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Fencing protected areas: A long-term assessment of the effects of reserve establishment and fencing on African mammalian diversity

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ABSTRACT

Conservation of biodiversity is one of the great challenges faced by present societies. Establishment and fencing of protected areas to isolate biodiversity from human activities is one of the most popular methods for achieving this protection. Here we analyze two long-term (~50 years) datasets on a diverse mammal community of 38 regularly occurring species including many of international conservation importance such as the rare, endemic mountain bongo (*Tragelaphus eurycerus isaaci*), the black rhino (*Diceros bicornis*), the elephant (*Loxodonta africana*), and the lion (*Panthera leo*). These data were collected in two different locations within a flagship protected area in East Africa. Our primary objective was to investigate patterns of wildlife populations and diversity before and after the installation of a perimeter electric fence. We find strong evidence for long-term human-induced edge effects at the site that is closest to the border of the protected area (Treetops); this site registered the strongest losses in total wildlife population numbers, aggregate wildlife biomass, and species richness. In contrast, wildlife populations at the site farther away from the edge of the protected area (The Ark) have remained relatively stable over the duration of the dataset. Our data reveal clear differentiation in the temporal changes of wildlife populations between the two sites. Establishment of the fence in 1989 led to temporary increases in wildlife populations near the park margins, but since the late 1990s these gains have been reversed and wildlife populations have continued to decline near the edge of the reserve. Without the intention of undermining the potential value of fences as conservation tools, our data suggest that fences are only as effective as the management and enforcement efforts that accompany them.

1. Introduction

Conserving biodiversity is one of the greatest challenges that modern societies face. Historic data have shown that for terrestrial mammals (the focus in this study) geographic ranges have been collectively reduced by up to 70% across Africa, Australia, Europe, and Southeast Asia (Ceballos and Ehrlich, 2002) due to human activities. The urgency to secure a lasting place for biodiversity is felt strongly across the African continent given the complex tug-of-war between resource use and preservation. Current figures estimate that approximately 12% of the land in Africa is designated as a protected area (Newmark, 2008). While the establishment of protected areas is argued to be the primary driver for long-term conservation (CBD, 2010; Saout et al., 2013), recent studies have shown that small size and isolation of protected areas, along with edge effects caused by human activities at their margins, drive the continued decrease and extinction of wildlife populations (Brashares et al., 2001; Estes et al., 2006; Newmark, 2008; Craigie et al., 2010).

An increasingly popular strategy to mitigate these effects has been the erection of fences to separate protected areas from surrounding human populations, although fencing protected areas to promote conservation is a contentious issue. On the one hand, there is much support for fencing as an effective solution for reducing human–wildlife conflict (Taylor and Martin, 1987; Thouless and Sakwa, 1995; O'Connell-Rodwell et al., 2000; Packer et al., 2013) and fencing has a long history as a management tool (Hayward and Kerley, 2009). Most recently, a meta-analysis investigating the fate of lion populations in fenced and unfenced lands across 11 countries in Africa found that fencing was critical in

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conserving lion populations and that half of the lion populations in unfenced lands face extinction in the next 20–40 years (Packer et al., 2013). On the other hand, arguments for fencing have been met with intense rebuttal. Creel et al. (2013) countered the Packer et al. (2013) meta-analysis claiming that fenced lion populations are typically small and held above carrying capacity and that unfenced lion populations are more ecologically and economically relevant. These debates stem largely from the lack of quantitatively rigorous information on the long-term effects of fence establishment on animal communities. There is a dearth of published studies on the effects of large-scale fencing projects on protected animal species communities, and given the high, immediate costs of fencing, there are usually few funds remaining to carry out expensive evaluations of the effects and effectiveness of fences for conserving wildlife. This often leads to management plans that are carried out on a trial-and-error basis (Thouless and Sakwa, 1995).

Here we analyze two previously unpublished long-term datasets that document wildlife population trends in detail in a protected biodiversity hotspot in Kenya. Aside from a few narrowly focused studies on two species (Sillero-Zubiri and Gottelli 1987, 1991, 1992a,b), there has been little published on the long-term changes in the whole species community in this region of Kenya. The purpose of this study is twofold: (1) explore the temporal patterns in the mammalian communities at two study sites located at different distances from the park edge and (2) to determine the effects of the perimeter electric fence on the resident mammal communities by comparing pre- and post-fence data. Because the fence of the region surrounding the two study locations was completed in 1991, this setting provides the rare opportunity to evaluate the effectiveness of an electric fence on a resident wildlife community using long-term historical data. Given the increased use of such fences around protected areas, this study can provide novel before-and-after data that can inform further conservation planning for systems facing similar pressures.

2. Methods

2.1. Study area

The Aberdare Conservation Area (ACA) (2185 km^2) is located in the Aberdare mountain range in the Central Province of Kenya. The Aberdare range lies southwest of Mt. Kenya and runs roughly in a north to south direction, thus forming the eastern rim of the Great Rift Valley. The ACA is comprised of the Aberdare Forest Reserves (1411 km^2) which surround Aberdare National Park (776 km^2). The Aberdare ecoregion has two rainy seasons; the long rains occur in April–June, whereas the short rains occur during the November–December season. Annual precipitation totals average 956 mm (SE = 80.9; n = 12), while mean daytime temperatures range from 16 °C (July) to 21.8 °C (February) (The Ark Lodge, unpubl. data).

Ten distinct vegetation zones exist along the elevation gradient of the Aberdare range (1850–4000 m). They can be grouped into three broader categories: the montane forests occur at the lowest elevations (1900–2400 m) and include the highest diversity of flora and fauna; they are followed by the bamboo zone (2400–3000 m) and then the high elevation moorlands (dominated by *Hagenia*, *Hypericum*, and various ericaceous species) at the highest reaches of the range (Rhino Ark, 2011).

Recent estimates suggest that the Aberdare range harbors 50+ mammal species, 270 species of birds, and over 770 species of vascular plants (Butynski, 1999). Beyond its global importance as a cradle of biodiversity (the Aberdare range belongs to the 'Eastern Arc and Coastal Forests of Tanzania and Kenya' biodiversity hotspot (Myers et al., 2000)), the Aberdare range provides valuable ecosystem services to local communities through its provisioning of an abundant and stable water supply.

This study focuses on a section of the ACA known as the Salient. The Salient is a 70 km^2 spur of the mountain range that extends towards the east (Fig. 1). The area is dominated by montane forest and transitions into one of the few savanna areas of the region at the far eastern edge of the protected area (Sillero-Zubiri and Gottelli, 1991). The Salient is known for its exceptionally high concentration of megafauna and has been the focus of most tourism and conservation activities in the area. Two of the oldest wildlife lodges in Africa, Treetops and The Ark, are located in this area and they are the two sites where standardized records of wildlife sightings have been collected on a daily basis since the mid-1960s.

Treetops: located at 1996 m asl and within the montane forest zone, Treetops sits at the edge of the protected area (Fig. 1). Because of the local conditions, and also because of a history of deforestation, the lodge is surrounded by one of the few areas of grassland in the ACA (Prickett, 1974). The proximity to the edge (<1 km) means that the site is exposed to possible edge effects.

The Ark: located 7.25 km from the entrance of the national park, the site for The Ark was chosen because of its seclusion from human activities. At 2316 m asl, the lodge lies within the montane forest zone and is visited by a variety of high elevation forest taxa such as the mountain bongo (*Tragelaphus eurycerus isaaci*).

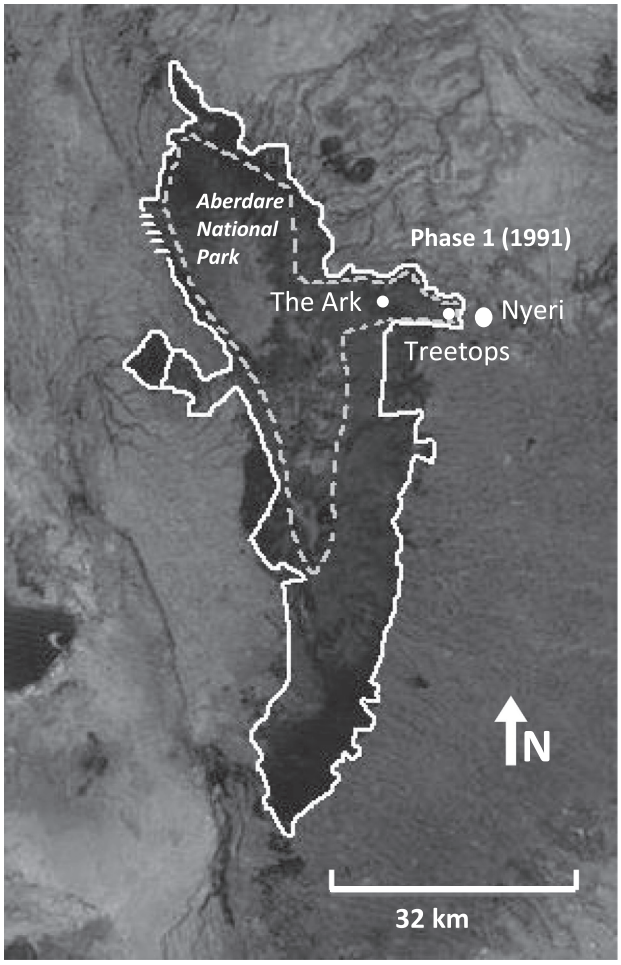

Fig. 1. Map of the greater Aberdare Conservation Area (ACA) and the surrounding fence (solid line). The area designated as Aberdare National Park is outlined with a dashed line. The first phase of the fence enclosed the Salient region, where Treetops and The Ark are located. The stippled line denotes a line of cliffs where no fence was built.