Journal for Nature Conservation 23 (2015) 9–18

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.de/jnc

Impact of land use on occupancy and abundance of terrestrial mammals in the Drakensberg Midlands, South Africa

Tharmalingam Ramesh, Colleen T. Downs*

School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, Pietermaritzburg, KwaZulu-Natal 3209, South Africa

ARTICLE INFO

Article history:
Received 23 September 2014
Received in revised form 3 December 2014
Accepted 19 December 2014

Keywords:
Camera trapping
Detection
Farmland mosaics
Relative abundance index
Site occupancy
Terrestrial mammals

ABSTRACT

Better management and knowledge regarding the effect of land use intensification on mammal abundance and occupancy is crucial for species conservation. This is particularly true in dynamic forest-farmland mosaics subjected to rapid human-induced habitat alterations for agricultural practices. We conducted camera-trap surveys at 44 locations across farmland use gradients between October 2012 and January 2013. We estimated occupancy and relative abundance of 10 terrestrial mammals in response to farmland use in the Drakensberg Midlands, South Africa. Occupancy modelling revealed the importance of available forest and wetland to several mammals. Occupancy estimates for *Leptailurus serval* were lower in cropland than for *Herpestes ichneumon*, *Atilax paludinosus* and *Potamochoerus larvatus*. Occupancy of *Leptailurus serval* and *Redunca rundinu* increased with relative human abundance while the relationship was inverse for *Hystrix cristata* and *Potamochoerus larvatus*. Livestock-related activity influenced occupancy of *Potamochoerus larvatus* positively and *Hystrix cristata* negatively. Pesticide usage had a negative impact on detection of several mammals, and occupancy of *Atilax paludinosus*. Commercial plantation influenced occupancy of *Tragelaphus scriptus* and *Potamochoerus larvatus* positively. Plantation supported the abundance of five species positively. Wetland influenced relative abundance of *Leptailurus serval* positively. Pesticide use significantly decreased relative abundance of *Leptailurus serval* and *Atilax paludinosus*. Livestock and human relative abundance were positively associated with relative abundance of *Leptailurus serval* and *Canis mesomelas* and negatively for other species. Our models proved the sensitivity of some mammals towards the natural habitat loss due to agricultural practices while others appeared to be tolerant to such human-modified habitats. We suggest feasible management implications for conserving diverse mammalian assemblages in farmland mosaics.

Introduction

Land use changes that increase fragmentation and habitat loss pose a threat to terrestrial biodiversity (Jetz et al. 2007; Pereira et al. 2010). Changes that restrict traditional animal movements can lead to decline in species distribution and abundance (Msuha et al. 2012; Pimm & Raven 2000). Economic demands have led to land use changes which convert natural habitats into human-modified habitats, such as secondary forests and heterogeneous agricultural landscapes in tropical regions (Mulwa et al. 2012). Humans persuade habitat changes and are responsible for major biodiversity loss worldwide (Green et al. 2005; Kleijn et al. 2009; Sala et al. 2000). The impact of changes in land use practices on ecological communities is least known (Estes et al. 2011; Haines-Young 2009; Msuha et al. 2012). Consequences of structural changes of land generally affect species diversity negatively (Blaum et al. 2007; Cingolani et al. 2005). Land use change, particularly, is of major concern in developing regions such as the Sub Saharan Africa, where human populations are expanding and the majority of people depend on natural resources for various livelihoods (Ceballos & Ehrlich 2006; Thuiller et al. 2006). Mammals are indicator species to study ecological disturbances such as structural changes of the landscape for conservation planning (Crooks 2002; Soule & Terborgh 1999; Woodroffe & Ginsberg 1998). Terrestrial mammals are an integral and valued part of land ecosystems. Understanding, how mammalian species respond to land use change provide important information for biodiversity conservation at the regional and global scale.

Historically, Protected Areas PA aimed to protect and maintain biological diversity and natural resources through legal means across the world (Naro-Maciel et al. 2009; Pressey 1996). While these areas may not provide sufficient protection for species residing outside PAs, some of them are too small to support long-term species survival (Naro-Maciel et al. 2009; Woodroffe and Ginsberg

* Corresponding author. Tel.: +27 33 2605127/04; fax: +27 33 2605105.
E-mail address: downs@ukzn.ac.za (C.T. Downs).

http://dx.doi.org/10.1016/j.jnc.2014.12.001
1617-1381/

1998). The persistence of mammals may depend on their survival outside PAs in southern Africa where they come into conflict with humans, and livestock (Kent 2011). Different carnivores may have a range of impacts on farmers (Kent 2011; Linnell et al. 1999). Farmland is the prevailing interface between mankind and nature, and has become a dominant form of land management around the world (Gall & Orians 1992; Gilpin et al. 1992). The intensification of farmland use has contributed to increase in production yields through technological advances by use of machinery, fertilizers and pesticides while it has a strong negative impact on biodiversity (Briggs & Courtney 1989).

If ecological integrity is to be maintained, priority should be given even in ecosystems surrounding PAs (Msuha et al. 2012; Newmark 1996; Woodroffe 2000), since they have the potential to hold significant populations of many wildlife species (Homewood & Rodgers 1991; Rowe-Rowe 1992). Studies have shown that increased intensity of land use reduces habitat and species diversity, distribution and abundance (Fitzherbert et al. 2008; Green et al. 2005; Maitima et al. 2009; Moreira & Russo 2007; Msuha et al. 2012; Wretenberg et al. 2010). Such intensification of land management typically reduces distribution and abundance of large sized ungulates and predators more than small sized ungulates and predators (Kinnaird and O'Brien 2012). Although some generalist species can show positive response to this change but territorial or habitat specialists may not sustain these changes. Effective biodiversity conservation can be achieved by understanding the level of relationship between terrestrial mammals and land-use intensity.

The farmlands of the Drakensberg Midlands in KwaZulu-Natal, South Africa are rangelands where humans, domestic livestock and wildlife coexist with varying degrees of success. The habitat types include montane grassland, wetland, patches of dense forest and bushland are being converted at large scale for agricultural purposes. A wide range of land management and livestock husbandry practices were apparent there (Pero & Crowe 1996). Knowledge regarding the impact of land use changes on many small and medium sized mammals is not well understood outside PAs (Pettorelli et al. 2010; Schipper et al. 2008). Species distribution and relative abundance are commonly used as state variables in evaluating the impact of different management interventions or anthropogenic disturbance on biodiversity (Kinnaird and O'Brien 2012; O'Brien 2008; Yoccoz et al. 2001). Camera trapping survey is considered as a better tool in determining abundance, occupancy, and habitat use of elusive species than other monitoring methods (Carbone et al. 2001; Ramesh et al. 2013; Tobler et al. 2009). Site occupancy can provide a reasonable estimate of population status in multi-species monitoring programs (Sarmento et al. 2011). Consequently our study aimed to explore the response of terrestrial mammal occupancy and relative abundance to different land use practices in farmlands under single season occupancy modelling and Generalised Linear Models in the Drakensburg Midlands region of South Africa.

Materials and methods

The amount of research conducted on commercial private farmland in South Africa is limited particularly in the province of KwaZulu-Natal (Rowe-Rowe 1992, 1994) and minority group that owns and manages these large areas of land. Our study was conducted in Fort Nottingham (Site A), Khamberg (Site B) and Mooi River (Site C) (29°41′–30°01′ E, 29°10′–29°28′ S) and for more detail see Ramesh and Downs (2013). Naturally occurring wild species include: common grey duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestris*), blesbok (*Damaliscus dorcas*), common reedbuck (*Redunca arundinum*), oribi (*Ourebia ourebi*), bush buck (*Tragelaphus scriptus*), bush pig (*Potamochoerus larvatus*), vervet monkey (*Chlorocebus pygerythrus*), samango monkey (*Cercopithecus albogularis*), chacma baboons (*Papio ursinus*), scrub hare (*Lepus saxatilis*), cape porcupine (*Hystrix africaeaustralis*), serval (*Leptailurus serval*), caracal (*Felis caracal*), black-backed jackal (*Canis mesomelas*), large grey mongoose (*Herpestes ichneumon*), white-tailed mongoose (*Ichneumia albicauda*), water mongoose (*Atilax paludinosus*), large-spotted genet (*Genetta tigrina*), African wild cat (*Felis lybica*) and feral cat (*F. catus*) (Rowe-Rowe 1992, 1994). We selected three sampling areas according to varied intensity of land use, and land-cover characteristics (GeoterraImage 2010, Fig. 1 and Table 1). The main land uses in this region are dairy production using indigenous grassland pasture, seed potatoes *Solanum tuberosum* and maize *Zea mays*. The minimum convex polygon size of the camera survey areas was 43.2 km^2 for A and 35 km^2 for both B and C.

Table 1
The percent area availability of land use habitats according to land cover characteristics (GeoterraImage 2010) within the survey area of farmlands in the Drakensberg Midlands, KwaZulu-Natal, South Africa.

Habitat types	Site A	Site B	Site C
Highland Sourveld Grassland	45	12	26.5
Cropland	30	75	57
Wetland	6	1	1
Plantations	8	1.4	3.8
Dense bush clumps with indigenous forest patch	4	0	1
Dam sites	3	6	3
Others	4	4.6	7.7

To document occupancy and relative abundance of mammals in the farmland, we conducted camera trapping survey between October 2012 and January 2013 using a systematic grid 2 km^2 covering all three different sites varied in land use patterns at 44 locations. We did not have large number of traps (15 traps) whereas we had to choose appropriate grid size 2 km^2 that represented most of the mammal species presence in the study area based on other published papers and our field knowledge (Ramesh et al. 2013). In total, we had 43.2 km^2 grids across the study areas and camera trapping survey was done on rotational basis to sample a larger area. Each grid had a minimum of one camera trap site with mean inter-trap distance of 1.7 km. Each camera was operated for 30 days amounting to a total effort of 1320 trap nights. Trap-stations were distributed covering three sampling areas. Photographs can provide large set of data on species distribution and abundance of mammals and this can be collected using camera traps (Kinnaird and O'Brien 2012; Pettorelli et al. 2010; Ramesh et al. 2012; Ramesh et al. 2013; Rowcliffe & Carbone 2008; Tobler et al. 2009). These surveys used fixed cameras (Camera LtI Acorn® 6210MC, Shenzhen LtI Acorn Electronics Co. Ltd., China), triggered by passive infrared sensors to "capture" digital photographs of passing animals and for more detail see Ramesh and Downs (2013). Cameras were placed along animal trails at approximately 20 cm above the ground to capture all encountering mammalian species and were left to operate for 24 h a day. We classified all animal photographs to species level and grouped photographic sequences into independent photographic events, where we considered all the photos taken per 5 min as one event. As estimation of abundance or density is difficult for many species, measure of relative abundance index (RAI) is a basic substitute for abundance. We used the number of independent photographic events per 100 trap days as RAI, and presence/absence of species in camera trapping sites during sampling session as occupancy of mammals. We generated mammalian species detection history (1100100) for each camera location consisting of values '1' indicating species detection during the sampling occasion and '0' indicating non-detection (Otis et al. 1978). Site occupancy is defined as the proportion of area or sites occupied