



## Original research article

## Impact of severe climate variability on lion home range and movement patterns in the Amboseli ecosystem, Kenya



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## ABSTRACT

In this study, we were interested in understanding if droughts influence the home range of predators such as lions, and if it does, in what ways the droughts influenced lions to adjust their home range, in response to prey availability. We monitored movements of ten lions fitted with GPS-GSM collars in order to analyze their home range and movement patterns over a six year period (2007–2012). We assessed the impact of a severe drought on the lion home range and movement patterns in the Amboseli ecosystem. There was a strong positive correlation between the home range size and distance moved in 24 h before and during the drought (2007–2009), while after the drought there was a significant negative correlation. A weak positive correlation was evident between the lion home range and rainfall amounts (2010–2012). The male and female home ranges varied over the study period. The home range size and movement patterns coincided with permanent swamps and areas of high prey density inside the protected area. Over the course of the dry season and following the drought, the ranges initially shrank and then expanded in response to decreasing prey densities. The lions spent considerable time outside the park boundaries, particularly after severe the drought. We conclude that under conditions of fragmented habitats, severe climate conditions create new challenges for lion conservation due to effects on prey availability and subsequent influences on carnivore species ranging patterns. Stochastic weather patterns can force wide-ranging species beyond current reserve boundaries, into areas where there will be greater conflicts with humans.

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## 1. Introduction

African lions (*Panthera leo leo*) are threatened to extinction across their range, and have been classified as 'vulnerable' on the global IUCN Red List (IUCN, 2013). They are also currently under consideration for the Endangered Species List, US Fish and Wildlife Society (US-FWS) (Place et al., 2011). Several authors have described the decline in lion population due to factors related to human interference (trophy hunting, poaching, agricultural and urban development, habitat fragmentation and conflicts) or due to natural factors related to the environment—climate variability, cover, prey availability and topography (Bauer and Van Der Merwe, 2004). There is however paucity of research on the impacts of stochastic drought on a lion population and their home ranges.

Conservation policy and habitat management based on scientific information is important for managing protected areas for large carnivores (Karanth and Chellam, 2009). However, climatic changes may modify the distribution and abundance of species and include some key variables that may have severe impact on ecosystems that adversely influence lions' natural habitat selections (Iverson and Prasad, 1998; Ohlemüller et al., 2006). Knowledge of a species' ranging behavior is both fundamental to understanding its behavioral ecology and a prerequisite to planning its management. Rainfall determines habitat quality and structure through its influence on vegetation health, mediated through edaphic and topographic/catenary gradients (Bell, 1982; McNaughton, 1983) and can induce changes in habitat suitability, which are capable of substantially modifying predator–prey relations (Smuts, 1978; Whyte et al., 1995). Besides prey availability and vegetation cover, rainfall also affects the distribution of drinking water, thereby modulating the spatial–temporal distribution of water-dependent herbivores and carnivores (Western, 1975; Hanby et al., 1995; Krebs & Dominique, 2006), "similarly, climate affects the distribution and abundance of mammals (Krebs & Dominique, 2006)"; Moreover, the impact of climate change and climatic variability shows a spatially heterogeneous pattern and may have already resulted in several recent local species extinctions (Pounds et al., 2006). These changes raise concerns about the effectiveness of existing species protection strategies (Halpin, 1997; Hannah et al., 2002; Peter and Darling, 1985).

Species conservation relies predominately on fixed systems of protected areas. Furthermore, the mandated goals of many conservation agencies and institutions are to protect particular species assemblages and ecosystems within these systems (Lemieux and Scott, 2005). Of particular importance are the challenges associated with conservation of carnivores outside protected areas, including both anthropogenic and ecological factors (Dolrenry et al., 2014). The home range size of large carnivores is a good predictor of its extinction probability relative to the size of the neighboring protected areas where home ranges extend significantly into non-protected areas relative to the size of the neighboring protected areas (Woodroffe and Ginsberg, 1998; Woodroffe et al., 2001). Increased anthropogenic activity as a consequence of rapid human population growth has resulted in the reduction of natural habitats for lions (Riggio et al., 2013, Bauer and Nowell, 2004) and increasing persecution (Tumenta et al., 2010).

Home range analysis of large carnivores provides answers to many biological questions related to population dynamics, social interactions, and spacing patterns. Lions' home range size varies in relation to a wide range of factors, including prey availability, social interactions, habitat quality and reproductive status (Gittleman and Harvey, 1982; Van Orsdol et al., 1985; Viljoen, 1993; Spong, 2002; Bauer and De longh, 2005). Abundant food and high quality habitat allow an animal to meet its biological requirements in a relatively small home range and vice versa (Gittleman and Harvey, 1982; MacDonald, 1983).

The home range area is used during its normal activities of food gathering, mating and caring for its young. The core of an animal's home range is defined as the most intensively used area within that animal's home range (Powell, 2000). In the case of lions, their home range is directly related to prey abundance and the presence of water, thus lower prey densities and low availability of water correspond with larger home ranges and vice versa (Celesia et al., 2009; Van Orsdol et al., 1985; Tumenta et al., 2013). However, other factors, such as social status, sex, age, season, disturbance and the presence of livestock may influence the home range (Schaller, 1972; Loveridge et al., 2009; Tumenta et al., 2012).

Group size and territoriality are social factors that also influence home range size (Packer et al., 2005), with home range size increasing with group size (Van Orsdol et al., 1985). Larger prides require more prey and therefore larger areas corresponding to prey biomass and density. Lion home range size being negatively correlated with prey abundance (Van Orsdol et al., 1985; Bauer and De longh, 2005; Loveridge et al., 2009). Maintaining a pride home range is of great importance, evident from the fact that fatalities are relatively common during intergroup encounters (McComb et al., 1994). Understanding the variation in animal home range size, and identifying the factors that underlie this variation, are fundamental to understanding the distribution and abundance of animals, and ultimately their population regulation (Wang and Grimm, 2007), habitat selection (Rhodes et al., 2005), community structure (Matias, 2013), as well as the management and conservation of ecosystems (Woodroffe and Ginsberg, 2000).

The present study is the first of its kind to analyze the effect of drought on lion movements, covering a period of three years before and during the drought period (2007–2009) as well as three year period after the severe drought period. Our study investigated the impact of a severe drought on lion's home ranges size and movement patterns, in relation to variation in food resources (prey biomass) before and during versus after a severe drought period.

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