Smuts, 1978:318). Possible destruction of unique types of trees and rare species of plants aroused high concern as elephants approached a peak in numbers. While studying elephants in Kruger during 1971, Harold Braack, then of the park's research section, and I drove to an unusually large and beautiful stand of baobab trees near Punda Milia in the northern part of the park. A picture of these same trees is shown by Pienaar (1972:7) and has the following caption: "This group of baobab trees is to be found near Punda Milia. The uncontrolled increase of elephants in a limited grazing area poses a threat to such trees. The culling of. . . elephants, therefore, has an auspicious effect on the flora of the Kruger National Park, which must also be protected." Such trees would have had no chance at all for survival in Tsavo or Kabalega National parks with their 1957 to 1973 elephant populations.

During August 1971 I participated in the cropping operations in Kruger National Park. Of 62 elephants harvested (Table 2) nearly 13 percent were calves (8 individuals) under 1 year in age. Among 90 other elephants observed during this time, 11 percent were calves (10 individuals). These figures, which are supported by the 11.3 percent calves observed among 6,586 elephants in 1967 (Table 1) and which indicate a high reproductive rate, are significantly higher than the 6.0 to 6.5 percent rate reported for Kabalega (Buss and Savidge, 1966). They are also higher than the 4.7 to 10.4 percent rate of increase reported for Tsavo National Park (Laws, 1969a:508).

In addition to the sustained yield status of vegetation and the high percentage of calves in the elephant population in Kruger National Park, there have been no important losses among the rare mammals in the park such as roan (*Hippotragus equinus*), sable (*Hippotragus niger*), tsessebe (*Damaliscus lunatus*), and waterbuck (*Kobus ellipsiprymnus*). Collectively these observations indicate that the elephant population, under the cropping program in Kruger National Park, was below carrying capacity (1.2 elephants per 1.6 km^2

Table 2

Age structure of 62 elephants collected in

Kruger National Park, August 1971

Date	Adults	Sub-Adults	Intermediates	Calves	Totals
2	5 FF	2 FF	2 MM	2 MM	11
3	2 MM				2
5	3 FF	2 MM	5 (2 MM)	1 F	11
11	2 FF	2 (M&F)	3 (1 F)	1 F	8
12	3 (1 M)	2 (M&F)	3 MM	1 M	9
13	5 FF	4 (1 M)	9 (3 MM)	3 (1 M)	21
	20 (3 MM)	12 (5 MM)	22 (12 MM)	8 (4 MM)	62

F = female

M = male

or 1 mile^2) in 1970. In this status, the elephant population can be expected to (a) maintain habitat, (b) assure a high reproduction rate, (c) increase the chance for survival of all age groups but especially the juveniles, (d) maintain high biotic diversity, (e) sustain a high flow of energy through the ecosystem, and (f) allow for human utilization of the resource rather than allowing only direct return into the ecosystem. Anyone who studied or saw the deplorable range conditions before 1973 in Kabalega Falls and Tsavo National parks will indeed be deeply and favorably impressed by studying or even just driving through Kruger National Park, where there are still plenty of elephants. Douglas-Hamilton (1977) quotes Dr. Salmon Joubert, Chief Research Biologist at Kruger as saying: "It must be emphasized that cropping of elephants is solely applied in the management of the population and that commercial cropping is not a goal in itself. Ivory obtained from cropping is traded. Illegal trade in ivory is not known to occur. Illegal hunting is virtually non-existent."

In any area, once a decision is made to begin cropping operations, success will hinge on careful planning of the program. Most considerations of a cropping program have been carefully set down by Elder and Rogers (1968:281-282). In addition the cropping program should have at least some flexibility and not be limited by biological, economic, or sociological factors. Climatic characteristics will vary widely among Africa's widespread elephant ranges, requiring harvest adjustments by place and time. Harvest can result in reduced average age of an elephant population, but this depends almost entirely on method of harvest. Likewise, collections made from service roads, as in Kruger National Park, will not keep elephants away from tourist access roads, and also will not foster elephant distrust of all vehicles. Finally, revenue to conduct research or mamagement of elephants could, under a cropping program, generate funds by sale of ivory and other elephant products.

Conclusions

Inadequate harvest of elephants in Kabalega National Park allowed populations to rise far above carrying capacity during the period from 1957 to 1973. In Tsavo National Park a similar situation resulted, generating much heated argument about whether to adhere to old park policy of non-interference, letting nature take its course, or to initiate scientific management, including annual inventories and harvesting of elephants, to reduce populations to carrying capacity. The upshot of these failures to change to a scientific management program within the parks is the primary cause for the acute loss (up to 80%) in former Ugandan elephant populations. The actual cause of mortality or loss is not as important as the fact that it did finally happen; the stage had been set too long.

In Kruger National Park, where cropping has been conducted annually since 1968, over-populations and habitat degradation are non-existent. By holding elephants at the logarithmic phase of population growth, fertility and reproduction are maintained at a higher rate and age composition typically remains younger than populations at any other phase of growth. Equally important, chances for survival have increased, high biotic diversity is fostered, there is increased flow of energy through the ecosystem, and an opportunity has been established for human utilization of the resource. The

10-year demonstration of harvest operations which began in Kruger National Park in 1968 provides a sound foundation for future management of elephants in practically all African parks and preserves where the elephant population has reached or exceeded equilibrium with the whole ecosystem.

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Editor's note: This paper by Irven O. Buss was reviewed by William H. Elder, Cynthia J. Moss and Sylvia K. Sikes. All made constructive comments which have been incorporated in the paper. Moss criticizes the paper by stating that "Aside from the material on Kruger National Park, the paper is basically a review of work carried out in Uganda and Tsavo, but as a review it is a continuation of an argument that is no longer productive." Sikes' criticisms were similar; she added: "The real issue today is not a scientific argument about management principles, culling techniques or the use of the products: it is the politico-cultural attitude of today's indigenous African politicians, administrators and field personnel." In response, the author notes that ". . . the main purpose (of this paper) is to point out the very important differences between a scientifically managed park (Kruger) and two parks that were not managed at all (Kabalega and Tsavo) . . . Where wild animals are managed, yesterday, today or tomorrow, management principles will always be involved, particularly maintenance within carrying capacity. There is no emphasis on culling techniques or use of the products in this report. Finally, the politico-cultural attitude of today's indigenous African politicians is not really new - I noticed this the first time I worked in Africa, in 1958."