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Introduction to the Second Elephant Conservation and Management Workshop

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After having being nearly eradicated from the Eastern Cape, elephants are increasingly being valued and recognised as a key natural resource for the economic development of the province. This is clearly shown in the recent study by Langholz & Kerley (2006) on the socio-economic role of private ecotourism-based operations. The ten private reserves in the study were jointly protecting a total of 116 608 hectares, representing six of South Africa's eight biomes and an immense diversity of plants and animals. In changing from farming to game-based ecotourism, the total number of employees increased by a factor of 4.5 on these properties and each of the 10 reserves is estimated to support an average of 107 full-time employees per reserve, as well as an additional estimated 3,745 dependents. Finally, conversion from agriculture to ecotourism resulted in a 32-fold increase in the average wage bill per reserve. These private reserves rely on the value of biodiversity as a primary resource, and elephants are often a prominent feature that attracts tourists.

Distressingly, despite the obvious significance of this emerging biodiversity-based industry, there is very little support and guidance for the developers of such private reserves from government. The private reserve managers are faced with numerous challenges in their pursuit of economic development and ecological sustainability, not least of which is the need for information on which to make ecological decisions. Few of these private reserves have been able to invest in professional ecological staff, and they have to rely heavily on external expertise. Experience elsewhere has shown that elephants will represent one of the greatest management challenges to these private reserves, and it is therefore an absolute necessity that available resources are pooled and lessons shared. The Centre for African Conservation Ecology has long recognised this responsibility, and has committed to providing the support it can. This, the second such workshop on Elephant Conservation and Management in the Eastern Cape, is an expression of this commitment. We trust that the issues of elephant conservation and management presented here will contribute to the further development of this region and the conservation of its biodiversity.

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Status of elephant populations in the Eastern Cape

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Keeping track of elephant populations in the Eastern Cape used to be straightforward – there was only one population and it was managed by South African National Parks. However since 1993 a number of private land owners have acquired elephants and the number of populations has increased rapidly to 14 (figure 1). This increase has been exponential in the last five years, and shows no sign of slowing down, as a further two populations are scheduled to be established this year.

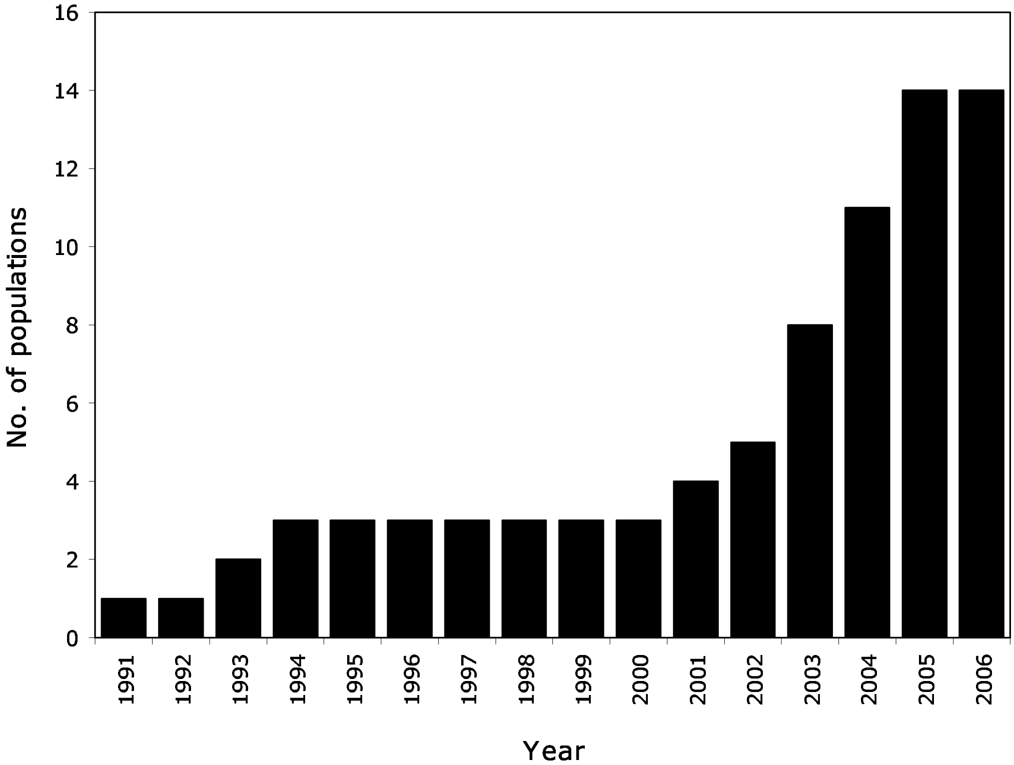

Figure 1: The rate of establishment of elephant populations in the Eastern Cape over the last 15 years.

Accompanying this increase in the number of populations has been an increase in elephant numbers (Figure 2). There are currently an estimated 646 elephants in the Eastern Cape, of which 448 (70%) occur in the Addo Elephant National Park. This means that nearly a third of the elephants (n = 198) in the Eastern Cape occur in small isolated populations, and a significant proportion of these do not have dedicated conservation scientists studying and monitoring them.

Experience elsewhere has shown that these populations will all start to present a set of challenges. It can be predicted that over time, and as the numbers increase, the impacts of elephants will be an increasing cause for concern. Management of these populations will then emerge as a major focus, and the age-old debate of elephant culling will rear its head. The option of contraception is already being investigated in at least one Eastern Cape population, and this needs to be further explored, particularly in terms of the ethical, social and ecological aspects. Recognising that all of these populations are too small to be considered viable, it can be predicted that they will be faced with genetic challenges, as already documented for the Addo population. Research on these issues is especially challenging given the limited resources and the difficulty of detecting such problems. It is therefore recommended that a metapopulation management strategy be developed, whereby all of the elephant populations in the Eastern Cape be linked together and managed as a larger unit, in order to minimise some of the problems around population size.

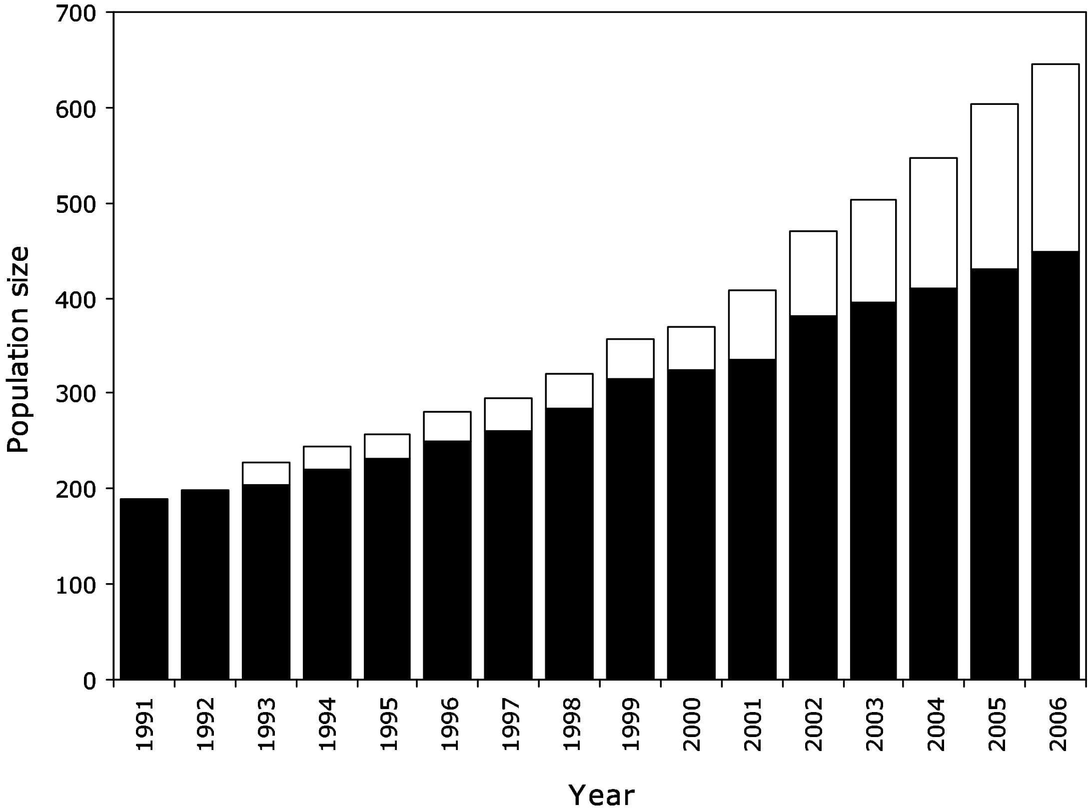

Figure 2: The increase in elephant numbers and the proportion in private ownership (light portions) in the Eastern Cape over the last 15 years.

It is important to place the current elephant populations in perspective: 300 years ago it is likely that there was only a single panmictic population in the Eastern Cape, rather than a number of disjunct populations. Furthermore, based on data generated during the Subtropical Thicket Ecosystem Programme (STEP) conservation assessment (Cowling *et al.* 2003), it has been estimated that there was a total of 5 964 elephant in the STEP domain. So, while it may appear that the status of elephant populations in the Eastern Cape is increasingly moving towards a healthy situation, it must be recognised that there are a series of constraints that need to be overcome to assure the future of elephants in the province. The current populations represent a small fraction of earlier populations. It is also worth noting that much of the area previously available to elephant has now been taken up into other land-uses.

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Lessons from Kruger: a SANParks perspective on elephant management in the Eastern Cape

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The purpose of this talk is to consider elephant management using lessons learnt from a study in the Kruger National Park that incorporated spatial and temporal dimensions of elephant feeding over multiple scales. Specifically, the study considered surface water availability as a patchy resource for elephants, using an underlying non-equilibrium paradigm. At the finest scale examined, the results supported previous findings that elephants select particular size classes and species of tree. At a landscape scale, however, the proximity to surface water determined impact intensity, while the density of surface water determined the intensity as well as the extent of elephant impacts. A framework for organism-generated heterogeneity, employed to synthesize the findings, emphasized that abundant and evenly spaced waterholes spread “intermediate” impact evenly across landscape. Elephant-induced changes to tree diversity should therefore be considered at broad (landscape) scales where water is abundant. However, where surface water is more patchily distributed, elephant-induced changes to tree diversity switch to finer-scale mechanisms involving differentially impacted vegetation patches in the landscape. Since surface water availability varies with time in savannas, both mechanisms can operate in the same system at different times. The framework provided insight into some of the controversy surrounding the role of elephants in changing biodiversity, by revealing that previous scale-neutral approaches resulted in scientists/managers arguing at different scales. It also illustrated that the use of elephant densities (i.e. carrying capacity) to prevent unacceptable biodiversity change is inappropriate in heterogeneous environments. This supports the use of a non-equilibrium paradigm for understanding and managing ecosystems, and implies that a certain amount of change is inevitable, and not necessarily bad, in the presence of elephants. Adaptive management has emerged as the most widely accepted means of dealing with complex, changing systems, and involves setting upper and lower limits of acceptable change to the desired state of an area by elephants, rather than pursuing a “magic number” to prevent undesirable change. Recommendations from this study are therefore that elephant management should focus directly on the vegetation concerns brought about by elephants, recognising the potential role of surface water availability and other variable environmental factors to manipulate the extent of elephant-induced changes to biodiversity. For Addo Elephant National Park, this suggests that artificial water provision should be minimised in newly acquired land, and a combination of other management options, such as contraception, practised. For private landowners, results indicate that elephant population size may be useful to provide an initial assessment of whether the area will have enough food to sustain the animals, but that elephants will eventually change any landscape, regardless of population size, because of the selective nature of their feeding. It is therefore up to the landowner to determine the range of tolerance to elephant impacts that (s)he is willing to accept, given the particular objectives for landuse of that property. Thereafter, management should strive for patchy impacts as far as possible, for example by careful placement of artificial sources of water, and base decisions to take management action on monitoring the extent of change to their landscape.

Searching for evidence of density dependent regulation in the elephant population of Addo Elephant National Park

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Successful conservation and management policies have led to large increases in elephant populations in many conservation areas throughout Africa. Elephants have the ability to transform habitats, particularly when they are at high densities, which may lead to a loss of biodiversity (Van Wyk & Fairall 1969; Laws 1970; Barnes 1983; Western & Gichohi 1989; Lewis 1991; Ben-Shahar 1993; Moolman & Cowling 1994; Cumming *et al*. 1997). The challenge to conservation managers is to identify mechanisms of limiting elephant population size without having to resort to culling. One management approach may be to rely on the natural regulation of population size through density-dependent effects (Laws 1970; Hanks & McIntosh 1973; van Aarde *et al*. 1999). Consequently, understanding how density-dependence influences elephant population dynamics is critical to the future management of elephants.

Density-dependence is defined as the phenomenon by which the values of vital rates (fecundity and mortality), depend on the density of the population, and that when resource utilization exceeds availability the vital rates of individual animals may change (Fowler 1987). We examined a long-term data set of elephant demography and population dynamics from Addo Elephant National Park (AENP). The Parks estimated carrying capacity is 0.1 – 0.5 elephants.km^{-2} (Boshoff *et al*. 2002) but the mean density for the period 1976-2002 was 2.4 ± SD 0.48 elephants.km^{-2} (range 1.8 - 4). Population growth rate was found to be positively correlated with increasing density. The fecundity and mortality rates did not indicate that this population was operating under density-dependent mechanisms. There was no relationship between birth rate or the age of first calving and elephant density; mean age of first calving was 12.3 ± SD 1.73 years and mean inter-calf interval was 3.3 years; mortality rates, particularly for juveniles (0 - 9 years), were low: 1.02 ± SD 1.94%. For full details of results see Gough & Kerley (2006).

The population has been consistently stocked at rates much higher than the estimated sustainable carrying capacity (and there has been a loss of phytomass and biodiversity) yet there is no evidence for density-dependent regulation. This is interpreted in light of the characteristics of the aseasonal habitat, succulent thicket vegetation which provides year round forage and the ability of elephants to utilize accumulated vegetation biomass. In conclusion, we suggest that management strategies within the AENP should not rely on population stabilization through density-dependence as this is unlikely before serious damage to the habitat has occurred.

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The effect of rainfall on calf survival: What does it mean for elephant populations in the Eastern Cape?

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Elephant numbers are increasing across much of southern Africa. Of concern to managers are the potential impacts that this may have on vegetation. Results of a previous study indicate that elephants born in high rainfall years survive better than elephants born in low rainfall years. The relationship is strongest in parks that are fenced and provide networks of artificial water sources. The provision of water opens new areas for elephants, while fencing restricts their movements. The combination of these factors likely increases elephant impacts during low rainfall years. A key feature of the study, however, is that it was conducted in more seasonal savanna systems. The Eastern Cape differs to savannas in that it receives rainfall throughout the year. As a result, elephants have year round access to high quality Thicket vegetation. An unfortunate side effect of this, however, is a lack of density-dependence (Gough & Kerley 2006). This suggests that by the time early warning signals (e.g. increased calf mortality, longer inter-calving intervals) become evident in Eastern Cape populations, elephants will have already severely affected the vegetation. Due to the uniqueness of the Eastern Cape, an elephant management plan different to the ones used in savanna systems is required.

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Foraging height of elephant – preference or availability?

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Elephants are a keystone species in many plant-herbivore systems and can influence the community structure and ecological processes. This holds true for the subtropical thicket of the Eastern Cape where elephants' foraging height is proposed to be important for vegetative reproduction and also as a mechanism for resource partitioning between indigenous thicket browsers. This study aimed to determine the preferred and actual foraging height of elephants and the implications thereof for co-existing browsers and vegetation. It was hypothesized that elephant preferred foraging height would be related to shoulder height; this was tested both experimentally and with field observations in the Addo Elephant National Park (AENP). The preferred foraging height of 22 tame elephant was determined by offering elephants food items at 25 cm intervals from ground level (0 m) up to 6 m. The shoulder height and maximum foraging height of each individual were also measured. The foraging height and shoulder heights of elephants in the field were measured in the AENP, together with the maximum and minimum available forage on the plant on which the elephant was foraging. Neither the preferred foraging heights of elephant nor the observed foraging heights in AENP were found to be related to elephant shoulder height. Elephants in the field were observed to forage above the preferred foraging height of 25 cm and below the maximum height of available foliage recorded (range 0.25 m – 1.93 m). The foraging height of elephants in the field is therefore not determined by morphology or preference, but by the availability of forage. Elephants foraged over a large range of foraging heights during the experimental trials (0 – 5.25 m) and in the field (0.20 m – 2.70 m) which overlapped and extended beyond the foraging heights of all the other indigenous browsers. The foraging height of elephants in the field is useful to assess the influence of foraging on plant morphology and there is a clear overlap with the foraging heights of the other indigenous thicket browsers. Together with implications of elephant foraging for other thicket species reviewed by Kerley & Landman (2006), the overlap in foraging heights may also have implications for the co-existing thicket browsers.

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Seed dispersal by elephants: Passage rates and seed germination.

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Endozoochory is defined as seed dispersal by an animal after passage through its guts. It is an important form of seed dispersal, especially in those environments in which herbivores are important drivers of vegetation structure and function, as is the case in Eastern Cape Subtropical Thicket. The benefits of endozoochory include dispersal away from the parent plant, removal of the fruit flesh (which may contain germination inhibiting chemicals, or form a source of infection), mechanical and chemical scarification encountered in the digestive tract may allow the diffusion of water and gases into the seed (thereby aiding germination), and seeds are often deposited in moist, nutrient-rich dung. However, seed mortality can be increased if scarification in the digestive tract is prolonged and therefore too severe. Many plant species have evolved to exploit their herbivore/frugivore seed dispersers and have developed methods of attracting potential dispersers through the production of large, brightly coloured, fleshy fruits. Elephants are of particular interest as endozoochores, as they have a broad diet, including *ca.* 146 plant species in thicket (Kerley & Landman 2006) (of which approximately half produce fruits which are brightly coloured and/or fleshy), are known to disperse the seeds of at least 20 thicket plant species, consume a large quantity of forage daily, have a relatively poor digestive system, and are highly mobile.

This study (Davis In prep) focused on the effect of the elephant's digestive tract on seed dispersal, and the specific aims were to determine whether:

1. Passage time through an elephant's digestive tract is affected by seed size,
2. Seed mortality due to elephant endozoochory is species specific, and
3. Passage through the elephant's digestive tract affects Total Percent Germination (TPG) in different seed species.

Feeding trials were conducted using five elephants. Passage times for different sized seeds were determined using round plastic beads in three sizes (4 mm, 8 mm and 12 mm) fed to each of the five elephants. Plastic beads were used so that effects of other seed traits such as seed shape and specific gravity, on passage rate, could be discarded. Seeds of four plant species, *Azima tetracantha*, *Acacia karroo*, *Grewia robusta* and *Opuntia ficus-indica* were fed to the elephants. All four plant species are eaten by elephants and the seeds of *A. tetracantha*, *G. robusta* and *O. ficus-indica* have all been found in elephant dung, indicating that these species are dispersed by elephants in thicket vegetation. The elephants were monitored for 72 hours and all dung was collected, hand-sorted and all seeds and plastic beads removed. Seed germination trials were conducted to determine Total Percent Germination (TPG), using the seeds recovered from the elephant dung, and a control treatment of seeds taken directly from the parent plants of each species. All seeds were placed in a germination cabinet to allow germination and monitored for 90 days.

The results indicate that when considered alone, seed size does not affect passage time. Plastic beads remained in the digestive tract for at least 12 hours after ingestion and 50% of all beads ingested were defecated within 39 hours. Seed mortality increased with a decrease in seed size. *O. ficus-indica*, the smallest seed species fed, had over 90% mortality. The exception was *G. robusta*, which although it did not have the largest seed size, had the lowest percentage mortality. It may be that its thicker seed coat prevented mortality due to mechanical and chemical scarification. TPG was significantly increased in *A. tetracantha* seeds exposed to the elephant digestion treatment. Passage through the elephant's digestive tract slightly inhibited TPG of *A. karroo* seeds and slightly enhanced TPG in *G. robusta* and *O. ficus-indica.* In all four species germination rate was slightly increased.

Elephants can travel over large distances daily, so the fact that most seeds are likely to remain in the digestive tract for more than 24 hours indicates that elephants effectively disperse seeds over large distances. Although seed mortality is high, especially in smaller seeded species, elephants do not significantly inhibit seed germination, but actually increase the rate of germination. These findings support the fact that elephants are important seed dispersers in Eastern Cape Subtropical Thicket.

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Threats to Important Plants in the Addo Elephant National Park, South Africa – evaluating the role of elephant herbivory

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Although numerous studies quantify the impacts of elephants on communities (e.g. Owen-Smith 1988; Cumming *et al* 1997, Lombard *et al.* 2001, Kerley & Landman 2006), the mechanisms driving these impacts are rarely identified. Elephant herbivory is often assumed the primary mechanism responsible for the structuring of plant communities (e.g. Laws 1970, Penzhorn *et al.* 1974, Barratt & Hall-Martin 1981, Owen-Smith 1988, Moolman & Cowling 1994, Lombard *et al.* 2001, Conybeare 2004), despite the fact that elephants influence a range of other ecological processes (e.g. trampling, seed dispersal, nutrient cycling – Boshoff *et al*. 2001). Identifying alternative mechanisms of elephant impact is particularly challenging given that many of the direct impacts may have a range of knock-on-effects (Kerley & Landman 2006). In the Addo Elephant National Park (AENP), elephant herbivory is apparently responsible for changes to plant richness, density and biomass (Penzhorn *et al.* 1974, Barratt & Hall-Martin 1981, Midgley & Joubert1991, Stuart-Hill 1992, Moolman & Cowling 1994, Lombard *et al.* 2001). Plants thought to be most vulnerable to elephant herbivory (Important Plants) are the regionally rare and endemic small succulent shrubs and geophytes (Moolman & Cowling 1994, Lombard *et al*. 2001) that decrease (abundance and richness) exponentially with increasing length of exposure to elephant browsing (Lombard *et al*. 2001).

We used faecal analysis to investigate the occurrence and extent of utilisation of plants with high conservation value (Albany Centre Endemics, Red Data Book taxa, taxa very rare within the Park, indicator species of elephant browsing intensity) in the diet of elephant in the AENP. One-hundred and forty-six plant species were identified in the diet (Paley & Kerley 1998, Davis 2004, Landman *et al*. In Press). Only 14 (*c*. 18 %) of the 77 Important Plants identified to be apparently particularly vulnerable to elephant herbivory occurred in the diet (Table 1).

It may therefore not be realistic to attribute the disappearance of these plants to elephant herbivory. This highlights the need to demonstrate appropriate cause-and-effect relationships when ascribing changing patterns to elephant impacts. The assumption that elephant herbivory is responsible for plant extinction in the AENP has resulted in other mechanisms (e.g. knock-on effects, trampling, zoochory etc.) receiving little attention.

Table 1. Important Plants identified in the diet of elephant in the Addo Elephant National Park (Paley & Kerley, 1998; Davis, 2004; Landman et al., In Press). ACE = Albany Centre Endemic; Indicator sp. = Indicator of elephant browsing intensity (Midgley & Joubert, 1991).

Family	Important Plants	Conservation status
Woody shrubs		
Asparagaceae	*Asparagus crassicladus*	ACE
Asparagaceae	*Asparagus subulatus*	ACE
Celastraceae	*Gymnosporia capitata*	ACE
Euphorbiaceae	*Jatropha capensis*	ACE
Lamiaceae	*Salvia scabra*	ACE
Succulents		
Asphodelaceae	*Aloe africana*	ACE
Euphorbiaceae	*Euphorbia inermis*	ACE
Euphorbiaceae	*Euphorbia ledienii*	ACE
Mesembryanthemaceae	*Platythyra haeckeliana*	ACE
Forbs		
Asteraceae	*Senecio linifolius*	ACE
Geophytes		
Asphodelaceae	*Bulbine sp.*	Unknown
Dracaenaceae	*Sansevieria aethiopica*	ACE
Mesembryanthemaceae	*Trichodiadema bulbosum*	ACE
Epiphytes		
Viscaceae	*Viscum sp.*	Indicator sp.

These mechanisms should be included in assessments of elephant impacts, to predict, and ultimately manage the changes to ecosystems caused by elephants in the AENP and elsewhere. By demonstrating appropriate cause-and-effect relationships between elephants and ecosystem change, we will be able to move beyond assuming that all the observed changes are due to elephant herbivory. The re-introduction of elephants into a range of private reserves in the Eastern Cape provides an opportunity to investigate the mechanisms of elephant impact. This is particularly important as more than 20 % of the Succulent Thicket flora is endemic to the Eastern Cape (Vlok *et al.*, 2003), and the AENP is the only reserve in South Africa where plant species are currently vulnerable to global extinction as a result of elephant impacts (Kerley & Landman, 2006).

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Elephants and Landscape Functioning In Grassland Habitats

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Elephants (*Loxodonta africana*) constitute one of the largest proportions of mammalian herbivore biomass across African savanna ecosystems. In addition, their influence on woody plant communities is profound and evidence of elephant-induced habitat alteration is widespread across the continent. However, their role in ecosystem functioning is, by comparison, very poorly understood. Elephants, like most large herbivores, can be regarded as drivers or triggers of ecosystem functioning by, for example, decreasing litter accumulation through defoliation. Thus, they are capable of altering landscapes, causing shifts from fully functional to more dysfunctional ecosystems, where the loss of vital nutrients becomes excessive and the lack of resistance to erosive disturbance increases.

We investigated the influence of elephants on ecosystem functioning within grassland habitats at five sites with elephants (treatment), and five sites without elephants (control) in the Eastern Cape Province, South Africa between December 2005 and March 2006. Using the landscape functioning analysis (LFA) we described the landscape organisation of each site and, using surrogates, calculated indices of habitat stability, infiltration and nutrient cycling.

There was no significant difference ($P > 0.05$) between control and treatment sites in terms of the number of patches of long-lived features present (e.g. grass or shrub patches), patch size or distance between patches. These results suggest that functional resource control at treatment and control sites is similar and that both sites are capable of effectively regulating scarce resources, such as water. Indices for stability, infiltration and nutrient cycling were higher, but not significantly different ($P > 0.05$) at control sites. These values correspond to values obtained for grazing experiments conducted in Australia and indicate that both treatment and control sites are essentially self-regulating and will probably be resistant to stochastic disturbance events such as erosion. However, our results do suggest that sites that have had elephants for longer (when controlling for differences in density) tend to have lower indices of stability, infiltration and nutrient cycling.

In conclusion, our data suggest that landscape organisation and physical ecological indices are not significantly different between treatment and control sites, despite apparent individual location differences. However, the current study was only conducted at sites that have had elephants for a relatively short period (longest 14 years) and we will extend the study to incorporate a reference site that has had elephants for longer to truly test the trends presented.

Elephant impact on black rhinoceros foraging opportunities: competition for the conservation of megaherbivores?

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Elephants are responsible for extensive habitat change within conservation areas, primarily due to their ability to affect plant communities as well as the tendency to manage these megaherbivores in relatively small areas at high densities. Elephants induce a reduction of plant species richness, density and biomass (e.g. Penzhorn *et al.*, 1974; Barratt & Hall-Martin, 1981; Midgley & Joubert, 1991; Stuart-Hill, 1992; Moolman & Cowling, 1994; Lombard *et al.*, 2001; Kerley & Landman 2006), and have the potential to severely reduce the foraging opportunities of co-occurring browsing herbivores. The Thicket Biome supports the highest density of black rhinoceros in the world and may play a significant role in the conservation of this species (Kerley *et al*., 2005).

We used information on black rhinoceros foraging behaviour (feeding height, bite size forage selection – Wilson 2002) to assess potential browse availability along a gradient of elephant utilisation, and quantified the potential loss in browse availability due to over-utilisation by elephants. We further investigated the potential for dietary competition between these megaherbivores in thicket vegetation. Results support the hypothesis that elephant and black rhinoceros display a large overlap (i.e. potential for interspecific competition) in dietary resource utilisation. Seventy-nine, of the 90 and 92 plant species identified in the diet of elephant and black rhinoceros, respectively, were utilised by both species. A 64% overlap in utilisation was obtained when considering the abundance of these plant species in the diet of the animals. Results further show that potential browse availability for black rhinoceros is reduced in areas with no elephant utilisation and those exposed to long-term utilisation by elephants. Moreover, the increase in elephant paths, associated with increases in elephant densities, initially facilitates access to browse by black rhinoceros, but the subsequent dominance of the landscape by these paths results in a loss of foraging opportunities.

The over-utilisation of thicket vegetation by elephant compromises the potential of this vegetation type to contribute towards black rhinoceros foraging, and hence conservation opportunities. There exists potential conflict between the management and conservation of these two megaherbivore species, which needs to be recognised and managed.

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The impacts of elephants on biodiversity in the Eastern Cape Subtropical Thickets

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We reviewed available information on the impacts of elephants on the Subtropical Thickets of the Eastern Cape in response to the need to develop appropriate elephant management strategies and the need to conserve biodiversity in this ecologically diverse region (Kerley & Landman, 2006). Our understanding of the role of elephants in the region is, however, limited to research on a single population in the Addo Elephant National Park (AENP) and is confounded by 1) the assumption that botanical reserves represent a 'control treatment' that can be used as a baseline to assess the impacts of elephants on thicket vegetation (thus, ignoring the potential of 'megaherbivore-release'), 2) the assumption that differences between botanical reserves and elephant-occupied areas can be directly attributed to elephants, and 3) the exceptionally high elephant densities (1.0 - 4.1 elephants.km-2) for the past 50 years (Figure 1).

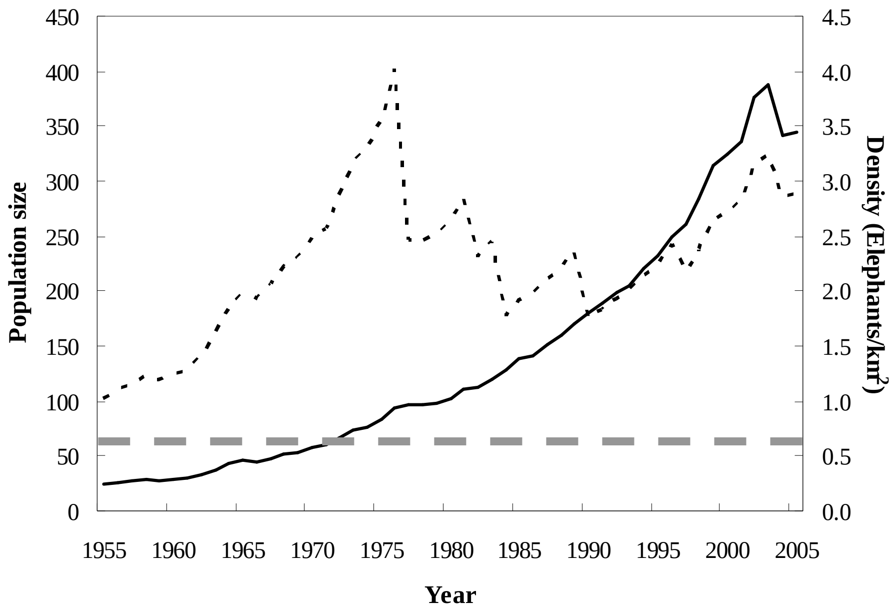

Figure 1. Elephant population size (solid line) and density (thin, dashed line) in relation to the maximum estimated ecological carrying capacity (thick, hatched line) for the elephant enclosure of the Addo Elephant National Park. The declines in density due to park enlargement in 1977, 1982, 1984, 1990 and 1997, and the translocation in 2003 of elephants to the Nyathi Concession Area, are shown

The results of research on elephant impacts associated with the Addo population has shown that these animals influence many ecological processes (14 of 19 ecological processes important in thicket), and patterns, including soil features (causing a decline in the proportion of the landscape that trap water, litter and nutrients), landscape patchiness (causing an increase in the proportion of the landscape transformed into open habitat) and plant biomass (causing a 55% reduction in plant biomass) and diversity (small succulents and geophytes being particularly vulnerable). Furthermore, elephants influence insect, bird and antelope (especially bushbuck and grysbok) abundances and reduce browse availability for black rhinoceros (Kerley & Landman, 2006). However, despite the demonstrated effects of elephants on biodiversity, this population showed no evidence of density-dependent (survivorship, fecundity) population regulation (Gough & Kerley, 2005).

We conclude that elephants affect biodiversity at all levels investigated but that further research is necessary to identify the mechanisms responsible. Of specific concern is the observation that the AENP represents the only current example where elephants may be driving many endemic plants to extinction. This suggests that managing elephant impacts in Subtropical Thickets, specifically, is a matter of urgency (Kerley & Landman, 2006).

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Second Eastern Cape Elephant Conservation and Management Workshop: Summary of Discussions

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There are currently 14 privately-owned elephant populations in the Eastern Cape, and more populations are being established. To ensure the long-term persistence of these populations, protect associated biodiversity and encourage associated tourism opportunities in the region, the following issues were raised and agreed upon during the workshop discussion session:

- **Population Management:** The generally small elephant populations in the Eastern Cape should ideally be managed as part of a meta-population, in order to address genetic risks. This will require a significant level of understanding of the relationships, demographics and behaviour of these elephants. There is also a need to invest in resources (technology, corridors, etc) to allow such meta-population management. Furthermore, a uniform approach of elephant monitoring across landscapes/reserves should be adopted. In this regard, it was agreed that the Eastern Cape Association of Private Game Reserves (Indalo) should encourage the establishment of a framework for the management and monitoring of these populations. This could follow the approach and methodology already being applied by Centre for African Conservation (ACE) for the Addo elephants.

- **Biodiversity Conservation:** A number of key research needs and opportunities on the impacts of elephants on thicket vegetation/biodiversity were identified:

  - There exists a range of opportunities to quantify and understand the impacts of elephants on biodiversity across landscapes in the Eastern Cape through a series of unplanned experiments using the 14 populations,
  - Temporal and spatial differences in the feeding impacts of elephants on thicket vegetation need to be investigated, taking the potential cultural (i.e hypothesized differences between populations) effects into consideration,
  - The time-specific impacts associated with the introduction of new populations should be investigated,
  - Replicated control sites, to monitor the impacts of elephants, should be established in all private reserves. However, it must be recognised that these control sites have limited validity (see Kerley & Landman, 2006 for review),
  - Piospheres (areas of heavy utilisation surrounding waterholes) are natural phenomena, but we need to strive to limit the number of

waterholes (and thus piosphere effects). Fewer waterholes allow some areas to regenerate following dry periods.
- Possible density-dependence in the different populations should be assessed, as per Gough & Kerley (2006), as this will be a strong indicator of resource limitation.
- Information on elephant impacts should be shared in order to allow the early detection of impacts and possible loss of biodiversity.

It was recognised that the ACE has played a leading role in megaherbivore research in the Eastern Cape, and the workshop participants urged ACE to maintain this capacity and momentum.

- **The way forward:**

  - Establish an Elephant Forum to discuss issues related to the management of elephant populations in small private reserves in the Eastern Cape,
  - Indalo to identify specific issues related to elephant management that require attention,
  - There exists a need for an elephant management strategy that is specific to the Eastern Cape, but that is informed by elephant research and management in other landscapes.

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