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Review of Options for Managing the Impacts of Locally Overabundant African Elephants

D. Balfour, H.T. Dublin, J. Fennessy, D. Gibson, L. Niskanen and I.J. Whyte

1st edition, 2007

African Elephant Specialist Group

SSC
Species Survival Commission

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Note

The terms 'overabundance' and 'overpopulation' are commonly used in an interchangeable way. In this document we use the term 'overabundance'.

Definitions

Adaptive management – Adaptive management incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring to systematically test assumptions while managing in order to adapt and learn.

Contraception – Reversible pharmacological inhibition of fertility.

Culling – Controlled killing of animals to reduce a population to a perceived optimum level consistent with the wider objectives of conservation[1].

Elephant corridor – Land, usually narrow and often striplike, joining two areas of habitat and through which elephants can pass relatively uninhibited, but in which they are unlikely to spend substantial time.

Fertility control – The permanent or temporary inhibition of reproduction in animals by any means.

Keystone species – A species that has a disproportionate effect on its environment relative to its abundance. A species whose impact on its community or ecosystem is disproportionately large relative to its abundance.

Local overabundance of elephants – Local overabundance can be deemed to exist when the conservation, management objectives or desired state of an area are not being met due to elephant activity.

Manipulation of water sources – The direct human alteration of distribution, abundance, quality or seasonality of water available to elephants and other animals.

Metapopulation – All elephants within a region; the word is used mainly in the context of a gene pool. The individuals may or may not be able to interact with each other without human intervention.

Non-intervention – A policy of not undertaking active management or failure to actively manage a population (such as translocation, contraception, culling and so on). In elephant management it usually refers to the process of allowing a population to increase or decrease with the only human contribution possibly being barriers to movement through human presence and activity or in some cases, through fencing.

Precautionary principle – A management principle stating that when there are threats of serious or irreversible damage to the environment the lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures in an attempt to limit such damage[2]. It is important to note, however, that the precautionary principle could be applied in two contrasting ways[3]: (1) to keep elephant numbers generally low in the hope of preventing feared losses in biodiversity components; (2) to avoid killing elephants until it has been clearly established that a larger population would indeed lead to losses in biodiversity before stabilizing at some resource-limited level.

Range expansion – Enabling an increased area of land to become available for animals to expand their movements and activities beyond some previously limited range.

Sterilization – The rendering of an animal permanently incapable of reproduction through surgical or chemical means.

Translocation – The deliberate movement (usually by means of mechanized transport) of wild African elephants from one natural habitat to another for the purpose of their conservation and/or management at the source site, release site or both[4].

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1 Introduction

The African elephant *(Loxodonta africana)* is the world's largest terrestrial mammal. It is a species of considerable economic, ecological, cultural and aesthetic value to many people in the world[1–10]. The elephant is a flagship species, providing a focus for raising awareness and stimulating action and funding for broader conservation efforts[11]. Some of the most important decisions that have had to be made, and will continue to be made in wildlife management in Africa, revolve around elephants[12].

There are many widely distributed populations of elephants in Africa. These range in size from fewer than 50 to more than 100,000 and experience varying levels of cohesion or isolation[13]. The dynamics of these populations also vary, with some declining and others experiencing an increase in numbers. Overall, southern Africa's populations grew significantly from 1994 to 2002[14].

Where elephant populations are growing through natural recruitment or compression caused by expanding use of the surrounding landscape by humans, and where there is limited opportunity for natural dispersal or concomitant range expansion, local elephant densities commonly increase. Where this is happening, the impact of elephants on their habitats and other species may also increase (see[15–23] for a few examples).

Depending on local values (cultural, aesthetic or other) and/or the land-use objectives (e.g. tourism, biodiversity conservation, agriculture) that have been established for the area concerned, increasing elephant impact has been seen as deleterious or undesirable, leading to concerns about ***local overabundance of elephants***[24–32]. Methods such as ***culling, translocation, range expansion, manipulation of water sources*****,** and ***contraception*** are options that have been used or proposed to reduce elephant numbers or densities[33–36].

Information about attempts to control wild populations of elephants is generally not readily accessible to the relevant managers and conservation authorities in Africa, much of it being scattered in diverse reports and scientific papers or as part of the body of unwritten expert knowledge. The main objective of this document is therefore to make available lessons learned from the past and from ongoing efforts to manage the negative ecological impact of African elephants, and to provide a summary of the main technical considerations and pros and cons of the different management options available.

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2 Context

2.1 Managing local overabundance of elephants

There is increasing alarm, especially across the southern African subregion, over the adverse local effect of increasing densities of elephants[1–3]. This local overpopulation or overabundance of elephants is today regarded as a major conservation and management challenge in most southern African elephant range States. Concerns over the adverse ecological effect of high densities of elephants have also been reported elsewhere in Africa, especially in areas known for their high plant biodiversity[4].

There is no unique density of elephants that can serve as a definition of 'overabundance' for any particular area. It depends instead on whether the impact that elephants have on their environment is acceptable. The relationship between elephant density and the ecological impact of elephants is complex and variable, and our understanding of these processes is still developing. Decisions as to whether to intervene to reduce elephant densities therefore have to be made with less than perfect scientific knowledge. When faced with such uncertainty, the ***precautionary principle*** is often advocated. This management principle states: *when there are threats of serious or irreversible damage to the environment the lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent such damage* (United Nations 1992)[5]. However, when dealing with the issue of whether elephant densities or numbers should be reduced to prevent feared losses in biodiversity, the principle may be applied in two contrasting ways: (1) to keep elephant numbers generally low in the hope of preventing losses in biodiversity components; (2) to avoid killing elephants until it has been clearly established that a larger population would indeed lead to losses in biodiversity before stabilizing at some resource-limited level[6].

Efforts to address the problem of local overabundance of elephants have typically focused on reducing elephant numbers to levels where their impact is considered not detrimental to vegetation or other species[7–10]. Artificial control to keep elephant numbers static may be managerially tempting but because of the complexity of ecological processes may not be successful[9,11,12]. It contradicts a view that conservation should maintain heterogeneity[e.g. 13], and it has been suggested that attempts to stabilize elephant numbers at a certain level could in the long run compromise habitat heterogeneity and resilience and ultimately reduce species richness[3,7–9,14–16]. In view of this, Owen-Smith et al. (2006)[6] suggest that it may be more appropriate to manage different areas differently to establish the consequences of different elephant densities, and to *allow changes to progress towards extremes to ascertain just where the thresholds beyond which no recovery takes place lie*[2].

There can be no prior knowledge of what size the elephant population should be in order to bring impact to an acceptable level, and there is no way of planning how much management is necessary in advance. Such uncertainties suggest that it is wise to follow an ***adaptive management*** approach[13] when managing elephant densities. This entails the regular evaluation of elephant impact through monitoring followed by appropriate readjustment of management activities, repeated until the management objective is reached. In other words, continued monitoring should be undertaken to indicate whether the management activity has been sufficient to maintain the habitat within the acceptable limits, or whether further intervention is necessary.

Whether elephant impact will be tolerated will ultimately determine their acceptability within the policy framework for the area in question. The absolute elephant density deemed to constitute overabundance might vary substantially among different areas, due to differences in management objectives as well as biological differences. For example, it was shown[17] that the productivity of mopane woodlands in Botswana could support many more elephants than other areas where at similar densities the woodland was being converted to scrub. Under one possible set of values and objectives, the elephant density would therefore be perceived as falling far short of overabundance, while under a set that valued the persistence of large trees, the elephants would be labelled as overabundant.

Some believe that the entire focus on elephant densities is wrong and tantamount to addressing the symptoms rather than causes of the problem[11]. They see range expansion that enables metapopulation dynamics to regulate elephant numbers as the solution to elephant overabundance in much of southern Africa[11]. However, and as discussed in section 5.2.2, large-scale expansion of protected area coverage is fraught with many difficulties and may not represent a real possibility for any but a few occasions.

In short, overabundance of elephants occurs when the agreed values or objectives for an area are not being met due to elephant activity. Overabundance can therefore only be defined in terms of land-use objectives (tourism, biodiversity conservation, etc.) set for a particular area and/or a set of defined human (e.g. economic, aesthetic, cultural) values. Making a judgement on whether the ecological impacts of elephants are negative and whether or when this problem should trigger some form of intervention to reduce such impact is thus outside the main scope of this document. Such decisions are best made by the management authorities in consultation with all relevant stakeholders.

Therefore, before considering the options discussed in this document we assume that *as a prerequisite for taking any management action,* the management authorities will have set clear conservation and management objectives for the area in question, and have established a clear decision-making process to guide their actions.

2.2 Important notes to users of this document

The applicability of each method or combination of management methods discussed in this document depends largely on the particular local or national context and circumstances[18]. Issues that can limit the range of options available include whether the elephant population or the area in question is small or large, open or confined, and considered together with the specific ‘time horizon’ of the managers. For example, managers of a small but growing population in a fenced park surrounded by human settlement may face a different set of constraints and often a more limited timeframe for action than managers of a large elephant population traversing an unfenced transfrontier range.

This document is not intended to be prescriptive or to promote any one method as a unique solution to perceived local overabundance of elephants. Rather, we try to present a thorough review of the main options available to managers and the main considerations that need to be taken into account for each of the options. Furthermore, although each of the options is dealt with individually, they can of course also be used in combination, or applied at different times or in different parts of the range of the population.

It should be noted that most of the examples given and the references used in this document come from southern Africa. This is because many of the methods discussed have been tried only in that subregion. Similarly, much of the most recent research into elephant–habitat interactions has also been carried out in southern Africa.

Finally, we wish to emphasize that this document deals only with reducing the undesirable ecological impact of elephants. We do not therefore attempt to cover the other forms of negative interactions between elephants and humans, commonly referred to as *human–elephant conflict*. For a comprehensive review of options for mitigating human–elephant conflict, the reader is advised to refer to Hoare (2001)[19] and to read the material provided on the website of the IUCN/SSC African Elephant Specialist Group: http://iucn.org/afesg/hec

A comprehensive reference list is provided after each section of this document. An additional bibliography, arranged by section, is also provided. We hope these will prove useful.

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3 Background information on the African elephant

3.1 Status and distribution

Elephants may have once inhabited most of the African continent[1]. They have been recorded from parts of northern Africa until 1000 AD[2] and are presumed to have been widespread south of the Sahara[3].

Recent studies [e.g. 4,5] provide strong genetic evidence to support the theory that the two subspecies of African elephant, the savanna elephant *(Loxodonta africana africana)* and the forest elephant *(Loxodonta africana cyclotis)* are actually two distinct species. However, the IUCN/SSC African Elephant Specialist Group (AfESG) believes that premature allocation into more than one species may leave hybrids in an uncertain conservation status and continues to consider the forest and savanna elephants as two separate subspecies[6].

The present conservation status of the African elephant varies significantly across its range. Currently elephants are found in 37 sub-Saharan African countries, with the largest populations concentrated in southern and eastern Africa[7]. It is estimated that there are at least 470,000 elephants on the African continent and possibly as many as 550,000; approximately 58% of the continental total is found in southern Africa[8].

Historically as well as currently, commercial ivory hunting, along with the expansion of human populations leading to habitat loss and fragmentation, are often cited as the principal causes behind the contraction of elephant range and associated population declines in Africa[1,7,9–11]. Thirty-one percent of the continent's elephants are found outside protected areas[8].

Many elephant populations straddle the borders of two or more countries. Management of such large transfrontier populations is particularly complicated by a need for each country to take their neighbours into account when developing the management policies and practices for that part of the population over which it has jurisdiction. Differences in land use, legislation, resource management, elephant population size and barriers to movement, such as veterinary fences, may also lead to difficulties in managing such populations.

3.2 International conservation status

The African elephant is listed as *vulnerable* in the IUCN Red List of Threatened Species[12]. At present all populations of African elephants are listed in Appendix I of the Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES), except those of Botswana, Namibia, South Africa and Zimbabwe, which are in Appendix II. CITES generally prohibits commercial international trade in specimens of Appendix I species, although trade may be allowed under exceptional circumstances, e.g. for scientific research[13]. International trade in specimens of Appendix II species may be authorized by grant of an export permit or re-export certificate, but these are granted only if the relevant authorities are satisfied that certain conditions are met, above all that trade will not be detrimental to the survival of the species in the wild[13]. Furthermore, appendices may be annotated to qualify the listing. For current annotations relating to Appendix II elephant populations, please see CITES website: http://www.cites.org/eng/app/appendices.shtml#1

3.3 Natural history*

The African elephant is a long-lived species with a relatively long period of sexual immaturity and slow rate of reproduction. This presents various problems in the study of their population dynamics[14,15]. Much of our understanding of the basic demographic and life-history characteristics of the species is derived from a few well-studied populations, such as those in Amboseli, Kenya, and Addo Elephant National Park, South Africa[15].

African elephants are intelligent animals that live in structured, family-oriented hierarchical societies in which individuals (particularly females) have strong permanent bonds with related animals[16,17]. In general, males show little allegiance towards their natal group, which they leave at an average age of 14 years[18], but females stay with their mothers as long as they are both alive[19]. This results in matriarchal groups with complex multitiered relationships and various degrees of cohesion, depending on a number of social and environmental factors, and the degree of human threat[20–25]. Such groups can comprise large numbers of animals that may span several generations of related individuals[26].

There are many advantages to calves growing up in such a family setting. It offers security, with many older aunts and sisters offering care and supervision[19]. There are many role models for teaching and learning, and many siblings for play. This results in improved survival of calves[16,19,27]. Matriarchs are the repositories of social knowledge in elephant society[28], and as leaders of these groups, they have a crucial role to play.

When matriarchs die or are killed or removed, the group tends to split, each daughter forming a new matriarchal group of her own, or to coalesce into other groups that usually maintain close social contact with each other[16,19]. It is known that elephants can have social bonds with up to 25 other families representing as many as 175 other adult females[28]. It is this structure and behaviour, as well as well their seemingly advanced capacity for cognitive and emotional behaviour[19,29] that sets elephants apart from most other animals, and that poses particular challenges to the ethical management of the species.

Elephants may live for over 60 years[3,14,30] but few do. Females generally become sexually mature at between 10 and 14 years of age[14,31–35] and may calve until death. Average calving interval is usually between 4 and 6 years in an increasing population[14,15,36].

Calef (1998)[37] predicted a maximum annual population growth of 7% for elephant populations, and in southern Africa many elephant populations are increasing at 4–5% per annum[38,39]. However, rates of up to 16.5% per annum have been noted under exceptional circumstances[40] although typical growth rates

* Descriptions in this section apply more to savanna than forest elephants.

are probably much lower. For instance, from 1979 to 1999 the Amboseli elephant population grew at an average annual rate of only 2.2%[14] while the Addo elephant population experienced a mean annual population growth rate of 5.53% between 1976 and 1998[15].

The age structure of elephant populations may vary greatly depending on environmental and other variables. For example, in the Amboseli population, which constitutes the only free-ranging population of African elephants that has been studied for several decades and that has been relatively unaffected by human activity, the population age structure changed markedly from 1976 to 1996[14].

Elephants are mixed feeders, switching from predominantly grazing in the wet season to mainly browsing in the dry season[41]. Their catholic diet may include grass, herbs, bark, fruit and tree foliage in varying proportions depending on season and habitat[42]. On average they can consume around 5% of body weight in 24 hours[43–46] and drink about 225 litres of water a day. Elephants are generally recognized as a keystone species in most of their habitats, which directly influence tree diversity and density, as well as forest and woodland structure.

For a full account of the natural history of the species (see [e.g. 47–49]).

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4 The ecological impact of elephants

The African elephant is capable of extensive habitat modification[1–17] and it has been shown that even at low elephant densities there can be significant effects on trees in some habitats[18]. This modification, commonly termed *elephant impact*, mostly takes place through elephants toppling (including pollarding) whole trees, by breaking and removing branches from their canopies (i.e. the elephants mechanically change the structure and composition of the canopy of trees, and by extension they change woodlands)[19] and by preventing or reducing recruitment and regeneration[20]. In such processes, browsing elephants commonly remove more material (biomass) than they finally consume[21]. Moreover, elephants commonly strip bark off tree trunks, which is likely to result in the eventual death of the tree once fire or wood borers enter the exposed heartwood. These factors (i.e. browsing that affects the structure of a plant, 'wasteful' feeding and bark stripping) mean that an elephant population may have an effect on woody vegetation and biomass loss beyond what would be predicted by the physiological needs of the animals. This disproportionate effect is what leads to the recognition that elephants are a keystone species[21,22].

The relationship between elephant density and ecological impact of elephants is complex[23] and likely to depend on various interacting ecological factors[8,9,24,25], some of which are poorly understood and which include:

- the spatial distribution of landscape resources (e.g. water) and habitats being heterogeneous[26–29]. Differential utilization of these resources by elephants results in the distribution and intensity of elephant impact being spatially heterogeneous[30,31].
- spatial movement, i.e. in a context where elephants are free to move unhindered, and thus have the ability to make a full set of choices about which element of the landscape they wish to use[32,33], they may have a very different impact on the vegetation than an elephant population of the same size but that is confined by fences or human habitation and thus is forced to use the landscape differently.
- ecosystems do not exist in some form of static balance but are dynamic[34–36]. Thus the resources and their spatial distribution are constantly changing, influenced by the complex interactions of fire, variations in weather patterns[37] and changes in densities of wildlife populations including those of elephants[8,34,38,39].

The ecological consequences of elephants grazing are poorly documented, although there have been numerous studies on changes in woodland as a result of elephant browsing[8,10,11,40]. This bias does not necessarily reflect the relative importance of browsing compared with grazing for elephants but likely, more closely reflects the interest (often expressed as concern) that has been shown by land managers and ecologists in the consequences of elephant feeding behaviour on the environment.

The immediate structural impacts of toppling trees or removing their branches are self-evident and widely documented[6,11,16,41]. Some tree species may be affected more than others[18,31]. There are also structural consequences for trees as a result of elephants stripping bark from their trunks although the effect is less immediate and less well understood. Trees respond differently to bark stripping—some recover[4,15] while others die from exposure to fire, borer beetles or fungal infection in the exposed xylem[41]. The cumulative loss of individual trees can lead to loss of woodland.

Although it may be difficult to tease out the response of vegetation to elephant impact because of other interrelated factors such as climate change, fire[42], drought, rainfall[43], disease and trampling[34,38,40], literature from many parts of Africa is substantial on the effect elephant activity can have on woodlands[1,3–13,15,17,40,44,45]. For example, the *Brachystegia boehmii* woodland in Chizarira National Park, Zimbabwe, was lost in six years when the dominant trees were knocked over or ring-barked at a rate of up to 21% per annum[7,46] and in the Budongo Forest in Uganda, over 35% of trees were damaged in a decade[45]. A combination of elephants and fire reduced some woodlands in Kruger National Park by 64%[42]. In Amboseli National Park, Kenya, habitat diversity declined as woodland and bushland habitats were replaced by grassland, scrubland and swamps[47].

Loss of trees and woodland structure can have secondary effects on other species that are dependent on the trees for habitat. Ungulate losses have been recorded; e.g. tsessebe disappeared from Chizarira Park in Zimbabwe after the loss of the *Brachystegia* woodland[7] and the displacement of several species from Amboseli National Park, Kenya, has been attributed to woodland loss due to elephants[47,48].

Broadly speaking, the relationship between elephants and compositional diversity is not well known and may be difficult to demonstrate[30]. To date only a few studies have attempted to do so[2,49–53]. For example, Herremans (1995)[54] found fewer canopy specialist bird species in elephant-modified riverine habitats than in less affected sites in northern Botswana. There was, however, no overall loss of avian diversity as there were larger numbers of generalist species in the heavily impacted sites. In Tanzania, disturbance by elephants was shown to benefit those species of butterfly that favour well-lit habitats although those that prefer shade declined in number[55]. A study by Cumming et al. (1997)[49], on the other hand, demonstrated a clear loss of arboreal bird species and other taxa where elephants had removed miombo woodlands on the southern boundary of Mana Pools National Park and in Matusadona National Park in Zimbabwe. In Addo Elephant National Park it was shown that elephants affect biodiversity at all levels and may be causing the extinction of some plant species[56]. Changes in woodland density and structure as a result of the presence of elephants can influence the spread, frequency and intensity of fire[8,57], which can in turn affect survival and regeneration of trees.

Elephants may, on the other hand, play important facilitating roles for other species, by influencing woodland density and structure in savanna ecosystems[58]. In woodlands they may benefit other browsers by making more browse available by lowering the height of available browse[59]. In forests, elephants may lead to short-term increases in biodiversity, as patchiness within the vegetation increases and fallen trees provide habitats for a range of smaller species[35]. Elephants may help disperse seed of some trees by eating the seed[60–62] as passing the seed through the gut of the animal promotes germination[63–65].

It is has been suggested[38] that riverine woodlands in northern Botswana are a 'transient artefact' resulting from low numbers of elephants (due to overhunting in the 19th century) and other herbivores (after the rinderpest epidemic of the late 19th century), which would otherwise have suppressed woodland development through browsing and prevention of tree recruitment. Du Toit et al. (2003)[66] argue that other herbivores can suppress woodland regeneration by browsing on young seedlings and therefore simply reducing elephant densities would not achieve the objective of reversing woodland loss. On the other hand, in the Sengwa Wildlife Research Area, a temporary reduction in elephant densities allowed vigorous regeneration of *Acacia tortilis* woodlands[67]. Recovery in woodlands has also been noted in Tsavo National Park, Kenya[22].

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5 Options for reducing the undesirable ecological impacts of African elephants

5.1 Introduction

The ecological impact of elephant populations can be managed either ***directly*** or ***indirectly***[1]. Indirect options do not target individual elephant or groups of elephant and include range expansion, exclusion and manipulation of water supplies. Direct management specifically identifies individuals or groups and includes translocation, contraception, driving or disturbance, culling and killing individual problem animals[2]. It is possible to use combinations of these options.

The most common management option has been ***non-intervention*** or the laissez faire approach. This is not strictly a management action and the intention is not to reduce elephant densities but it may allow a natural decline to take place, such as when there is a resource-induced crash or a disease outbreak. An overview is therefore provided here.

While non-intervention in the management of elephants has often been by default, it has been justified in one or more of the following grounds[3].

- Protected areas are set aside as ‘natural’ areas excluding human influence. They cannot serve as undisturbed control areas against which human activities can be measured, if they are managed. Within the value system implied by such policy, no proactive management interventions are permissible.
- Natural regulatory mechanisms, both density dependent and environmental forces, should be left to maintain the integrity of ecosystems by allowing elephant numbers to vary in time and space[4,5].
- Managing an ecosystem to keep its components constant may weaken processes that enable it to resist change on its own account, decreasing its stability and resilience[6–9].
- Species richness may be maximized by the spatial heterogeneity and temporal variation that result from unhindered ecosystem processes[7,10,11].
- Present vegetation composition and structure have developed in the absence of some herbivores (such as elephants) and is now being returned to its ‘natural’ state by the increase in number of herbivores[12].
- A population crash may result when animals are overstocked, but after the crash a healthy population will emerge from those individuals that are better adapted for and that have survived harsh environmental conditions[13,14].
- Knowledge of the ecosystem is inadequate to justify interventions that may lead to undesirable outcomes[15,16].

- Use of some management options, especially lethal ones, may result in negative publicity and reduce the tourism potential of an area[17].

Direct management interventions have been justified on the following grounds:

- Intervention may be necessary to achieve management objectives.
- Undesirable changes in the ecosystem can result from an overabundance of elephants and management is necessary to maintain biodiversity and to prevent loss of other species of plants or animals[18].
- There is no such thing as 'natural' because human populations influence conservation within and outside protected areas and have done so for generations[19].
- Creating a national park or protected area from which human influences are excluded is in itself a management action that subsequently results in the necessity for environmental management of one form or another.
- Knowledge of ecosystems is indeed inadequate but intervention may prevent undesirable outcomes of non-intervention such as erosion[20] and loss of biodiversity in plants and animals.
- Management may or may not affect stability or resilience but the current situation may be unacceptable (exceeding the limits to acceptable change).
- Allowing populations of animals to crash is wasteful and inhumane[21].

The sections following deal with various management options in more detail.

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5.2 Indirect options

5.2.1 Non-intervention

Introduction

Some African wildlife management authorities and range State governments have adopted non-intervention or laissez faire, de facto, as an elephant management policy. Kenya is one such country although translocations have taken place. In other countries such as Botswana, there has been the intent to intervene but logistics, lack of capacity, sensitivity to the opinions of those with anti-culling viewpoints, and lack of suitable destinations for translocated animals have led management authorities to do nothing to control elephant numbers. In this case non-intervention has been the default management option although it is not the stated policy. Other countries such as Zimbabwe and South Africa have in the past adopted culling to reduce or maintain population numbers, and more recently they have used translocation to reduce locally overabundant populations by small numbers.

Positive impacts of non-intervention

Positive impacts of non-intervention are summarized as follows:

- Even when a big segment of a population crashes due to limited resources, there are survivors that can repopulate the area[1,2].

- When elephants die of starvation, the survivors may be those best suited to their environment, whereas artificial reduction cannot be selective in the same way[1,2].
- Elephants are not evenly distributed over the landscape and, particularly in larger areas, habitat heterogeneity may be increased by their localized effects[3–6].
- Management may have a negative impact on the stability and resilience of ecosystems[3,7–9].

Negative impacts of non-intervention

The very issues that lead to concerns about overabundance (section 2.1) will continue following a policy of non-intervention:

- Conversion of woodland to shrubland or grassland is likely to result in the localized loss of those species dependent on woodland or bushland habitats such as arboreal bird species[4,10,11], although this effect may be reduced when the areas being considered are large.
- Increased soil erosion occurs in areas where vegetation has been removed (e.g. in Chobe National Park, Botswana[12]).
- Incidents of human–elephant conflict may continue to increase with resultant increases in economic losses (loss of income, increased costs of mitigation, etc.).
- Die-offs may occur[13,14], a situation that some may consider unethical[15].
- Possible loss of other water-dependent species during dry spells due to elephants totally dominating water sources[16].

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5.2.2 Range expansion

Introduction

Fragmentation of home ranges into ever-decreasing pockets of undisturbed land and habitat loss as human activities expand are two of the major causes of decline in elephant populations. These two factors commonly bring with them increasing conflict with humans, higher risks of illegal hunting and more severe impact on habitats, as elephant densities increase through compression and recruitment.

Apart from the obvious effect of making more land available for elephants and the consequential reduction in overall elephant density, range expansion has the added advantage of removing some of the restrictions on movement resulting from the initial range restriction. With increased movement come increased options for landscape use by the elephant population. Restricted movement has been identified as one of the factors resulting in excessive habitat impact in confined (fenced or otherwise) areas and thus the release of this restriction along with the reduction in overall density have the possibility of reducing the severity of elephant impact[1]. This however remains untested.

Hoare and du Toit (1999)[2] have shown elephants can co-exist with people up to a threshold of approximately 15 persons per square kilometre. Therefore, at least in theory, elephants could be allowed to colonize much of their former range, especially in parts of southern Africa where human population densities are relatively low[3] but where local elephant densities are high[1]. Much of the success of this option however would depend on the expectations of the individual people concerned.

Free-ranging elephants require large ranges and their populations are capable of increasing at an average growth rate of around 5% per year[4–6]. If density is the sole issue determining the ecological effect of elephants, range expansion would be a relatively short-term measure, as expanding a park to twice its size would alleviate the population densities for only 14 years (since an elephant population could double its size in that time). The effectiveness of range expansion in fact would depend on the nature of the additional range. High-quality range capable of supporting a growing population (a 'source population') would contribute very differently than would poor range, which might accommodate marginal populations only and might effectively serve as a 'sink area' (or could be managed as a 'sink area' by allowing harvesting or hunting, for example) for the population[1].

Whether range expansion is achieved by developing corridors or by opening new areas as part of transboundary initiatives, the needs of the local communities within the elephant range have to be adequately considered[7]. Tolerance toward elephants can be improved by enabling communities to benefit directly from the presence of the animals and by providing adequate protection and support.

Methods

Range expansion is a non-lethal option for reducing densities of populations. It could be achieved thus:

- increasing the area available for elephants by
    - increasing the size of protected areas.

    - creating new protected areas.
    - allowing elephants to colonize lands already inhabited by humans.
    - increasing elephant range by removing humans from the area in question.
- opening corridors to allow elephant movement between patches of suitable habitat.
- increasing the area available for elephants.

Increasing the size of conservation areas is the objective of most transboundary initiatives. With growing political support for the Peace Parks initiative in southern Africa, there has been significant range expansion in recent years. For example, dropping fences—at least partially at the time of writing—between Kruger National Park and the adjacent Limpopo National Park in Mozambique has added approximately 15,000 km^2 of range to the growing elephant population in Kruger[8]. An initial attempt to move elephants into the new range had mixed success as initially all 25 animals translocated from Kruger returned to their former ranges within a short period. However, a later survey in part of Limpopo National Park[8] revealed 630 elephants where initially there were none, so range expansion may have become a reality.

With increasing need for land by humans, expanding existing protected areas is increasingly difficult. However, this has been achieved in a few areas in South Africa (Addo and Kruger National Parks)[9–11].

Removing humans from land to allow elephants to replace them is a political decision and not a technical one. In many contexts this option would be seen as unacceptable, but such a decision is beyond the scope of this document.

Opening new elephant corridors. Expanding range by simply dropping fences is not always a practical possibility and creating corridors between an area of high elephant density and a nearby area of suitable elephant range has been suggested as an alternative mechanism for expanding available range.

There are many examples of active elephant corridors in India[12] but as yet comparatively few have been identified and described in Africa[13,14]. Those that have been described are often cases where elephant ranges have been split by human settlements and the separate portions of the former ranges are still within the memory of the animals. It remains to be seen whether corridors will be 'discovered' and used by elephants and if so if this will take place in a way that does not increase conflict with humans. The use of corridors is largely untested and there is little accumulated wisdom to guide decision makers as to whether a proposed corridor will be used by elephants.

To identify appropriate options for corridors, it is necessary to identify the boundaries of present elephant refuge. This would best be achieved by broad-scale surveys to produce maps of density distributions of elephants and of human occupation and activities. Similarly, detailed information on resource distribution (e.g. seasonal water availability and cover or shade), and current and historical elephant ranges is useful for planning range expansion. Identifying historical migration routes or movement patterns may be useful but determining suitable routes that will be practical in terms of likelihood of animals using them, and importantly in terms of impacts on local communities, is essential.

In some populations, using telemetry to observe long-distance movements of individual animals has shown that elephants use corridors between safe havens[13]. This sort of information could support moves to provide protection for animals moving in these corridors.

Technical considerations

It is assumed that given an opportunity to move into new areas, elephants will immediately do so. Various studies have shown that this is not the case and that most elephants remain within their home ranges where they know where to find water and food all year round. However, they will expand their range slowly where this has been made possible[9] with resources to support them. When the fence was removed between the Sabie-Sand Private Nature Reserve and the Kruger National Park in 1993, the Sabie-Sand population grew from 60 to 913 in 2005[10]. The movement out of Kruger National Park did not result in a reduction of densities within the park as the population has continued to increase[11,15]. However if there had not been the opportunity to disperse, densities would have been higher than they are. Males are more likely to disperse widely than family groups, although this is also a gradual process.

Security considerations

Sufficient security measures must be in place in the new range areas and corridors to ensure elephants are protected in their new environments, and there must be post-expansion monitoring of elephant populations to determine whether colonization has been successful or not.

Political and socio-economic considerations

Transfrontier parks, such as those between Botswana and South Africa (the Kalahari Transfrontier Park) and between South Africa and Mozambique (the Limpopo National Park and the Tembe-Futi Transfrontier Park) require high-level political cooperation, particularly regarding the management of the joint population after the fences are removed and the corridors between the participating countries must be maintained.

Opening corridors and increased conservation areas obviously requires political will and careful planning[12]. Impact on livelihoods of people living within proposed range expansion areas is likely to increase. Unless such rural communities benefit from the presence of elephants, expansion schemes are bound to fail.

Allowing elephants to colonize inhabited lands is likely to be problematic as a result of a negative effect of elephants on rural livelihoods. Cooperation of occupants of both new range areas and corridors between ranges should include agreements for increasing the sharing of benefits to be derived from elephants, mitigation measures against human–elephant conflicts, and tight control of illegal hunting of elephants[16]. Introducing community-based natural resource management programmes that will mitigate impact and improve tolerance for elephants by inhabitants of corridors is an option that must be considered.

Ecological considerations

Few range-expansion experiments have been conducted; therefore, it is not known whether increasing the range would alleviate the adverse effect of elephants adequately, as the population within the original range could increase to former levels from both immigration and reproduction. As elephant populations grow, densities would ultimately reach similar levels in the new as well as the old ranges, with effects unacceptable in both areas.

It has been argued that opening and maintaining corridors linking patches of habitat will alleviate the problems of local overabundance of elephant by providing routes for the animals to move between suitable habitats[11,14] and between 'source' and 'sink' populations[1,17]. There are, however, a number of unknowns to this approach, mainly because it has not been tested in elephant populations. Linking fragmented populations may reduce the risk of genetic problems such as inbreeding[18]. This assumes that one of the areas will indeed act as a 'sink'. This argument is as yet untested, and it is perhaps more likely that elephants will avoid sink areas as the elevated mortality experienced there may well serve to deter their movement.

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5.2.3 Other indirect options

Providing supplementary water sources is a widely used management activity in southern Africa[1–3]. However, while manipulating water sources to directly manage the size and distribution of wild animals is a possibility[4–6] and has been proposed for some protected areas[7], it has not been reported as a management tool outside of southern Africa. It has been shown that elephants in the vicinity of artificial water sources[8,9] increase the mortality of trees and other herbivores hinder regeneration. The realization that an increased number of waterholes is likely to increase the density (and potentially the impact) of elephants in many areas has recently resulted in a number of waterholes being closed down in many South African protected areas[6]. Providing water is therefore not advocated as a general technique for managing local overabundance of elephants. Where water has been previously provided, gradually removing it can allow for a more natural distribution of elephants.

Barriers[10,11] are sometimes used to prevent elephants from reaching fields or infrastructure, in human–elephant conflict situations or for specific items of concern such as a valued tree. These barriers can include fences, moats, walls, buffer crops and trenches. Their usefulness varies and without other conflict-mitigating measures they are often ineffective.

Electric fences are reportedly[10] the most successful form of barrier but, as with all barriers, their layout must be carefully planned and the effect on other non-target species must be considered. Regular and continual maintenance is essential with all forms of barriers but especially with electric fencing. Other types of fence such as cable fencing can also prevent elephant movement as long as the elephants do not learn that the fences are breakable[10].

Fences have been most widely used in South Africa, where they are constructed to keep most of the national elephant herd inside protected areas. This has led to overabundance rather than reducing it[12,13].

Moats and trenches are a big undertaking to construct and are usually ineffective because elephants learn to kick in the sides and therefore enormous effort is needed to maintain them.

Barriers made with large, sharply pointed rocks are very effective around infrastructure such as pumps and wells (D. Dugmore, pers. comm.) but are likely to be impractical for large areas.

Most buffer crops (sisal, tobacco, trees, chilli) have shown to be ineffective[14] as the elephants walk through them to reach their target. However chilli extracts rubbed onto fencing is a good deterrent[15].

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5.3 Direct options

5.3.1 Translocation

Of the non-lethal options, *translocation* has been dealt with in detail under a separate issue of AfESG guidelines[1] and the reader is advised to refer to these for more detailed guidance.

Translocation avoids some of the ethical and moral dilemmas associated with killing animals and is therefore emotionally appealing to the general public and finds international approval. Translocation can also be used to enhance populations that have declined or to reintroduce elephants to areas where they have become extirpated.

However, translocation as a population management tool has a number of drawbacks and limitations[1]:

- Capture can be stressful to the elephants if not done properly and may disrupt the social structure[2–4]. The disruption, both on those moved and those left behind, may be considerable.
- Translocation operations, especially when conducted by inexperienced crews, can be dangerous to both elephants and humans.
- As elephant populations can increase at average rates of 5% per annum, the numbers that can be translocated may be insufficient to reduce the population adequately. Unless translocation is used together with other management options, maintaining the numbers at a given level may require translocating large numbers every year, thus rendering this option logistically or economically unfeasible.
- Translocations are technically complex and expensive, and they require specialist skills, knowledge and financial resources that are lacking in many range states[5,6].
- Translocation may not work, especially if the capture and the release sites are close to each other, as translocated elephants may return to their former ranges.
- Translocation may, in effect, merely transfer the problem elsewhere[3,7].
- The use of translocation is limited to sites with suitable terrain and adequate access roads.
- Acceptable destinations that could accommodate surplus animals may be limited[6,8]. For example, sites with high levels of illegal killing of elephants or high incidence of human–elephant conflict would generally not be considered acceptable destinations.
- Wild capture and translocation of elephants into captive use raise numerous technical and ethical issues[9,10].
- Translocation may not be feasible or acceptable if it does not have the support of local people at both source and release sites, especially where elephants represent an important asset or liability to affected communities.
- Translocation involving the movement of elephants across international borders requires full permission and involvement of all relevant government agencies in both source and recipient countries.
- Veterinary considerations may also pose constraints to translocation activities. For example, if a pathogen that can cause serious ill health or death and can cross species barriers and be asymptomatic (e.g. *Mycobacterium tuberculosis*) is known to be prevalent within a source range, then elephants from such areas should not be translocated.

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5.3.2 Fertility control

Introduction

Fertility control, which includes contraception and sterilization (see 'Definitions'), is an option when the ultimate intent is to stabilize the population. Mackey et al. (2005)[1] have shown through population modelling that over extended periods of time (> 40 years), fertility control can be very effective, assuming a contraception rate of 75% of breeding females and a 4% annual mortality. While the logistics and costs of current technologies would seem to preclude this as an option in some of the larger free-ranging populations with resource constraints, fertility control has been successful in smaller ones[2–4].

In general, however, fertility control methods are not practical for reducing an elephant population because the effect would be extremely slow; the rate of decline would be determined by the natural mortality rate, which is small. This is a problem common to all long-lived species like the elephant. Preventing conception in all females will stabilize only the population and this will also occur only when all the pregnant females have calved. Gestation time in elephants is 22 months, and so for a period of about two years after all females have been treated, the population will still increase, usually at a rate of between 5% and 7% per year[5,6]. A decline in the population will occur only in response to natural mortalities and start only after the youngest elephant reaches breeding age. This is a very slow process.

Research into contraception for elephants has been undertaken in a few populations. Two main methods have been investigated thus far—hormonal control using subcutaneous estradiol-17-fl implants, and the immunocontraception technique using porcine zona pellucida (pZP) antigen vaccinations.

Other potential contraceptive techniques may also exist. Some have as yet not been tested under field conditions and are considered by some to have potential ethical or logistical problems. These include using laparoscopic techniques (males by castration or vasectomization and females by tubule ligation), sterilization of males or females or both through chemical means, and female sterilization through chemically induced abortions.

Methods

Female contraception methods

Computer models of elephant population responses to various contraception regimes have shown that to stabilize a population, approximately 75% of all breeding females must be continually under treatment[7]. For example, from a sample of 3208 randomly culled elephants in Kruger National Park, 1215 (38%) were breeding females; 75% of these females (911) is equal to 28% of the total sample. As a general rule, in a population with a normal sex and age structure, around 38% of the animals would be breeding females (the rest being juveniles or males), and therefore 28% of the total population would have to be under treatment. Kruger National Park, with a current population of 12,500, would thus involve about 3500 females.

Two main methods, hormonal treatment and immunocontraception, have been tested. The main lessons learned from their use are summarized here.

Oestradiol-17-fl is a hormonal treatment that prevents ovulation through slow, sustained release of oestrogen from subcutaneous implants. A research project was initiated in Kruger National Park in 1996 to test the efficacy of this hormone but was quickly terminated on humane grounds[7]. This method was shown to be effective in preventing conception, but there were several undesirable complications[7,8]:

- Females under this treatment are induced into a sustained state of 'false oestrus'. The high levels of oestrogen are metabolized and secreted in the urine in quantities sufficient to be detectable by bulls. The pheromonic signal to the bulls is that these cows are in oestrus, when in fact they are not. In Kruger this resulted in the bulls harassing the cows, separating them from their families and even from their small calves[7,9]. Three of the 10 calves whose mothers had been treated died during the research period. Over the same period none of the 20 calves involved in the pZP project died.

- Two and three years after the project was terminated, ultrasound examination showed the ovaries still to be completely inactive, which suggested that they had been permanently affected[10]. 'Permanent' inactivity of ovaries for older females with established families might be acceptable, but for younger females, sterility is a dubious ethical option. This would deprive them of the natural learning processes of allo-mothering, gestation, parturition and raising a baby, and of the advantages of large families described earlier.

- Known side effects of oestradiol-17-fl include cystic ovaries, oedema of the vulva with prolapsed vagina and/or rectum, aplastic anaemia, open cervix leading to a pyometra, cystic hyperplasia of the endometrium and cervix, hypertension, myocardial infarction, endometrial carcinoadenoma, mammary carcinoadenoma and hepatic adenoma[11].

- Oestradiol implants must be replaced every six months and as they cannot be delivered remotely, each replacement requires full immobilization of the animal and a surgical procedure. Helicopters and veterinarians must be used and therefore costs for treating large populations of elephants would usually be prohibitive.

- Another issue is that the meat of these treated elephants would contain high levels of oestradiol that might adversely affect people or scavenging animals consuming the meat.

- Finally, family size, structures and group dynamics would be altered with all of the unknown consequences for social groups.

These ethical and health considerations far outweigh any contraceptive[11] advantage and so this method is not considered a humane option in wild elephants[7,11].

Porcine zona pellucida (pZP). Immunocontraception through pZP vaccination of adult elephant females has been shown to successfully contracept elephant females[10,12]. The pZP antigens used in the vaccine are purified from pig oocytes. The vaccine stimulates the elephant's immune system to produce antibodies that bind to the cow's maturing follicular oocytes, which prevents the sperm cells from binding and fertilizing the oocyte.

General considerations

- Before embarking on a contraception programme, managers must realize that for it to be effective, there must be full commitment to continue the project into the future. This is not a one-off inoculation programme. The programme will need to be maintained into the foreseeable future, and funding, staff, equipment, drugs and vaccines must be assured. Without this, the project will fail.

- Early consideration of implementing a contraception programme is critical. Implementation should be effected before the problems exceed the capacity of such a programme to limit the population's growth, and before population reduction becomes necessary.

Veterinary considerations

- Elephants can be immunocontracepted for two successive years with a single booster. Furthermore, the vaccine is 100% reversible once the treatment has been terminated. The vaccine is also safe when administered to pregnant animals and has no known effects on the neonate[2,12–14]. Also, as the vaccine has no hormonal component, none of the side effects associated with hormonal contraceptives have been observed[2,15].

- This method has no known somatic[16] or behavioural[7,12] consequences. The vaccine has been shown to be 80% effective when free-roaming elephants were darted remotely in Kruger National Park[17]. More recent work has shown that rates as high as 100% of treated animals can be achieved[2,15].

- Remote delivery of the vaccine does not require surgical procedure and can be accomplished by trained technical staff. This obviates the need for full-time deployment of veterinarians.

- An immunocontraception programme in wild mares showed that their ovarian activity was reduced[18] after five years. They cycled less regularly and had a reduced luteal phase, but the reduced ovarian activity was reversible after withdrawal from the pZP vaccination programme.

- Another effect seen with long-term immunocontraceived mares was that their survival and general body condition increased markedly[19] due to the absence of lactational and gestational stress.

- It has been postulated that the increased frequency of oestrus may have some health consideration over the long term as multiple oestrus cycles without breaks due to pregnancy have resulted in increased incidents of leiomyomas and cysts in captive elephants[20,21]. While the increased risks of leiomyomas and cysts are cause for concern, there is as yet no evidence to suggest that these may cause discomfort or contribute to an increased risk of mortality. A properly implemented contraception programme that reduces conception frequency but allows a female an occasional calf may considerably reduce the probability and risks of uterine pathologies.

Technical considerations

- Kirkpatrick (2003)[22,24] concluded that the only significant hurdle left to overcome with the use of pZP vaccine is the need to deliver a year or more of contraceptive in a single inoculation. Currently this technology requires an initial inoculation and one or two boosters at about three–four-week intervals[23] to elevate antibody levels to the point that they will provide the required contraceptive effect. This effect lasts for about two years and annual boosters are necessary thereafter. This makes the field delivery rather labour and cost intensive, and generally would preclude its use in large populations.

- A single administration (one-shot), multiple release pZP vaccine has recently been developed and shown to be effective in horses[13]. The one-shot vaccine should provide a contraceptive affect lasting at least two years following a single administration. The vaccine consists of a fluid portion (the primary vaccine in the barrel of the dart) and three types of slow-release pellets (in the needle of the dart). The pellets release vaccine after 1, 3 and 12 months. Three captive elephants were treated with the one-shot vaccine and all three developed antibody titres that were in fact better than with the conventional vaccine. This indicates that the one-shot vaccine can be successfully applied in free-ranging elephants. The next step will be to perfect the remote delivery of the one-shot vaccine by darting and test it on captive and free-ranging elephant (H. Bertshinger, pers. comm.). The development of an effective remote delivery system would greatly facilitate the application of a pZP contraception programme. The reduction in cost and logistical benefits might render the technique suitable for use in larger populations. However, a considerable amount of research is still required before it can be widely applied as a management option.

Social and behavioural considerations

Considering the natural history, social structure and behaviour of elephants, it is clear that contraception programmes intended to limit population growth will affect the structure and fabric of elephant society. Main considerations include the following:

- The choice of which females to vaccinate needs careful consideration. Young or maiden females probably need to be allowed to undergo the natural learning processes of gestation, parturition and acquiring maternal skills for raising a baby while being around other older and wiser females, and should not be treated.

- As with the oestradiol technique, family size, structures and group dynamics will be altered and these may have some as yet unknown consequences for elephants (social problems, reduced calf survival rates, etc.). A recent study however showed no adverse effects on these parameters over a six-year observation period[15].

- As treated females do not conceive, their mating frequency will increase. Under normal circumstances, females come into oestrus, mate and conceive only once in every four years. For example, the mean calving interval over 12 years in Kruger National Park from a sample of 1668 adult females was 3.99 years[24]. This frequency increases to around once every 15 weeks when conception does not occur[15]. This has been shown to have no adverse effects on behaviour over a six-year observation period[15].

- Evidence from recent studies suggests that the constant oestrous recycling of many treated females appears to have no adverse effect on bulls with regard to change to musth cycle, increase in aggressive interactions or increase in mortality[15,25].

Ethical considerations

- The non-lethal characteristics of fertility control techniques make them appear ethically appealing, but whose ethics should apply? To an African farmer, an average westerner, or an animal rights advocate, ethical elephant management may mean very different things. Consultation programmes with communities adjacent to Kruger National Park have shown that they have little understanding of (and even opposition to) spending large amounts of money on contraception programmes when to them, elephants represent a potential sustainable harvest (Ian Whyte, pers. comm.).

- Families are the basic fabric of elephant society[26] and the changing of this family structure is an issue that requires ethical consideration and debate[11].

Financial and logistical considerations

- In both contraception techniques, hormonal and immunocontraception, logistical and economic costs can be high and this may constrain their use in larger, under resourced populations. The cost of applying contraception programmes will vary tremendously depending on the size of the target population, size of the area, availability of human resources and equipment, etc. In 2005 the costs of pZP vaccine administration in Makalali Conservancy, South Africa, were 880–1000 South African rand (approx. USD 125–140) per elephant inclusive of helicopter time, cost of darts, vaccines and veterinary fees[15].

- In the past, radio collaring was generally deemed necessary to relocate treated individuals[27] but more recently it has been suggested that ‘blanket’ inoculations of large numbers of adult females followed up with a second ‘blanket’ inoculation could result in a large enough sample of treated animals to achieve a significant reduction in population growth[15]. Although such a technique would reduce costs and effort, resource limitations may still constrain this management option in some populations. Indeed, Bertshinger et al. (undated)[28] have suggested that the only constraint to the contraception of large populations using this method would be resource limitations.

Induced abortions

Technical considerations

- It has been suggested[15] that chemically induced abortions may be a way of controlling unwanted increases in elephant populations. They suggest that uncomplicated abortion induced by luteolysis would follow the administration of a prostaglandin F analogue at any stage of pregnancy. This could be achieved by a single intramuscular injection delivered remotely from a dart gun. However, pregnant Asian elephants, when experimentally treated with prostaglandins did not abort, and future research is still required.
- To have a high proportion of females sterilized could leave the population very vulnerable to either a proliferation of poaching or to a disease epidemic (which may drastically reduce the population), leaving it with a grossly impaired ability to recover. There is also a possible risk associated with contraception of a large proportion of breeding females in the face of population crashes induced by periodic and unpredictable climate conditions (P. Cowan, pers. comm.). Ideally therefore, a reversible contraceptive technique is required which may have a long lasting effect which would reduce the number of booster treatments, but which would allow the female to return to breeding condition once boosters were terminated. Such a technique is not yet available, as the only ones so far tested require regular boosters to maintain the contraceptive effect. This considerably increases the financial and logistic costs of the programme, particularly in large free-ranging populations in large protected areas.

Ethical considerations

- Abortions also pose ethical questions. The expulsion or reabsorption of a near-full-term foetus may present physiological complications, reducing the potential of induced abortion as an ethically acceptable technique.

General conclusion on female contraception methods

With hormonal contraception, all treated elephants must be fitted with radio collars to allow location from a helicopter when implant replacement or booster vaccinations become due. Helicopters and veterinarians must be used and therefore costs for treating large populations of elephants would usually be prohibitive. Collars are expensive and need replacement as batteries run down. The additional trauma of recapture to females under treatment for replacing collar batteries is also an ethical consideration.

Male contraception

There presently are no ‘male’ approaches to contraception that have a likelihood of maintaining or reducing existing populations. Behavioural data suggest that even if a large number of males were removed from the population and only a few reproductively intact bulls remained, a high number of pregnancies would still result[29]. This has been contested by Bokhout et al. (2005)[30] who maintain that vasectomization of enough dominant bulls will achieve this because only a few bulls are responsible for most conceptions (see *Vasectomization* below).

Castration. In elephants the testes are situated internally near the kidneys. Castration therefore requires major abdominal surgery. Furthermore, castration will not serve any useful purpose in limiting elephant populations, as castrated bulls will simply not compete for oestrus cows, and the matings will be done by uncastrated bulls. Castration would merely remove such animals from the breeding population.

Vasectomization. It has been shown to be possible to vasectomize adult elephant bulls through endoscopic techniques that could be very useful for managing smaller populations. The method requires that the animal be suspended in a sling to keep him upright in a standing position during the procedure. This clearly requires sophisticated equipment and veterinary staff.

Technical considerations

- Vasectomization does not affect the condition of musth in mature bulls[15,25] but it is important to establish scientifically which bulls and how many should be vasectomized in order to achieve an impact on population growth.

- Conceptions can occur throughout the year though there is a peak in the rainy season[24,31,32]. A few dominant bulls whose musth periods fall during the main breeding season are responsible for most conceptions[33]. Bulls come into musth for the first time at about 25 years of age, once they have achieved both physiological and psychological maturity. From then on, musth becomes an annual event lasting for various lengths of time (weeks to months), depending on age and physical condition. The timing of a bull's musth period depends upon his position in the hierarchy. The top bull is in musth during the peak breeding season when a large proportion of females come into oestrus. A bull low in the hierarchy comes into musth at a time when very few cows are in oestrus[33]. It seems clear therefore, that the bulls that should be vasectomized (if lowering the conception rate is the goal) would be the most dominant ones, high in the hierarchy. They would be the ones doing the mating and keeping the lower-ranked bulls away from the cows in oestrus.

- A problem with vasectomizing these bulls is that the cows that do not conceive will return to oestrus about 15 weeks later, at which time the dominant bull may have dropped out of musth. So when the cow returns to oestrus condition, she may consort with a bull lower in the hierarchy, who may also have been vasectomized. If so, she will again not conceive, and will then again return to oestrus another 15 weeks later. Eventually, she will come into oestrus in the non-breeding season when all the dominant vasectomized males have dropped out of musth, and she will then be mated by a young unvasectomized bull in one of his early musth periods.

- Being mated by a young unvasectomized bull would be undesirable for two reasons:

- The objective of preventing the female from conceiving will not have been achieved.
- If a cow is going to conceive, clearly it is to the genetic advantage of the population that the 'fittest' bulls should sire the offspring.

Thus, to stabilize an elephant population, it would be necessary to vasectomize a much larger proportion of the mature bulls than just those high up in the hierarchy, and even then the birth rate mat be only marginally reduced, as most cows will eventually be mated by unvasectomized bulls in one of their subsequent oestrus periods. This aspect still requires verification through field studies.

Chemically induced sterility. Recently, advances seem to have been made in developing a single injectable treatment that would permanently sterilize either males or females of any species[34]. Nett et al. (2003)[34] reported they had achieved success by conjugating a cytotoxic agent (pokeweed antiviral protein [PAP]) to an analogue of gonadotropin-releasing hormone (GnRH). The treatment targets and kills only the gonadotropin-secreting cells of the anterior pituitary gland and would permanently disable gonadotrope function. The treatment showed promise in rats, sheep and dogs, and may therefore hold some promise for elephant population control. Considerable research is still required, and managers would need to carefully consider the dangers of permanent sterilization, as well as potential dangers from human consumption of treated elephants.

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5.3.3 Safari hunting

Safari or sport hunting is included here because there is an incorrect perception in some circles that this is an option for reducing the size of elephant populations.

Elephant bulls are killed for sport by individual hunters (usually from countries outside the range States) who pay a considerable fee to be able to do this. The ivory and hide are usually taken but rarely anything else. The aim of the hunters is to satisfy their own ambitions and goals, which commonly take the form of enjoying an outdoors experience as well as having shot an elephant and acquiring its tusks. Usually the bigger the tusks, the more desirable the animal. Safari hunting targets male elephants and is usually at an annual quota of around 0.5% of the population to allow an acceptable mean trophy size to be produced sustainably[1]. However, because males (and seldom females) are killed, hunting has no effect on the size of the population, and is therefore not a realistic option for population reduction or managing local overabundance. Nevertheless, because male elephants are often responsible for more tree damage than females, hunting may reduce adverse effects in localized key habitat areas[2–4].

5.3.4 Culling

Introduction

The culling of elephants has been, and is, the cause of much controversy and vociferous, often emotional discussion (see e.g.[5–11]). For this reason, culling is largely considered a last resort. No large-scale culls have been reported anywhere in Africa since the last cull in the Kruger National Park in 1994, and opposition to the activity has led to the development and research into alternative population reduction methods such as translocation and contraception as mentioned.

Culling is used to reduce the size of populations rapidly and by large numbers. On average, with a professional and well-equipped team, 60 elephants can be killed per day, producing an average of 4 kg of ivory and a tonne of meat (wet weight) per animal. For instance in Zimbabwe, professional culling teams killed up to 5000 elephant in less than 4 months[12].

Although culling can rapidly reduce elephant numbers, this effect may be short lived in open (unfenced) or large closed protected areas if new individuals move into the areas where densities have been reduced[13]. After culling in Kruger National Park, elephants moved in from surrounding areas to such an extent that elephant numbers actually increased locally after culling[13–15]. Additionally, culling does not change the ability of the remaining animals to reproduce and the reduced population will continue to grow if not otherwise controlled. Culling is therefore not a 'one-off' solution and may need to be undertaken repeatedly to maintain lower population sizes[13,14].

Once the decision has been taken to cull, the following considerations need to be taken into account.

Pre-cull considerations

Because of the emotional and ethical sensitivity around culling, stakeholder consultation and public awareness campaigns should be conducted to explain the reasons for culling and to mitigate negative publicity.

Methods

A herd of elephants is not a random mixture of animals but has a distinct structure, family members usually being in close proximity to one another, and each family usually distinct from the next. The group selected for culling should thus usually comprise one or more family groups. Experience has shown that *entire* family groups comprising mainly adult females and immature animals of both sexes should be killed in a culling session. Apart from the ethical considerations (see *Humane considerations* below), the removal of entire herds minimally disturbs the demography of the remaining population—in other words, the age and social structure of the remaining population is changed as little as possible from the natural state. To maintain the natural demography of the population, 'bachelor groups' (comprising adult and subadult males) should be culled in the same proportion as they occur in natural populations. In the Kruger National Park, bachelors comprise about 15% of the population, and 15% of all culls were therefore bachelors[16].

Important points to bear in mind in any culling operation include:

- Culling (or cropping) should only be carried out by a professional team with proven experience. Because there have been few if any culls during the recent past, there is a general lack of expertise, which would need to be addressed through training by the few people who have been involved in culls in the past.
- The use of scoline (succinylcholine chloride) for culling is not advocated. This compound was used in Kruger National Park until it was shown that scoline is an inhumane way to kill elephants[17–19]. In animals such as buffalo, the action of scoline is rapid as all of the body's muscles are affected simultaneously and death is very rapid. In elephants, however, the locomotory muscles are immobilized initially, rendering the animal recumbent, and only a while thereafter is the diaphragm affected, stopping breathing. The heart muscle continues to function and the animal eventually dies of asphyxiation. During this process the brain is unaffected, and so the animal remains fully conscious during the whole process.
- After selecting a suitable herd, all animals in the herd must be shot. The matriarch is usually targeted first as once she has fallen this 'anchors' the herd and prevents the rest from dispersing.
- Killing should be done by a brain shot using heavy calibre rifles. The correct choice of weapon is important. Both .458 and .375 calibres are useful for bulls, and the .762 is adequate for smaller animals in the family herd, but a heavier calibre rifle should be on hand as back-up, to be used if necessary.
- No animals should be shot at a water point to reduce disturbance to other animals and to avoid pollution of the water.
- It has been suggested that culling could affect tourism[7] and it would be insensitive, even if there had been public consultation and awareness campaigns about culling, to shoot animals within sight of a tourist route or within hearing distance of a tourist facility.
- Salted and dried hides can be stored for a long time and these are potentially very valuable, provided markets can be found for them.
- In order to maximize knowledge and learning, biological information should be recorded from all culled elephants[20,21]. Tissue and blood samples for genetic, disease and toxicological analyses can also be collected[21]. Excessive remains of carcasses create abnormal ecological conditions for scavengers. For this reason amounts of offal left at the cull site should be minimal.

- Where an abattoir is available to process the meat, skins can be removed and the meat salted and dried, canned for sale or used for field staff rations. In Kruger, fat was extracted and sold to the cosmetic industry, and carcass meal was made from all other carcass remains.
- Where there is no abattoir, culled elephants can be butchered in the field, skins removed and salted, ivory removed, meat salted and cut into strips for drying. Such culls are limited to the dry season to facilitate access and to allow for proper drying of the meat and skins.

Two methods of culling have been used most recently to reduce elephant populations. In the first one a helicopter is used as a platform for shooting or darting, while in the second, a highly skilled team of sharpshooters does the shooting from the ground.

Elephant culling from a helicopter

Although culling elephants from a helicopter was initiated in 1967 in Kruger National Park, the only detailed description of the method has been provided by Whyte (1996)[20].

For reasons of the safety of personnel conducting the operation, culling elephants in Kruger has always been conducted from a helicopter. The helicopter was used to search for a suitable group to cull and was a platform from which to shoot the animals at close range at the selected culling site—usually an open area free of tall trees. All members of the selected herd were brain shot by a marksman in the helicopter.

Any of the culled animals still showing signs of life when the ground crew moved in were immediately brain shot by a marksman on the ground. The throat of each dead animal was cut to ensure proper bleeding as many of the products of the carcasses were used for human consumption. Carcasses were then loaded onto large trucks and transported to an abattoir.

Elephant culling from the ground

The use of high-powered rifles to kill elephant from the ground was the preferred method in a number of countries[22–27]. A small spotter aircraft was used to locate a suitable group for the cull, and to guide the sharpshooters to the group via radio. A team of three highly experienced sharpshooters, each backed by an armed ranger, approached the group from downwind. The lead hunter occupied the central position and the two subordinate hunters positioned themselves on his left and right, and they approached the herd as close as they could get. Adults were shot first, particularly the matriarch to reduce the likelihood of the rest dispersing. Any bulls were shot quickly as they would break away and run, taking the herd with them. Once all the adults were down, the rest were quickly dispatched. An efficient team could cull up to 40 elephant in less than two minutes.

Thomson (2003)[27] gave an indication of the requirements for such an operation:

- An experienced manager in overall charge of the field operation.
- A suitable spotter aircraft (e.g. Piper Super Cub), experienced pilot and aircraft support crew.

- Three expert hunters with one in reserve.
- Transport: three 4x4 vehicles, a mobile hydraulic crane, two tractors with trailers.
- Two five-ton trucks preferably also 4x4 with a maintenance crew.
- A labour force of 100–150 people plus supervisory officers with sufficient equipment—axes, shovels, knives and crowbars.
- Several tonnes of salt for curing skins, bales of hessian or woven plastic bags for bagging dried meat.
- Sufficient fuel (including aviation fuel), lubricants, mobile water tanks, water pumps and pipelines.
- A team of biologists with their own transport and technical help for data collection.
- Tents, food, cooking and eating utensils.
- A good and reliable transport and administrative system for re-supply, and for the transport of skins, ivory and dried meat.

Humane considerations

Humane considerations are of paramount importance when considering the option of culling elephants.

It is of crucial importance that the operators are experienced to ensure that there is minimal possibility of wounding animals or splitting families. In the unfortunate event that elephants are wounded, or manage escape from a group identified for elimination, the operators must act to ensure that such situations are dealt with as humanely as possible to minimize emotional or physical suffering.

The effect of culling on the remaining population of elephants may be considerable if members of family groups are left behind[28]. The removal of entire herds, as opposed to individual members of those herds, is intended to minimize distress and disturbance to the population. However, it is possible that because families routinely split up for varying lengths of time, animals remaining after a cull may be distressed by the culling activities as well as by the loss of family members (as would be the case after translocation). The degree of disturbance would depend on the proximity of the animals to the cull site[29].

In early days of culling in Zimbabwe and South Africa, the equipment and expertise had not been developed to enable translocating intact families. Some juvenile elephants were therefore not killed during culls and were kept alive for the captive market or to establish founder populations in parks where elephants had earlier been exterminated. Today, this practice is generally considered inhumane and unethical, and the removal of entire family units is advocated. There is evidence that elephant bulls translocated as juveniles may sometimes become 'rogue' in adulthood[5,30] having grown up in a population lacking a normal social conditions[30] and normal age and sex structure[31,32].

Ethical considerations

An ethical question in relation to culling is whether it is morally justifiable to kill elephants. Many people believe that elephants are sentient animals and as such consider it wrong to kill them. However, while some may find the killing of elephants distasteful, many have a different view and argue that it is not acceptable for other species to be threatened due to elephant activity.

Allowing the possibility that elephants themselves may die as a result of their overpopulation is also considered by some to be unethical[33]. Allowing elephant populations to increase to such an extent that large numbers may die of starvation and to waste a significant resource that could benefit poverty-stricken people may also be questioned on ethical grounds[29].

Culling purely for economic reasons is generally not considered ethical in protected areas, where objectives are ecosystem management and maintenance of biodiversity.

Economic and socio-economic considerations

Economic costs and gains from elephant culling are difficult to calculate because of trade regulations. Where possible, all products should be used fully—meat dried or processed, skins prepared for storage prior to curing and tusks stored securely against the possibility of future legal commercial use. All costs and gains should be documented and calculated accurately so that the net return can be calculated accurately.

In areas where safari hunting is permitted, targeting only family groups would lead to an increased number of bulls available for hunting.

Political considerations

Because different societies have different values, there are political issues that need to be considered. The decision as to whether culling should be used to manage an elephant population depends on the societal values of the range State faced with the decision.

Conclusion

Ultimately the question of whether culling elephants is acceptable is not a technical one. The answer will depend upon societal values and other objectives set for an area. It is currently the only method that enables large elephant populations to be reduced rapidly but humane, ethical and political considerations all contribute to making any decision to cull elephants a difficult one.

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5.3.5 Other direct options

Disturbance methods

Sensitive habitats, provided they are small enough, could in theory be protected against elephant damage by applying various direct disturbance methods. Such methods usually rely on a combination of loud noise and bright lights to scare away elephants. A wide variety of methods, ranging from traditional practices such as banging drums to 'elephant drives' using vehicles or aircraft, have been experimented with in different parts of Africa. While such methods have met with some success, they rarely remain effective for long, as the elephants become habituated to them[1–4]. Such methods can also be very costly and labour intensive to implement[5].

There is very little evidence to support the hypothesis that shooting an elephant as 'an example to others' is effective at keeping elephants out of an area[1].

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