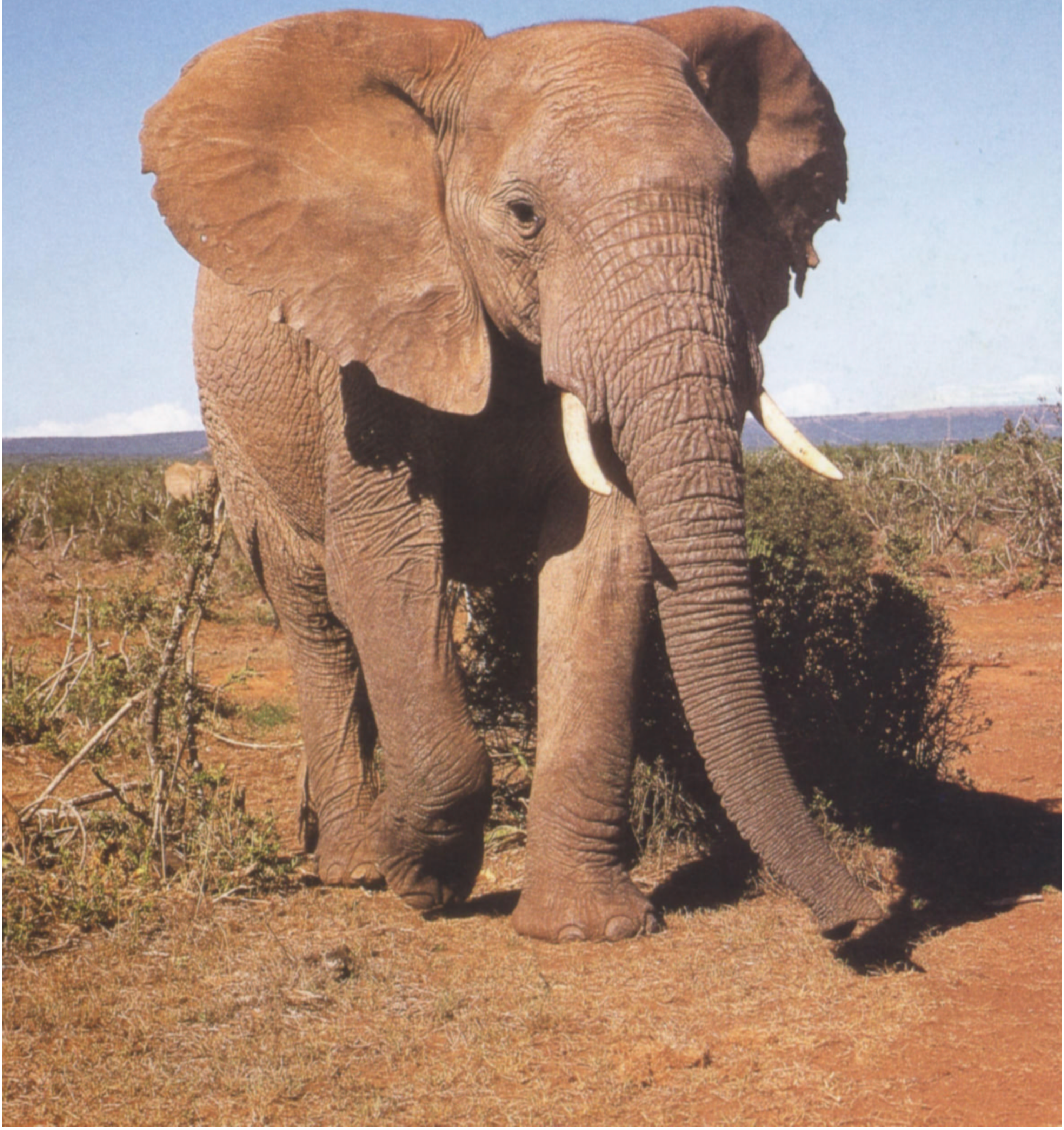
ELEPHANT CONSERVATION AND MANAGEMENT IN THE EASTERN CAPE

WORKSHOP PROCEEDINGS

Edited by
Graham Kerley, Sharon Wilson and Ashley Massey



ELEPHANT CONSERVATION AND MANAGEMENT IN THE EASTERN CAPE

PROCEEDINGS OF A WORKSHOP HELD AT THE UNIVERSITY OF PORT ELIZABETH

5 February 2002

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Graham Kerley, Sharon Wilson and Ashley Massey

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Introduction to the Workshop on Elephant Management and Conservation in the Eastern Cape

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Introduction

In 1900 the Eastern Cape boasted the largest remaining population of elephants in South Africa, but this was not to last. The then notorious Addo elephants were in conflict with the economic principles of the day, and the Cape Administration ordered their eradication (Hoffman 1993). The ruling sentiment of the time towards the Addo elephants was probably well captured in an article in the Eastern Province Herald (1919) which stated "*There is, it may be noted, no case made out for the preservation of the herd for the pleasure of animal lovers, - no man in his senses would venture to enter the Addo Bush to sight the wild elephant since he would have to crawl within a few yards before he could even dimly see the outline of an animal, and then if he were scented his further interest would be blotted out in a charge*".

Fortunately for the elephants and the people of the Eastern Cape, the Addo elephants managed to persevere into the 21st century, and now represent a crucial resource for the nature-based tourism industry, despite the contrary sentiments expressed in the above-quoted article. In addition, the Addo elephants have played a critical role in establishing the Eastern Cape as "big game" country, which is reflected in the increasing number of private game reserves and hunting operations. Furthermore, the wildlife based tourism industry is increasingly being recognised as one of the few opportunities for sustainable economic development for the people of the Eastern Cape.

This new-found enthusiasm for wildlife is reflected in the surge of newly established elephant populations in the last decade, so that by the beginning of this year there were well over 400 elephant in five populations in the Eastern Cape. This is a considerable improvement over the 11 elephant that represented the pitiful remnants of the Addo herd in 1931.

Together with the increase in the number of elephant populations, there has also been an increase in the area available to elephants, from about 2 270 ha in 1954 to over 47 500 ha in 2002. This is particularly heartening, not only for elephant conservation, but also for the conservation of entire ecosystems, as it has been postulated that elephants play a keystone role in the functioning of particularly thicket vegetation (Kerley *et al*. 1995). This is a consequence of the processes that they drive as megaherbivores.

However, the situation is not all that simple, as elephants can also cause profound transformations of ecosystems if present in too high numbers. By virtue of their sheer body size and longevity, elephants are able to affect the plants and animals around them, while being relatively isolated from these effects themselves. Thus throughout their shrinking range in Africa, elephant are recognised as being able to virtually destroy the remaining habitat to which they are confined, with ultimately serious consequences for themselves and their habitats (euphemistically known as the "elephant problem"). The Eastern Cape is no exception, as a number of studies have demonstrated the negative impacts that elephants may have, particularly on plants. Elephants also present a number of other management challenges, principal among which is that of managing population sizes in this surprisingly fecund animal – a problem that is compounded by the negative reactions that elephant culling stirs up, particularly in the developed countries.

So, together with the elation and excitement of increasing elephant populations, comes an increasing sense of responsibility to understand the consequences of maintaining these charismatic animals on the landscape, as well as the need for appropriate management strategies. This is especially important if we are to sustain both the spectacular biodiversity of the Eastern Cape, as well as support the burgeoning wildlife based industry upon which so many hopes are pinned.

The solutions to these problems lie in understanding the elephants, the ecosystems they affect, as well as the consequences of managing (or not managing) elephants. It was with these perspectives in mind that we developed the following goals for this workshop:

- To synthesize information on the current status of elephants and the understanding of their ecology and management in the Eastern Cape Province
- To identify priorities and guidelines for management and research on elephant in the Eastern Cape Province
- To provide a forum for interaction between elephant managers and researchers.

To this end we invited a number of managers and researchers directly involved in elephant conservation and management in the Eastern Cape to offer their experiences in addressing the abovementioned issues. This workshop will not solve all these problems, but it will serve to more clearly identify them, many of which are unique to the Eastern Cape. In addition, the workshop will, through the exchange of ideas, identify management solutions that are available, as well as provide guidance for future research into elephant conservation and management in the Eastern Cape.

In order to sustain elephant populations in the region, it is imperative that conservation and management decisions are firmly guided by the outcomes of robust research programmes. In this vein, *ad hoc* decisions could have serious consequences for these populations and the regional biodiversity, as well as the tourism industry based on both elephants and biodiversity.

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- Elephants in the broader Eastern Cape - An historical overview

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Introduction

This article provides selected information and interpretations relating to the pre-historical and historical occurrence, distribution, numbers, habitats and movements of the African elephant *Loxodonta africana* in the broader Eastern Cape region, defined here as the present political Eastern Cape Province and adjacent areas. The re-constructed distribution is based on an interpretation of the early records and the ecological requirements of elephants. The demise of the elephant population of the region is chronicled. For further information, the reader is referred to the selected bibliography provided at the end of the article. For practical reasons, present-day names have been used to indicate specific places and areas.

Occurrence, Distribution and Numbers

Pre-history: the archaeological record

The formal archaeological record indicates that the African elephant has been present in southern Africa from at least 30 000 before present (BP). Although this record is incomplete, it is apparent that elephants were present, or potentially present, up until historical times, in much of what is today known as "South Africa". Five sites that provide evidence of the pre-historical occurrence of elephants in the broader Eastern Cape are presently known and described; these contain material dated to the following periods (all BP): 6000-4000, 4000-2000, 2000-1500, 1000-500, 500-Recent.

The meagre evidence from the formal archaeological record, for the pre-historical occurrence of elephants in thicket and thicket-associated habitats in the Eastern Cape Province, is supported by the recent (during the past 100 years) discovery of elephant remains, mainly tusks and molars but also skulls and other skeletal parts (see later). It is also supported by the presence of numerous rock paintings and rock engravings that depict elephants; these were made by the San people who lived in these parts for two thousand years and longer. Although there is always the possibility that the artists depicted animals that they had seen elsewhere, it can probably be safely assumed that elephants have been present for a very long time on the thicket-dominated landscapes of the broader Eastern Cape.

Historical record

The next body of evidence is derived from the written records left by early European travellers, naturalists and hunters. For the sake of convenience, the broader Eastern Cape has been divided into four zones.

1. Swellendam to Humansdorp

Travelling eastwards from Swellendam, the cover of forest, thicket and grassland increases, and this provided increasingly suitable habitat for elephants. They were recorded on the coastal plain south of the Cape Fold Mountains, i.e. in the districts of Mossel Bay, George, Knysna, Plettenberg Bay and Humansdorp, during the latter part of the 17th century and during the 18th and 19th centuries. There are no early sight records of elephants from the Little Karoo but there is reference to the presence, in 1689, of an "elephant path" over the Attaquaskloof Mountains and into the Little Karoo. Given that water must have been available in these inland areas, it is possible that they would have been visited by elephants, at least on an ephemeral basis. Evidence to support this is provided by the unearthing of a number of elephant tusks in the Oudtshoorn district. In 1775 elephants were recorded 17 km west of Humansdorp, and they were recorded as being “rare” in the Langkloof. There are no known records of elephants in the Baviaanskloof but it is entirely possible that they could have reached there, by moving from the upper Gamtoos River valley along the Kouga and Baviaanskloof rivers.

The elephants in this region probably occupied habitats comprising grass covered uplands, interspersed with forest in the valleys and associated lowlands. Being mixed feeders (i.e. grazers and browsers), they would have utilised mainly the forest fringes and the adjacent grasslands, and largely avoided the forest interior and the fynbos associated with the mountains. It is also likely that the elephants utilised the dune thicket in the coastal areas, and the thicket vegetation of the Gouritz River valley must have provided highly suitable foraging conditions.

The numbers of elephants that occurred in the Swellendam to Humansdorp area are not known. A “well-informed” estimate put the numbers in the George-Tsitsikamma area at 400 to 500 individuals in 1876. However, by this time, the elephants in the area had been persecuted for at least 100 years and the numbers in the pre-European era must surely have been much higher. It is probably safe to assume that at least 1000, and possibly thousands, of animals once occupied this area.

2. Humansdorp to the Great Kei River

Moving eastwards from the Tsitsikamma, the landscape changes markedly, with the narrow coastal plain opening up to form a broad (up to 70 km) coastal plain, bounded in the north by the Zuurberg mountain range. This zone extends further inland to a sub-coastal plain, bounded in the north by the Great Escarpment.

This region was clad in a mosaic of thicket vegetation types, grassy areas and forest and, judging by the relatively numerous historical accounts of elephants there, it clearly provided very suitable habitat for them. They were recorded throughout most of this region during the late 1700s and 1800s. The thicket of the Gamtoos River valley would have provided particularly appropriate habitat for elephants, as indicated by the presence of elephant hunters there in 1752.

The elephants readily utilised the coastal areas, and there is a record from 1773 of elephants at “Kragga Kamma” and near the coast at Seaview, west of Port Elizabeth. An account from 1820 states that the forest “swarmed” with elephants in the Van Staden’s River area, also west of Port Elizabeth. Their former presence in the Algoa Bay area is substantiated by the frequent unearthing of elephant remains there. As early as 1702 a large party of European hunters, in search of ivory, arrived in the area, and in 1775 elephants were shot near the mouth of the Sundays River and near the Zwartkops River.

There are accounts from 1797 and 1820 of “large numbers” of elephants along the course of the Sundays River, and in 1875 a herd of “more than a hundred” was recorded at Grassridge, east of Port Elizabeth. A “game census” from about 1910 lists “approximately 160” in the Uitenhage District and “approximately 140” in the Alexandria District, and there are several references to elephants in the Coerney area, and their presence in the Zuurberg was recorded. In the period 1790 to 1820 there were considered to be “great numbers” of elephants in this area; they were also recorded as being “abundant” in the Paterson district. The published accounts suggest that numbers in the area between about Kirkwood, Paterson and lower Alexandria must have been relatively high. Most of this area would have been clad in mesic thicket, associated with patches of savanna and forest. In 1919 and 1920 some 120 elephants were destroyed in the Addo area.

There are numerous historical accounts of elephants from the Albany (= Grahamstown) and Bathurst districts. For example, in 1779 a herd of 80 was seen near Fort Brown, on the Great Fish River some 23 km NW of Grahamstown, and "400-500" individuals were sighted on one occasion in 1797 between the Kariega and Bushman's rivers. An account from 1839 states that elephants used to "abound" throughout the Bathurst district, and it is mentioned that in 1820 the Kowie River area "abounded" with elephants, whilst the Great Fish River area "swarmed" with them. There is a record of elephants at Trompetter's Drift, on the Great Fish River, in 1779. Based on the written accounts, the valley of the Great Fish River held particularly high numbers of elephants. Reports relating to the densities of elephants in the Albany Sourveld, SSW of Grahamstown, vary from "numerous" to "few" to "casual visitors" and it could be surmised that elephants were perhaps not as abundant in these areas as they may have been in the Great Fish River valley.

Box 1: Contradictions ?

Some of the evidence from the written historical record appears to be contradictory, with certain diarists noting the absence, or relative absence, of elephants in an area, whereas others, travelling in the same area during roughly the same period, noting an apparent abundance. This is considered to be a manifestation of the generally nomadic nature of elephants, with herds moving around and being seen by some travellers, and missed by others. In addition, the nature of the habitat, especially forest and thicket, in many places would have made it easy for some travellers to pass close to a herd of elephants without seeing them.

The presence of elephants in the Albany and Bathurst districts in pre-historical and historical times is substantiated by numerous references to the unearthing of elephant tusks, teeth and bones, and to the presence of elephant paths through the thick "bush" and "forest", respectively. Further evidence from the historical record that

Plate 1. The highest historical density of elephant in the broader Eastern Cape region appears to have been in the mosaic of forest, thicket and savanna in the coastal belt, especially eastwards from the Sundays River (Photo: Graham Kerley).

elephants occurred in the coastal and sub-coastal belts of this region comes from the fact that there are more than 20 place names that incorporate the name “olifant” (= elephant) in the Albany, Alexandria, Bathurst, Humansdorp, Port Elizabeth, Steytlerville, Uitenhage, Uniondale (in part) and Willowmore districts.

Although no historical sight records exist, elephants may have been present in relatively recent times in the Grootrivier Mountains north-west of Steytlerville. This area is well watered and contains extensive areas of thicket. Intriguingly, there is a smoothed rockface in the Sandkraalspoort in these mountains – it is known locally as “olifantsklip” (= elephant rock) because, according to folklore, it was once used as a rubbing post by elephants.

In contrast to the coastal plain, records of elephants from the subcoastal areas are relatively scarce. During the 1820s these animals were still present in river valleys in the Bedford, Adelaide and Fort Beaufort districts. For example, 53 animals were recorded along the Koonap River in 1822. It would appear that the elephants moved from the coastal areas up relatively wide river valleys (such as those of the Koonap and Kat rivers), and penetrated deep into the mountains that form the Great Escarpment, including the Winterberg range. The former presence of elephants in this area has been confirmed by the unearthing of elephant remains. It is perhaps interesting to note that there are no historical records of elephants away from the thicket-clad river valleys.

There are no historical sight records of elephants from north of the Great Escarpment, i.e. from the Eastern Cape midlands. The only evidence that they previously occurred there comes from remains – tusks, molars, skulls - unearthed in the Aberdeen, Graaff-Reinet, Cradock, Jansenville, and Murraysburg districts. Some of the Aberdeen remains have been estimated to have survived from 500 to 600 years BP. There is always the danger that remains could represent discarded hunting trophies, that originated from animals that had been killed elsewhere and transported to the site of discovery, and in this case good elephant hunting was to be had not far (50 km) to the south. However, the find 27 km south-east of Murraysburg comprised an entire skeleton and therefore could not have represented a discarded trophy ! There are, however, excellent rock engravings and rock paintings depicting elephants in the midlands. It is noteworthy that there are no place names in this region that refer to elephants, suggesting that early white farmers did not encounter them there.

There are no historical records from the upper Gariep (= Orange) River, the nearest being from the lower Gariep, in the vicinity of Augrabies in 1779. However, there is mention of hunters who travelled northwards from Somerset East, in 1778, to “hunt elephants on the Grootrivier (= Gariep River)”. Elephants were present in the Kenhardt district in 1779 and may well have been present along the eastern part of the Gariep River, i.e. on the northern boundary of the midlands. Rock engravings in the Upper Karoo that depict elephants predate the early 19th century, and elephants appear to have become extinct in this area around 1800.

Elephants were not recorded in the midlands when early travellers and hunters passed through this area during the 18th and 19th centuries. There is, however, no reason why they could not have occurred there since there are well-watered valleys with adequate forage, albeit it mainly on an ephemeral basis, in the Murraysburg, Graaff-Reinet and Cradock districts. That elephants did occur in these parts, prior to the arrival of the first European diarists, is confirmed by the unearthing of their remains in places. The concentration of recent (200-500 years BP) bone remains in the Sundays River valley suggests that it could have served as a migration corridor. Similarly, remains from the Cradock area suggest that the Great Fish River valley may also have served this purpose.

Good evidence of the former occurrence of elephants in the Peddie, Alice, Keiskammahoek, Stutterheim, Komga, King William’s Town and East London districts is provided by the discovery of remains from a number of sites. By the 1730s elephant hunters had moved through the region, on the way to Pondoland, whilst others were active in the Keiskamma River area in 1752, and “many” hunters were present in the Peddie-King Willam’s Town districts during the late 18th and early 19th centuries. The size of the elephant population in this area clearly made it a worthwhile destination for elephant hunters.

The historical record suggests that elephants were relatively abundant in this region, especially in the coastal areas. For example, in 1804 a herd of “at least 300” was sighted near Alice, and in 1823 there were “immense herds” north-east of Peddie. Similarly, “swarms” of elephants were reported from the area between Begha and Grahamstown in 1824. Supporting evidence for the presence of large numbers of elephants in the region comes from the fact that in 1824 an ivory market was established at Fort Willshire, near Alice. Similar markets were also established at other localities in the region. The available information tells us that many thousands of kilograms of ivory were traded, within a relatively short period, at these markets. For example, at Fort Willshire, 22 928 kg was traded within seven months of the establishment of the market and, taking 10.8 kg as the mean mass of an elephant tusk, this would represent the death of some 1061 tusked animals (but see “Demise” for a perspective on this information).

It is interesting to note that elephants were considered to be widespread over “open” country in the 1820s, and that forests were not considered to provide good elephant habitat. Remains have been unearthed from forests in the region – but did these perhaps come from animals in transit to other habitats ?

Moving further inland, the discovery of tusk and bone material provides evidence of the presence of elephants in the Cathcart, Tarkastad and Queenstown districts. It is possible that elephants moved northwards into this region, away from the dense thicket-clad areas along the coast, by travelling along the tributaries of the Great Kei River. From there it would have been easy for them to move into adjacent river catchments that were vegetated with thicket and forest, for example the Tyumie, Keiskamma and Kat River valleys. Perhaps the Great Kei River and its tributaries also served as migratory corridors for elephants moving into the interior, perhaps *en route* to the Gariep River ? There is, however, no evidence to support these scenarios.

3. The Transkei and East Griqualand

Elephants were seemingly most abundant in the coastal region where, it is assumed, they were mostly associated with the shallow thicket- and forest-clad river valleys, and grass-covered interfluves. They must have moved up the river valleys to reach localities relatively far inland – elephant remains have been found in the Qumbu district, some 100 km from the coast.

Elephants were reported in 1782 to be present in “great numbers” in the Transkei. That a relatively large population existed there is alluded to by the fact that the region attracted elephant hunters from far afield, and as early as the 1730s, and reference to the possible trading of thousands of kg of ivory from the area.

4. KwaZulu-Natal

Elephants occurred, during historical times, in the coastal and sub-coastal regions of southern KwaZulu-Natal (as well as further north to Zululand and beyond); they were recorded in the southern parts as recently as the 1870s. Here, as in large parts of their range to the south, they would probably have been concentrated in the shallow valleys clad with thicket and forest, and associated upland grasslands. They would probably have moved up the river valleys to penetrate deep into the interior.

General

There is no way of determining the total number of elephants that used to occupy the region in question. They undoubtedly occurred here in the thousands, and probably in the tens of thousands – given the presence of extensive areas of highly suitable habitat. The total number of elephants, at any one time prior to say 1650, will never be known but an unsubstantiated estimate mentions a figure of “25 000” for the former Cape Colony (it is postulated that there may have been as many as 100 000 elephants in “South Africa” before this date).

Habitats

Based on the available evidence, it appears that elephants were once widely distributed, across a range of biomes and vegetation types within the broader Eastern Cape during historical and pre-historical periods. These range from the Forest Biome (afromontane and coastal forest), the Thicket Biome (dune, valley, xeric succulent, mesic succulent, and spekboom succulent thicket), the Grassland Biome (south-eastern mountain and coastal grassland) to the Savanna Biome (sub-arid thorn bushveld and eastern thorn bushveld). They would probably have been present only on an ephemeral or patchy basis in elements of the Fynbos and the Nama-Karoo, and possibly even in the Succulent Karoo, biomes.

Most references to high numbers of elephants relate to areas where thicket is, and presumably was, the dominant vegetation type. Thicket provides highly suitable forage for elephants – it is evergreen, the trees and shrubs are generally low-growing (1-3 m), and are therefore readily accessible to browsing elephants, and the nutrient content is high. In addition, thicket is often interspersed with grassy patches and it occurs in the form of forest-thicket ecotones - both provide suitable grazing and browse, respectively.

The extant evidence suggests that elephants were more persistent, and occurred in the greatest densities, in areas clad in coastal and mesic succulent thicket, and where these thicket types formed mosaics with forest and savanna elements. These conditions were prevalent in the coastal belt, broadly from the Gamtoos River valley in the west to Pondoland in the east. Our reconstructions of relative density, status and habitat type are mapped in Figure 1.

Box 2: Did the elephants live in true forest ?

There are a number of historical accounts of elephants occurring in “forest” in the broader Eastern Cape. The extent to which they actually inhabited true forest (i.e. tall, canopied forest) will never be known but these records must be treated with circumspection since the term “forest” was loosely used in the early texts. For example, it was used for treed thicket, open thicket, and even for low growing and sparse thicket.

Movements

Local movements

Evidence of local movements by elephants is provided by the historical accounts, in the form of numerous references to the presence, and use by humans, and also other animals, of paths made by elephants through the dense “bush” and forests.

For example, there is mention from the late 1700s and early 1800s of an “elephant path” over the Attakwaskloof Mountains, thereby linking the coastal plain with the Little Karoo, and of “elephant paths” running in a north-south direction on the coastal plain south of the Outeniqua Mountains, suggesting that the elephants undertook regular movements between the coast and the foothills of these mountains.

ıder Eastern Cape: Some of the place names and areas mentioned in the text, and the likely distribution during late
ɜars BP) and historical times, according to probable relative density, status and habitat:

	Sub-coastal belt	Inland zone
	▪ Relatively low density.	▪ Largely absent, or very low density.
ɜments were	▪ Some were probably resident but mostly present as local migrants and nomads.	▪ Present only as occasional migrants and nomads, and probably mainly as travellers between the coastal/sub-coastal areas and the Gariep River.
is mosaic of	▪ Occurred mainly in the wide river valleys vegetated with riverine forest and thicket.	

There is an account, from 1821, of a journey on horseback down “elephant paths” through the forest on the southern slopes of the Zuurberg Mountains, and several accounts refer to the “labyrinth of elephant paths” at Langebos, in the forest south of the town of Alexandria. There are also references from 1779, 1815, 1818 and 1850 to “elephant paths” in the Albany and Bathurst Districts.

Extensive use was made of the elephant paths by early travellers and hunters to penetrate and pass through the thickly vegetated areas, and mention is made of the use of the paths as ambush sites by opponents during tribal conflicts and during the Frontier Wars of the 19th century. Elephant paths were also readily used by hunters to facilitate access to their quarry in dense vegetation.

The above accounts clearly illustrate the actions of elephants in “opening up“ the dense vegetation. This is an ecological process that will have ceased to operate when the elephants were exterminated from almost the entire Eastern Cape.

Long distance movements

Elephants are known, throughout their global range, for their ability to undertake long-distance movements. The historical record alludes to such behaviour in the Eastern Cape.

There is a statement from 1931, the source of which cannot be traced, that “Addo elephants used to trek considerably – even as far as the Knysna forest”. Similarly, an account from the 1850s alludes to the possibility of elephants, disturbed in the Fish River valley by the early frontier war of 1836, trekking eastwards through the King William’s Town District and across the Great Kei River to the Umzimvubu district in the Transkei. Other written accounts also make mention of elephants moving across the landscape, in some cases possibly in response to hunting pressure.

Based on archaeological finds from the Karoo, and historical accounts, it has been surmised that as recently as 1750, i.e. 250 years BP, elephants moved freely between the coastal and subcoastal parts of the Eastern Cape to the Gariep River in the north, via Cradock and Colesberg. Such a migration pattern is surely feasible, given the ability of elephants to cover long distances in highly arid areas, e.g. in the Kaokoveld region of north-western Namibia.

General

The written evidence suggests that the elephants in the broader region undertook local movements, including those between adjacent river valleys. The (unsubstantiated) reports of long distance movements, some possibly in response to disturbance by humans, are intriguing. Did the elephants exploit local food resources and then move on when these became depleted ? And to what extent were any movements related to behavioural and genetic patterns and requirements, respectively ?

Demise

It would appear that the San, the Khoi and the Bantu-speaking peoples did not undertake large-scale exploitation of the elephants and that they used only those elephant products that they acquired through low levels of utilisation. For example, the Xhosa people used elephant tusks for making bracelets and other adornments and to them the ivory had no commercial value. There is no evidence of commercial exploitation (in the present-day sense), of the animals by these peoples. This low level of exploitation is unlikely to have had a significant impact on the elephant population of the broader Eastern Cape region.

The almost total demise of the elephants in the region was undeniably brought about by the direct actions of people of European descent. The destruction began at least as early as 1702, when a large party of European hunters arrived in the Algoa Bay area in search of ivory. By 1736 elephant hunters had penetrated as far

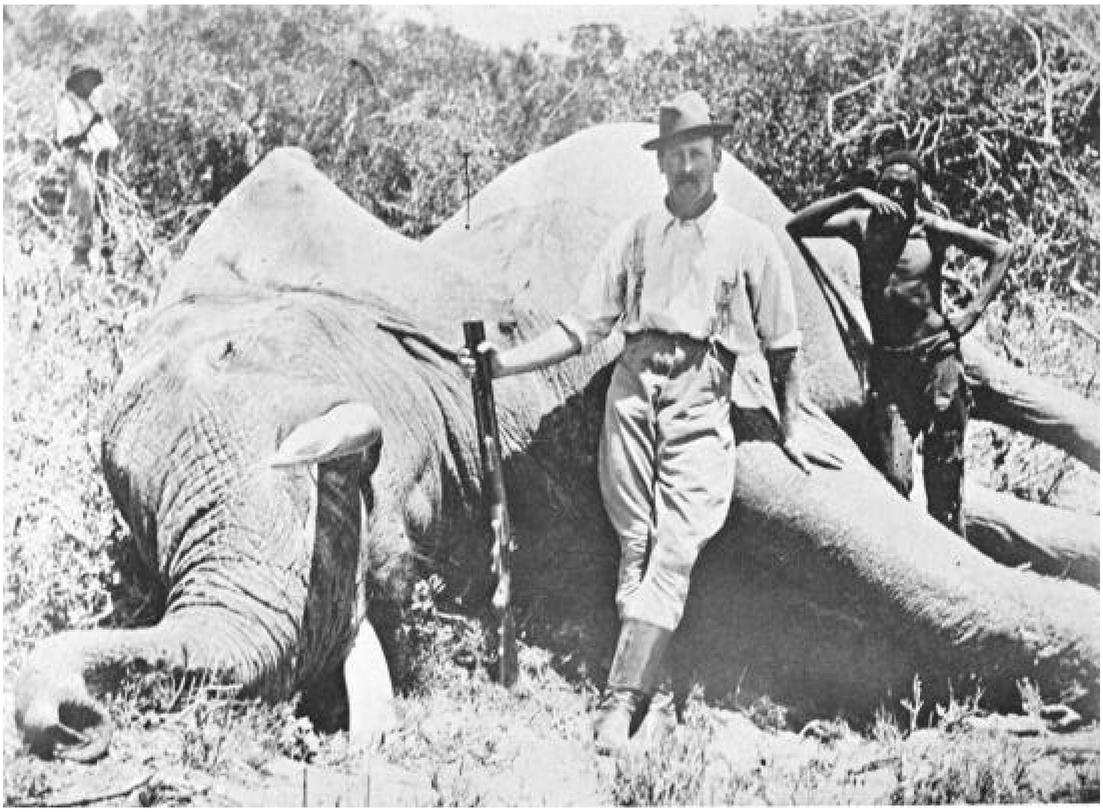

Plate 2. European hunters in search of ivory were largely responsible for the destruction of the elephants. They often used “a short, thick elephant gun with a bullet weighing a quarter of a pound”. Pitfall traps were also commonly used to kill these animals.

eastwards as Pondoland, in the eastern Transkei, and there is evidence that they were active in 1752 in the Gamtoos River and Keiskamma River areas. During the 1770s there was severe hunting pressure in the George-Tsitsikamma area and the elephant population there was in a state of decline, leading to its virtual extinction in “Outeniqualand” (the area between Mossel Bay and George) by 1775, although elephants were “still present” beyond the Keurbooms River in “Sitsikamma”. In 1773 pitfall traps for elephants were operating at Loerie, 15 km east of Hankey, and in 1775 “white men” were recorded hunting elephants in the area of the Sundays and Bushmans rivers. There were “many” hunters active in the Peddie and King William’s Town districts during the late 1700s and early 1800s, and whilst elephants were still abundant in certain areas, their decline was noted in others. The operation of pitfall traps in the George area was noted in 1782, as was the virtual elimination of the elephants from the area south of the Outeniqua Mountains. In 1782 elephants only occurred “sparingly” in the Swart River area, between George and Knysna. It is noted in the historical literature as far back as 1775 that the elephants in the Knysna-Tsitsikamma area had become exclusively forest dwellers, apparently in an attempt to escape the persecution.

In 1790 it was reported that elephants were being killed for ivory in the Transkei and there is reference to the possibility of thousands of kilograms of ivory being purchased from hunters at the time. In 1797 it was recorded that elephants were “becoming scarce” in the King William’s Town district and by 1803 hunting had removed them all from the above-mentioned Swart River. In 1818 “marauding elephants” were killed at Enon Mission, east of Kirkwood, and by 1823 there were “few” remaining in the George area. By the early 1900s the George-Tsitsikamma population had been reduced to around 50 individuals (Table 1).

Table 1: The decline of the George-Tsitsikamma elephant population, 1650-2001, based on historical evidence.

Year/Period	Estimated numbers
1650	1000s ?
1876	400-500
1879	"not less than 200"
1884	200
1900	40-50
1905	20
1910	15
1920	13
1925	12
1969/1970	10-13
1990	4
2001	3

The destruction of the elephants in the area eastwards from Humansdorp appears to have reached a peak during the 1820s and 1830s. A market, where large amounts ivory were traded, was established at Fort Willshire near Alice in 1824 (see earlier), and nearly 8000 kg of ivory were exported from the harbour at Port Elizabeth in 1837. Ivory markets were also established at other localities in the region - for example, there was a market operating at Grahamstown around 1850. The information relating to the volumes of ivory that were traded at Eastern Cape markets, and exported from its harbours, must be treated with caution. It is known that many of the early hunters and traders made trips far into the interior of southern Africa and then transported ivory and skins to the Eastern Cape for sale on local markets. In addition, hippo ivory was readily acquired and traded.

By 1820 the decrease in the elephant population in the Albany and Bathurst districts had been noticed, although they were still present in the area. The persecution was relentless. For example, in 1826 the sons [of one David Cawood] "paid £30 for a great-gun and shot about 100 elephants near the Fish River mouth" [the "great-gun" is considered to have been a large so-called "elephant gun", probably of .450 calibre].

There is a record from the 1820s of elephants being hunted at Langebos, south of Alexandria, and the last elephant in the district of Salem, south-west of Grahamstown, was killed in 1826. In 1839 it was stated that whereas elephants used to "abound" in the Albany and Bathurst districts, and in the Great Fish River area, they were now "rarely seen" and they appear to have become extinct in Lower Albany around the mid-1840s. In addition to the quest for ivory, the elephants were undoubtedly shot in the name of sport, as evidenced by accounts of hunts in the country between the Keiskamma and Great Fish rivers in 1845.

By 1850 there were "a few" elephants at Addo and Zuurberg, and traces of "old paths and "bones" could still be seen in at places in the Albany and Bathurst district. By the early 1850s there was "nothing to be seen" of elephants in "British Kaffraria" (the land between the Great Kei and Great Fish rivers) and they had "years ago left the retreats of the Fish River Bush". In the 1860s there were possibly between 60 and 70 individuals remaining in the "Addo bush" and the last elephants in the Bathurst district were destroyed during the first decade of the 20th century. Clearly, the elephant population in the area had been severely reduced by the mid-1800s.

The direct persecution of the elephants in the Addo area, as part of a government-sponsored programme to protect agricultural developments, the scarce water supply and human lives, is well known. Briefly, a contracted professional hunter, Major P J Pretorius commenced the killing in June 1919 (when the population was in the region of 130 individuals) and by August 1920, when the programme was halted, had destroyed around 120 elephants, sparing only 16. By 1931, when the Addo Elephant National Park was proclaimed, the Addo population had declined to a mere 11 individuals. These animals formed the nucleus of the present population of over 320 individuals in the Park (see Whitehouse & Knight, in this volume, for more details).

Elephants were present in southern KwaZulu-Natal (KZN) until the 1870s. Only after 1820 did the elephant hunters move their activities from northern KZN to southern KZN and the Transkei, and mention is made of the removal of thousands of kg of ivory. By 1826 the decline in the population in eastern Pondoland had been noted and the last known record of elephants in western Pondoland was made in 1860.

Plate 3. Mr Hume's Waggon (sic) with Ivory and skins from the Interior of Africa on the Grahamstown Market. December 26 1848. Painting by T Baines, Albany Museum (History).

The end of the road

The destruction of the great herds of elephant, that were once a prominent feature of much of the broader Eastern Cape, commenced in earnest in the early 1700s and gathered momentum to reach a peak during the late 1700s and the early 1800s. The 1820s and 1830s appear to have witnessed their destruction on a huge scale. By the mid-1800s they had become scarce throughout the region, and by the end of the century virtually all the remaining herds had been destroyed. By 1900, or shortly thereafter, the elephants had been extirpated from the region in question, save for the two tiny relict populations – one in each of the Knysna and Addo districts – comprising fewer than 25 individuals in 1931. The elephants were killed mainly for their ivory and other products, but apparently also for sport, sometimes seemingly in the form of wanton killing. To a far lesser extent, marauding elephants were killed to protect crops and even human lives; the sanctioned persecution of the Addo herds is a notable example here.

Apart from the large-scale destruction of the elephant herds in the region, the settling and development of large parts of the land by European settlers had another far-reaching impact on the remaining populations. This was the permanent blocking of migration corridors, by the erection of buildings, roads, fences, dams, canals, ditches and the like, and the significant transformation of the habitat within such corridors. This precluded the possibility of natural movement of individuals between the Knysna and Addo populations, and between these populations and those far to the north in northern KwaZulu-Natal.

The elephant is, however, an important component of the region's ecosystem and it is therefore desirable that it be re-introduced as widely as possible, in suitable habitats. The decade of the 1990s, and the early 2000s, has seen many commercial farms in the Eastern Cape and adjacent regions being consolidated and converted to wildlife-based tourism operations. Some of these are now witnessing the re-introduction of small herds of elephants. In addition, the elephant population in the Addo Elephant National Park has shown positive growth. Thus, after declining almost to extinction, the overall population of elephants in the region in question has slowly increased, to some 425 individuals in early 2002.

Acknowledgements

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The Addo population: population history and present status

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Introduction

Addo Elephant National Park (AENP), situated approximately 60 km NNE of Port Elizabeth in the Eastern Cape Province of South Africa, was established in 1931 to preserve the last remaining elephants in the region. Prior to the arrival of European settlers, elephants roamed throughout South Africa, with an estimated population size of 100,000 in 1650 (Hall-Martin 1992). However, by 1900 extensive hunting had virtually eliminated elephants from the country. Just four small remnant populations remained at Olifants Gorge in the Transvaal (this area was later to become part of the Kruger National Park), Tembe in northern Natal, Knysna on the Cape south coast, and at Addo in the Eastern Cape (Hall-Martin 1992). The single largest population ($N \approx 130$) was at Addo, where the elephants' survival has been attributed largely to the dense and impenetrable nature of the region's Valley Bushveld (Acocks 1975) vegetation, which "formed a barricade daunting even the most intrepid adventurer" (Archibald 1955).

In the early 1900s, developing agriculture led to conflicts between the elephants and local farmers in the Addo region (Hoffman 1993). These conflicts resulted in demands for the extermination of the elephant population, and a professional hunter, Maj. P. J. Pretorius, was hired to undertake this task. Between July 1919 and August 1920 he killed approximately 120 elephants in the area (Pretorius 1947), but fortunately the slaughter was halted before the task was completed, and 16 elephants were left. These were initially given no proper protection, and numbers dwindled during the 1920s. The proclamation of AENP in 1931 finally provided protection for the 11 surviving elephants.

Reconstruction of population history

The history of the population since the creation of the park in 1931 has been reconstructed (Whitehouse & Hall-Martin 2000) using photographs analysed in conjunction with all available written records (SANP reports, rangers notes, newspaper articles, published papers, etc.). Elephants can be identified in photographs taken throughout their life by study of their facial wrinkle patterns and the blood vessel patterns in their ears, which are unique for every elephant and do not change throughout their life. More than 8600 dated photographs of the Addo elephants taken between 1934 and 1996 were compiled and analysed. The photographs were obtained from SANP archives, newspaper archives, local photographers, families of early park wardens, and responses to national public appeals. Individual elephant life histories were traced, dates of birth and death were estimated and, wherever possible, the identity of the individual's mother was ascertained. Maternal family trees of the entire population (dating from 1931 to the present) were compiled. The resulting detailed demographic data set, spanning a period of 70 years, was used to facilitate further analyses of the population.

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Founder population

Records left by Trollope, the park's first warden, in the form of letters and reports are not entirely clear as to the exact size and composition of the founder elephant population in 1931. The most detailed information is in a report submitted to the National Parks Board by Trollope on 1st November 1931, in which he writes:

"With regard to the number of elephants I am sure of not less than 10, there may possibly be 11, but not more… They are a sociable troop, there is one big bull and another more than half grown, the balance are females and young things" (Trollope 1931)

Reconstruction of the population's history makes it clear that the initial population size must have been Trollope's higher estimate of 11 animals. These consisted of eight females (six sexually mature, and two immature) and three males (two mature: one full-grown, named Pretorius, and one half-grown, WMB; and one male calf, HT).

Early population growth

The early growth of the Addo elephant population following the creation of the park was hindered by the loss of all of the population's founder males and by the lack of a secure boundary fence (Whitehouse 2001). Each of these will be considered in turn:

Loss of the founder males

On two occasions during 1932 the adult bull WMB destroyed one of the windmills used for pumping water within the park. Costly repairs were necessary, and as a result the park management gave instructions for WMB to be shot. In 1937 the other founder adult male, Pretorius, killed an elephant calf and then later in same the year he killed one of the park's rangers. Consequently, this bull was also shot.

The destruction of these two bulls left no sexually mature bulls in the population. The only other male in the founder population was HT, and he was not yet sexually mature. In 1940, before reaching sexual maturity, HT was hit by a train whilst roaming outside the park, and was killed.

There were 18 births between 1931 and 1938, when Pretorius' last offspring were born, and population size at the end of 1938 was 25 animals. A nine-year hiatus in recruitment followed, during which population size decreased to 18. The first male calves born in the early 1930s reached sexual maturity in 1946 so that recruitment resumed in 1948 (elephant gestation period = 22 months).

The hiatus in recruitment resulting from the deaths of all three founder males not only considerably slowed the initial rate of recovery of Addo's elephant population, but also imposed a considerable risk on population persistence. Although the park had been recently proclaimed in order to preserve the elephant population, within seven years management had reduced the effective population size to zero. The susceptibility of small populations to demographic stochasticity is well understood by conservation biologists today (Goodman 1987). Clearly the survival of male calves to sexual maturity, preventing extinction of the Addo elephants, was good fortune rather than good planning.

The need for a fence

Between 1931 and 1954 AENP was not surrounded by a secure boundary fence (Pringle 1948, 1973). Elephants frequently broke out of their proclaimed protected area, and this resulted in many deaths. Seven mature elephants and two calves were shot by farmers in retaliation for the damage they caused whilst on the farmers' land, and two elephants were involved in fatal collisions with trains whilst outside the park.

An elephant-proof fence was constructed in 1954. This led to a significantly decrease in population mortality (from 5.0 % prior to 1954 to 1.2 % post-1954, Figure

1) and a significant increase in annual population growth (from 3.2 % prior to 1954 to 6.1 % post-1954). Although it is clear that the lack of a secure fence markedly slowed the populations initial rate of recovery, it should be noted that management did realise the urgent need for a fence long before 1954 (Pringle 1948). However, construction of the fence was delayed by lack of technical expertise, as the there was no known means at that time of confining elephants who were determined to escape. It took several years for Graham Armstrong (Park Warden, 1943-55) to devise a structure which did prove to be elephant-proof (Pringle 1973)

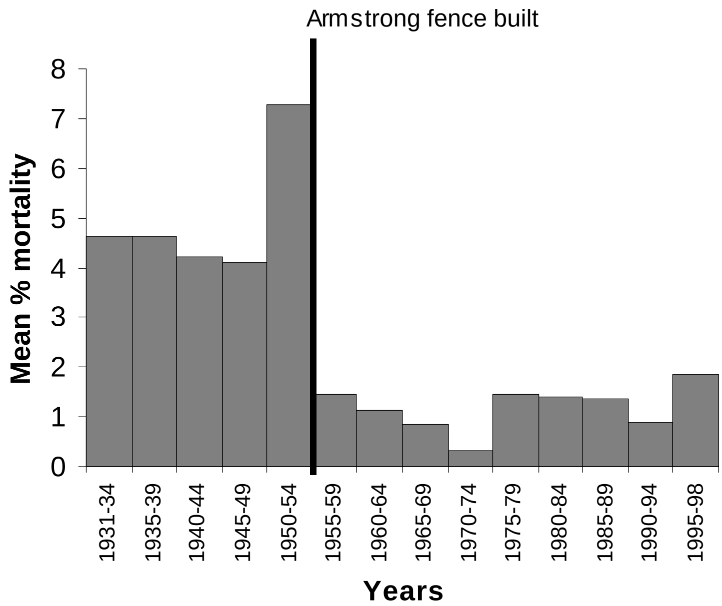

Figure 1. Addo elephant population mortality, 1931 – 1998. Mortality for the population as a whole was calculated as a percentage of population size for each year. Here, the mean mortalities, calculated for blocks of five years, are illustrated (with the exception of the first and last bars, which represent shorter periods of four years each). The date of fencing of the park is illustrated.

Current population

Since 1954, the Addo elephant population has grown rapidly (Figure 2), with a doubling time of 13.6 years (Whitehouse 2001). Total population size at end 2001 was 336 individuals. Female fecundity is high, with a mean age of first calving of 13.0 years and a mean inter-calf interval of 3.8 years (Whitehouse & Hall-Martin 2000). There are an equal number of immature elephants of each sex within the population, but the adult sex ratio is female biased, due to higher male mortality (Whitehouse 2001).

The population is divided into six matriarchal family groups, and 60 independent mature males (Whitehouse 2001). Mean family group size (N = 46) is considerably larger than elephant group sizes observed elsewhere. The groups range in size from 14 to more than 90, and although not all are cohesiveness, both the smallest and largest groups are relatively cohesive and rarely spit up. The four intermediate sized groups do divide up into stable sub-groups on a fairly regular basis, and these sub-groups may eventually warrant being termed family groups in their own right, with the original groups considered as bond groups.

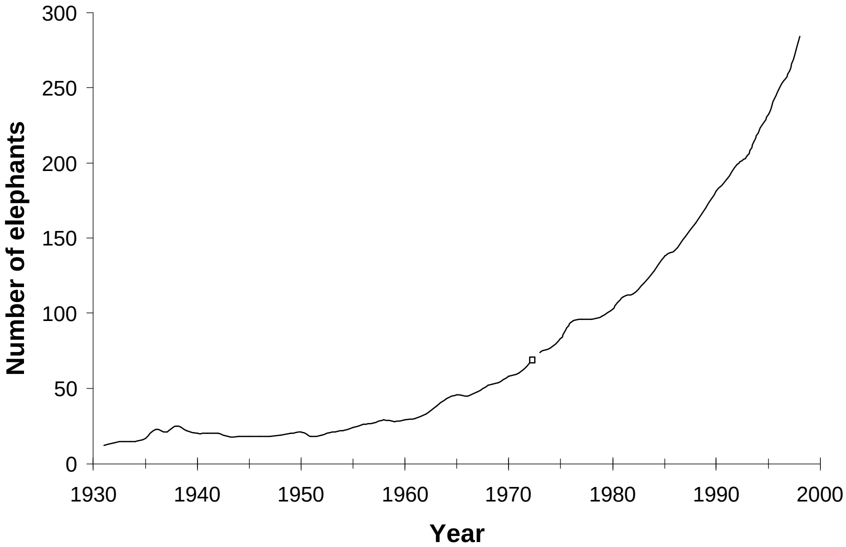

Figure 2 Addo elephant population size, 1931-1998, derived from reconstructed annual population estimates.

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Recently Established Elephant Populations in the Eastern Cape

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Introduction

By the late 19th Century the range of the African elephant *Loxodonta africana* in the Eastern Cape had been reduced to one small population (Hall-Martin 1992). The remnants of this group, found in the dense Subtropical thicket (Valley Bushveld) of the lower Sundays River near Addo, was protected when the Addo Elephant National Park was proclaimed in 1931. At that time there were only 11 elephants left (Whitehouse & Hall-Martin 2000). Since then the protection afforded this population, the management of the park and in particular the provision and maintenance of perennial water sources, has resulted in the population increasing to 340 animals by February 2002. The growth in elephant numbers has, in recent years, fortunately been steadily matched by the purchase of land to expand the range of the population.

With the advent of the technology to translocate elephants over long distances, albeit initially only young animals, the options of establishing new elephant populations in the Eastern Cape became possible. The first such new population was established in the Shamwari Game Reserve from 1992. A small population followed in the Double Drift Game Reserve in 1995, and two more groups were established on Kwandwe Private Game Reserve and Bayethe Private Game Reserve in 2001.

Current Status

These four elephant populations currently number 89 animals. They are made up of a total of 54 successfully translocated animals and 35 calves born in the Eastern Cape. The largest population by far is that of Shamwari which currently consists of 53 animals. The Kwandwe population consists of 23 animals, Bayethe 10 animals and the Double Drift group consists of only three animals.

Source Populations

The elephants of these four populations originated in the Kruger National Park, or the Madikwe Game Reserve in the North West Province. The Madikwe animals in turn were originally introduced from the Gonarhezhou National Park in the eastern lowveld of Zimbabwe. The Gonarhezhou population has historically been continuous with the Kruger population either through direct contact by animals moving across the Limpopo River, or by a more tenuous link, at least until the 1970s through the adjoining Mocambique population. All the Eastern Cape elephants, outside of the Addo Elephant National Park, therefore, are of the same genetic origin.

Location and History

Shamwari Game Reserve

This privately owned reserve is situated in the Albany and Alexandria districts, just off the N2 highway and about halfway between Port Elizabeth and Grahamstown. The property is 18 000ha in size, of which 15 500 ha is available to the elephants. The property is managed primarily as an upmarket tourism destination. The first groups of elephants were introduced between 1992 and 1994 at a time when South African National Parks (SANParks) followed a policy of live capture of calves out of family groups destroyed in the annual elephant culling operations. These calves were between 3-8 years old, came from different areas in the Kruger National Park, and were segregated according to size class.

The introduction of these calves was spread over three years so as to get a better spread of age classes. A total of 22 young elephants were successfully established. This cohort included 8 calves (10 –13 years old) that had originally been moved from Kruger to the Mpongo Game Park near East London and after a few years on to Shamwari. During this phase two calves died due to stress originating from the truck that transported them being overturned in a road accident.

By 1997 the practice of moving calves out of Kruger had been stopped as SANParks by then had the capacity to move entire family groups of elephants. In that year a family group of 9 animals was translocated to Shamwari. Two of these animals died as a consequence of the group breaking out of the introduction boma immediately after offloading. They then went through the boundary fence, and had to be herded back by helicopter. Two animals, the matriarch and a young bull had to be captured. The matriarch was subsequently put down, and the young bull died some time later after never joining up with the herd. In 1999 two young females, that had been moved from Kruger to the Knysna forest and had not settled successfully were captured and moved to Shamwari.

It is unfortunately true that the elephants moved to Shamwari, mainly because of the time when the translocations took place, were to a greater or lesser degree traumatised animals. They have, however, had time to settle and establish more normal social structures. The animals that originated as orphans in the Kruger have bred successfully and are usually found together forming a herd of 39 animals. The family group from Kruger and the two young females from Knysna form a separate herd of 14 animals. The two groups spend some time together, but separate regularly.

The behavioural problems associated with male elephants in Pilanesberg that had grown up as orphans, have also been experienced at Shamwari (Slotow & van Dyk 2001). The oldest male killed a white rhinoceros in 1997 and was euthenased. The next oldest bull was euthenased at the age of about 19 years due to dangerous aggressive behaviour towards vehicles when in musth. Tranquillisers administered to the bull while he was in musth did not curb his aggression. The oldest male in Shamwari is currently about 21 years old.

Double Drift Game Reserve

This reserve is part of a complex of three contiguous provincial nature reserves known as the Great Fish River Complex (Double Drift, Sam Knott, and Andries Vosloo) that covers 45 000 ha along the lower Great Fish River valley. The reserves are managed by the provincial nature conservation authorities of the Eastern Cape.

A group of five orphans from Kruger were introduced in 1994 to a fenced area of 4000 ha at the south-eastern sector of the complex. Two of the animals died within days of their introduction due to pneumonia. The remaining three animals (two males, one female) have since settled. They are now about 10 years old. The main management objective of the reserve complex is biodiversity conservation. Limited hunting, live game sales and increasingly tourism developments are planned to ensure sustainability.

The authorities have an ambitious fencing programme under way that will, when completed, allow the complex to be managed as a single entity. This fencing should be completed by 2003. It is hoped to then introduce a viable population of elephants from the Kruger National Park. The exact number of animals to be introduced has still to be determined. While the carrying capacity of the reserve complex is probably in the region of several hundred elephants, a phased initial introduction of about 50 animals is being contemplated. In the light of current practice, it can be assumed that the introductions will consist of several stable family groups and a number of adult bulls.

Kwandwe Private Game Reserve

Kwandwe lies in the Great Fish River valley, about 35 km from Grahamstown, and upstream of the Andries Vosloo Nature Reserve. It covers 15 800 ha and the vegetation is mostly Valley thicket and Xeric Succulent thicket. The development of this game reserve out of stock farms was initiated as recently as 1998. The only abundant wild species on the properties then were kudu, bushbuck and duiker. Since then a wide range of animal species, including buffalo, black rhinoceros, white rhinoceros, several species of plains game and elephant have been introduced and are now well established. The larger carnivores, including lion, leopard and cheetah, are also present. An upmarket lodge has been opened and is already well known in the local wildlife tourism market.

The elephant population was established through the introduction of four groups of animals. The first introduction consisted of a family group of eight animals from the Malelane area of the Kruger National Park that was introduced in August 2001. In September two adult bulls from Kruger were introduced. The larger of these animals is 30-35 years old and the smaller one 20-25 years old. The next introductions were a family group of 9 animals from the Madikwe Game Reserve, and two adult bulls from the Letaba area adjacent to the Kruger, moved in October 2001. As with the two Kruger bulls, it was established before capture that these two animals were moving together, and were familiar with one another.

There were no mortalities during transport but three animals received deep wounds in their trunks, presumably caused by tusks, and were immobilised and treated before release. The introduction boma was well built, set in an area with good vegetation that provided food and cover. An innovation that worked extremely well was the erection of an internal fence parallel to the boma fence, consisting of four slack electrified wires. This introduced the elephants to the “hot wires” before they could get as far as challenging the equivalent of the reserve’s boundary fence. The elephants all settled well in their new environment, with social contact between the two family groups and among the bulls and family groups being quickly established. Of special interest was the fact that the Madikwe herd did not leave the holding boma for 9 days. They appeared quite settled and relaxed, fed and watered normally, but stayed put. This may be due to them having experienced a previous translocation from Zimbabwe to Madikwe.

The Kwandwe elephants have settled well, are good tourism subjects (particularly the bulls) and two calves have been born since their arrival on the reserve. The current Kwandwe elephant population now stands at 23 animals.

Bayethe Private Game Reserve

This is a smaller, recently established reserve. It is currently only 4000 ha in size but there are plans to significantly increase the size. Bayethe is situated around the small historical village of Sidbury immediately to the east of Shamwari and close to Grahamstown. Access to Bayethe is just off the N2 highway. The vegetation is a complex mosaic of not only Valley Bushveld thicket, it also has a significant area of open grassland, Afromontane forest along drainage lines, and thicket of the Albany type that is rich in plant species diversity. The reserve has a fine upmarket lodge and is intended to cater for primarily overseas visitors.

Like Kwandwe, it was until relatively recently still used for livestock, with a portion of it (Welcome Woods) being developed earlier for wildlife. Good populations of plains game have been introduced as well as buffalo and white rhinoceros.

A family group of elephants was moved from Madikwe late in September 2001. The operation was dogged by problems. The truck transporting the animals broke down on the road and was delayed for 12 hours. The total time that the elephants spent in the transport containers was 42 hours. To compound the difficulties there had been a massive downpour at Bayethe during the time that the elephants were in transit. As a consequence of the rain and flooding the truck could not get to the introduction boma and the animals were released directly into the veld without any time to be reminded of the potential effects of electric fences. A further complication soon after their release was a rockfall from a steep cliff that damaged part of the boundary fence, breaking the electric circuit. The elephants left the reserve through the damaged fence and had to be driven back by helicopter. A few days later the elephants broke through another boundary fence and the matriarch had to be shot in defence of life. Since then the remaining animals settled down and a new calf has been born. The family group was augmented in October 2001 by two adult bulls (25-30 years of age) from the Letaba area adjoining the Kruger National Park. These bulls were kept in the introduction boma for 4 days and no problems have been experienced, or are expected from them. As with the bulls introduced to Kwandwe, it was established before capture that they were companions.

Conclusions

Transport

Until recently the SANParks game capture unit based at Skukuza was the only entity capable of moving breeding herds of elephants and adult bulls. Operators in the private sector have now also acquired the skills and equipment to move these categories of elephants safely. The breeding herds moved from Madikwe to Kwandwe and Bayethe were handled by Specialist Game Services (Kester Vickery) of Heidelberg. This company also handled the capture and transport of the four adult bulls moved from the Letaba area adjacent to Kruger to the Eastern Cape.

Introduction boma

The importance of the proper design and construction of the introduction boma and the critically important role that it plays in training elephants to respect electric fences (Carr 2001) has been confirmed by the experiences in the Eastern Cape. The problem that Shamwari had with the breeding herd breaking out of the reserve was due to them not spending any time in the introduction boma as they broke out immediately upon release through a weak gate. The circumstances around the breeding herd at Bayethe can also be described as a direct consequence of the animals not being held in an introduction boma.

Break-out protocol

The experience gained in earlier introductions in the Eastern Cape and elsewhere in the country more recently was put to good use during the Kwandwe and Bayethe operations in setting up “Break-out protocols”. This included radio collars on matriarchs and adult bulls, as well as a helicopter and capture equipment on standby during the first few days after release. When required, as in the case of Bayethe, it was possible to act quickly and successfully.

Management issues

The managers of the four Eastern Cape elephant populations documented here are fully aware of the need to monitor the ecological impact of elephants in small areas. They are supportive of initiatives to develop appropriate monitoring systems. The uniformity of the vegetation structure of these four areas and the Addo Elephant National Park indicates that it would probably be possible to apply the same monitoring techniques to all these areas. It is also clearly understood that the long-term requirements of elephant management on these properties may include population control in some form. To this end some definitive conclusions as to the applicability of different proposed elephant contraception methods are deemed highly desirable.

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The economic value of elephants – with particular reference to the Eastern Cape

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Introduction: what is "economic value"?

It is important to differentiate between *intrinsic value* (inherent worth) and the concepts of *financial value* and *economic value*. "Financial" usually refers to the actual income/expenditure figures of a business or project and is concerned with profits or balancing the budget. "Economic" implies a much bigger social dimension, and economic measurements may include other important social goals, such as employment or conservation.

"*Value*" is an anthropocentric or human-centered concept – and is therefore not a reflection of the intrinsic or actual *worth* of something. Value is not static, but changes over space and time and from person to person. It is a reflection of availability (supply) and perceived need, relative to other needs (demand). The value that individuals or society places on something is also affected by information (i.e. how much do we know about it and its importance) and whether there are any substitutes available. It is often culturally based.

The shift during the last century towards putting a value on wildlife is largely due to the increasing scarcity of wildlife. This coincides with an increase in institutional arrangements, including legislation to protect or restrict access to wildlife resources, and incentives for wildlife conservation, including privatisation of wildlife resources. Decision-makers – both public and private – need to make choices about where to spend money. It is often very difficult (in the absence of ethics) to make sound judgements regarding budgets, investments, etc. without having some quantification of relative "values".

How can value be measured?

In a perfect marketplace, the price of say, an elephant, would reflect its total economic value (TEV, or the sum of direct use + indirect use + non-use values) – but there are no perfect markets. Many aspects of the value of an elephant are not captured by the market – and are therefore very difficult to quantify. Many people (including many economists) believe that it is not possible to measure the total value of wildlife, but the past few decades have seen considerable efforts to develop methods for quantifying at least some of the values. These are expressed as a monetary figure – since exchanges in the market place are usually accompanied by money changing hands.

Total Economic Value of Elephants to the Eastern Cape			
Use values			Non-use values
Direct use values	Indirect use values	Option value	
Products (primary, secondary production): meat, hides, ivory, live animals, crafts Amenity: tourism, recreation Research, education	Ecological functions e.g. nutrient cycling; contribution to biodiversity processes	Future uses: all categories	Existence value Bequest value Spiritual value (Intrinsic value)

The use value of wildlife to early man was probably restricted to subsistence hunting for food and clothing, although some species later assumed greater significance, e.g. the religious importance of cats in Egypt and cows in India. Subsistence hunting was later expanded to include recreational hunting, commercial cropping and commercial trophy hunting. Increasingly recreational "viewing", or tourism, is becoming the economic activity of choice.

Today, the economic value of elephants to the Eastern Cape is largely a reflection of:

- Direct (non-consumptive) use: elephants are key drawcards for the growing tourism industry. This is a balance of the need for recreation (on the demand side) and opportunity costs (on the supply side). Benefits include direct income to households through employment, ownership or equity in tourism-linked businesses, foreign exchange earnings for the government, and government income through taxation of individual earnings, sales taxes and corporate taxes. Much of this economic activity can be tracked and measured.
  - The tourism product is focussed on wildlife viewing tourism – either low numbers / high paying (no self drive, overnight lodges – e.g. Shamwari) or high numbers / low budget (self-drive, camping or day visitors – e.g. Addo). Safari hunting tourism does not apply to elephants in the Eastern Cape at this stage and would probably conflict with the sensibilities of the current tourist market – in other words, it is likely that hunting of elephants would be in direct competition to elephant viewing. The importance of elephants to international tourists seeking a "Big 5" experience should not be under-estimated.
  - A spin-off of the attraction of elephants for tourism, is that large tracts of landscape need to be set aside for elephants – and large numbers of "lesser" species are able to survive together with elephants, whether they have a large economic value or not.
  - Non-measured benefits include recreation value measured as "consumers' surplus" – in other words, the actual price paid for the tourism experience is less than the value (or benefit received). This means that the price charged for the experience could increase.
- Indirect use as keystone species (megaherbivores) in the ecological functioning of the Thicket Biome. Apart from their importance in ensuring biodiversity conservation as a spin off of conservation use and management of land, elephants play an important biological role in ecosystem functioning, ensuring the survival and continued evolution of many species.
  - This value is not usually measured or captured. However, work is underway to quantify some of these ecosystem benefits – such as research at Addo to calculate elephant seed dispersal.
  - Species conserved for current or future use as a result of the umbrella role of elephants, may themselves have direct use value for amenity, medicinal or horticultural purposes – such as buffalo, aloes or plumbago. There is also a trade-off, as elephants may impact negatively on certain species.
- Non use values
  - The global concern for the continued existence of elephants is expressed by the donations of public money expressly for the elephants' cause, or for conservation and community benefits.

The direct use value of elephants to the Eastern Cape is primarily linked to tourism, since availability of (and demand for?) elephant products such as meat, hides and ivory are low. Numbers of elephants in the Eastern Cape are low and the market for live sales is limited. Indirect use values are difficult to quantify, but are a very important component of total economic value. Such values relate to the importance of elephants to ecological functioning, contributing to a range of ecosystem services, including biological diversity.

Non-use values refer to the value people who may never even see an elephant place on their continued survival. Non-use values can be very important if ways can be found to appropriate or “capture” the value. This has been achieved to a certain extent with regard to elephants in the Eastern Cape – as shown by the considerable donations made by international organisations, such as IFAW, to elephant conservation as well as grants from the GEF for biodiversity conservation and community benefits.

Elephants in the Eastern Cape: current status

Until fairly recently, elephants in the Eastern Cape were limited to the AENP. A number of privately owned reserves have recently introduced small herds, in order to attract tourists, especially international tourists.

Reserve	Size, location	Number of elephants	Main activities	Notes: Economics / Finances	
Addo Elephant National Park	14 000 ha elephant camp; plans for >200 000 ha Kirkwood / Paterson	335 (up from 11 in 1954)	Self drive Day / night visitors Guided drives Hiking Horse trails No hunting	120 000 visitors: ± 90 000 day ± 30 000 night	Mostly public sector driven (through national fiscus) Some new concessions and public-private partnerships Must show social benefits and equitable sharing of benefits
Double Drift (Fish River complex)		Currently only a few, but plan to introduce larger herds			
Shamwari Private Game Reserve	18 424 ha Paterson / Albany	60 (first 5 orphans introduced in about 1991, followed by a family group in about 1996)	Photo safaris Cultural tourism Environmental education Hiking Day packages Lodges Night drives Live sales No self drive No hunting	14 000 visitors: ± 75 % are overnight	Driven by wealthy entrepreneurs with a sense of civil responsibility and a love of nature
Bayeti	2 415 ha Albany District	10 (introduced in Nov 2001)	Photo safaris Hiking Day visitors Night drives No hunting	Opened in mid-Dec 2001: already several hundred day visitors	
Kwandwe Private Game Reserve	13 773 ha Albany district	23 (21 introduced in August 2001)	Photo safaris Hiking Day visitors Night drives No hunting		

Costs of elephants

One of the most important costs associated with elephants in areas of Namibia, Botswana and other parts of Africa where herds are generally not fenced, is the conflict between people and elephants. Elephants can kill people and damage property and are not compatible with human settlements and farming activities. Soon after the AENP was established in 1931, it became clear that the major concern regarding elephants is to minimise contact between elephants and neighbours.

Apart from the costs of land purchase (which is increasing), costs of fencing are one of the major costs associated with elephants and other large mammals. Costs of fencing for elephants ranges from R140 000 per km (AENP “Armstrong fence”) to about R40 000 per km (electrified game fencing).

The actual purchase price of elephants is relatively low, when compared to other large game like rhino – an indication of their relative abundance on the market. Small breeding herds (usually 8 – 10 animals) cost about R15 000 – R20 000 per head. Transport costs about R15 per km. However, the cost of bull elephants are high, because bulls are important for the hunting market and a large bull (with large tusks) can fetch as much as R250 000, whether it is to be used for hunting or ecotourism. Ongoing costs obviously include staff salaries and other management costs, which may become significant as the herd grows, particularly on small properties. Reserves need to have long-term plans in place for dealing with elephants, which may require significant financial outlay as management costs increase – especially on small reserves. Game reserves need to ensure that they are insured against public liability and damages.

Benefits of elephants

Elephants are a key species in the tourism industry, especially for the international market. However, it is difficult to separate out the value of elephants alone, as compared to the attraction of other “Big 5” species: lion, leopard, rhinoceros and buffalo. All are important draw-cards in their own right, but especially as part of the “package” that is marketed to tourists. Nevertheless, elephants do seem to excite visitors the most, probably because of their sheer size, but possibly also because they are sociable, charismatic and intelligent. Joe Cloete of Shamwari – based on his experience and that of game rangers and guides, suggests that elephants may account for as much as 30 – 40 % of the “reason to visit” or the overall viewing enjoyment of visitors. Predators are also very important to most international visitors. A survey conducted at AENP in 1996 indicated that most visitors to AENP (88 %) want to see elephants, but also want to see a greater variety of species.

Tourism is financially important (even essential) to game reserves, whether public or private. Tourism is also an important industry in the wider economy, due to important linkages to other sectors, for employment creation, and because it is a source of foreign exchange. Tourism expenditure contributes to economic sectors such as transport (air travel, local car hire, petrol), communication, manufacturing (including foodstuffs, beverages, clothing), trade (retail, accommodation, catering, crafts) and the financial sector. Currently, economic statistics are compiled in such a way that the contribution of tourism to the economy is not reflected as a separate sector, and needs to be calculated, based on best available information. The majority of domestic and international tourists to South Africa currently visit KwaZulu-Natal, Western Cape and Gauteng. The Eastern Cape received an estimated 8,2 – 13,6 % share of the national Travel & Tourism GDP in 1999, depending on which survey information is used to estimate the share. Grant Thornton Kessel Feinstein, leading quantifiers of tourism in South Africa, have predicted an average annual growth of the tourism sector of 7 % between 2000 and 2010.

According to a recent SATOUR survey, about 10 - 15 % of international visitors to South Africa visit the Eastern Cape. While the majority of domestic visitors to the Eastern Cape come for the coast or to visit friends and relatives, AENP is a key attraction for international tourists to the Eastern Cape. Most international visitors to AENP travel through the Garden Route as part of their trip and many stay overnight in Port Elizabeth. Smaller enterprises in the Eastern Cape benefit from the marketing expenditure of large operations like AENP and Shamwari. This has spinoffs for private sector initiatives – since the area is a “long haul” destination it is important to be able to offer a range of attractions to encourage visitors to stay longer. The average length of stay of overnight visitors to AENP and Shamwari seems to be around 2 – 3 nights. Only a quarter of visitors to AENP stay overnight. More than 50 % of visitors to AENP are foreigners and a challenge is to persuade more of the 90 000 day visitors to stay overnight, since this will be an important way to increase revenue. Entrance fees for day visitors are ridiculously low and contributed less than

8 % to total income from tourism during 1991 – 1995, declining every year. (Presumably this cost is subsidised by government to achieve wider social goals – but could also be cross-subsidised by international visitors).

Shamwari on the other hand, has specifically targeted the foreign market, since the capital cost of establishing the reserve was so high. When Shamwari opened in 1992, bed nights cost R275 – today the top rate is R3 500 per person per night. One could argue that this increased rate is possible since visitors now have a chance of seeing a wide range of large game, including elephants. It could also be a reflection of increasing demand for the product.

It is very difficult to compare AENP with Shamwari or the newer smaller reserves, since the history, management objectives and institutional contexts are so different. Increasingly however, the objectives of the national park are dovetailing with those of the private reserves, although the emphasis of each is different: primarily biodiversity conservation; or primarily profit making. The increasing value of all forms of conservation is illustrated by the increasing land values in areas surrounding "Big 5" reserves, whether public or private, for example in Mpumalanga near the Kruger National Park, or near Phinda in KwaZulu-Natal. The area between Port Elizabeth and the Fish River is experiencing an important growth in wildlife-based tourism. The higher income potential of game reserves / game farms is reflected in the higher price that new landowners are willing to pay for the land. While a stock farmer cannot afford to pay more than about R700/ha, land suitable for game can fetch twice that amount. The per hectare value of Shamwari (after considerable investment) has probably increased 10-, 20- or even 40-fold over the past decade, although this can only be tested by offering it for sale on the open market.

Issues to be considered

The "use it or lose it" approach to wildlife conservation in favour today is open to question, since this approach is inadequate given the fact that markets are imperfect and many values of species and ecosystems go uncaptured. The wholesale slaughter of elephant herds for the ivory trade is a case in point.

Biodiversity is a public good and it will be difficult if not impossible to pay for conservation through market forces and privatisation alone. Government needs to play an important role – especially in terms of meeting the provisions of the Constitution for fundamental rights such as security, economic opportunities and biodiversity conservation. Government needs to play a regulatory role with regard to environmental management. Tourism as an industry relies heavily on public infrastructure such as roads, airports and services such as water, electricity, communications, policing, etc. Tourism agencies play an important role in marketing.

The Eastern Cape is very poor. Conservation (or farming with elephants) takes land away from other use (i.e. there are opportunity costs). It is important that these costs are not borne only by those who may have obtained jobs on stock farms, for example – while the benefits are felt by land owners, tourism operators, government and tourists. Tourism must increase benefits to poor people: or it will ultimately fail. At the same time – allow the market to reflect true value – as the market dictates that those who value the elephants and the ecosystems of which they are a part, should pay those providing them. If international visitors value elephants more highly, and are willing and able to pay for them, then they should pay more than local people.

Recognition of the value of wildlife increased throughout the last century, but more "traditional" economists and decision makers tend to pay attention only to those values which are captured in the markets. Economic valuation is often contentious when it comes to valuing life, or individual species, but it provides an indication of what society feels about certain options, and how much they may be willing to pay for certain products. Information plays a crucial role in influencing that value – and tourism operators need to manage the expectations of tourists to ensure that the landscape and biological diversity as a whole is valued, and not just a few species.

Elephant translocations and introductions with reference to small populations

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Summary contents of presentation to the workshop on elephant conservation and management in the Eastern Cape Province held at the University of Port Elizabeth on 5 February 2002

Background

Elephant translocation within South Africa has evolved significantly in the last 2 decades. Up until 1993 only orphaned elephants from the Kruger National Park culling operations were translocated in any significant numbers. Apart from the odd exception and tame elephant, no adult elephant were introduced into small reserves.

A number of newly established smaller reserves were stocked with these juvenile elephants (e.g. Pilanesberg, Umfolozi/Hluhluwe, Madikwe) but after a number of years social aberrant behaviour were noticed in a number of the reserves where these young elephants were introduced.

In 1993 Clem Coetzee developed the technique to move adult elephant. His team came to the Kruger National Park who have taken his ideas and refined equipment to be able to move large numbers of elephants in the form of family units and adult bulls. The introduction of functional elephant family units and adult bulls does appear to have solved the behavioural problems seen in populations introduced as youngsters.

No introduction of elephant other than structurally complete family units or single adult bulls is recommended, with the exception of occasional introductions of single animals that would otherwise be destroyed or wandered in from other populations (as seen in the boundary areas of KNP, Botswana and Zimbabwe).

Capture technique

Elephant capture should only be attempted with experienced personnel and the right equipment. Immobilisation of such a large mammal is a specialist function and the biggest difficulty with the recovery system is to get the adult elephant off the ground into/onto a recovery vehicle so that it can be transported to the new destination safely and humanely, without danger to people or traffic.

Basic equipment needed

- Truck with heavy-duty crane
- Recovery trailer and winch
- Recovery chamber for larger elephant to get up in
- Well constructed, strong transport containers

Currently only SANP, Christie Mostert and Specialist Game Services have recovery equipment that can handle adult elephant safely and humanely. Experienced personnel, especially for long-distance trips, must accompany elephants as fighting does occur and tranquillisation will be necessary. Provincial permits are necessary and often are only issued if a proper management plan for the elephant is in place.

Release bomas

All newly introduced elephants have to be kept in a small boma (1-2 ha) before release so that they can become familiar with electric fencing and learn to respect it. The boma must be well constructed and "break-out proof" by being securely fenced with cables and have a good and functional electrification system in place. Elephants must stay in the boma for at least 24 hours but not too long so that they become nutritionally deprived or bored (especially the bulls). Gates must be sturdy and slide and not swing open. All gates must also be electrified at all times. Supplementary food may be needed if more that one group are to be released from the same boma in a short period of time.

Issues on smaller reserves and populations

A proper habitat assessment must have been done and a good idea of the estimated carrying capacity must be known. A management plan for the elephant must be in place before elephants are introduced into smaller reserves.

A proper monitoring system must be in place for newly introduced elephants (radio collar on each herd/mature bull). Microchips are essential for all introduced elephant and photo identikits are also essential for population management.

Fences must be electrified to the minimum specifications as required by the province and is only as good as its maintenance. Unless the fence is an Armstrong fence constant monitoring is necessary. A contingency plan for breakouts is also necessary.

Breakouts

Family units generally do not break out, and are easier to chase back into the reserve than bulls. Bulls between the ages of 25 – 40 years are most problematic and often move rapidly away from the reserve once they have broken out, showing no respect for fences even if they are electrified and functional. The initial breakout can almost always be traced back to a section of fence where the electricity did not work properly or not at all.

It is the intention of SANParks to have basic recovery equipment in place in the major parks outside KNP (Addo and Marekele) so that emergency recovery can take place should newly introduced elephants break out. The human safety element must always be considered, which may mean that, with merit, certain breakout elephants will have to be destroyed. This must be done by experience personnel and as humanely possible for the elephant.

In Summary

- Elephant capture and translocation can only be done if experienced personnel and specialised equipment are used
- A management plan, release boma and functional and maintained fence are prerequisites before elephant can be released onto a reserve
- Radio collaring of newly introduced elephant is essential for proper management and monitoring, also developing an identikit for each elephant
- Contingency plans must be in place to deal with possible breakouts of elephant after release.

Elephant Management in Addo Elephant National Park

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Introduction

The large and increasing African elephant *Loxodonta africana* population (342) in Addo Elephant National Park (AENP) is South Africa's second largest, outside of the Kruger National Park, and the biggest in the Eastern Cape. However, of equal significance it remains the only surviving population in the Eastern/Westen Cape, with the exception of the last few individuals in the Knysna forests, thus making the conservation of the Addo population from a genetic perspective very important. The fact that the Addo population arose from a small founding group of 11 animals has lead to a genetic bottleneck, the implications of which will be discussed below and elsewhere in the proceedings.

Addo Elephant National Park was proclaimed in 1931 with the express purpose of conserving the remnant elephant population (Hall-Martin 1992). But rather fortuitously, and not from design, this led to the conservation of the now threatened Subtropical Thicket vegetation type, as well as a remnant population of the disease-free eastern Cape buffalo *Syncercus caffer* population. It has also become one of South Africa's important conservation areas for the endangered black rhinoceros and in particular the arid-adapted ecotype *Diceros bicornis bicornis.* With the vision to expand the park as part of the greater Addo programme, the incorporation of a broader diversity of vegetation types within the park has now taken a more biodiversity focus in its development and management goals. This is reflected in the Park's conservation objectives which are 'to maintain biodiversity and ecological processes, with an emphasis on preserving the unique floral assemblages and associated large herbivore species, particularly the African elephant *L. africana*, and black rhinoceros D*. b. bicornis' (*Knight & Castley 1999).

Thus, the management of AENP's elephants as discussed below is done in the context of an expanding park, with the aim of incorporating more habitat for the growing population. A suite of concerns associated with conserving elephants need be considered, many of which will be of relevance to private land owners with elephants or wanting to establish their own populations. These are listed below with examples from the AENP situation:

1. Population policy

A reserve-specific and coherent elephant policy as part of a management plan remains an essential component of any reserve management. It sets the framework by which elephants are established and how they should be managed. Such policies should incorporate the following issues:

- **Management goal**: for biological, tourism, recreation, hunting or a combination of reasons need to be defined;
- Population size and notion of **population viability**: Effective population sizes of between 50 - 500 breeding adults are thought to be viable in the long-term (Franklin 1980). Current thinking suggests around 200 adults is a minimum effective population size which has implications for small population management.
- **Genetic diversity**: the founding population size and origin is important, as the larger and more diverse the group the greater the genetic diversity (or heterozygosity) and hence less probability of inbreeding depression problems. A founding population of not less than 30 individuals appears to provide sufficient genetic diversity (Lacy *et al.* 1995). The isolation of conservation areas requires

population supplementation at frequent intervals, with a minimum of one breeding adult once per generation thought to suffice most small populations.

- **Meta-population management**: To minimise genetic and demographic problems associated with small isolated populations, a suite of such non-viable populations should be managed collectively as one larger viable population or meta-population.

Fundamentals of the AENPs elephant policy

Goal:
To conserve a viable population of the remnant E. Cape elephant population in the Addo Elephant National Park.

How:
1.Viability: Maintain an effective population of a minimum of 200 breeding adults (ie > 600 total population), within a single area of no less than 300 km^2.
2. Maintain the ecological carrying capacity (ECC) for specific vegetation types at:
- Subtropical thicket: <2 elephant km^{-2}
- Nama Karoo & grasslands: <0.1 elephants km^{-2}
- Savanna (Eastern Thorn Bushveld): <0.6 elephants km^{-2}

3. Genetic diversity: Maintain as genetically diverse a population as possible through population supplementation of at least one breeding individual (preferably bulls) per generation (ie 15 years) from the closest original resident population (ie Tembe, KNP, Tuli in that order).
4. Meta-population management: Until such time as the population exceeds an effective population size of 200 individuals pursue a meta-population management approach with other appropriate elephant populations in the region.
5. Population regulation: To actively seek the most humane and cost effective means of population regulation through:
- Conservation range expansion through active land purchases and other contractual means in consultation with the conservation plan for the greater AENP.
- Transfer (preferably through sales) of animals to new conservation areas.
- Implement contraceptive means of population regulation only once it has been proved to be an effective and humane method, readily implementable in large free-ranging populations.
- Standard culling operations once all other alternatives have been exhausted.
- Implementation of selective and ethical hunting operations in accordance with park policies and park management plan.
- Implement selective problem animal control of specific individuals noted to show persistent aggression towards humans or endangered species such as black rhinos.

6. Break out policy: Develop a break-out management plan in conjunction with surrounding land owners and provincial authorities to handle elephant break outs. The safe retrieval of the animal/s as soon as possible is the first option, with shooting to be used only as a last resort.
7. Monitor elephant impacts on the vegetation and other herbivore species composition through scientific research.

Consideration of the **founder population size** is an important aspect in long-term population management. Genetic models predict that the smaller the founder group, the lower the probability of the population surviving and similarly the lower the genetic diversity of the population (Figure 1). It also indicates that smaller populations are more susceptible to catastrophes.

Population **supplementation** remains a key management tool in boosting genetic diversity in small populations. The introduction of a minimum of one breeding individual per generation appears to be sufficient to boost genetic diversity and the probability of population survival (Figure 2).

Managing a group of small non-viable populations as one single larger population (known as **meta-population** management (Levins 1970)) by transferring individuals between satellite populations has positive survival and genetic consequences for the individual populations (Figure 3).

The above principles are being incorporated into the genetic management of the AENP elephant population. Whitehouse & Harley (2001) showed that as a result of the small effective founder group size of seven animals, the AENP population went through a genetic bottleneck that has resulted in a genetically homozygous population. As a result, SANParks plans to supplement the Addo population with adult bulls from the heterozygous Kruger National Park (KNP) population in 2002. These bulls will be introduced into the present elephant camp and new areas to be stocked with breeding groups from the main population. Breeding groups from Kruger may be introduced to new areas in the park at a later stage, initially well removed from the present population, but that would later be incorporated into the park. Furthermore, it may be prudent to extend this approach to the other Eastern Cape elephant populations as part of a regional meta-population strategy.

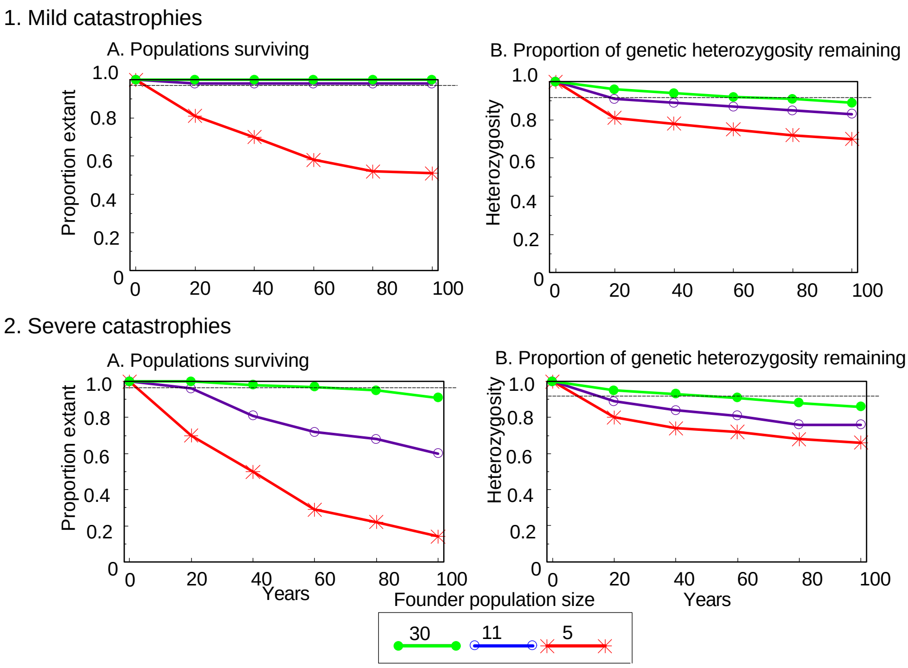

Figure 1. Population survival and genetic heterozygosity in populations with different founder population sizes in responses to mild and severe catastrophes (mild= survival in drought (70%), from poaching (85%) and disease (95%); severe= survival in drought (60%), from poaching (80%) and disease (90%)).

2. Habitat suitability and available areas

In estimating the 'ecological carrying capacity' (ECC) of conservation areas, the vegetation types, their extent, distribution and condition need be assessed. Estimation of ECC's remains unprecise given the dynamic nature of climate-soil-plant-animal relations and hence only provide rough guidelines by which to stock areas. Hall-Martin & Barratt (1991) estimated that the ECC for the Subtropical Thicket associated with the present elephant camp in Addo was about 2 elephants/km^2 . This was based upon a stabilisation in plant canopy volume at this density of elephants. However, for the greater AENP, Boshoff *et al.* (2001) estimated that only about 50% (1870 km ^{2}) of the 5686 km^2 large greater AENP planning domain would be suitable to carry elephants on a permanent basis, 30 % (1110 km^2) on a seasonal /patchy basis and the remainder (720 km ^{2}) not at all (Figure 4). Using agricultural LSU equivalents Boshoff *et al* (2001) estimated ECC varied from as low as 0.02 elephants/km^2 in Noorsveld to 0.54 elephants/km^2 (about four times less than that estimated by Hall-Martin & Barratt (1991)) in savanna-thicket mosaic vegetation types, with an estimated total population of about 800 elephant over the entire proposed planning domain. Estimating the expected elephant stocking rates helps considerably in the park planning, development and subsequent management process. It also forms the basis for any monitoring programme setting a baseline against which one would need manage adaptively and reassess ECCs.

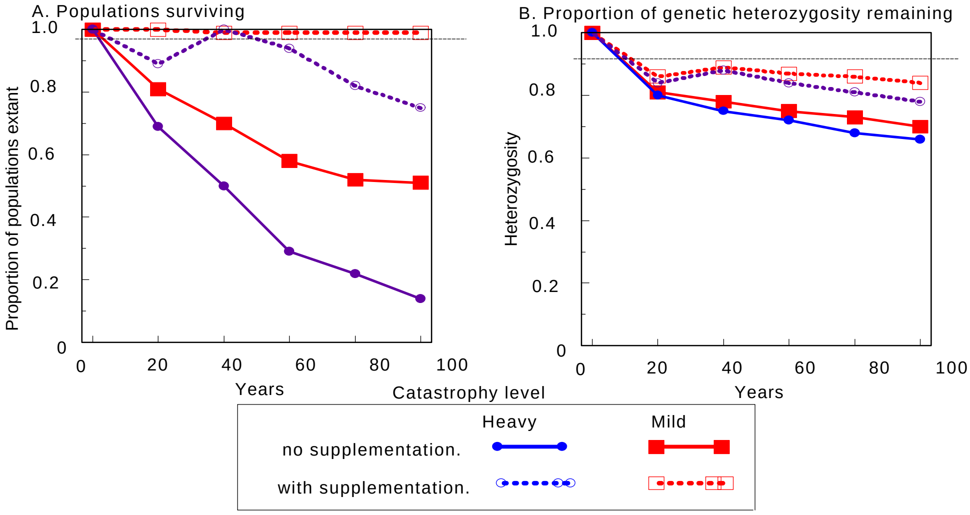

Figure 2. Population survival and genetic heterozygosity of small founder populations with five individuals with and without supplementation (2 adults/15 years) under severe and mild catastrophes.

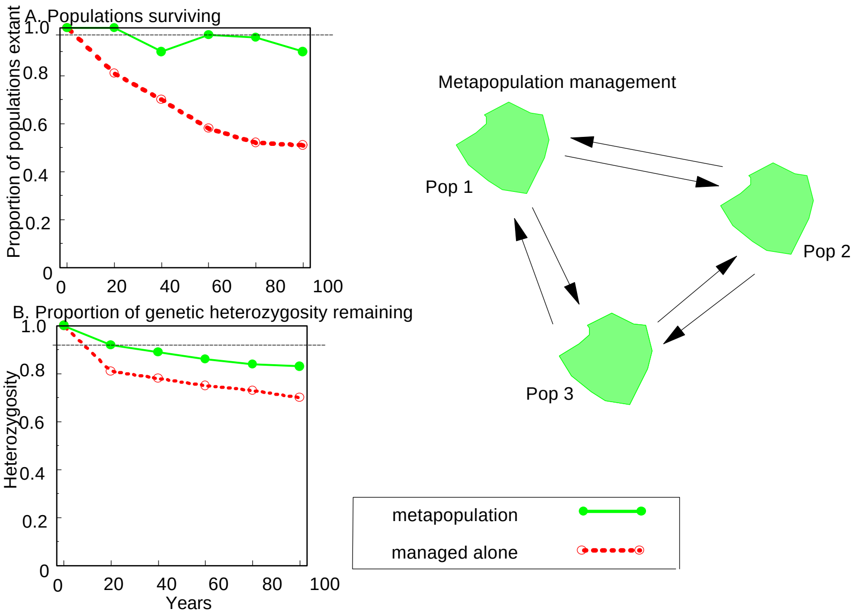

Figure 3. The probability of survival and genetic heterozygosity of a small founder populations (5 individuals) managed either alone or as part of a meta-population management approach.

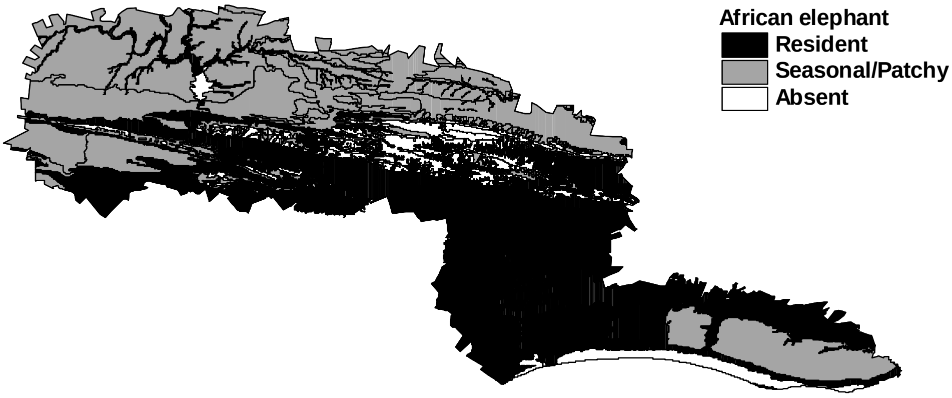

Figure 4. Expected elephant habitat use in the GAENP (Boshoff *et al.* 2001).

After mankind, elephants remain the next greatest agent of change on the African continent. Hence, their impact on different habitats and biodiversity need be monitored and should form an important part of any management plan (Ben-Shahar 1997). In this regard the AENP probably has the longest dataset monitoring elephant impact on vegetation (Hall-Martin & Barratt 1991). Designing further monitoring programmes will be essential as elephants expand into new vegetation types, but expert advice is required to provide the most scientifically defensible results.

The opening of Addo's new areas in the AENP to the expanding elephant population will be undertaken in a phased approach, so as to not destroy the present elephant viewing product, as 88% of the visitors to the park are primarily drawn to see the elephants (Geach 1997). Tourism expectations appear to be met with densities of elephants up to 2.5 elephants/km^2 (Novellie, Knight & Hall-Martin 1996). However, such densities are in direct conflict with the maximum recommended stocking rate of 2 elephants/km^2, thus exposing the potential conflict between tourism, ecological carrying capacities for elephants and biodiversity conservation. Opening new areas to elephants and tourism need be done simultaneously, otherwise mass movements of elephants into new areas without tourist access in one form or another may degrade the viewing product. This happened to some degree when the Gorah and Addo Heights sections were opened to elephants. Thus, new areas will be separately fenced and stocked with animals from the present elephant camp to fulfill the duel purpose of reducing elephant pressure in the original area and re-establishing a population in an orderly fashion in the new area. In due course, fences between the two sections would be dropped when tourism issues and logistical constraints (such as road barrier affects) have been addressed.

3. Fencing

Woodd (1999) showed the positive affect of the erection of the Armstrong fence in the 1950's on the Addo elephant population. It saw a reduction in conflict with surrounding land owners, and an increase in the population growth rate to over 5%, approaching the maximum rate of increase of 7% possible for elephants (Calef 1988). In South Africa, and particularly in the relatively well-developed and populated Addo area, the reliable Armstrong fence remains a vital aspect in containing the elephant population. In its history, the fence has only been breached on two occasions, once by the resident bull Hapoor in 1968 and secondly by a family of elephants split from the remainder of the group during the introduction of black rhinos into the Marion Baree and Addo Heights areas in 1998. AENP remains the only park in South Africa that uses the Armstrong fence. Its prohibitive erection price of about R130 000/km accounts for its lack of general support, yet its durability and low maintenance would make it more cost-effective in the long-term. The use of modern electrified game fencing remains an initially cheaper option at about R55 000/km, but is only effective as long as it is well maintained, with such costs estimated at about R2000/km/year. Break-outs of elephants have occurred in a number of Eastern Cape and Northern Province reserves of late, mostly as a result of poor fence maintenance, poor introduction boma management, and reduction or termination of the electrical supply to the fence at the time. Furthermore, electrified fences require an education programme for the elephants.

In the case of Addo, the Armstrong fence will only be erected along potentially high risk areas such as those adjacent to human settlements, citrus groves, major roads and railway lines. Elsewhere, electrified fencing will be used such as in the more mountainous and inaccessible areas. However, as the electrification education programme for elephants will primarily focus on those elephants going through the translocation process to new areas in the park, there remains a risk that as the park sections are joined, the new electrified game fence sections may be tested by uninitiated elephants. To partially meet these needs it is planned to electrify the present Armstrong fence against elephants and carnivores, which may help in the education process. Its also expected that as the Addo elephants generally respect fences, they will not contest them particularly as their movement into new sections would be largely in a passive process.

4. Barriers

Barriers to elephants can take the form of physical obstacles such as mountains, rivers, fences, roads etc. or actual human presence. In the case of the AENP, the development of the park within management units defined by roads and railway lines makes for managerial problems. However, the Addo elephants historically used railway culverts or underpasses (A.H. Hall-Martin *pers comm*.) that would allow the physical linking of these otherwise separated sections of the park thus allowing the important ecological processes associated with elephants to function over the broader landscape. However, a preferable (but more expensive) over-pass system as used in Banff National Park, Canada may be more appropriate option and probably suitable for a broader range of species.

5. Provision of drinking water

The provision of artificial supplies of water for wildlife is a recognized management activity, particularly as most conservation areas in South Africa are no longer pristine and fenced-off from the greater landscape. However, with the provision of water comes a suite of ecological problems associated with such management actions such as local over-utilization of vegetation, loss of other herbivore species and biodiversity, loss of productivity, and changes in soil structure (Moolman & Cowling 1994, Sinclair & Fryxell 1985; Walker & Goodman 1983, Grant & van der Walt 2000).

Every endeavour should be made to try and emulate the natural supply of water in the park but this could be in direct conflict with tourism demands. As AENP expands, plans should include the provision of water along natural supply areas such as the Coerney, Wit, Kabouga and Sundays rivers and provide it over as long a front as possible to minimise local impacts. The alternative of providing water in a uniform manner over the landscape, where it may only have seasonally or temporarily occurred, should be avoided in order to provide refuge for more water independent species, low density game areas and 'reserve' grazing areas.

Given the uncertainty around the ability to rehabilitate Subtropical Thicket, consideration will need be given to the future and maintenance of the presently heavily impacted Hapoor, Guarrie Dam and Domkrag waterholes in the AENP. It may be necessary to consider these as sacrificial/experimental areas, but to open no more waterholes away from natural supplies as the park expands. Given the sensitivity of the Thicket vegetation it may also **not** be prudent to use artificial waterholes on a seasonal basis to manipulate elephant and other species utilization of the park. Alternatively, other waterholes should only be sited in open, and disturbed areas at suitable distances from thicket vegetation to minimize any impacts.

6. Population regulation

The fragmentation of the African landscape through human activity has resulted in most conservation areas becoming small isolated areas, often no longer functioning as an integral part of the former broader landscape. As such conservation areas are largely no longer seen as pristine, self-regulating areas, but islands in a transformed landscape. The erection of fences in southern Africa, largely driven by the *res nullius* legal clause, has furthered this isolation of conservation areas, leading to interventionist type thinking in the control of our large mammalian herbivores, and in particular that of elephants. Images of habitat alteration in the face of increasingly confined elephant populations (Parker 1983) led to active population control or culling programmes such as in the KNP and Hwange NP (Pienaar 1983; Cumming 1983).

As culling remains a very emotive and controversial issue (Caughley 1983), other means of regulating elephant populations have recently been initiated. Two methods of contraception, that of hormone implants in the form of an oestradiol application and the immunocontraceptive approach of using porcine zona pellucida (pZP) have been tested in free-ranging KNP elephants (Fayer-Hosken *et al* 2001). Although the evidence is not conclusive both methods appear to show a reduction in fertilization, with the former method suggested to produce aberrant behaviour with questionable reversibility, while the later seems to be reversible but not as effective in reducing conception. The important questions around the use of these methods remains their applicability in large free-ranging elephant populations (Pimm & van Aarde 2001), and the long-term behavioural effects, which remain to be tested. At this stage of development these methods of contraception may be ideal in regulating small (<50 -100 individuals) elephant populations but not larger ones such as in the AENP.

Currently SANParks prefers to exercise the option of expanding the range of elephants within the park through land purchases and other contractual means, while the contraceptive approaches are more fully explored. This does not discount the culling option in regulating elephant populations in the future.

7. Political aspects

The emotional attachment shown towards elephants places management issues associated with this species largely in the international public domain as reflected by protracted debates within CITES and the IUCN around the conservation status of the species. Thus, it remains imperative that any elephant management policy should remain explicit, meeting the parks/reserves goals. Furthermore, it also emphasises the fact that elephants remain an international issue and that one cannot necessarily ‘’go it alone’’ in managing one’s elephants, but in cognizance of national government policies and regulations. If the exploitation of elephants for commercial gain (such as through trophy hunting and sale of ivory) is to be sought in the long-term to make conservation more profitable, it will need be done in unison with the national government approval. This will require greater unification between land owners and greater cooperation with provincial and national conservation organizations as it will require strict population status reporting, records of ivory stock piles and illegal activities.

Conclusion

Elephants remain one of the most charismatic species on the African continent. Yet with the species comes a suite of expensive and demanding management and political decisions. Yet as in the AENP, where elephants are seen as part of an important ecological process, their integration into the greater AENP remains a priority. But at the same time their impact on the system needs to be closely monitored so we can learn more about the subtle ecological relationship between this mega-herbivore, other species and the environment. Although, the aim is to make the AENP South Africa’s third largest national park, it must not be seen in isolation from the smaller provincial and private reserves in the Eastern Cape. A meta-population management approach and interchange of ideas and experiences need be encouraged amongst elephant parks/reserves in the Eastern Cape to provide overall better management of this important resource.

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Managing small elephant populations: lessons from genetic studies

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Introduction

Small populations present conservation biologists and wildlife managers with a host of challenges. Amongst these is the importance of understanding the implications of the genetic dynamics within such populations (Soule 1986; Caughley 1994). Loss of genetic variation, accelerated genetic drift and inbreeding depression all occur with increasing frequency as population size decreases, and particularly whenever a population goes through a bottleneck (Soule 1986, 1987). These genetic changes can result in reduced fitness, which may have an immediate or delayed negative impact on the population.

A population bottleneck occurs when population size is drastically reduced for any reason, or when a new population is artificially created with a limited number of founders. Allele loss inevitably accompanies a bottleneck, with rare alleles being lost most frequently (Nei *et al*. 1975), and the resulting population is of lower genetic variation than the pre-bottleneck population (or the source population, where the "bottleneck" is the establishment of a new population). If post-bottleneck recovery is slow, further loss of genetic fitness may occur due to the small population size (Nei *et al*. 1975).

Breeding between close relatives inevitably occurs more often in smaller populations. Such inbreeding increases the chance that deleterious recessive alleles will be expressed in resulting offspring (Ralls *et al.* 1986; Lacy 1993). It is these deleterious recessive genes that are responsible for the classic symptoms of inbreeding depression, namely birth defects, high infant mortality, health problems, and so on. However, inbreeding does not always lead to inbreeding depression. If there are no deleterious recessive alleles, which will be expressed in their homozygote form, there may be no immediate negative symptoms following inbreeding. Yet, inbreeding will lead to allele loss and decreased heterozygosity, and this may reduce future population fitness by decreasing the adaptability and evolutionary potential of the population (Burger & Lynch 1995; Lacy 1997).

In contrast to inbreeding, outbreeding refers to breeding between members of the same species who are from different populations and are adapted to different environments. The results of breeding between these different individuals are offspring who are not adapted to either environment and consequently may be less fit than their specialised parents (Maynard Smith 1989). Although theoretically possible, outbreeding depression is unlikely amongst elephant populations, since genetic studies show considerable uniformity throughout the savannah elephant populations across Africa (Roca *et al.* 2001).

Population genetics research

Understanding genetic processes and assessments of the genetic variation within small populations are important to assist sound conservation management of these populations (Amos & Hoelzel 1992). Microsatellites provide a powerful tool for such population genetic studies (Bruford & Wayne 1993). Extensively distributed

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throughout the eukaryotic genome, microsatellites consist of variable numbers of tandem repeats of a simple core sequence, usually less than six base pairs in length. Length variation is thought to be caused by DNA slippage during replication (Levinson & Gutman 1987; Schlotterer & Tautz 1993) and, since microsatellites are non-coding regions, they tend to evolve relatively rapidly. As a result, microsatellite loci are highly polymorphic (e.g. Amos *et al.* 1993; Primmer *et al.* 1995), and typically exhibit more variation than allozymes or mitochondrial DNA. They are therefore particularly important for studying the genetics of populations with low variability (Hughes & Queller 1993; Paetkau & Strobeck 1994).

The study of microsatellites is facilitated by the polymerase chain reaction (PCR) (Mullis & Faloona 1987; Saiki *et al.* 1988), which can amplify single microsatellite loci from minute quantities of DNA. Furthermore, microsatellite alleles can be sized exactly and data are highly reproducible. Therefore, accurate comparisons can be made across gels (especially important when studying large populations - Schlotterer & Pemberton 1994) and between different laboratories. Finally, since microsatellite alleles are codominantly inherited, they can be used for analysis of parentage, and they are increasingly chosen as the preferred marker for such studies (Queller *et al.* 1993).

The Addo elephant population

In this paper, we focus on the Addo elephant population as a case study. The effects of this population's bottleneck on population genetics and fitness are investigated, and management recommendations are made in the light of the findings. Although our attention will be centred on the Addo elephants, general lessons can be learnt from this case study, which are pertinent to the management of all small elephant populations.

The Addo elephant population originates from just 11 animals in 1931 when Addo Elephant National Park was created (Whitehouse & Hall-Martin 2000). Evidence suggests that at least two, and possibly as many as four, of these original elephants died without leaving any descendants (Whitehouse 2001). No immigration or introduction of elephants into the population has occurred during the history of the park. Thus, today's Addo elephant population originates form a very small gene pool.

Loss of genetic variation within the Addo elephant population can be expected to have occurred following its bottleneck. In addition, the relatively small current population size will result in continued accelerated rates of genetic drift, leading to increased homozygosity and allele loss. Furthermore, it has been hypothesised that genetic variation within the Addo elephant population may be further limited by breeding behaviour. It was suggested that, at any one time, a single dominant bull monopolises all matings, and that possibly as few as three bulls are responsible for fathering most calves born throughout the history of the park. The current dominant bull, Gaatjies, was thought to have been responsible for most, if not all, matings between 1983 and 1996 (A.J. Hall-Martin, pers. comm.) – during which time the population more than doubled, with nearly 200 calves born. If Gaatjies was indeed the father of the majority of these calves, this markedly skewed male reproductive input would have a significant impact on population genetics.

Responsible management of the Addo elephant population should take into consideration the potential genetic threats posed by the population's bottleneck, small size, and the possibility of exceptionally high variance in male offspring production. Microsatellite analysis was therefore employed to assess genetic variation and paternity within this population, and so provide relevant data upon which to base management decisions that embrace the theories of small population genetics.

Methods

Tissue samples were collected from 105 Addo elephants by means of biopsy darting (Karesh *et al.* 1987). In addition, two samples of Addo elephants killed in 1920 by Major Pretorius were obtained from their dried hides stored at the South African Museum. Finally, skin samples from 111 Kruger elephants were taken at random from the collection of salted and dried hides of culled animals stored in the Kruger National Park.

DNA was extracted from all the above tissue samples, and variation at nine polymorphic microsatellite loci was investigated. Genetic diversity within each population was quantified using measures of the number of polymorphic loci, allele numbers and heterozygosity, and paternity was analysed using exclusion analysis as well as a likelyhood-based approach. See Whitehouse (2001) for full details of laboratory methods and data analysis procedures.

Results

All nine loci were polymorphic in the Kruger population, but only seven were polymorphic in the Addo population. Fewer alleles were observed in the Addo population at all loci except one, in which both populations had two alleles. The mean number of alleles per locus and mean heterozygosity were both significantly lower in the Addo population in comparison to the Kruger population (Table 1).

Table 1. Allelic diversity and heterozygosity of the Addo and Kruger elephant populations.

Population	Total no. of alleles	Mean no. of alleles per locus	Heterozygosity
Addo	17	1.89	0.180
		*	*
Kruger	35	3.89	0.444

* Significant difference – tested using Wilcoxen signed rank test, P < 0.001

At two loci, alleles not represented in the present day Addo elephant population were present in the two 1920 Addo specimens. Analyses suggest that allele number, frequency and heterozygosity in the museum specimens are more similar to the Kruger population than the modern Addo population – although sample size for the museum specimens (N = 2) is clearly insufficient to provide the basis of any robust analysis.

Lack of genetic diversity in the Addo elephant population severely limits paternity analyses. Nevertheless, using exclusion analysis, Gaatjies was rejected as father of 34 % of calves sampled. The likelihood-based approach assigned Gaatjies as the most likely father of a maximum of 28 % of calves – but none of these suggested paternal relationships could be assigned with a confidence of 75 % or more.

For full details of results see Whitehouse 2001, Whitehouse & Harley 2001, and Whitehouse & Harley (in press).

Discussion

Genetic diversity

The results of this study clearly indicate reduced genetic variation (both in terms of allele numbers and heterozygosity) in the Addo elephant population in comparison to the Kruger population. It is likely that the population’s bottleneck, following its attempted extermination (Hoffman 1993) in 1920, is responsible for much of this observed loss of genetic variation, although relatively small post-bottleneck population sizes will also have contributed.

Data indicate that the Addo population represents a genetic subset of the Kruger population. Until recent times southern Africa's elephants would have formed a continguous, panmictic population (Hall-Martin 1992) with wide-spread gene flow taking pace throughout (Georgiadis *et al.* 1994). The Addo elephants have probably only been isolated for approximately 150 years, which represents just five or six elephant generations (assuming generation length to be 25-30 years – Whitehouse 2001). The genetic differences between the Addo and Kruger populations suggest that rapid genetic drift has occurred in the Addo population since its isolation. This concept is supported by the data on the 1920 Addo population, which appears to be genetically more similar to the Kruger population than the present day Addo population.

Paternity

Although lack of genetic variation severely limited paternity analysis, the hypothesis that a single bull, Gaatjies, monopolised matings between 1983 and 1996 can be rejected. Therefore, there is no evidence to suggest that an unusually skewed male reproductive input is causing further limitation of the population's genetic variation.

Despite the abundance of elephant research in recent decades, many questions about male elephant breeding behaviour and reproductive output remain unanswered. Although the Addo population's low genetic diversity currently hinders detailed paternity analysis, if this problem could be solved by the use of additional microsatellite loci, then the Addo population provides an excellent opportunity to study elephant paternity in greater depth. The detailed knowledge of the current population and long-term individual-based demographic data provide an invaluable foundation for a comprehensive study of elephant breeding behaviour - albeit within a small, closed population.

Implications of findings and management recommendations

Given the potential threats posed by a loss of genetic diversity, the Addo elephant population's genetic fitness is of concern. Although the population is currently showing no noticeable signs of inbreeding depression (fecundity is high and mortality is low – Whitehouse 2001), complacency is inadvisable since some studies have shown that inbreeding depression can begin to have a serious impact upon a population with very little warning (Frankham 1995). Additionally, the very low level of genetic variation within the Addo elephants limits the future adaptability and evolutionary potential of the population (Lacy 1997). Exposure to disease (O'Brien *et al.* 1985; O'Brien & Evermann 1988; Patenaude *et al.* 1994), or significant environmental change (Burger & Lynch 1995) could seriously threaten the population's future survival.

The potential future risks posed by the Addo elephant population's low genetic diversity are unquantifiable. Nevertheless, it is important that managers are aware of the risks, and are striving to prevent any further loss of genetic diversity. In addition, consideration should be given to management options that will boost the population's current levels of diversity.

Growth of the Addo population should be encouraged in order to minimise further genetic drift and loss of diversity. Expansion of AENP is underway, but the current target elephant population size for the enlarged park (N = 200, G.I.H. Kerley, pers. comm.) is too small to be regarded as genetically viable (Armbruster & Lande 1993). In the long term, the Addo population may need to be managed as part of a meta-population (see below).

In order to boost current levels of genetic diversity, introduction of elephants from elsewhere into the Addo population should be considered. Clearly, such management action carries its own potential problems, and managers should weigh up the risks imposed by the population's genetic deterioration against the possible risk of introducing a disease or social disruption as a result of intervention. Careful planning should minimise these risks, and is essential prior to any introduction.

Firstly, the source population would have to be carefully chosen. Genetic analyses have shown the Addo population to be a genetic subset of the Kruger elephants and, thus, outbreeding depression is highly unlikely. Logistically this park would also be a good choice: it is the largest elephant population in South Africa, and has experts in game capture and translocation on staff. Elephants captured for translocation should be carefully examined to avoid the risk of introducing disease to the Addo population (Woodford & Rossiter 1994). Modern translocation techniques and the expertise of experienced personnel should be employed to minimise stress levels of the elephants.

In order to ensure rapid gene flow into the Addo population from the introduced elephants, it would be preferable to introduce mature males. If females were introduced their genetic composition would not spread into and influence the population at large until maturity of their first male offspring, which may take several decades. Given the high levels of mate competition amongst male elephants (Poole 1982), together with the preference of oestrous females for mature musth males (Moss 1983), it would be advisable to select large adult males between the ages of approximately 35 and 50 years for introduction, in order to maximise their chance of successful mating.

Due to the unusually high levels of aggression between male elephants in AENP (Whitehouse 2001), the risks to newly introduced males of being killed by established males may be especially high. However, if family groups are translocated into new areas within the expanding park, it may be possible to introduce new males into these areas, thus enabling contact between introduced males and Addo females whilst avoiding risks of competitive interaction between introduced and established males. Behavioural monitoring should be mandatory in order to evaluate the success of the introductions of new males. Additionally, the genetic composition of the introduced males should be determined by means of microsatellite analysis and, after several years, the genetic composition of calves born in areas with the introduced males should be investigated, in order to assess rates of gene flow from introduced males into the Addo population.

Application to other small elephant populations

An increasing number of elephant populations are being established in South Africa: between 1979 and 1994 alone, 38 discrete new populations were created by translocation of elephants (largely from Kruger National Park) into new areas within the species natural range (Anon 1994). The majority of these reintroduced elephant populations are relatively small, occurring in areas ranging from six to 900 km^2 in size (Anon 1994). It is doubtful whether any of these will be able to reach a size that is considered genetically viable.

The Addo case study documents the loss of genetic diversity in one small, bottlenecked elephant population. Similar losses in other populations should be avoided. Yet, with a population size of more than 300 individuals, the Addo population is considerably larger than many of South Africa's elephant populations will ever be. Therefore, it may be necessary to adopt a metapopulation management strategy in order to prevent loss of genetic variation throughout South Africa's small elephant populations (van Jaarsveld *et al.* 1999). As in many captive breeding programmes, exchange of breeding individuals and/or semen may enable maintenance of population genetic diversity, as well as management of population demography (Foose 1986). The possible introduction of new males into the Addo elephant population may provide opportunities for research investigating the feasibility and likely success of such intensive management.

Key points

- The Addo elephant population is very low in genetic diversity.
- This poses unquantifyable long-term risks, and is of considerable concern.
- To counter these risks, the introduction of new genetic stock should be considered.
- In order to make an immediate impact, introduced animals need to be breeding age (*c.* 35-45 years) bulls.

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Managing elephants: lessons from behavioural studies

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Introduction

Conservation management of animals within parks and reserves currently pays little attention to behavioural issues, although behavioural enrichment is increasingly recognised as a necessary part of the management of captive populations (Shepherdson 1994). Yet, as wildlife habitats diminish and become increasingly fragmented, and as confinement of populations and intensive management become necessary, the distinction between "wild" and captive populations is reduced. As a result, many so-called wild populations are currently found within relatively artificial environments. For example, the Addo elephants are restricted to a limited, fenced range, with exceptionally high population density, no predation, and permanent water.

It is suggested that a fully integrated approach to conservation should seek not only to conserve individuals and species, but also to conserve natural behavioural patterns. Wildlife managers should be aware that their management actions may influence behaviour, and should seek to select management options that minimise any adverse behavioural changes.

Elephant are intelligent and sentient animals with a complex social structure (Moss & Poole 1983). An understanding of elephant behaviour and the influences of management intervention are essential to responsible elephant management, particularly of smaller, and therefore more intensively managed, populations. However, despite the abundance of research conducted on elephants during the last five decades, we still cannot claim to be able to fully understand them and we often cannot predict how they will respond to management intervention. It is imperative that management is treated as scientific experimentation, so that lessons are learned from choices made today, enabling tomorrow's managers to make more informed decisions (MacNab 1983)

In this paper we highlight some of the influences of management on elephant behaviour. First we consider various forms of management, which have a direct impact on social functioning. We then use the Addo elephant population as a case study to examine the consequences of confining elephants within restricted areas, noting critical differences between the behavioural responses of males and females. Finally, the concept of social carrying capacities is introduced and discussed.

Elephant social organisation and the influence of management

Elephant society is organised into matriarchal family groups and independent mature males (Moss & Poole 1983; Moss 1988). A female usually remains within her natal family for life, and the bonds between her and the other female members of her group are strong and long-lasting. Male elephants are evicted from the family group when they reach sexual maturity (at approximately 12-14 years of age) and thereafter they may be found alone, in small bachelor groups, or temporarily associating with females, but no stable associations are formed.

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Within a population, elephants have extensive and multi-tiered social networks (Moss & Poole 1983). They are able to recognise numerous other individuals and respond appropriately according to their relationship to them (McComb *et al.* 2000). Amongst the males, a dominance hierarchy exists (Moss & Poole 1983), and each male is aware of his position in the hierarchy relative to other males. Within family groups, matriarchs and older females have enhanced social discriminatory abilities, which can influence the social knowledge of the group as a whole (McComb *et al.* 2001).

This complex and intricate web of social relationships within an elephant population may be disrupted by various forms of management. Some of these are briefly discussed below, and lessons which have been learnt as to how to minimise negative behavioural responses are highlighted.

Translocation and establishment of new populations

For many years juvenile survivors of culls were translocated to different parks and reserves and used to establish new populations. Behavioural problems following these translocations of juveniles has led to increased understanding of elephants and their need for a more natural social environment, and has necessitated revision of the old translocation policies. For example, during the 1980s juvenile orphan elephants were translocated into Pilanesberg National Park (Anderson 1993). Several years later the problem of white rhinos being killed by the introduced elephants began to occur (Lemonick 1997; Slotow *et al.* 2000). With hindsight, it is apparent that these behavioural problems resulted from the Pilanesberg elephants growing up in the absence of normal elephant social structure and without adult supervision and discipline. It is now recommended that elephants should only be translocated as intact family groups (Garai 1997), and that mature adult males are also necessary in order to avoid abnormal behaviour amongst teenage bulls in translocated populations (Slotow *et al.* 2000).

Culling

Understanding of the close-knit bonds between elephant family members has led to recommendations that when culling takes place, entire family units should be removed. However, it should be noted that family groups are not static, and they frequently split up and reunite. Therefore, the elephants seen together on the day of a cull do not necessarily constitute an entire family. Moreover, elephants have strong relationships outside their family group with other members of their bond group (Moss & Poole 1983) – and these will be disrupted by the removal of one family. Although culling may be necessary under some circumstances, managers should be aware of the potential social disruptions and their possible ramifications.

Contraception

The use of contraception may provide an alternative means of population control, avoiding the need to cull in some instances. However, the behavioural ramifications of contraception must be given thorough consideration. Research is needed to investigate both the short term impacts of contraception on behaviour (do the contraceptives administered have any direct impact on behaviour?), as well as any long-term behavioural changes that using contraception may cause (e.g. how does the reduced birth rate influence the population?; if there are fewer calves in the population, young female elephants will get less opportunities to babysit and learn mothering skills – how will this later affect their proficiency new mothers?).

Problem animal control

Where elephant populations come into conflict with humans, the solution is often the removal of those individuals (“problem animals”), which are identified as the key offenders. However, recent evidence suggests that populations may have a “problem component”, and as individuals responsible for conflicts are removed, others take their place (Hoare 2001). This highlights the importance of understanding the impacts of management actions on behaviour – and exposes the futility of management in the absence of understanding.

Tourism

Although the exposure to regular tourist vehicles may lead to habituation of an elephant population, a high volume of tourists may have unknown negative influences on the elephants. Moreover, the pressure to manage an elephant population to satisfy tourists may lead to managers trying to meet the expectations of the tourist at the expense of the elephants. For example, there may be pressure to maintain the elephants at an exceptionally high population density, so that the tourist has a good chance of seeing elephants during his visit. Yet, this may compromise the elephants behavioural requirements (see below). In Addo Elephant National Park the elephants were fed for many years, to provide a spectacle for tourists to enjoy. However, it was eventually realised that this was resulting in stress, as the elephants fought over the food (on one occasion killing a calf), as well as unnatural ranging behaviour (the elephants all hung around in the area they were expecting to be fed in) – and so the practise was stopped in 1978 (Hall-Martin 1980).

Consequences of confining elephants

The elephant population of Addo Elephant National Park (AENP) is used as a case study to examine the impacts of confinement on behaviour. AENP was securely fenced in 1954 in order to reduce the high mortality that was resulting from elephants straying outside their protected area (Pringle 1948; Pringle 1973). Following the fencing of the park, population mortality was significantly decreased and, as a consequence, population growth increased (Whitehouse 2001). It appeared that the population responded favourably to confinement.

However, demographic analyses conducted on the two sexes separately revealed markedly lower survival and higher mortality amongst males in comparison to females since the fencing of the park (Whitehouse 2001). Although recruitment to the population is not sex biased, the adult (> 12 years) sex ratio is significantly female biased, with 1 male: 1.53 females at the end of 1998 ($\div^2 = 5.45$, $P = 0.0196$). Male survival is considerably lower than that of females (Figure 1), and whilst the oldest female in the park was 60 years of age, no male was older than 44 years (Whitehouse 2001).

The causes of mortality amongst adult males and females prior to and since the fencing of the park were analysed (Figure 2). Prior to 1954, the majority of deaths resulted from elephants leaving the park and being shot by neighbouring farmers, or colliding with trains. Since the secure fencing of the park, the majority of female deaths have been due to natural causes (old age, etc.). However, the primary cause of death amongst adult males is intraspecific fighting, with a minimum of 70 % (14/20) and possibly as many as 90 % of adult males who have died since 1954 being killed in this manner (Whitehouse 2001).

Although sparring is common amongst all male elephants, and is necessary for them to establish and maintain their position in the male dominance hierarchy (Poole 1982; Moss 1988), in natural populations “records of elephants dying in fights with one another are few and far between” (Hanks 1979), pg 119). Evidence suggests that the unusually high frequency of fatal fights amongst the Addo bulls is linked to the fencing of the park and the confinement of the population.

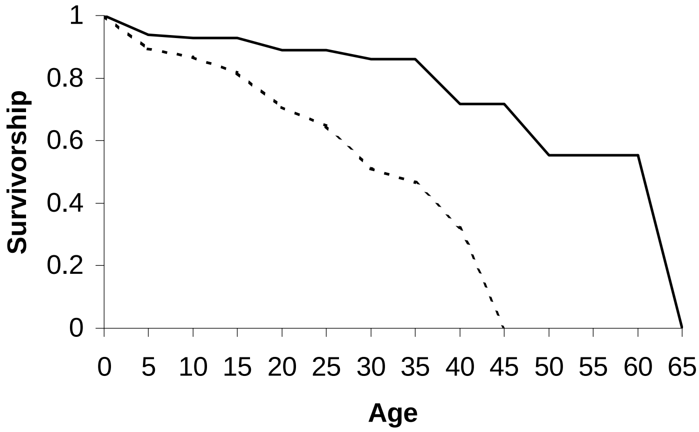

Figure 1. Survival curves for male (dashed line) and female (solid line) elephants within the AENP, based on population data between 1976 and 1998.

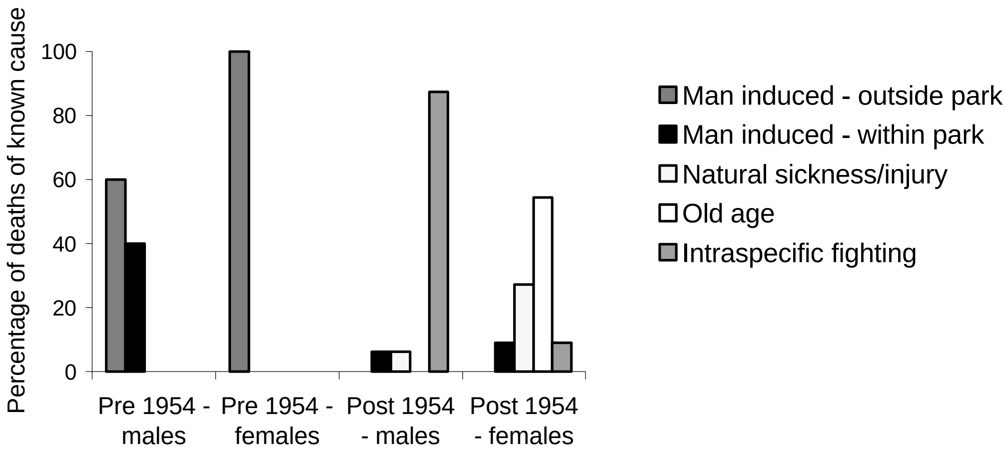

Figure 2. Causes of death of adult (> 12 years of age) male and female Addo elephants who died before and after construction of the elephant proof fence in 1954. Chart indicates the causes of death as a percentage of the total number of deaths of known cause in each category (pre-1954 male, N = 5; pre-1954 female, N = 6; post-1954 male, N = 16 post-1954 female, N = 11).

Research on the Addo elephants' ranging behaviour (conducted using radio-tracking) and social interactions throws further light on the causes underlying the exceptionally high levels of male aggression (Whitehouse 2001). There is no evidence that insufficient space and/or resources are directly responsible for the observed conflicts. However, the small size of the park and confinement of the population leads to elevated levels of male-male competition (Whitehouse 2001).

Oestrous cows are able to advertise their condition throughout the park, and males can reach them quickly and easily. Since calving in AENP is aseasonal, the availability of receptive cows is dispersed in time, allowing a single male to serially dominate at each cow that comes into oestrous. Therefore, subordinates will rarely have opportunities to mate, since the dominant males are likely to be present wherever there is a receptive female. Furthermore, extended musth periods are observed in the Addo bulls, enabling the older males to maintain unusually long periods of dominance. It is suggested that these extended musth periods may be facilitated by the fact that musth males in AENP do not need to travel increased distances in search of receptive females (given the small size of the park and clumped female distribution), and so do not loose body condition as rapidly as musth males elsewhere. All of the above factors lead to exceptionally high levels of mate competition between males. Due to the closed nature of the park, where conflicts do arise, losers may be unable to escape, and this may decrease their chance of survival.

Social carrying capacities

Although "ecological carrying capacities" (Caughley 1983; Lindsay 1993) are widely understood and readily accepted as a necessary component of elephant management plans, consideration is rarely given to behavioural issues or to any form of "social carrying capacity". When a population exceeds the ecological carrying capacity of its habitat, individual nutritional levels decrease, causing increased mortality and decreased fecundity (Caughley 1976). Similarly, we may expect that when a population exceeds its social carrying capacity, individual stress levels may be elevated, also resulting in increased mortality and decreased fecundity.

Evidence from AENP indicates that maintaining elephants within small confined reserves can negatively influence behavioural patterns and increase mortality (Whitehouse 2001). Therefore, a social carrying capacity for the Addo elephants may have been exceeded. Since the social environment and behavioural requirements of male and female elephants differ, social carrying capacities are likely to be sex specific. This is supported by the Addo case study above, in which it is primarily the males who show a negative response to confinement.

The concept of social carrying capacities deserves further consideration. Its relevance to conservation and the practicality of applying this concept to the management of elephant populations should be discussed.

Key points

- Management of elephants will influence behaviour: we need to strive to minimise adverse behavioural changes.
- We do not fully understand elephants, and therefore cannot always predict how they will respond to management intervention.
- Individual based population monitoring is necessary to ensure a continual process of learning and facilitate improvement of management strategies.
- The concept of a social carrying capacity for elephants needs to be considered.

Acknowledgements

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Impacts of elephants on the flora and vegetation of subtropical thicket in the Eastern Cape

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Introduction

African elephants (*Loxodonta* africana) are megaherbivores (Owen-Smith 1992) and are keystone species in many ecosystems where their impacts can influence profoundly the community structure and ecological processes (Owen-Smith & Danckwerts 1997). This is presumably true of the subtropical thicket of the Eastern Cape where browsing animals, especially megaherbivores (elephant and black rhinoceros *Diceros bicornis*) are the primary source of defoliation, unlike many other African ecosystems where fire, tree-falls and drought – in addition to herbivores – are agents of biomass reduction (Kerley *et al*. 1995). It follows that browsing animals, and elephant in particular, have exerted a key selective regime in thicket and that their maintenance – at appropriate, albeit variable, densities – is essential for the maintenance of biodiversity and the processes that underpins this (Boshoff *et al*. 2001).

In precolonial times, African elephants were significant herbivores in the dense, spiny and succulent thicket of the Eastern Cape (Boshoff *et al.* this volume). These animals were targeted by hunters that preceded colonial expansion into the region, and were largely extirpated by the late 1800s (Pringle 1982). A remnant population of about 130-140 individuals persisted in the dense thickets of the Addo area until 1919 when they were systematically eradicated by official decree (Hoffman 1993, Whitehouse 2001). This campaign was abandoned when only 10-20 individuals remained. The Addo Elephant National Park (AENP) was proclaimed in 1931 to protect this population which was effectively secured in an “elephant camp” of 2 270 ha in 1954 (Penzhorn *et al*. 1974). Throughout the history of the AENP, elephant populations have remained at levels regarded by most as in excess of the “carrying capacity”, ranging from 1.6 – 3.8 km^{-2} (Penzhorn *et al*., 1974; Barrat & Hall-Martin 1991, Moolman & Cowling 1994). Therefore, the only area where it has been possible to study the long-term impacts of elephant on the flora and vegetation of Eastern Cape thicket represents a situation that is probably unprecedented in this ecosystem.

This paper addresses the question: what are the impacts of elephants on the flora and vegetation of Eastern Cape thicket? We do this by reviewing the literature on these impacts in the AENP, the only area which – until relatively recently – has supported populations in the wild. We start with a brief overview of the mechanisms for elephants to impact on ecosystems; we then review the literature chronologically; and finally conclude by pointing out that (i) at the high densities in the AENP, elephant have a negative impact on the endemic plant biodiversity of thicket, (ii) research is urgently required on the impacts of elephant on thicket ecosystems at lower densities.

Mechanisms for elephants to impact on ecosystems

Feeding

Elephants are mixed feeders, consuming a wide variety of forage items, ranging from grasses through browse and bark, and including fruits and bulbs. Within the AENPark, elephants have been observed feeding on a total of 70 plant species, (Paley & Kerley 1998). The grass *Cynodon dactylon* and succulents *Portulacaria afra* and *Platythyra haeckeliana* were the dominant food items in this study (winter 1997), although it can be expected that the diet of elephants will vary as forage availability changes (Owen-Smith 1992, Paley & Kerley 1998). The amount of forage required daily varies between about 150 kg for a cow and 300 kg for a bull. Hence it is clear that elephants individually consume an enormous amount. A further aspect of feeding that needs to be taken into account when assessing elephant impacts is that they are wasteful feeders, commonly discarding a large proportion of the plant material that they remove from the plants. Paley (1997) estimated this to be in the region of 67 % of the actual food requirements of the Addo elephants.

Trampling

Although poorly documented, the trampling effects of elephants are well recognised. This physical crushing of vegetation underfoot and the opening up of paths have numerous consequences, from altering microclimates in dense-canopied vegetation, to accelerating the input of material into the decomposer system as litter. Furthermore, the opening up of dense vegetation by elephants alters habitat suitability for a variety of species. For example, within the AENP grysbok numbers appear to decline with increasing elephant impacts (M.H. Knight, pers. comm.), and it can be expected that open habitat species would benefit from such trampling. The use of wallows by elephants creates depressions that act as moisture and nutrient traps, although this has not been quantified in the Eastern Cape thicket.

Nutrient cycling

By virtue of their size and ability to ingest large volumes of a variety of forage, elephants are able to contribute significantly to nutrient cycling. Elephants have been estimated to represent 63 % of large mammal energy flux in the AENP (Slabber 2001), and they deposit large amounts of urine and faeces of high nutrient content (Erasmus *et al*. 1978). Megaherbivores are capable of altering soil nutrients through nutrient cycling, with consequences for plant community structure (Owen-Smith 1992), although this process has not been studied in Eastern Cape thicket.

Seed dispersal

By virtue of the broad diet, large volume of forage, limited mastication and relatively poor digestion, elephants have the potential to be important agents of seed dispersal. Elephant have been shown to disperse the widest (among large herbivores in the AENP) variety of plant species in thicket, and these seeds have an extremely high viability (Mendelson 1999).

Impacts of elephant on flora and vegetation of the Addo Elephant National Park

Background and context

The AENP was established in 1931, primarily to protect the last 11 elephants of the Eastern Cape population, one of only four elephant populations in South Africa which survived into the twentieth century (Kerley & Boshoff 1997). An area of approximately 2 270 ha was fenced in 1954 to enclose the elephants (Figure 1, Original Elephant Camp), and since then, their numbers have grown rapidly to more than 300 individuals (Whitehouse 2001). The elephant camp has been gradually expanded to accommodate the growing population, and is currently approximately 12 000 ha (Figure 1, Elephant Camp). The current stocking rate of 2.2 elephants/km^2 is extremely high in comparison to other African ecosystems (Kerley & Boshoff 1997), but only marginally higher than the rate of 2.0, deemed low enough to maintain the abundance of food plants in the succulent thicket vegetation of this region (Barratt and Hall-Martin 1991, Novellie *et al*. 1996).

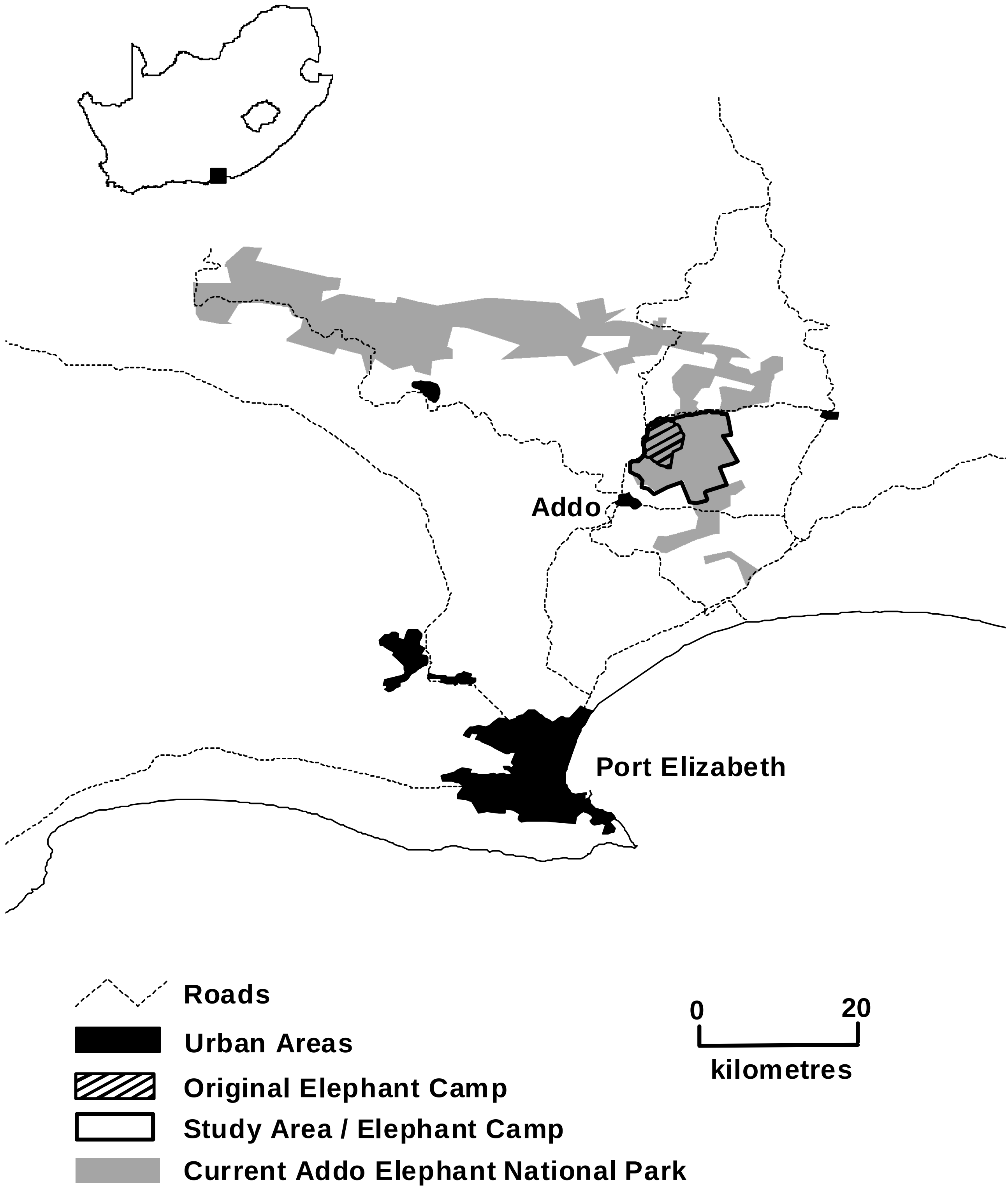


Figure 1. Current extent of the Addo Elephant National Park, South Africa, showing location of original elephant camp. From Lombard *et al*. (2001).

The vegetation of the AENP's Elephant Camp is "valley bushveld" or succulent thicket, a dense, spiny and evergreen shrubland to low forest (Cowling 1984, Everard 1987). Succulent thicket, which is largely endemic to the Eastern Cape (Low & Rebelo 1996), is the major component of the Albany Centre (Davis *et al.*, 1994), an area rich in threatened and endemic plants, especially succulents and geophytes (Nordenstam 1969, Van Jaarsveld 1987, Hartmann 1991, Cowling & Hilton-Taylor 1994). Owing to its botanical importance, extreme threat from overgrazing and clearing, and inadequate representation in the protected area system (national parks, and provincial and local authority reserves), succulent thicket is regarded as the highest conservation priority in the Eastern Cape (Hoffman & Cowling 1990). The AENP is the only national park located in this endemic-rich succulent thicket of the Albany Centre, although a number of provincial and local authority reserves do contain some succulent thicket. The current objectives of the AENP are to conserve a viable population of elephants, as well as to "preserve intact a viable example of valley bushveld'', or succulent thicket (Novellie 1991)

At the time of enclosure, the Park authorities established a botanical reserve in the centre of the AENP (units 3 and 4 in Figure 2; see also Table 1), as a benchmark site against which to compare the vegetation in elephant-impacted areas and in surrounding farmlands. Two other areas (units 1 and 2 in Figure 2) were similarly but incidentally protected as a result of the rationalization of the perimeter boundary. Most studies on the impacts of elephants in the AENP have exploited opportunities provided by this system of elephant exclosures and elephant-exposed areas.

Table 1. Characteristics of "management units" used for research on the impacts of elephants in the Addo Elephant National Park. Vegetation types are according to Archibald (1955). South African National Parks provided management history (current to the end of 1996). Note that one botanical reserve has been divided into two units (units 3 and 4) on the basis of vegetation type. The configuration of the units is shown in Figure 2. From Lombard *et al*. (2001).

Unit	Vegetation type	Management history	Area (ha)
1	Spekboomveld	Incidental botanical reserve, not grazed by elephants since 1954	165
2	Spekboomveld	Incidental botanical reserve, not grazed by elephants since 1954	416
3	Spekboomveld	Botanical reserve, not grazed by elephants since 1954	367
4	Bontveld	Botanical reserve, not grazed by elephants since 1954	49
5	Spekboomveld	Original elephant camp, fenced in 1954; exposed to elephants for the last 42 years	1906
6	Spekboomveld	Overgrazed section of original camp around waterholes; exposed to elephants for the last 42 years	428
7	Spekboomveld	Exposed to elephants for the last 20 years	1362
8	Karoo-Bushveld	Exposed to elephants for the last 20 years	205
9	Spekboomveld	Exposed to elephants for the last 15 years	578
10	"False" Karoo-Bushveld	Cleared in 1950s to provide habitat for springbok; exposed to elephants for the last 15 years	592
11	Spekboomveld	Exposed to elephants for the last 13 years	986
12	Mixed Shrub & Grassveld	Exposed to elephants for the last 13 years	90
13	Bontveld	Exposed to elephants for the last 13 years	328
14	Spekboomveld	Incorporated private land; exposed to elephants for the last 13 years	879
15	Spekboomveld	Incorporated private land; exposed to elephants for the last 6 years	1491
16	Degraded land (originally Spekboomveld?)	Incorporated private land (cleared for agriculture); exposed to elephants for the last 5 years.	2187

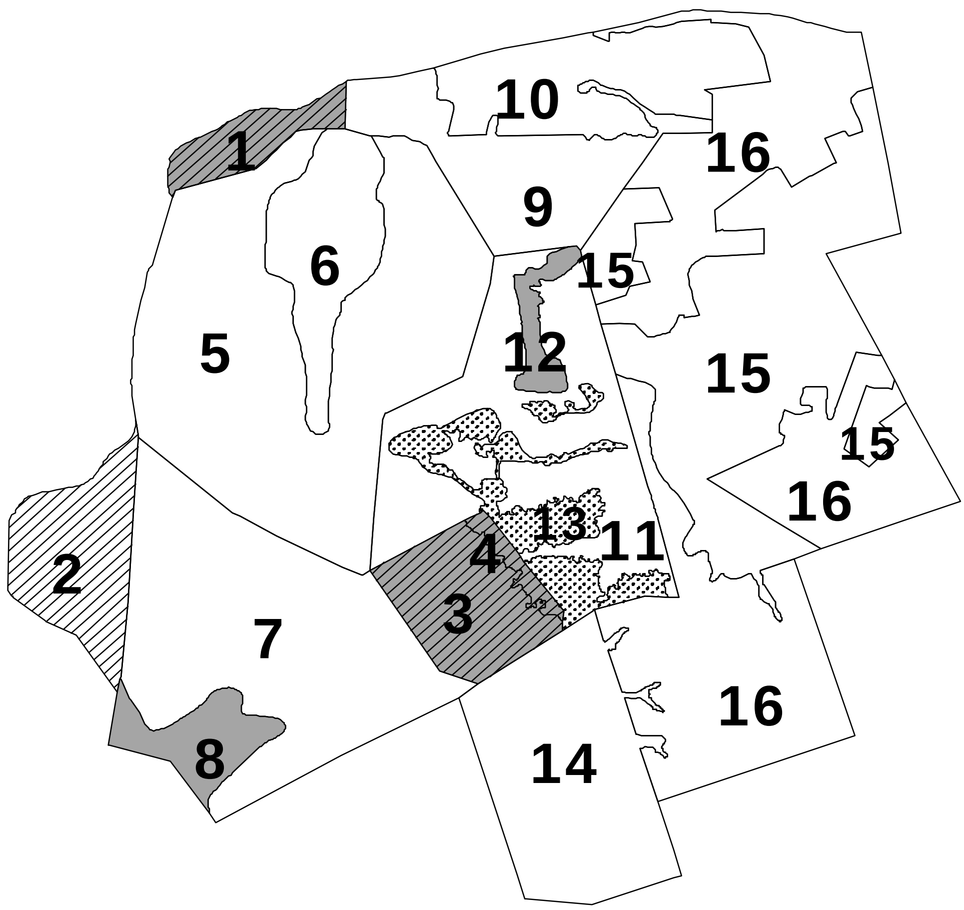


Figure 2. Map of study area showing “management units” used for research on the impacts of elephants in the Addo Elephant National Park. Characteristics of units are given in Table 1. Unit 13 is stippled for ease of reference. Diagonal lines indicate the four existing botanical reserves (units 1-4; unit 4 falls between units 3 and 13). The five core reserves recommended by Lombard et al. (2001) that will achieve targets for the conservation of special (endemic, Red Data Book and rare) species are shown in grey (units 1, 3, 4, 8 and 12). From Lombard *et al*. (2001).

Important assumptions

There are two important assumptions that underlie almost all of the impacts of elephants on the flora and vegetation of the AENP. These are:

(i) herbivore and other impacts within those parts of the AENP exposed to indigenous herbivores are largely attributed to elephants; and

(ii) the so-called botanical reserves and other elephant exclosures represent a “control treatment”.

(iii) meaningful results on treatment effects can be inferred from “snapshot natural experiments” comprising paired plots across fencelines.

All of these assumptions are potentially problematic. Both Penzhorn *et al*. (1974) and Stuart-Hill (1992) explicitly make the first assumption. Stuart-Hill states that “elephants contributed (in 1990) 78% (of the 50 kg livemass ha^{-1} in the Park) and it is realistic to attribute most of the defoliation effect...to them”. However, it may not be realistic to attribute all of the direct impact to elephants. For example, by creating a network of paths through the otherwise impenetrable thicket, elephants may create opportunities for other herbivores to gain access to certain plants. One suggestion is that the decline in geophytes and some dwarf succulent groups in elephant-browsed areas relative to botanical reserves (Moolman & Cowling 1994, Lombard *et al*. 2001) could be attributed to tortoises that have accessed thicket clumps along elephant paths (Kerley *et al*. 1999a).

With regard to the second assumption, the absence of large herbivores in the botanical reserves represents an unnatural situation in succulent thicket. Elephant, black rhinoceros, buffalo and kudu have, to varying degrees, always been components of succulent thicket and have probably played a major role in the maintenance and evolution of biodiversity in this ecosystem (Kerley *et al.* 1995). Areas lacking these animals almost certainly do not represent a suitable benchmark for comparative purposes (Stuart-Hill 1991).

A more general problem of much of the research on elephant impacts in the AENP relates to the experimental design of the studies. In essence, the design of most studies is that of a "snapshot natural experiment" (Diamond 1986). Thus, sites were selected where the treatment was already running and a "snapshot" of the system was observed rather than the trajectory that led to it. Drawbacks of this type of experiment are the absence of a temporal sequence of events, the fact that difference is only inferred, and difficulties in minimizing differences in variables, other than those whose effect is to be examined, between experimental and control sites. Only Stuart-Hill (1992) and Moolman & Cowling (1994) explicitly acknowledge this problem, although most studies attempted to match plots across treatments in terms of site variables (slope, soil type etc.). However, all of the "fenceline contrast" studies were constrained by the fact that elephant densities in the Park have fluctuated considerably, in response to population growth and Park enlargement, since the first enclosure was established in 1954 (Whitehouse 2001).

Review of research findings

The first published reference to impacts of elephants in the AENP is found in Archibald (1955) where it was reported that the elephants were eliminating populations of *Aloe africana* in units 5 and 6 (original elephant camp) (Table 1, Figure 2).

Penzhorn *et al*.'s (1974) study was the first comprehensive research on the impacts of elephants on the vegetation of the AENP. They sampled the identity of all species and biomass of those species > 1 kg/plot in 10 sites, each comprising paired plots (2 m x 10 m), one exposed to elephants, the other not. The exposed plots were located along the Armstrong fence in unit 5 (original elephant camp) and the non-exposed plots were located opposite these in units 7, 9 and11 (Figure 2). The latter comprised areas that had been incorporated into the Park but not yet opened up for elephants (Table 1). At the time of sampling (1973), there were 67 elephants in 2 270 ha (2.7 km^{-2}), up from 20 (Whitehouse 2001) at the time of enclosure in 1954.

Penzhorn *et al*. (1974) showed on average a 45% lower biomass ($P < 0.05$) in the elephant exposed than non-exposed plots (Figure 3). The average mass/plot of *Portulacaria afra, Schotia afra, Azima tetracantha* and *Euclea undulata* – all canopy dominants – within the elephant camp was less than half the value outside, although none of these results was statistically significant. However, the mean mass of *Capparis sepiaria* was 50% higher inside the elephant camp while the values for *Sanseviera* showed little difference between treatments. Two species, *Aloe africana* and *Viscum rotundifolium*, were commonly recorded outside the elephant camp, but never within it. However, there was no difference in species richness between the two treatments. In order to avoid further impacts on thicket vegetation, Penzhorn *et al*. (1974) recommended two alternative management policies:

(i) reduction by more than half (to 30 individuals) of the present elephant population and its stabilization at that level; or

(ii) substantial enlargement of the Park.

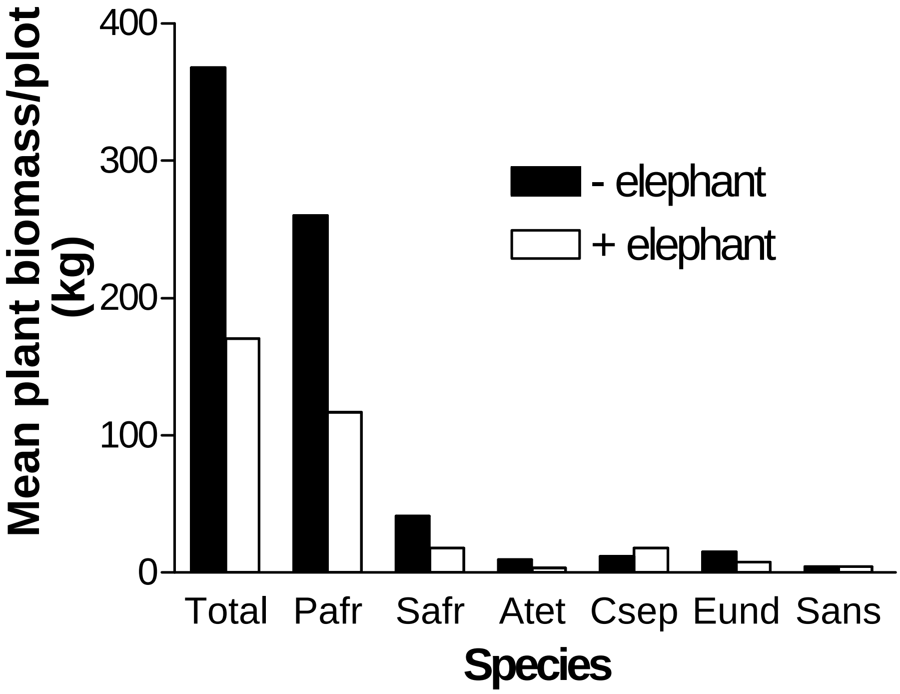


Figure 3. Mean plant biomass (wet weight) of thicket in 2 m x 10 m plots (n = 10) in the Addo Elephant National Park protected from elephants since 1955 (- elephants) and exposed to elephants for 18 years (= elephants). Pafr = *Portulacaria afra,* Safr = *Schotia afra*, Atet = *Azima tetracantha,* Csep = *Capparis sepiaria,* Eund = *Euclea undulata*, Sans = *Sanseviera* spp. Data from Pentzhorn *et al*. (1974).

After the publication of Penzhorn *et al*. (1974), the AENP was expanded by more than 5 500 between 1977 and 1984, (Figure 2, Table 1) to alleviate the "elephant problem" (Barrat & Hall-Martin 1991). In 1977, 38 monitoring transects were laid out in the Park in the original elephant camp (Region 1); the 1977 enlargement (Region 2); the 1982-84 enlargement (Region 3); and the botanical reserve (Region 4) (see also Figure 2 and Table 1) (Barrat & Hall-Martin 1991). An additional seven transects were placed at regular intervals away from a permanent water point inside the original elephant camp. Individual plants were sampled for identity, height (minimum height for inclusion in the sample was 1 m), perpendicular crown diameters, canopy volume and elephant damage. Transects were sampled in 1977, 1981 and 1989. During this period elephant density ranged from 3.8 km^{-2} (1977 – original camp), 2.6 km^{-2} (1981 – after first enlargement) and 2.0 km^{-2} (1989 - after second enlargement). Thus, this study incorporated as explanatory variables both time since exposure and elephant density.

Barrat & Hall-Martin's (1991) results clearly show the impact of elephants on canopy volume of thicket vegetation in the AENP (Figure 4). In the absence of elephants (Region 3: 1977-1981 and Region 4), canopy volume increased. Volume also increased between 1977 and 1981 in Region 1, possibly as a result of lower overall elephant density associated with the opening up of Region 2 in 1977. However, after exposure to elephants, volumes in Regions 2 and 3 declined, tending towards the 1977 values in the original elephant camp (Region 1). This observation led Barrat & Hall-Martin to speculate that “elephant utilization appeared to reach a loose equilibrium between plant biomass loss to elephant browsing and total biomass regeneration”. Given that elephant density, and therefore browsing intensity, fluctuated over the observation period in all regions exposed to elephants, it is difficult to justify this statement.

Other findings by Barrat & Hall-Martin (1991) include:

(i) no change in mean species (> 1 m) richness in all regions but significantly lower richness in elephant exposed regions than the botanical reserve (Region 4) in 1989;

(ii) 2.5-fold lower canopy volume within 300 m of a watering point than 1 km distant in 1977 in Region 1 (after 22 years of utilization;

(iii) no change in canopy volume in the watering point zone (see (ii) above) between 1977 and 1989;

(iv) loss of *Aloe africana* from elephant exposed regions.

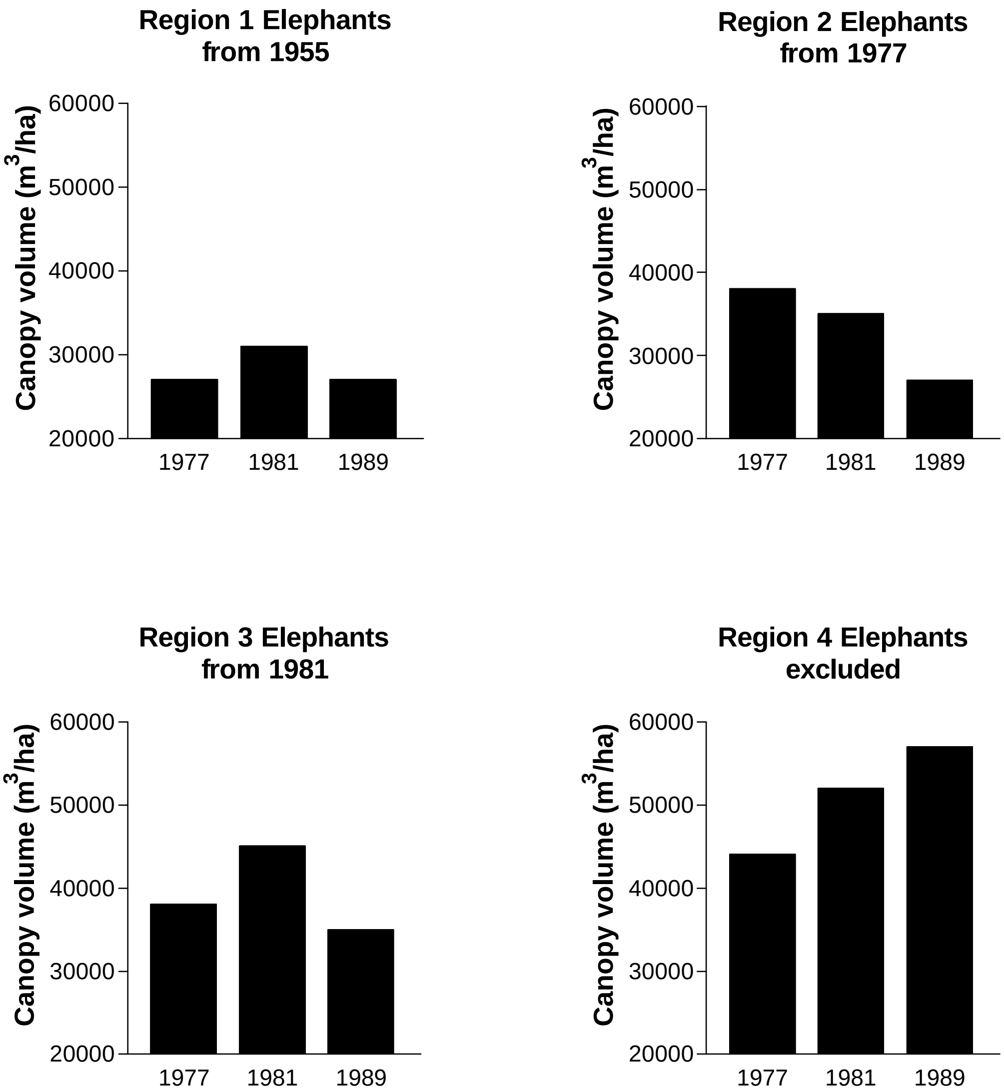


Figure 4. Mean canopy volume of thicket in belt transects (13 m – 30 m) in the Addo Elephant National Park in regions subject to different histories of exposure to elephants. Data from Barrat & Hall-Martin (1991).

Following the observation by Pentzhorn *et al*. (1974) that *Viscum rotundifolium* was absent from the elephant camp, Midgley & Joubert (1991) observed the size and frequency of three misteltoes (*Moquinella rubra, Viscum crassulae* and *V. rotundifolium*) and the frequency of their respective host plants in paired elephant-exposed and elephant-protected transects at three sites in the AENP. Despite a high incidence of host plants in elephant-exposed areas, they recorded no misteltoes there, whereas the frequency of mistletoes in elephant-protected transects ranged from 76% (*V. rotundifolium* on *Gymnosporia buxifolia*) to 7% (*V. rotundifolium* on *Acacia karroo*). Midgley & Joubert (1991) suggest that owing to their high nutritional status, mistletoes could be useful indicators of browsing intensity.

By the early 1990s there was unequivocal evidence that at the densities in the AENP, elephants were having a negative impact on the composition and structure of thicket vegetation. In a seminal paper, Stuart-Hill (1992) expanded the debate by comparing the impacts of elephants and goats on thicket, using the opportunities provided by the AENP and surrounds. Using the botanical reserve and other areas that incidentally excluded large herbivores as "controls", he found that the impacts of goats were far more deleterious than elephants. He concluded that "...thicket (in particular *Portulacaria afra*) is adapted to elephant utilization but not to utilization by small domestic ungulates (i.e. goats) stocked at equivalent biomass." This he attributes to the "top-down" browsing by elephants, which protects canopy cover at ground level as opposed to the "bottom-up" browsing by goats, which produces umbrella-shaped shrubs that are vulnerable to mortality and less likely to reproduce vegetatively. Here we report only on the elephant-impact component of Stuart-Hill's (1992) study.

Stuart-Hill located seven sites along the western, northern and north-eastern perimeter of the AENP. At the time of sampling, the Park was 8 600 ha in extent and had not yet incorporated units 15 and 16 in Figure 2; elephant density was 2.0 km^{-2}. Only five "controls" could be located, two in relatively large units incidentally protected (1 and 2; Table 1), and the remainder in smaller slivers along the Park boundary. The matched elephant –impacted sites would have had a variable history of exposure, ranging from seven to 38 years during which elephant density would have fluctuated considerably. Seven circular (radius = 2.3 m) plots were sampled in each "treatment" site and the frequency of 23 common shrubs species and thicket canopy cover was enumerated in each plot. These plots were treated as pseudoreplicates; mean values were used for statistical analyses, thereby (and appropriately so) reducing the degrees of freedom considerably. In addition, all plants were assigned to one of three categories: triangular with base on the ground, umbrella-shaped or box-shaped. Further measurements were made on the architecture of *Portulacaria afra* individuals and an index of density of all 23 species was obtained.

When compared to the "control", elephants increased the density of all woody species significantly ($P < 0.05$) but not for *P. afra* (Figure 5). Elephants also reduced canopy cover significantly ($P < 0.05$) but had no significant impact on woody species richness. Elephants did not have large, significant effects on the frequency of woody species with the exception of *Euphorbia mauritanica* (82% decrease; $P < 0.05$) and *Rhigozum obovatum* (80% decrease; non-significant) (Table 2). They also reduced by 50% the frequency of *Crassula ovata* (non-significant) and eliminated all individuals of *Aloe africana*; both of these species are succulents. All *P. afra* plants growing in the control sites were either box-shaped or triangular in profile; elephants reduced the fraction of box-shaped plants, thereby increasing the fraction of plants with triangular or umbrella-shaped canopies (Figure 6a). Most of the control plants had well developed "skirts" of rooted branches, only 8% having none; elephants increased the fraction of "full skirts" in relation to the control but this was not significant. (Figure 6b). It must be borne in mind that of the plant variables presented above, goats had a significant deleterious impact on all, relative to both the control and elephant-exposed sites, except canopy cover (cf. elephants). In particular, goat exposure resulted in an overwhelming preponderance of umbrella-shaped *P. afra* individuals lacking “skirts”.

Table 2. Increase (%) in frequency of 14 common trees and shrubs in circular quadrats (radius = 2.3 m) in thicket of the Addo Elephant national Park with various histories of elephants exposure (n = 7), relative to the frequency measured in areas protected from elephants since 1955 (n = 5). From Stuart-Hill (1992)

Species	% increase
Azima tetracantha	4
Capparis sepiaria	17
Carissa haematocarpa	33
Euclea undulata	38
Euphorbia mauritanica	-82
Grewia robusta	-21
Lycium oxycarpum	-41
Maytenus spp.	1
Portulacaria afra	-1
Asparagus spp.	5
Rhigozum obovatum	-80
Rhus undulata	19
Schotia afra	25
Zygophyllum morgsana	0

Stuart-Hill (1992) concluded that the impacts of elephants on thicket were not nearly as detrimental as goats stocked at current levels. He recommended the replacement of goats in favour of large indigenous herbivores, including elephants. Not only would this practice be more ecologically sustainable, but it may also be more economically stable. The latter hypothesis remains to be tested.

With the exception of Midgley & Joubert (1991) all studies published thus far had focused on the dominant, woody components of thicket. Moolman & Cowling (1994), however, shifted attention to the minor components of thicket, namely the geophytes and low to dwarf succulent shrubs (mainly Crassulaceae and Mesembryathemaceae). These groups comprise the bulk of thicket species endemic to the Albany Centre and hence have considerable conservation value (Johnson *et al*., 1999). They adopted a similar design to Stuart-Hill (1992) in order to evaluate the impact of goat- and elephant-browsing, relative to protected “controls”, on the diversity and cover of these plant groups. Specifically, Moolman & Cowling (1994) hypothesised that “ since the dominant thicket shrubs are adapted to “top-down” grazing by elephants (which preserves beneath-canopy” microsites) but not “bottom-up” grazing by goats (which destroys shrubs and microsites) (Stuart-Hill 1992), (there would be) less impact from elephant grazing than goat grazing on the endemic-rich component”. Moreover, owing to their large bite size, elephants would be less likely to select these small-sized plants. Furthermore, the mosaic of paths and dense thicket clumps chatacteristic of elephant-impacted areas would support a greater array of microsites than either the exclosures (dense thicket only) or the goat-grazed sites (open savanna of umbrella-shaped shrubs).

Moolman & Cowling (1994) sampled the five sites identified by Stuart-Hill (1992) where it was possible to match control, elephant-impacted and goat-impacted treatments. At each site and for all treatments, they located a 25m x 100m plot. Within each plot they sampled geophytes and succulents in 20 1 m^2 subplots in each of three microsites: open (no canopy shrub cover), under *Portulacaria afra* plants, and under *Euclea undulata* plants. All species were characterised as endemic (to the Albany Centre) or non-endemic, and succulents were categorized taxonomically

(Crassulaceae, Mesembryanthemaceae, other). As was done by Stuart-Hill (1992), the site mean values were used for statistical analyses (df = 4). Here we report only on the elephant-impact component of the study.

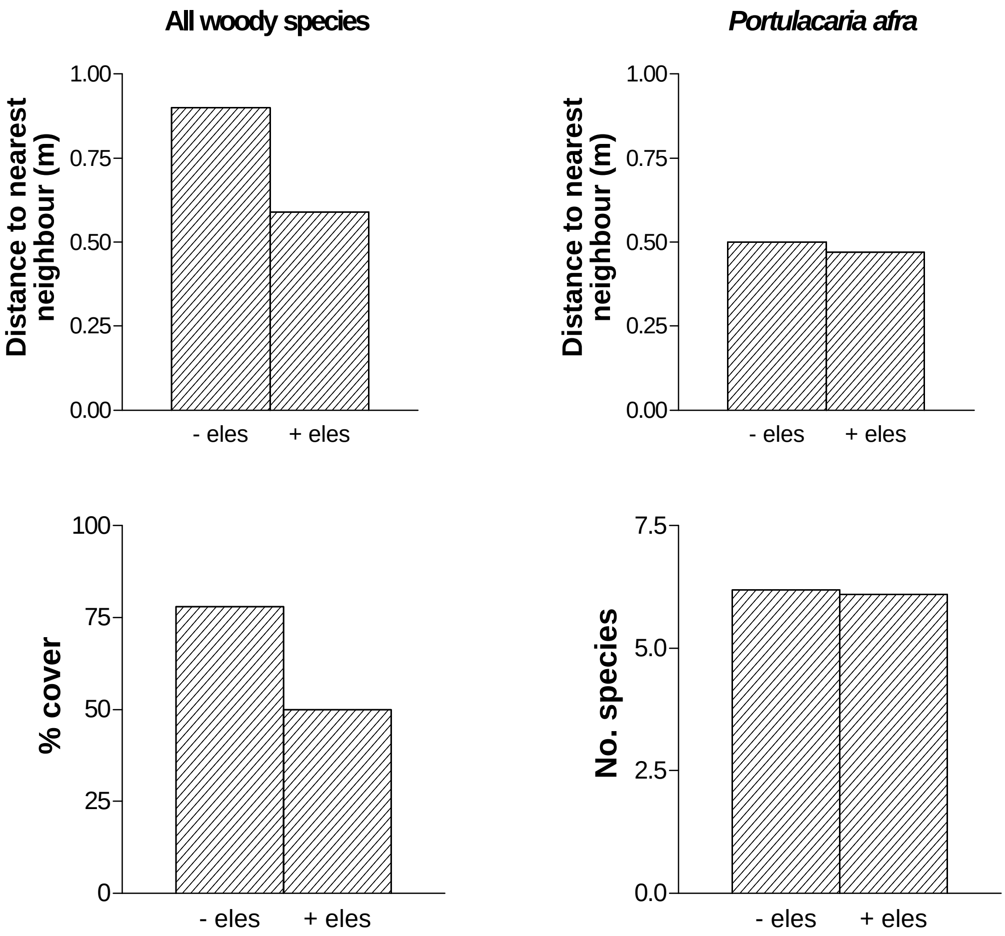
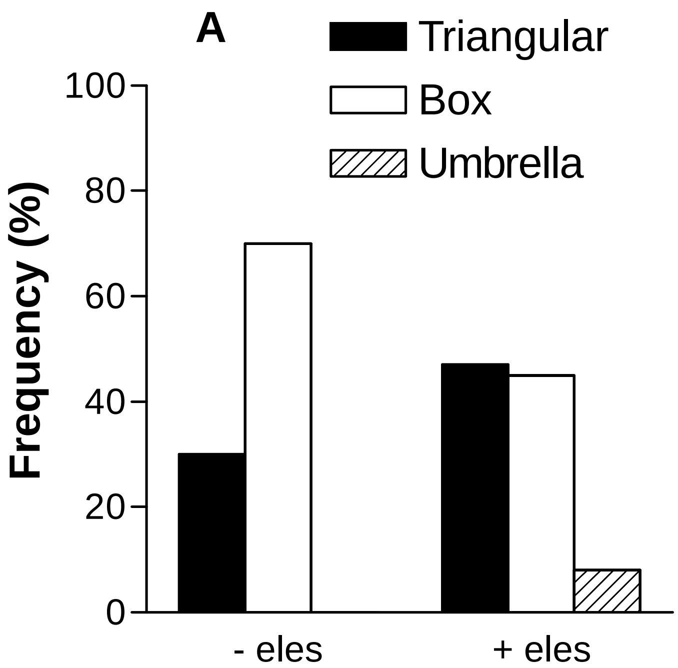


Figure 5. Mean nearest neighbour distance (index of plant density), canopy cover of woody plants and mean number of woody species in circular quadrats (radius = 2.3 m) in thicket of the Addo Elephant National Park. Five quadrats were in areas protected from elephants since 1955 (- eles), and seven quadrats had various histories of elephant exposure (+ eles). Data from Stuart-Hill (1992).

Of the 53 species recorded, 19 were endemics. Across both treatments, nearly all endemics occurred in open sites, most under *Euclea* shrubs and less than 50% under *Portulacaria* shrubs. All endemics noted in the study were present in the protected sites but only 63% were recorded in the elephant-impacted sites. Since Moolman & Cowling (1994) used analysis of variance to test for differences across all treatments, and did not present the results of range tests, it is not possible to present the results of statistical analyses here. Generally, total species richness was highest in open sites and lowest under *Portulacaria* shrubs, and higher in the in the protected than elephant-exposed sites, except for the *Portulacaria* microsite (Figure 7). A similar pattern was observed for species density, % cover and number of endemic species. However, cover was higher in the *Euclea* microsite in elephant-exposed than protected sites. This difference is attributed to the Crassulaceae, a group capable of vegetative reproduction and probably resilient to the impacts of elephants. The absence of marked differences in plant measures between the two treatments in the *Portulacaria* microsite is undoubtedly a consequence of the “top-down” browsing by elephants, which preserves this habitat (Stuart-Hill 1992). However, overall plant richness was lowest in this microsite.



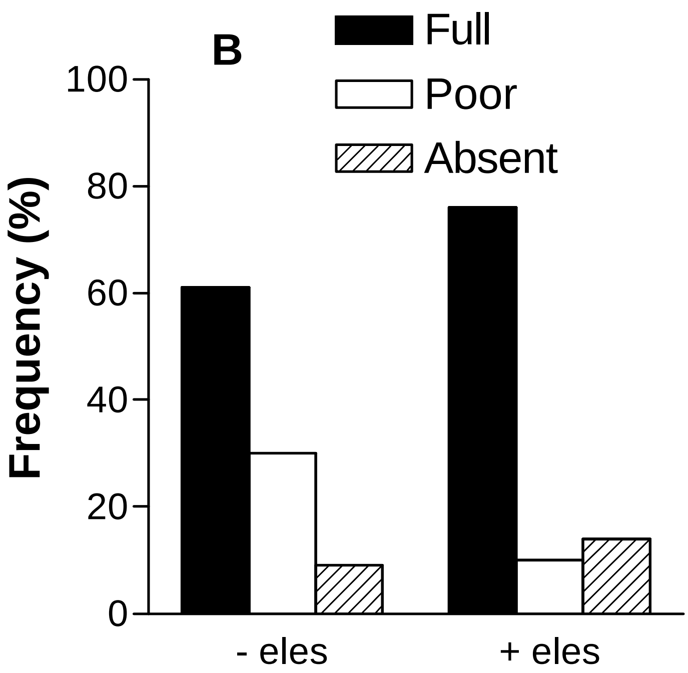


Figure 6. Mean population frequency distributions a) of canopy profiles of *Portulacaria afra* individuals, and b) characterizing the development of "skirts" of *P. afra* individuals from five quadrats in areas protected from elephants since 1955 (-eles), and seven quadrats with various histories of elephant exposure (+ eles). Data from Stuart-Hill (1992).

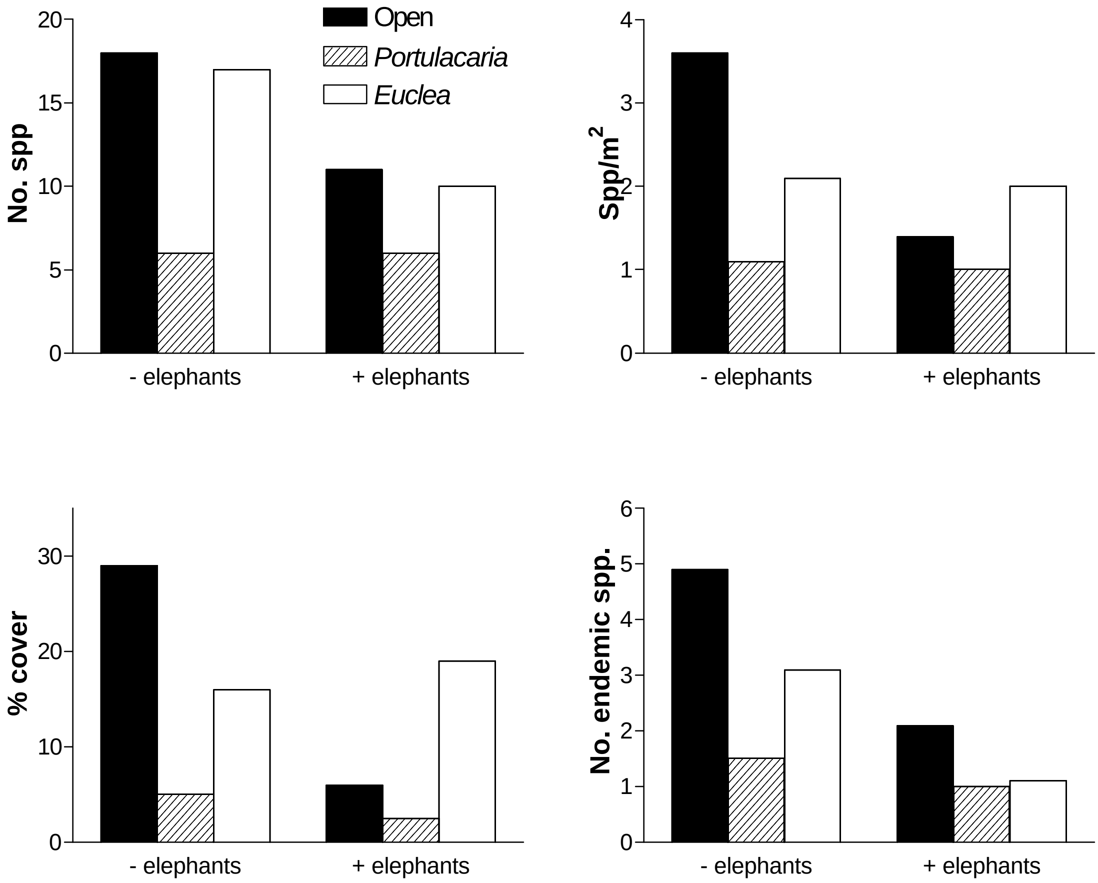


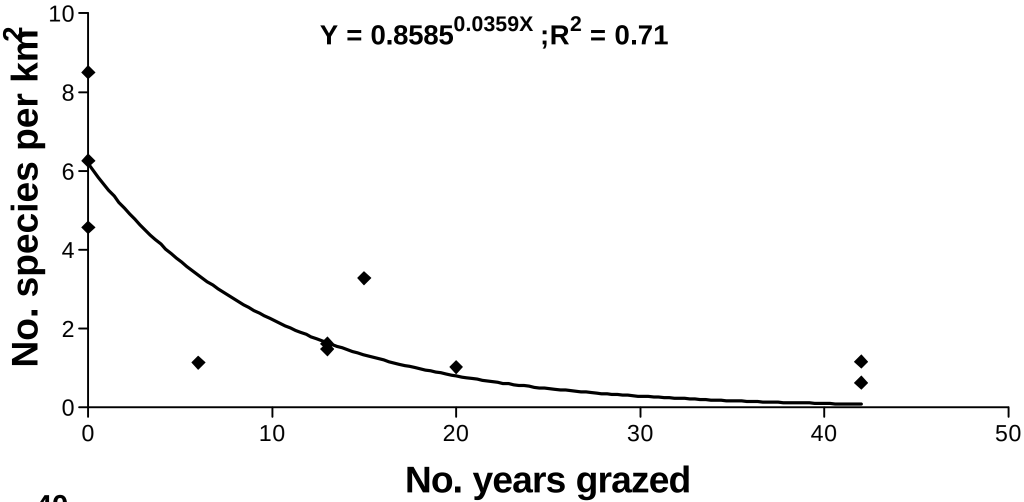
Figure 7. Mean cover and diversity of geophytes, Crassulaceae, Mesembryanthemaceae and other succulents in 100m x 25 m quadrats (n = 5) in three microsites (open, under *Portulacaria afra,* under *Euclea undulata*) in thicket of the Addo Elephant National Park. Paired quadrats were located in areas protected from elephants since 1955 (- elephants), and in areas with various histories of elephant exposure (+ elephants). Data from Moolman & Cowling (1994).

Moolman & Cowling (1994) conclude that elephants have a negative impact on the geophyte and dwarf succulent shrub component of thicket vegetation, something that had been overlooked by earlier workers. If the goal of the AENP is to maintain a viable example of a thicket ecosystem (Novellie 1991), then the density of elephants need to be reduced drastically, preferably by expanding significantly the area accessible to them.

The most recent study on elephant impacts on thicket vegetation is that by Lombard *et al*. (2001). The major objective of this study was to identify a core system of botanical reserves within the Park, using an iterative reserve-selection procedure that would achieve conservation targets for 70 regionally endemic and Red Data Book plant species, as compiled by Johnson *et al*. (1999), as well as five species very rare within the Park, and two epiphytic parasites, *Viscum rotundifolium* and *V. crassulae* that are indicators of elephant grazing intensity (Midgley & Joubert 1991). Each of the units shown in Figure 2 was sampled for the presence and frequency of these “special species” in transects 1 m wide, with the length scaled in proportion to the size of the unit, seven times at regular intervals between September 1996 to June 1997 in order to capture the seasonal variation in appearance of the geophytic component, and to collect reproductive material of all species for identification purposes. Transect lengths varied from 10 m in the smallest unit to over 350 m in the largest unit. These data enabled Lombard *et al*. (2001) to model the richness by fitting the data to an exponential equation and assess the abundance of species in terms of grazing history. In order to accommodate for the different sizes of the units (Figure 2), richness and abundance values were expressed per km^2. Richness was modelled only for the Spekboomveld units (n = 10); patterns for the other vegetation types were depicted in a scatter diagram, since there were inadequate data for modelling.

Grazing history had a strong impact on the richness and abundance of species. In the Spekboomveld units, species richness declined exponentially with length of exposure to elephant grazing; according to the predictions of the exponential model, species numbers were halved with approximately every seven years of exposure (Figure8a). Similarly, Bontveld exposed to 13 years of grazing (unit 13) was seven times poorer in species than ungrazed Bontveld (unit 4) (Figure 8b). The low richness of unit 10 (False Karoo-Bushveld) is attributable to the fact that it was mechanically cleared of thicket in the 1960's to provide grazing for springbok. Both units 8 (Karoo-Bushveld) and 12 (Mixed Shrub & Grassveld) had a much higher richness than would be predicted from the Spekboomveld relationship in Figure 8a; however, these vegetation types do not provide good habitat for elephants and grazing impacts were accordingly lower than in Spekboomveld.

a)



b)

Figure 8. Relationship in the Addo Elephant National Park between exposure to elephant impacts on the richness of special (endemic, Red Data Book and rare) and indicator species in (a) Spekboomveld units, and (b) units containing Karoo-Bushveld (8 and 10), Bontveld (4 and 13) and Mixed Shrub & Grassveld (12). See Table 1 for characteristics of units. From Lombard *et al*. (2001).

Across all units, there was a trend for abundance of species to decline with increasing length of exposure to elephant grazing (Figure 9). Only in the ungrazed units were a large percentage of species recorded at high densities. After 20 years of grazing, most species were recorded at low densities. In units exposed to grazing for 42 years, over 50 % of the remnant flora was confined to small populations.

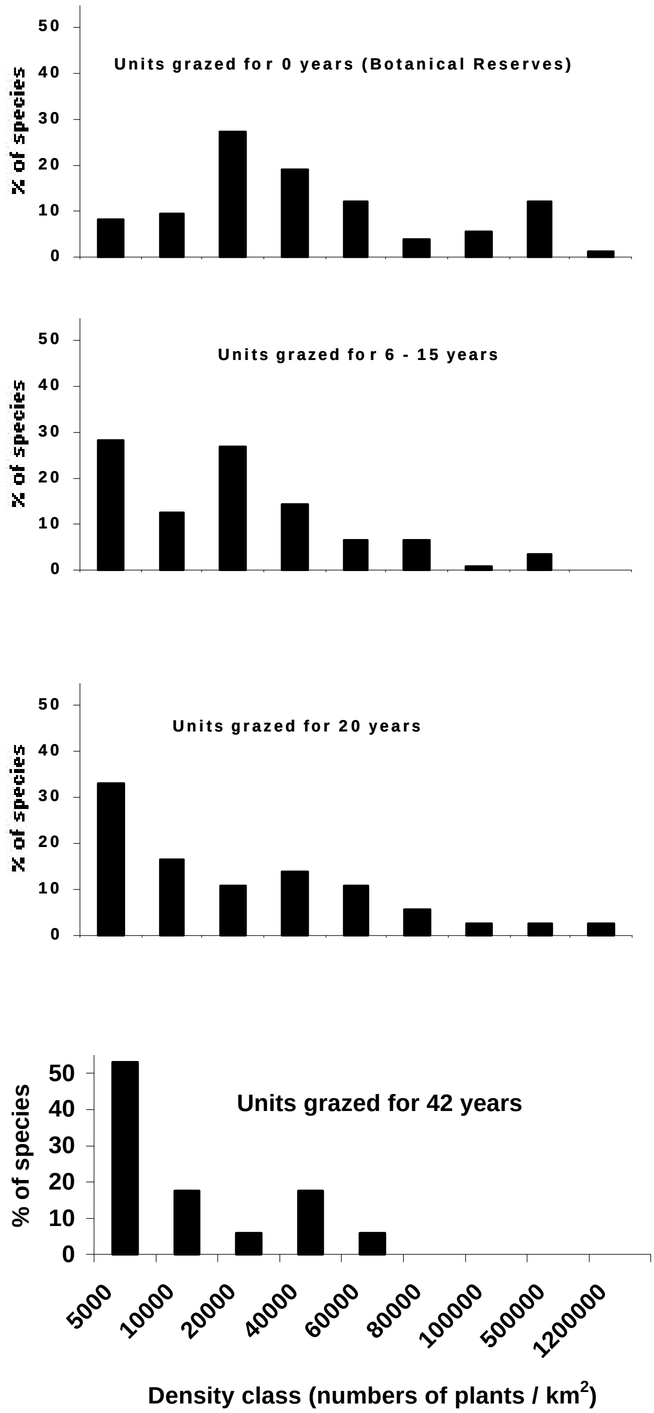


Figure 9. Percentage of special (endemic, Red Data Book and rare) and indicator species in nine different density classes in the Addo Elephant National Park. Data for units in different grazing-history categories appear in separate histograms.From Lombard *et al*. (2001).

Lombard *et al.*'s study is the first to show a clear relationship of time since exposure to elephants and their associated impacts. Their study is particularly disturbing since it indicates that the loss of species will continue unabated under current stocking densities. Moreover, the species that are being lost, or experiencing reduced population sizes, are the ones with highest conservation potential. They conclude: "The ongoing decline in the diversity and abundance of inadequately conserved, endemic and threatened species within a national park is unacceptable, and at variance with the Park's stated objective of preserving intact a viable example of the succulent thicket ecosystem". They recommend a system of botanical reserves, in addition to those already proclaimed, in order to conserve this floristic component. To date, despite a report having been submitted to the Park's authorities in 1999, no action has been taken.

Summary of key findings

All of the studies reported on here show that elephants, at least at the densities maintained in the AENP, have a substantial impact on thicket vegetation. In particular, biomass and cover of dominant woody species is reduced relative to areas protected from elephants, as is the number and population size of species of special concern, most of which are dwarf succulents and geophytes. However, the composition and biomass of dominant woody species are not significantly impacted, although there is considerable variance in the reported data. It would appear that *Portulacaria afra* is least impacted by elephants and may even benefit from their herbivory.

There are two major problems associated with these results.

(i) elephant densities in the AENP are exceptionally and unusually high, and

(ii) the elephant-protected sites ("controls") represent the extreme case of a continuum from complete protection to excessive impact.

Two other points need to be made. Firstly, the impact of elephants, even at these high densities, is considerable less serious than the impacts of goats (Stuart-Hill, 1992; Moolman & Cowling 1994). Secondly, elephant impacts – and presumably that of goats – are ongoing, at least in terms of impacts on special species. There is no evidence that an "equilibrium" state is reached where populations stabilize and species loss levels off. Contrary to Barrat & Hall-Martin (1991), we cannot accept the notion that there is an equilibrium between elephant off-take and thicket production in the elephant-exposed areas of the AENP. One certainly cannot infer this from repeated measures of plant abundance. The reason for this is that elephant density has covaried with exposure time in a non-linear manner.

Future research questions

The AENP has provided excellent, albeit limited opportunities to explore the impacts elephants have on thicket flora and vegetation. Although many questions have been addressed, the natural experiment that the study area provides can be further exploited to answer the following questions:

(i) how does plant architecture (branching patterns, spinescence etc.) vary in relation to forage nutritional status in elephant-exposed and protected sites?

(ii) what differences are there in soil ecosystem patterns (soil fauna, organic matter – cf Kerley *et al.* 1999b) and processes (decomposition rates)?

(iii) what differences are there in plant reproductive patterns and processes?

(iv) to what extent are population reduction the results of direct or indirect elephant impacts?

The plans to open up the sector of the AENP north of the existing elephant enclosure provide very exciting opportunities for research. It is imperative that this is preceded by the establishment of a system of enclosures located in a random, stratified manner. Such a design (with treatment sites randomly located) will enable the formulation and testing of many hypotheses on elephant impacts in thicket.

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The Elephants of Kwandwe: history and status report

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Introduction

Kwandwe Private Game Reserve is situated in the Great Fish River Valley north of Grahamstown. The reserve is 15 800 ha in extent and saddles the Great Fish and Bothas Rivers. The land was intensively used to farm dorper sheep, goats, cattle and ostriches. The five properties were purchased between August of 1998 and March of 2000. All internal fencing was removed as well as signs of organised agriculture. The main focus of the property is eco-tourism and this is where the elephant introductions were paramount to the future success of the project.

The vegetation is made up of grassy dwarf shrubland, bushclump savannah, short succulent thicket and riverine thicket. Ample water is available from the Great Fish River as well as widespread dams, particularly the two on the Bothas River.

Summary of elephant introduction

The population consists of four groups, two breeding groups and two pairs of bulls.

1. Kruger herd

This was a group of eight animals caught in the Malelane area of KNP. The group comprises of three adult females, two sub-adults and three calves. The herd has since had an additional calf. The animals were introduced in mid-August 2001. Matriarch fitted with radio collar 148.60

2. Madikwe herd

This herd was caught in the Tshukudu area of Madikwe Game Reserve in the North-West Province. The group is made up of three adult females, three juveniles and three calves. An additional member has since been born. Matriarch has been fitted with radio collar 148.17. The animals were translocated in October of 2001.

3. Kruger Bulls

These bulls were caught in the Skukuza area of KNP in September 2001. The one bull is 30-35 years old while the other is 20-25 years. Both are fitted with radio collars 148.08 and 71.

4. Letaba Bulls

These bulls were caught in an area adjacent to the KNP in October 2001. They are roughly the same ages as the ones above. Both are fitted with radio collars 148.18 and 99.

Status

The herds presently live in different areas of the property. They have met up and spent three days together before moving off. The bulls have joined from time to time but generally stick to their original pairs. The Madikwe herd has had two calves since arriving, while the Kruger herd has had one calf.

Management approach

The matriarchs of both herds have collars and each bull has a collar. The whereabouts of each animal and group of animals is determined every day. The movement of the animals is mapped in order to keep a record.

Ten vegetation transects have been done to monitor the vegetation as well as a fixed-point photography project of twenty sites is in progress. We also have an exclosure that will give Professor Winston Trollip and his students the opportunity to study vegetation recovering after goat browsing as well as the comparison with the elephant area and the exclosure. We have an additional area that has only buffalo and eland in it for comparative studies.

Future prospects

No further introductions are envisaged. It is our intention to closely monitor the elephants and explore every avenue and option of elephant management as they become available. The possible addition of land cannot be excluded. In Dr. Anthony Hall-Martin's introduction and management plan written for the game reserve, he advises a ceiling population of 190 animals. This independent view is a great deal higher than what we initially thought, so it is more our interest to monitor the impact of the elephant and determine a conservative approach to their population management.

The elephants of Shamwari Game Reserve: history and status report

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Introduction

Shamwari Game Reserve is a private game reserve situated in the Albany and Alexandria Districts of the Eastern Cape, located north of the N2 half way between Grahamstown and Port Elizabeth. Shamwari began in 1990 by purchasing farms and transforming and consolidating them into a reserve. Shamwari opened to the public in 1992 and is an eco-tourism venture. Elephant, being a high profile animal both from tourism and ecological points of view, play a major role at Shamwari which is now 18 000 ha in extent of which 15 500 ha is available for the elephant (Breeding Centre being excluded). The vegetation is very diverse, comprising 6 biomes and 15 vegetation management units, and is dominated by thicket (54%).

Summary of elephant re-introductions

- Two groups of orphans from the Kruger National Park were re-introduced in 1992 and 1993 totaling 14 elephant, comprising 7 males and 7 females.
- In 1994 8 Kruger orphans were brought to Shamwari from Mpongo Park (East London). These elephant were roughly 10 - 12 years old and comprised 4 males and 4 females. The objective of re-introducing the Mpongo elephant was to create a better age structure.
- A family herd of 9 elephant was re-introduced in 1997. Only 7 survived comprising 2 males and 5 females. The matriarch was euthenased after escape and a calf died after being separated from the herd.
- Two females were brought to Shamwari from Knysna (ex Kruger) in 1999 as a result of not joining up with the Knysna elephant and causing damage to farms.

Current status

Of the 31 elephants introduced (13M: 18F, all ex Kruger) the population has now grown to 53 (22M: 28F, 3 unsexed). The oldest bull is about 18 years old. The elephant are divided into two herds, the family herd and the orphan herd. The two herds spend a majority of the time together but regularly separate

Table 1. Shamwari elephant growth (2002 in italic as not included in average growth rate)

YEAR	ELEPHANT TOTAL	CALVES/YEAR	ANNUAL GROWTH RATE
'98	33		
'99	39	6	18.2%
'00	43	4	10.3%
'01	49	6	14.0%
'02	*53*	*4*	*8.2%*
TOTAL		**20**	**14.2**

Therefore projections assuming no change in growth rate are:

YEAR		ELEPHANT
2002	-	56
2003	-	64
2004	-	73
2005	-	83
2006	-	95
2007	-	109
2008	-	124
2009	-	142
2010	-	162

Management approach

Two bulls had to be euthenased. One because it killed a white rhino, the other due to aggression. International 'students' from our student program monitor the elephant under the guidance of a B.Tech. student formulating an identikit of each elephant. Elephant damage will form part of the vegetation monitoring research being done through UPE Botany Dept. by Shamwari's ecologist. Shamwari's Wildlife Manager and vet is looking into the implications of contraception.

Future prospects

There are no further introductions planned.

Ecological carrying capacity (ECC)

Method 1:

Working on a conservative elephant carrying capacity of 0.6/km^2 (National Parks guideline 0.6 - 2 elephant per km^2)

Area available to elephant at present = 13 609 ha

Therefore ECC = **82 elephant**

Elephant will reach ECC at current growth rate by **2005**

If the farms Retreat, Sydbury Park and Sweetkloof are added to Shamwari

13 609 ha + 4 240 ha = 17 849 ha available for elephant.

Therefore ECC = **107 elephant**

Elephant will reach ECC at current growth rate by **2007**

Method 2:

For Valley Bushveld elephant carrying capacity is 2 elephant per km^2.

At present there is 5 575 ha Valley Bushveld available to elephant (Table2).

Therefore ECC = **112 elephant**

ECC at current growth rate will be reached by **2008**

With the addition of the farms Retreat, Sydbury and Sweetkloof, only 1 500ha of Valley Bushveld can be added.

Therefore ECC = **142 elephant**

ECC will be reached by **2009**

The above are conservative estimates of ECC and the projections take the average growth rate at constant. However, this growth rate is extremely high and should slow down (Kruger elephant average growth rate 6 -7%). This will result in ECC being reached at a later date. The estimated ECC also ignores other vegetation types for Method 2 (see Table 2).

Table 2. Relative percentage and area in hectares for each vegetation unit of Shamwari Game Reserve

BIOME AND DISTURBED LANDS	VEGETATION TYPE	AREA IN HECTARES	RELATIVE %
Forest Biome	Afromontane Forest	68.23	0.5
Thicket Biome	Subtropical Thicket (Succulent and Woody)	5,575.08	44.2
	Bontveld	1,002.25	7.9
	Bushclump Savanna	251.28	2
Savanna Biome	Riverine Bush	361.53	2.9
	Primary *Acacia* Thicket	755.64	6
	Secondary *Acacia* Thicket	177.73	1.4
Fynbos Biome	Grassy Fynbos	678.26	5.4
	Calcrete Fynbos	0.8	N/A
Nama Karoo Biome	Karoo Scrub	260.33	2.1
Grassland Biome	Montane Grassland	1,072.36	8.5
	Lowland Grassland	571.96	4.5
Disturbed Lands	Cleared Lands	213	1.7
	Cultivated Lands	1,620.49	12.9

Options

1) Start soonest investigating and, if appropriate, initiating contraception.
2) There is only one breeding bull at present, remove him and introduce adult bulls at a later stage.

Genetic viability

The founder population was fairly substantial, 31 individuals. There have been 4 bulls that have been breeding to date, however only one remains. The introduction of adult bulls in the future is recommended to maintain genetic diversity.

Research

Various aspects of elephant biology and ecology must still be researched:
1) A comprehensive elephant photo id for each individual must be compiled.
2) Intercalving periods need to be established.
3) The implications, social and biological, of contraception researched.
4) Elephant damage per vegetation unit needs to be assessed.

The Elephants of Double Drift: history and status report

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Introduction

Double Drift, proclaimed in 1982, was originally known as the L.L. Sebe Reserve. The land, 23 000ha, had been bought from commercial white farmers with the formation of the then Ciskei Republic. Together with the Sam Knott reserve, it makes up an area of 45 000ha. An area near the main gate was fenced (Nyathi Camp) off and stocked with non-endemic as well as naturally occurring species. The reasoning behind this was that valley bushveld was perceived to be unsuitable for game viewing and so a reasonably open area was stocked with high numbers of game to create a 'zoo type' effect. This area was later enlarged to 3 800 ha, into which elephant were introduced. The elephant are valuable in terms of drawing tourists to the reserve. Most visitors from abroad will only consider a reserve or park worthy if it has the Big 5. Double Drift has 4 of the Big 5 including black rhino, but excluding lion.

Summary of elephant re-introduction

A group of 5 elephant orphans were introduced on 16 July 1994. They comprised of 2 males and 3 females. Unfortunately due to a cold snap 2 females died while still in the release boma. These elephants originated from the Kruger National Park, and were under 2 years of age on their arrival.

Current status

The group is very co-hesive and never ventures more than a few metres from one another. They have never really tamed and prefer to keep well away from people. They have been observed doing mock charges and throwing sticks and branches at white rhinoceros in the Nyathi Camp.

Management approach

Thus far management has been to do various research projects in conjunction with the University of Fort Hare. This has been expanded to include the area outside of the Nyathi Camp in order to have baseline vegetation data to which to refer to with the impending elephant introduction. The only other significant management approach was to increase their area to the present size.

Future Prospects

Fencing projects have started to adequately enclose the whole Fish River reserve. It is envisaged that this will be completed later this year, after which further elephant re-introductions will commence. The sub adults will be moved out of their present camp into the greater reserve. SANPARKS have approved 100 elephant for this introduction, but it is not likely that a number near this will be introduced.

Conclusion

We deem elephants to play a vital role in the management of the valley bushveld type found in the Fish River reserve. Concerns however are in determining the exact carrying capacity of the reserve without damaging the vegetation structure and composition. From a tourism viewpoint, elephants are a major drawcard, which translates into much needed income for the reserve, especially with the tendency for Government to cut back on grants for protected areas.

The Elephants of Bayethe: history and status report

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Introduction

Bayethe Private Game Reserve is situated in the Bushmans River Valley near the historic village of Sidbury, southwest of Grahamstown. The reserve is 4000 ha in extent and there are plans to expand the area. Previously, the property was used for sheep, goat, cattle and ostrich pastoralism. Subsequent to the establishment of the reserve in 2001 all internal fencing was removed. The vegetation is made up of Valley bushveld. There is currently no vegetation monitoring plan, but this is being developed.

Summary of elephant introduction

To date two introductions have been made, a breeding group and a pair of mature bulls.

1. Breeding herd

This group of nine animals were introduced from Gonarezhon in September 2001. The group comprised of four adult females, three sub-adult males and three sub-adult females. Subsequently a single male calf has been born.

2. Kruger Bulls

Two bulls (estimated ages 28 and 31 years) were introduced from Kruger National park in September 2001.

Status

Subsequent to their introduction, it was necessary to kill a single adult female due to her repeated breakouts. The Bayethe herd therefore currently comprises 12 elephants: two bulls, two adult females, three sub-adult males, three sub-adult females and a male calf.

Elephant Conservation and Management Workshop: Summary of Discussions

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Issues that were raised during the question periods and discussions

1. Managing the Eastern Cape elephant populations as a single meta-population.

There will soon be several geographically separate populations of elephants in the Eastern Cape. There seems to be a lot of sense in trying manage these populations as a single meta-population, particularly when it comes to managing genetic diversity.

2. Balancing tourism and conservation goals.

Tourism and conservation goals need to be carefully held in tension, as either has the ability to be dominant at the expense of the other. It is recognized that tourism is a driving force in the management of private and national reserves. However, genetic and ecological laws cannot be changed and elephants are going to have an impact on the ecosystems in which they live. On the other hand, tourist expectations can be managed through a variety of educational programmes. There is also the possibility of maintaining fewer elephants and assisting the tourists in finding them (e.g. radio or satellite tracking). These types of applications will be particularly suited to the private sector.

There is a need to research the views and expectations of tourists visiting the reserves in the Eastern Cape. Based on this research, creative ideas need to be developed to manage tourists.

3. Is feeding behaviour population specific?

There seem to be some populations in the country that have particularly destructive feeding behaviour (especially those from the KNP). There have been relocations from these populations to the Eastern Cape. This raises two issues: firstly, is the undesirable behaviour continued in the relocated population; and secondly, what are the implications of bringing such animals into the Eastern Cape? It may be better to relocate from Tembe as the elephants there are not as destructive but are very similar genetically to those from the KNP.

4. Should the last Knysna elephant bull be relocated to AENP?

It was argued that it was cruel and a waste of genes to leave the last remaining bull elephant in the Knysna forests, as it has no chance of reproducing and had no social structure in which to interact. There is a possibility that tourism in the region may suffer from the relocation, yet there is no research to back this up.

5. What are the key issues in the social carrying capacity concept (SCC)?

Anna Whitehouse's research indicates that there are constraints to elephant populations other than food. As population densities have increased in AENP, so have the number of mortalities due to fighting. There are many issues to be explored under this topic. Little is understood about the implications of interfering with the social structure of families or populations. Bearing this in mind, it is important that managers on all reserves document unusual behaviours by their elephants and share them with other managers, perhaps through the medium of a regular newsletter or forum.

6. Need to implement well-designed experiments to monitor the impacts of elephants in newly opened areas.

Many new areas have been opened up for occupation by elephants, particularly in the AENP. There are also many new private reserves introducing populations on their properties. Each of these incidences represents an opportunity to study the impacts that elephant have on the ecosystem. There is a clear need for a well-designed experimental approach to monitor these impacts. These research programmes must be sustainable over time and will involve some level of commitment from SANP and private reserves. Compared other regions on the continent, the Eastern Cape has excellent baseline vegetation data that can form the basis for such research. Many of the research / monitoring issues can be implemented through the provincial permit policy, so that elephants can only be relocated into the province if some form of acceptable monitoring programme is already in place. Each reserve should have at least one exclosure.

7. What options are there for population control?

All managers of elephant populations are going to face the problem of over-population at some point. There needs to be a regional framework on how to deal with over-population in the Eastern Cape so that when it occurs, the policy is already in place. The owners of all new introductions must be clearly informed of the risks of long-term population growth and made aware of the provincial policy. The option of contraception needs to be explored further, including the social and behavioural impacts of cows not having calves when they should.

8. There is a need for a forum through which managers and researchers can continue to interact.

A number of issues have been identified during the workshop and there is a need for a forum for the outworking of these issues. The administration of this forum requires some resources in terms of personnel, time and finance. Membership to the forum and a fees structure may be necessary. The Terrestrial Ecology Research Unit has been suggested as a suitable home for the forum and will provide a provisional budget with the proceedings.

Table 1. Summary of the issue identified during the workshop with an indication of whether they fall under research (**Res**), conservations (**Cons**), management (**Man**), biology & ecology (**B / E**) or social & political (**S / P**).

Issue	**Res**	**Cons**	**Man**	**B / E**	**S / P**
Develop an understanding of the mechanisms of elephant impacts on ecosystems from landscapes to species level.					
Development of meta-population management options					
Begin population monitoring using at least photographic record.					
Develop the concept of a social carrying capacity.					
Develop protocols for monitoring vegetation in newly opened elephant areas.					
Develop our understanding of benchmarks and encourage the use of enclosures to protect benchmarks					
Explore the use of contraception as means of population control, including social impacts.					
Develop our understanding of the social and economic value of elephants.					
Explore options to manage tourist expectations rather than managing elephants for tourism at the detriment of the environment.					
Establish a forum of managers and researchers that can identify the critical issues and provide inputs into a regional management plan for the Eastern Cape. Also must identify and appoint an organization to adopt ownership of the forum and make resources available to that organization.					

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