



## The performance of African protected areas for lions and their prey



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### ABSTRACT

Using surveys of experts associated with 186 sites across 24 countries, we assessed the effectiveness of African protected areas (PAs) at conserving lions and their prey, identified factors that influence conservation effectiveness, and identified patterns in the severity of various threats. Less than one third of sampled PAs conserve lions at  $\geq 50\%$  of their estimated carrying capacity (K), and less than half conserve lion prey species at  $\geq 50\%$  of K. Given adequate management, PAs could theoretically support up to  $4\times$  the total extant population of wild African lions ( $\sim 83,000$ ), providing a measurable benchmark for future conservation efforts. The performance of PAs shows marked geographic variation, and in several countries there is a need for a significant elevation in conservation effort. Bushmeat poaching was identified as the most serious threat to both lions and to wildlife in general. The severity of threats to wildlife in PAs and the performance of prey populations were best predicted by geographic-socioeconomic variables related to the size of PAs, whether people were settled within PAs, human/livestock densities in neighbouring areas and national economic indicators. However, conservation outcomes for lions were best explained by management variables. PAs tended to be more effective for conserving lions and/or their prey where management budgets were higher, where photographic tourism was the primary land use, and, for prey, where fencing was present. Lions and prey fared less well relative to their estimated potential carrying capacities in poorer countries, where people were settled within PAs and where PAs were used for neither photographic tourism nor trophy hunting.

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### 1. Introduction

Protected areas (PAs) are critical to the protection of biodiversity and habitat integrity (Geldmann et al., 2013). Approximately 209,000 PAs exist globally, covering  $\sim 15.4\%$  of the world's land and inland waters (Juffe-Bignoli et al., 2014). State-owned terrestrial PAs in Africa cover  $14.7\%$  of the continent's land area, slightly less than the global average

(Juffe-Bignoli et al., 2014), yet some African countries have set aside vast PA networks. For example, Botswana has gazetted  $40\%$  of its terrestrial area as PAs, Zambia  $38\%$  and Tanzania  $32\%$  ([www.protectedplanet.net](http://www.protectedplanet.net), accessed October 2016, Botswana Department of Wildlife and National Parks unpublished data). African countries are also home to some of the largest individual PAs. For example, Tanzania's Selous Game Reserve and adjacent buffer zones cover  $\sim 90,000$  km<sup>2</sup>, the Luengue-Luiana-Mavinga complex of parks in Angola  $\sim 84,200$  km<sup>2</sup>, and Kafue National Park complex in Zambia  $> 66,000$  km<sup>2</sup>. Furthermore, several (mainly southern) African countries have established treaties to conserve even larger areas through the establishment of transfrontier

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conservation areas (TFCAs) (MacKinnon et al., 2015), such as the ~520,000 km<sup>2</sup> Kavango-Zambezi TFCA.

PAs contain essential habitat for many of Africa's most iconic, threatened and endemic species (Bergl et al., 2007). Parks and reserves are a central component of sub-Saharan Africa's tourism industry, which creates millions of jobs and which has been valued at US\$25 billion (WTTC, 2016). PAs are thus of key importance from ecological, economic and social perspectives, and through the provision and maintenance of ecological services (MacKinnon et al., 2015; Van Zyl, 2015). However, while frequently valuable on national levels, PAs rarely cover their costs at a site level (MacKinnon et al., 2015), and can impose significant costs on local people through human-wildlife conflict and foregone opportunities for using the land for alternatives (Brockington and Igoe, 2006). Such issues can undermine political support for government expenditure on PAs and local support for their existence.

The importance of PAs to conservation efforts will increase with time as human populations grow and habitat in unprotected lands is converted for agriculture and settlement or to compensate for decreased productivity on over-utilised land (Caro, 2015). This is of particular significance in Africa, where the human population is projected to grow from 1.1 to 2.8 billion by 2060 (Canning et al., 2015). Even under current human population densities, the effectiveness of many PAs at conserving biodiversity is questionable, and many are underperforming (Craigie et al., 2010; Lindsey et al., 2014). This is particularly evident in West and Central Africa (Bouché et al., 2010; Henschel et al., 2014a; Henschel et al., 2015; Bauer et al., 2015a).

Human pressures on PAs take various forms, including poaching, encroachment by humans and livestock, mining and deforestation (Okello and Kiringe, 2004; Lindsey et al., 2014). These anthropogenic pressures on PAs are becoming more severe, yet resources available for management and protection are often far from adequate (James et al., 1999; Mansourian and Dudley, 2008; Lindsey et al., 2016; Henschel et al., 2016) and there is little information on the impacts of these threats on conservation outcomes. In addition, the functionality of PAs is often undermined further by mismanagement and corruption (Smith et al., 2003).

### 1.1. Protected areas and African lion conservation

The African lion (*Panthera leo*) is an iconic and charismatic species that is highly valued by society (Macdonald et al., 2015). Lions play a key ecological role due to their status as apex predators (Ripple et al., 2014), and have significant economic value as drawcards for photographic tourism and trophy hunting (Lindsey et al., 2007; Lindsey et al., 2012a). The species has significant cultural value to some societies (in Africa and elsewhere), such as being symbols of royalty, acting as sports emblems, or being totems. Lions also confer value in some places through the illegal and legal trade in lion body parts (Williams et al., 2016).

Despite their social, ecological, and economic value, lions have undergone significant declines in numbers and geographic range in recent years. Lion numbers declined ~43% during 1993–2014, with particularly marked declines in West and Central Africa (Bauer et al., 2015a). As few as 23,000 individuals persist in the wild and the species is listed as Vulnerable on the IUCN Red List (Henschel et al., 2015); in West Africa, they are considered Critically Endangered (Henschel et al., 2015; Bauer et al., 2015c). Approximately ~56% of lion range has protected area status; when well managed, these PAs can frequently support high lion densities (Riggio et al., 2012).

Key threats to lions include human-lion conflict, habitat destruction, depletion of prey populations, targeted poaching of lions for their body parts and poorly regulated trophy hunting (Bauer et al., 2015a). However, the relative importance of those threats in specific PAs is poorly understood. Threats to lions and other wildlife are often exacerbated by unfavourable policies, political and economic instability and institutional weakness on the part of state wildlife authorities and lack of adequate

resources by protected area authorities to mitigate these threats (MacKinnon et al., 2015). There have been some attempts to understand the determinants of conservation success for lions in West Africa (Henschel et al., 2016), and a narrow focus on the role of management interventions such as fencing in influencing conservation outcomes (Packer et al., 2013; Creel et al., 2013). However, little is known about the performance of individual PAs continent-wide, patterns in the threats facing them and the factors that influence their effectiveness (Geldmann et al., 2013).

Thus, we build upon previous work by looking more broadly at the role of PAs in conservation success, using the African lion as our focal species. We sought to understand, at a protected area level, (1) which PAs are currently sustaining lion populations at 50% or above estimated carrying capacity, (2) what factors are associated with positive conservation outcomes for lions and their prey, and (3) to understand patterns in severity of five main threats to African wildlife in PAs, namely: illegal hunting for bushmeat, encroachment by humans for settlement or agriculture, encroachment by livestock for grazing, human-wildlife conflict, and the poaching of wildlife for non-meat body parts (e.g. ivory, skins, scales, teeth or other products).

## 2. Methods

### 2.1. PAs in lion range

We assessed the number and area of PAs in lion range, and estimated the potential lion population that could be conserved on such an area. The potential carrying capacity for lions for each site was estimated using a model that predicts the variation in lion density based on soil type and rainfall (Loveridge, 2009). For the purposes of estimating the area of land under protection in lion range, and estimating potential lion numbers if those areas were managed optimally, we defined PAs as being state-owned land officially gazetted as a protected area, and where wildlife conservation/utilisation is considered to be the primary land use (excluding private land and community 'conservancies', which typically occur on land with customary tenure/ownership). We excluded wildlife areas on private and community land to provide a conservative estimate of the lion range that is protected because the legal protection status of such land is variable. However, we do acknowledge that private and community conservation areas are of high conservation value. Our definition included hunting areas and other local protected designations as well as national parks. We excluded PA complexes (individual PAs or groups of contiguous PAs) of <1000 km<sup>2</sup>, except in South Africa, where fencing and intensive management allows for the maintenance of lion populations in smaller areas (Packer et al., 2013). Consequently, in South Africa, where PAs are fenced, our cutoff for inclusion was 500 km<sup>2</sup>. A cutoff of 500 km<sup>2</sup> allowed for the inclusion of some South African reserves, while excluding very small reserves where management is likely to be so intensive as to preclude meaningful comparison with PAs in other parts of Africa.

### 2.2. Surveys

We conducted an online questionnaire survey of individuals with expertise of PAs within lion range (Appendix 1). The survey was designed to obtain insights into the performance of populations of lions and their prey, to understand the main threats to both, and to provide insights into the determinants of conservation success. In order to obtain a larger sample for the surveys, we expanded our definition of PAs to include legally recognised conservancies or other wildlife areas occurring on private and community lands. 'Experts' were defined as those who are working in the PA in the context of management (n = 102) or research related to lions or their prey (n = 32). Respondents had a mean of 9.31 ± 1.1 years of experience in the area in question (range 1–40 years) and were identified through professional networks and via 'snowballing' sampling technique (Atkinson and Flint, 2001).

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