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Elevated elephant density does not improve ecotourism opportunities: convergence in social and ecological objectives

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Abstract. In order to sustainably conserve biodiversity, many protected areas, particularly private protected areas, must find means of self-financing. Ecotourism is increasingly seen as a mechanism to achieve such financial sustainability. However, there is concern that ecotourism operations are driven to achieve successful game-viewing, influencing the management of charismatic species. An abundance of such species, including the African elephant (*Loxodonta africana*), has been stocked in protected areas under the assumption that they will increase ecotourism value. At moderate to high densities, the impact of elephants is costly; numerous studies have documented severe changes in biodiversity through the impacts of elephants. Protected areas that focus on maintaining high numbers of elephants may therefore face a conflict between socioeconomic demands and the capacity of ecological systems. We address this conflict by analyzing tourist elephant-sighting records from six private and one statutory protected area, the Addo Elephant National Park (AENP), in the Eastern Cape Province of South Africa, in relation to elephant numbers. We found no relationship between elephant density and elephant-viewing success. Even though elephant density in the AENP increased over time, a hierarchical partitioning analysis indicated that elephant density was not a driver of tourist numbers. In contrast, annual tourist numbers for the AENP were positively correlated with general tourist numbers recorded for South Africa. Our results indicate that the socioeconomic and ecological requirements of protected areas in terms of tourism and elephants, respectively, converge. Thus, high elephant densities and their associated ecological costs are not required to support ecotourism operations for financial sustainability. Understanding the social and ecological feedbacks that dominate the dynamics of protected areas, particularly within private protected areas, can help to elucidate the management challenges of minimizing ecological trade-offs while meeting ecotourist demands and achieving sustainability.

Key words: Addo Elephant National Park, African elephant; Eastern Cape Province, South Africa; ecotourism; elephant density; elephant viewing success; Loxodonta africana; *Protected Areas as Socio-ecological Systems; resilience; sustainability.*

Introduction

The main goal of most protected areas is to conserve biodiversity (species, communities, landscapes, and ecosystems) of regional, national, and international significance (Margules and Pressey 2000). Protected areas are subjected to both natural and human-induced disturbances (e.g., drought, poaching, water abstraction, and political change), and effective management approaches are required to enable conservation objectives to be achieved while ensuring that human needs are met (Newton 2011). Protected areas can thus be viewed as linked social–ecological systems, consisting of a suite of actors (managers, tourists, animals, plants) that co-occur in and around the protected areas. For protected areas to persist, they therefore need to be resilient in both the social and ecological domains (Newton 2011). Resilience can be defined as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain the same function, structure, and feedbacks (Walker et al. 2004).

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Ecotourism, however, plays a large role in the functioning of protected areas, especially in private protected areas that depend on wildlife-based ecotourism as their primary means of financial support (Langholz and Kerley 2006). Thus, achieving tourist satisfaction has become the driving goal in the management of many protected areas (Novellie 1991), often at the expense of biodiversity objectives. High numbers of charismatic species are stocked in protected areas to achieve successful game-viewing sightings (Novellie 1991, Carter et al. 2008), placing pressure on vegetation and communities of other organisms, and potentially affecting ecosystem resilience. A conflict thereby exists between the ecological intention of protected areas conserving biodiversity and the managers' need to achieve economic sustainability.

Management can either undermine or build resilience in a system, depending on how the system organizes itself in response to disturbances (Carpenter et al. 2001, Holling 2001). Understanding the social and ecological dynamics of the system is thus important in guiding management interventions to improve the long-term performance of social–ecological systems (Anderies et al. 2006). When there are conflicts between the social and ecological systems, the prospects of achieving resilience decline substantially. We address one such example here.

The African elephant (*Loxodonta africana*) has been identified as one of the key tourist attractions in South Africa, especially in the Eastern Cape Province (Kerley et al. 2003). Tourists apparently expect a high chance of seeing this charismatic species (Novellie 1991, Kerley et al. 1995, 2003) and therefore high numbers of elephant are stocked in the Addo Elephant National Park (AENP) under the assumption of increasing ecotourism (Novellie 1991). These charismatic species have positive consequences for the social–ecological system in terms of both the ecological processes that they provide (Kerley et al. 1995, Rouget et al. 2006) and the income and support that they generate through ecotourism (Geach 1997). However, there are also negative aspects associated with the stocking of elephants in protected areas, especially at high densities, where they have been implicated in declines in biodiversity (Cumming et al. 1997, Kerley et al. 2008), particularly in the subtropical thicket characteristic of the AENP (Kerley and Landman 2006). Elephants are very large, social, and equipped with specialized feeding adaptations (the trunk and tusks) that allow them to forage differently than other, smaller herbivores (Kerley et al. 2008). Studies have documented how this megaherbivore influences the fate of more plant species than any other large herbivore (Barnes 2001, Kerley and Landman 2006). Elephants exhibit a destructive feeding action that may lead directly to the death of trees through felling or uprooting, or indirectly through bark removal (Kerley et al. 2008). In Botswana, elephants have played a significant role in the disappearance of the riverine acacia woodlands along the Chobe River (Barnes 2001, Skarpe et al. 2004). In the subtropical thicket of South Africa, high elephant densities cause a reduction in plant biomass (Pentzhorn et al. 1974, Barrett and Hall-Martin 1991) and the loss of a range of plant species, including a number of endemic or near-endemic succulents and geophytes (Moolman and Cowling 1994, Lombard et al. 2001, Kerley and Landman 2006). It has also been postulated that changes in habitat structure brought about by high elephant numbers in the AENP and elsewhere have reduced the richness and abundance of a variety of animal species (Novellie et al. 1996, Fenton et al. 1998, Kerley and Landman 2006, Kerley et al. 2008). Maintaining species diversity is not only the core objective of protected areas but also this diversity plays an important role in attracting tourists to protected areas (Okello and Yerian 2009). The impacts from stocking protected areas at high elephant densities may therefore fundamentally alter the nature of the ecosystem within protected areas and could shift the social–ecological system into an undesirable state (Anderies et al. 2006).

It is thus important to stock elephants at low densities in fenced reserves to reduce their impact, to maintain other species (Novellie et al. 1996, Skarpe et al. 2004, Kerley et al. 2008), and, ultimately, to ensure sustainability of protected areas. One recommendation is that densities in the AENP should not exceed 0.4 elephant/km^2 (Pentzhorn et al. 1974), and Boshoff et al. (2002) recommend between 0.25 and 0.52 elephant/km^2. Since the fencing of the park in 1954, elephant densities have consistently exceeded these recommended figures, by up to eight times for some periods (Kerley and Landman 2006).

There is thus a need to provide managers with insights as to how many elephants are required to achieve tourist satisfaction, while keeping numbers low enough to ensure that protected areas adequately fulfil their function of conserving biodiversity. We tested the hypothesis that high elephant densities are needed for tourist satisfaction and that increased elephant densities thereby increase tourist numbers (Novellie 1991). This hypothesis was tested using a number of elephant-based ecotourism operations, with varying elephant density, to determine the relationship between elephant density and viewing success by tourists, as well as the relationship between elephant density and tourist numbers.

Methods

Study sites

Five private protected areas and one private ecotourism operator in the AENP in the Eastern Cape, South Africa, were used as study systems (Fig. 1). These ecotourism operations are fenced reserves, varying in terms of their elephant abundance and total reserve size, separated by a matrix of uninhabitable land. Amakhala Game Reserve covers an area of 69 km^2 and stocks a total of 19 elephants. Hopewell Game Reserve represents the smallest study site (27 km^2) and stocks 12

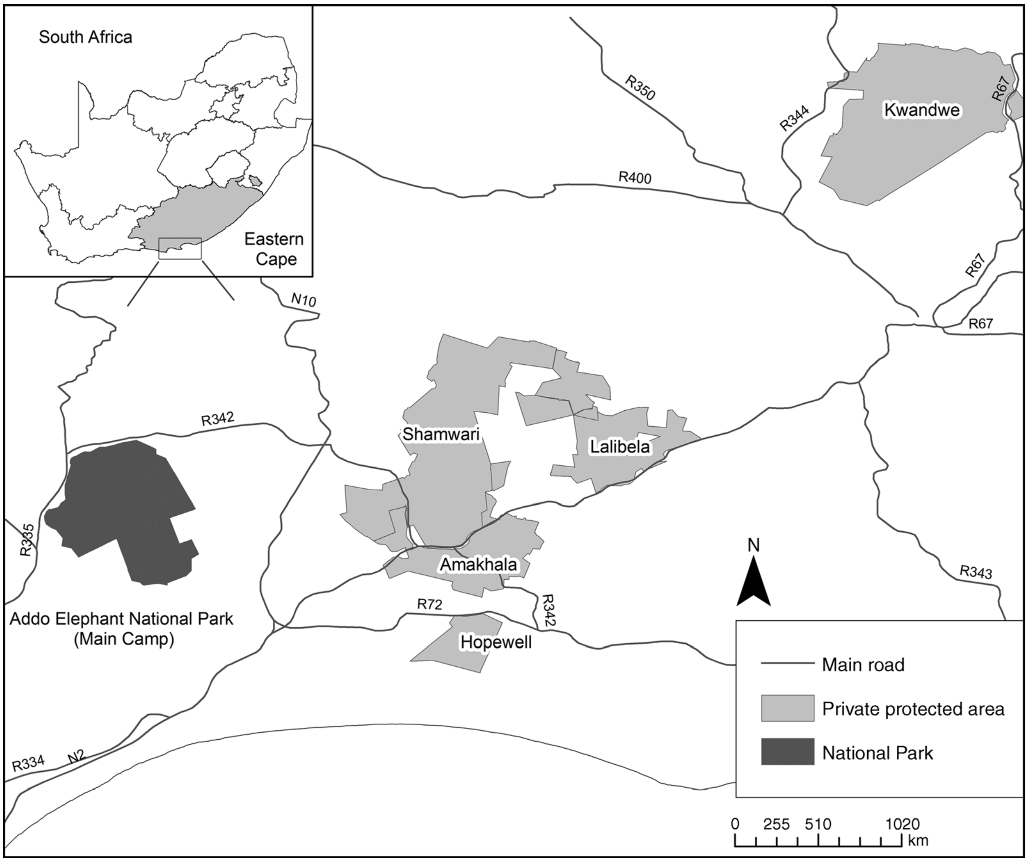

FIG. 1. Map of the Main Camp of the Addo Elephant National Park (AENP) and the private protected areas used as study sites in the Eastern Cape Province of South Africa.

elephants. Fifty elephants are enclosed in Kwandwe Private Game Reserve, which covers an area of 195 km^2 (Fig. 1). Lalibela Private Game Reserve stocks a total of 25 elephants in an area of 62 km^2. Shamwari Private Game Reserve is the largest privately owned study site (212 km^2), where 60 elephants are found. Gorah Elephant Camp is a tourism concession within the AENP that utilizes the AENP Main Camp during game drives (Fig. 1). These sites are all characterized as supporting substantial areas of subtropical thicket. At all of these sites, ecotourism operators provided guided game drives. On these drives, tourists are driven in an open-game viewing vehicle and accompanied by a trained guide to observe the various aspects of biodiversity of interest.

The AENP is situated approximately 60 km NNE of Port Elizabeth in the Eastern Cape of South Africa (Fig. 1). As the name implies, elephants are a major feature of the AENP (Kerley et al. 2003), which supports the highest density of elephants of any protected area in South Africa (Geach 1997) in a section known as the Main Camp. The Main Camp was fenced in 1954 (originally 26 km^2) to enclose 22 elephants, and since then their numbers have grown rapidly (Kerley and Landman 2006). To accommodate the growing population, Main Camp has expanded on five occasions: in 1977, 1982, 1984, 1994, and 2000, with subsequent expansions between 2000 and 2010 (Kerley and Landman 2006). At the time of data collection, before the major 2010 expansion, Main Camp covered an area of 125 km^2 and stocked 426 elephants (Fig. 2).

Data collection

Elephant densities and viewing success.—Tourist satisfaction was expressed in terms of elephant-viewing success. Daily animal sighting records were collected from the six game-viewing operations to extract the frequency of elephant sightings in relation to the number of game drives conducted in 2010, and were used to calculate the elephant-viewing success. The relationship between viewing success and elephant density was assessed using a linear regression model. In addition, elephant-viewing success of the guided game drives was compared with published elephant-sighting records from both self-drive (i.e., tourists in their own vehicles and without a guide) and guided drives in the AENP during December 1995 to May/June 1996 (Kerley et al. 2003).

Elephant densities and tourist numbers in AENP.—Elephant population size and annual tourist numbers for the AENP from 1954 to 2011 were obtained from

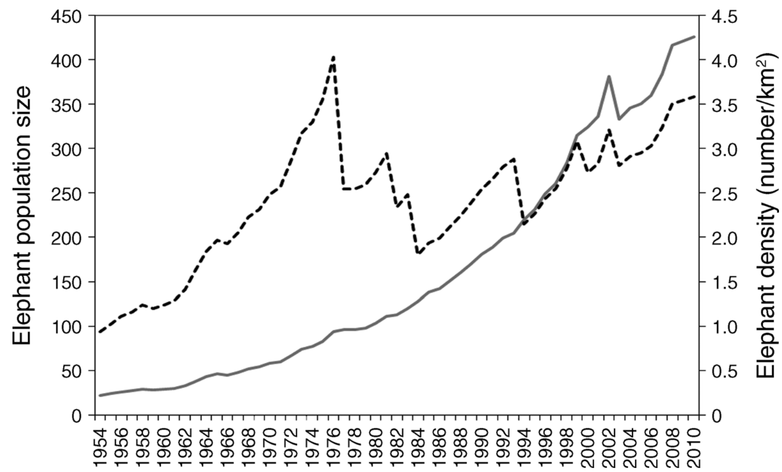

FIG. 2. Elephant population size (solid gray line) and elephant density (dashed black line) for the elephant population in the Addo Elephant National Park (AENP) Main Camp from 1954 to 2010 (adapted from Kerley and Landman 2006).

SANParks, (South African National Parks). Elephant population size was assessed as a density measure, calculated as elephants per square kilometer, which was compared to the other study sites. No data on numbers of tourists were available for 1975–1976, 1984, 1996, and 2001, thus, these years were removed from subsequent analysis. A multiple regression was run to determine how year and elephant density were related to tourist numbers. The relative importance of year and elephant density on tourist numbers was assessed using hierarchical partitioning analysis (MacNally 2000).

The relationship between annual AENP tourist numbers and the total number of tourists arriving in South Africa (South African Tourism 2010) was investigated using regression. All statistical analysis was performed in R version 2.11.1 (R Development Core Team 2011), where significance was determined at the level $P < 0.05$.

RESULTS

Elephant densities and viewing success.—No significant relationship ($F_{1,5} = 1.48$, $R^2 = 0.23$, $P = 0.28$) was found between elephant density and viewing success across all study sites (Fig. 3). Elephant-viewing success above 80% was found in Kwandwe, Shamwari, Lalibela, and AENP (Gorah), with densities ranging over more than an order of magnitude, from 0.26 to 3.4 elephants/km^2 (Fig. 3). The viewing success in AENP varied between 97% when elephants were stocked at 2.6 elephants/km^2 in 1997, to 85% when elephants were stocked at a higher density of 3.4 elephants/km^2 (Fig. 3). Self-guided tourists' viewing success (83% ± 3.83%, mean and 95% CI; data from Kerley et al. 2003) did not differ from that of guided viewing success (78.8% ± 2.2%).

Elephant densities and tourist numbers.—In 1954 the elephant population comprised 22 individuals, and increased to 426 individuals in 2011 (SANParks data; Fig. 2). There has been a 20 times increase in the

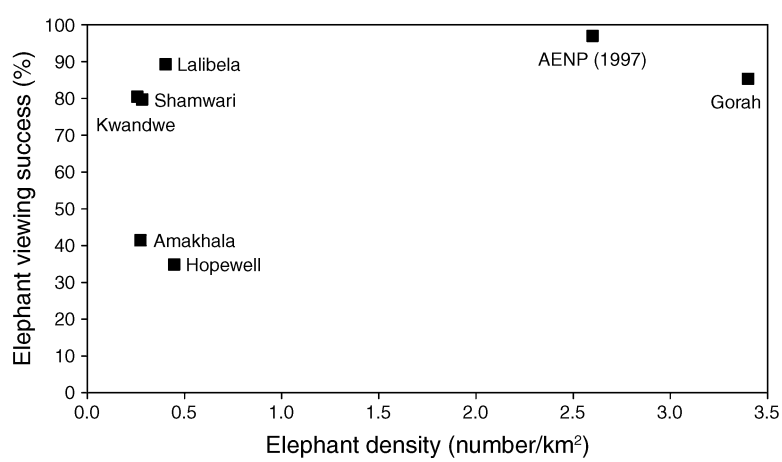

FIG. 3. Relationship between average elephant density and elephant-viewing success (percentage of game drives that recorded elephant), determined from protected areas in the Eastern Cape.

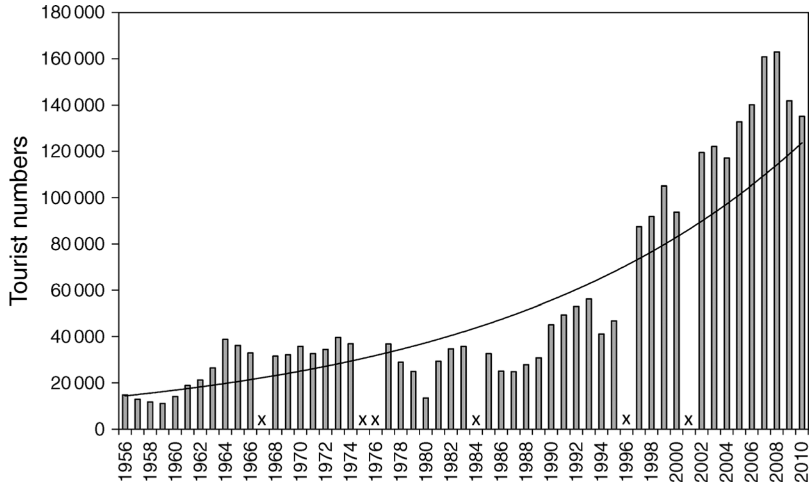

FIG. 4. Annual tourist numbers in the Addo Elephant National Park (AENP) in the Eastern Cape for the period 1956–2011. (x indicates no data for that year).

elephant population in the AENP between 1954 and 2011 (Fig. 2), while the area available has increased by 5.5 times (from 23 km^2 to 126 km^2). A significant variation was found for elephant density over time ($F_{1,50} = 60.06$, $R^2 = 0.55$, $P < 0.05$), increasing from 0.9 elephants/km^2 and peaking at 4.0 elephants/km^2 in 1976 prior to the expansion of area in 1977, with a density (mean ± SD) of 2.4 ± 0.73 elephants/km^2 (Fig. 2). The fluctuation in elephant density reflects both growth of the population and the periodic increase in available area.

Tourist numbers in AENP also increased significantly ($F_{1,\ 55} = 149.3$, $R^2 = 0.73$, $P < 0.05$) from 1954 to 2010 (Fig. 4). Even though elephant density also showed a significant increase over this period, ($F_{1,55} = 41.29$, $R^2 = 0.42$, $P < 0.05$), the increase in elephant numbers only accounted for 26% of the increase in tourist numbers, whereas "year" was a more important driver of tourist numbers, accounting for 74% of the variance in annual tourist numbers. An increase in tourist numbers over time was therefore taking place largely independently of the increase in elephant numbers in AENP. From 2008 to 2010, tourist numbers in the AENP declined, despite an ongoing increase in elephant numbers (Figs. 2 and 4). A significant relationship ($R^2 = 0.81$, $P < 0.05$, df = 5) was found between annual tourist numbers for AENP and the total annual tourist numbers recorded for South Africa between 2003 and 2009.

DISCUSSION

In AENP, the elephant density has consistently exceeded the recommended stocking rates (Pentzhorn et al. 1974, Boshoff et al. 2002) as managers assume that tourists require high densities to achieve game-viewing satisfaction (Novellie 1991). This has been accompanied by substantial impacts on biodiversity (reviewed by Kerley and Landman 2006). However, in this study no significant relationship was found between elephant density and elephant-viewing success. Tourist numbers in the AENP were not related to elephant densities, which coincides with the suggestion of Lindsey et al. (2007) that maintaining high densities of elephants at the expense of biodiversity is unlikely to be economically beneficial in terms of ecotourism.

Elephants may play an important role in attracting tourists to the AENP (Kerley et al. 2003), but there is no evidence that stocking this charismatic species at high densities leads to an increase in tourist numbers. The number of tourists visiting the AENP has significantly increased over time, but our results indicated that this increase was independent of the change in elephant density. This trend was particularly evident in the beginning of the study period, when the number of tourists remained relatively stable prior to 1994, while the elephant population numbers increased rapidly. The decrease in tourist numbers between 1993 and 1994 was apparently a response to the political events before and after the elections in South Africa (Kerley et al. 1995). Furthermore, tourist numbers declined in the period 2008–2010, coinciding with the global economic crisis. This suggests that tourist numbers in protected areas are more sensitive to extrinsic factors, such as political and economic events, than to the density of elephants. Between 1994 and 1998, tourism in South Africa increased by 12% (South African Tourism 2006). This trend was mirrored in our data, which show that tourist numbers rapidly increased after 1994. The highest number of tourists visiting AENP was between 2006 and 2008, which is the same period when South Africa recorded its highest number of foreign tourists, with a 14% increase (South African Tourism 2010).

Studies have found that the high elephant numbers in the AENP have led to changes in habitat structure, which have reduced the richness and abundance of a variety of mammal species (Novellie et al. 1996, Fenton et al. 1998, Kerley and Landman 2006, Kerley et al. 2008). Tourists are attracted to high species diversity (Okello and Yerian 2009), which suggests that stocking animals at high densities to increase ecotourism may present a paradox as it may ultimately lead to a decrease in ecotourism attractions, as also suggested by (Lindsey et al. 2007). Stocking high numbers of elephants in protected areas may have detrimental consequences for the environment (Kerley and Landman 2006, Blignaut et al. 2008, Cousins et al. 2010) and could prevent protected areas from fulfilling their primary function of protecting biodiversity, thereby affecting the long-term sustainability of this social–ecological system.

For a protected area to be effective, it is important that managers address the factors responsible for biodiversity loss (Newton 2011). It is thus strongly recommended that elephant densities in the AENP be reduced and that the population be maintained at the stocking rates and distribution patterns recommended to maintain biodiversity. The findings of this study concur with the recommendations by Owen-Smith et al. (2006) that, in protected areas, elephant density, distribution, and population structure needs to be managed locally to meet biodiversity objectives.

This system provides a textbook example of how management decisions made within a protected area may influence social and ecosystem characteristics, thereby affecting the outputs and outcomes of the social–ecological system (Ostrom 2009). However, further research is required to explore potential social and ecological consequences (sensu Kerley and Shrader 2007) of maintaining animal population sizes within assumed "carrying capacities." There is scope for conducting experimental studies on protected areas to determine the threshold at which tourist viewing satisfaction saturates.

More generally, our analysis demonstrates the importance of adopting a social–ecological perspective when managing protected areas. It is imperative that managers think about the resilience of their social–ecological system and the potential risks of straying from established carrying capacities. Assumptions about social variables and their importance for protected areas may be as deeply entrenched as assumptions about ecological processes, and (as for ecological management) may not always be correct. In this context, interdisciplinary studies have an important role to play in revealing the true trade-offs that are involved in decision-making, and encouraging managers to review their assumptions.

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