Improving the conservation prospects for lions in the Greater Limpopo Lion Conservation Unit; determining key threats and identifying appropriate solutions.

Progress Report, June 2015

By Kristoffer Everatt

Project summary

This is a research project aimed at improving conservation prospects for lions in the Greater Limpopo Lion Conservation Unit of South Africa, Mozambique and Zimbabwe. Our focus is to improve knowledge of lion conservation biology in the Mozambican components, determine key threats and identify appropriate solutions to improve lion conservation management and planning at the landscape level.

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Project Rational

The need to identify and secure lion populations in high conflict landscapes and to maintain connectivity between populations is critical for lion conservation. However, opportunities for conservation are rapidly diminishing with increasing human pressures both inside and outside of protected areas (Newmark, 2008). Lion conservation efforts must therefore prioritize high-conflict landscapes, learn how to facilitate lion-human co-occurrence and secure connectivity between populations.

The Greater Limpopo Lion Conservation Unit (GLLCU) in southern Africa is important for the regional and global viability of lions because it is one of Africa's ten remaining population strongholds (IUCN, 2006)). However, although the region is vast (~73, 000 km^2), the majority of the GLLCU are high-conflict landscapes (Dunham *et al*., 2010a) where lions may be faced with the compounded challenges of prey depletion caused by bushmeat poaching, targeted or accidental snaring, retaliatory and pre-emptive killing by pastoralists and loss of habitat (including prey) to agricultural land conversion. While Kruger National Park supports a stable and protected population of > 1600 lions (Ferreira & Funston, 2010), Gonarezhou National Park supports only a small population below ecological carrying capacity (Groom *et al*., 2014). Limpopo National Park supports a population of 66 lions existing at 1/3 of their carrying capacity due to anthropogenic pressures including bushmeat poaching and pastoralism (Everatt *et al*., 2014). There is therefore a pressing need to identify and secure lion populations in this region before their habitat is further fragmented or irretrievably lost. Furthermore, in the context of acute continental range declines, it is crucial to improve the conservation status of lions in Limpopo and other areas of the Mozambican portion of the GLLCU thus making the best use of these available habitats. Opinion surveys suggest lions may persist in Banhine National Park and Zinave National Park (Chardonnet *et al*., 2009); however, there are no reliable data available on these potentially at risk populations.

Identifying regionally appropriate conflict mitigation strategies is required to implement effective lion conservation management in human influenced landscapes (Bauer *et al*., 2010). However, without reliable quantification of the influence of humans on lion ecology in the GLLCU, it will be difficult to identify and promote appropriate mechanisms for lion-human co-occurrence. Promoting lion persistence in landscapes impacted by pastoralism may ultimately be dependent on determining the factors influencing lion selection or avoidance of livestock as prey (Kissui, 2008) and on identifying and maintaining a minimum threshold of wild prey and space (Bauer *et al.,* 2010).

Bushmeat poaching is a serious threat to wild prey populations and therefore to the viability of lion populations (Lindsey *et al*., 2013). Additionally, bushmeat poaching can effect lion populations directly through mortalities resulting from by-catch in snares and targeted poaching of lions (Becker *et al*., 2013; Everatt *et al.,* 2014). Trade in lion parts is a potentially serious threat to wild lion populations; however, there is limited information available on the extent and impact of these pressures (IUCN, 2006). There

is therefore an urgent need to quantify the impact of human activities on lion ecology and understand the socio-economic drivers of conflict.

The persistence of a meta-population of lions in the GLLCU will ultimately be dependent on either artificial gene movements or the identification and securement of functional conservation corridors. However, the designated Sengwe Corridor between Kruger and Gonarezhou suffers from high levels of human encroachment and may not be suitable for lion dispersal (Dunham *et al*., 2010b). Areas of Mozambique between Kruger and Gonarezhou may be more permeable for dispersing lions; however, this has yet to be determined. Additionally, if lions exist in Banhine then there is an urgent need to determine if connectivity with Limpopo can be maintained.

Furthermore, to increase the viability of protected populations in Kruger and Gonarezhou, it is important to quantify the impact of edge effects (Woodroffe & Ginsberg, 1998) imposed by adjacent human impacted lands in Mozambique. Finally, it is equally important to determine if the Mozambican lands adjoining Kruger and Gonarezhou are acting as sink habitats or as ecological traps (Battin, 2004). Sink habitats, although low in quality, can facilitate lion dispersal and offer additional lion numbers (Mitchell & Hebblewhite, 2012). However, if these areas are instead acting as ecological traps, they may be compromising the viability of protected lion populations in Kruger and Gonarezhou, in which case appropriate mitigation measures must be identified. Increasing human densities and the associated risks of conflict, prey depletion, habitat loss and fragmentation underscore the importance and urgency of undertaking research to support lion conservation management at the landscape scale in the GLLCU.

Lion pride in the Mozambican Greater Limpopo Lion Conservation Unit

Specific Objectives

1) Quantify the impact of poaching on habitat availability and population viability of lions in the GLLCU. Specifically,
   - Quantify the impact of bushmeat poaching on lion prey availability and on lion distribution, demographics and densities.
   - Quantify the extent of lion poaching and impact on lion population viability.
   - Understand the socio-economic drivers of bushmeat and lion poaching.

2) Quantify the impact of conflict on habitat availability and population viability of lions in the GLLCU. Specifically,
   - Quantify the impact of livestock grazing on lion habitat availability.
   - Quantify lion selection or avoidance of livestock as prey.
   - Quantify the perceived extent of lion-livestock conflict and lion persecution in response to depredation.

3) Quantify connectivity (i.e., dispersal barriers and functional corridors between sub-populations) and source-sink dynamics for lions in the GLLCU.

4) Evaluate management and land-use strategies required to maintain a viable lion meta-population across the GLLCU, including to; 1) reduce lion-human conflict, 2) reduce poaching of lions, 3) promote an increase of lion abundance and range, 4) secure critical lion habitat (including prey) and dispersal corridors, 5) increase community socio-economic benefits from living with lions and government benefits of protecting lions.

Narrative Report

Activities conducted to date: (July 2014-June 2015).

1) Landscape scale occupancy sign surveys have been conducted to quantify the occurrence of lions, their prey, habitat and threats in Limpopo and Banhine National Parks, the Lebombo and Maunge Conservancies and adjacent community use lands in south-western Mozambique (Fig. 1, Appendix 1).
    - 2 909 x 1km transect samples walked
    - 76 x 200km^2 grid cells sampled

2) Detection dog surveys have been conducted in Limpopo and Banhine National Parks (Fig. 2) to produce robust density estimates for lions and to quantify species connectivity and source-sink dynamics.
    - 686 km of transects surveyed
    - 71 x 50km^2 grid cells sampled

3) Distance sampling for ungulates has been completed in Banhine and Limpopo National Parks to produce reliable density estimates of lion prey.
    - 1 164 km of transects surveyed in Limpopo
    - 610 km of transects surveyed in Banhine

4) GPS collaring of lions in the Mozambican GLLCU has been initiated to determine the influence of free grazing cattle on lion prey and space use.

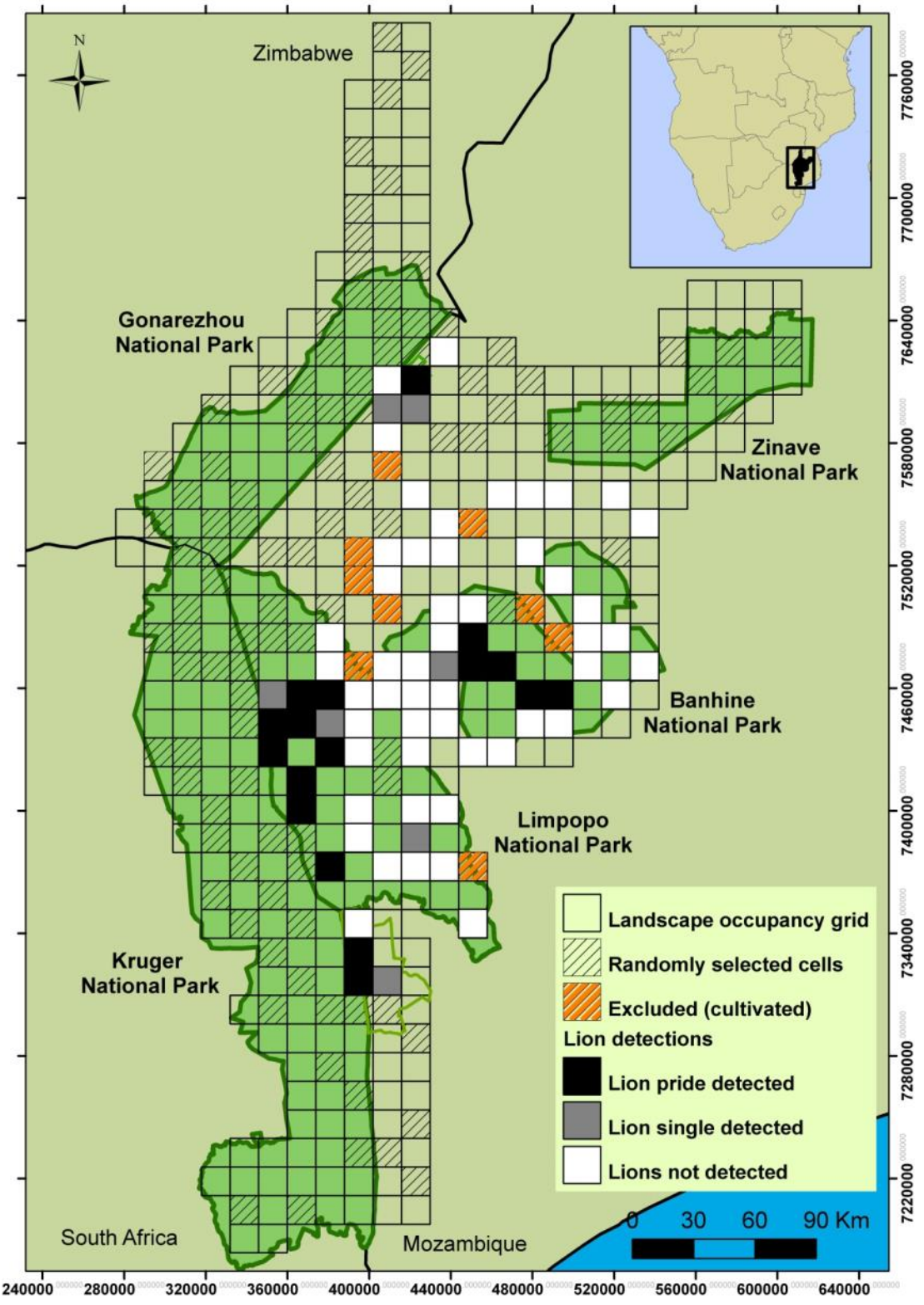

Figure 1. The Greater Limpopo Lion Conservation Unit, showing 180 randomly selected 200km^2 grid cells to be surveyed; cells surveyed were lion prides or single lions were detected; and cells excluded from sampling because they contained more than 80% human settlements. Within each cell 40 x 1km transect samples are surveyed on foot for the detection or non-detection of lions, prey and threats.

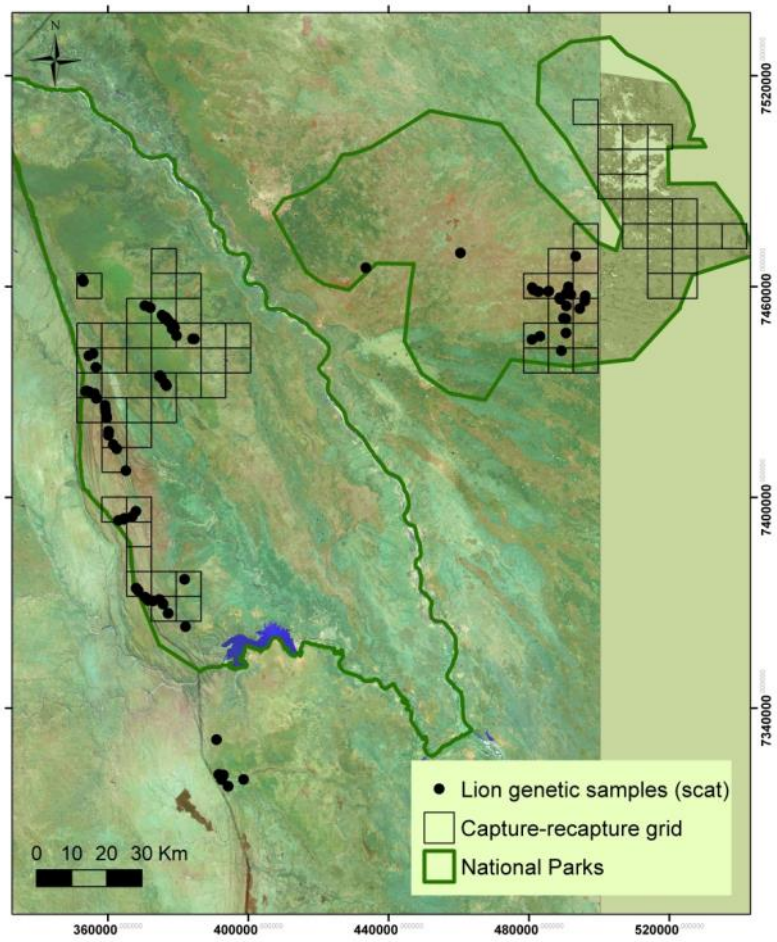

Figure 2. Genetic capture-recapture grids and locations of 143 and 46 lions scats collected in Limpopo and Banhine National Parks, respectively. Scats located within 50 km^2 grid cells were collected during August-October 2014 on 304 km and 382 km of detection dog surveys and 382 and 379 km of human-only surveys in Limpopo and Banhine National Parks, respectively.

Preliminary findings

Lions and other wildlife in the Mozambican GLLCU are in a dynamic state; with some populations recovering after decades of persecution and others suffering increasing overexploitation. Our efforts show that lions and their prey are distributed heterogeneously across the vast unfenced landscape. Considering the declining status of the species, each of the individual (sub)-populations that we have found are invaluable to the regional lion meta-population and to African lion conservation. Our surveys documented the presence of lions in 32% of a 15 200 km^2 sampled area of the Mozambican GLLCU (Fig. 2). From these data we have identified a minimum of eleven lion prides including; seven in Limpopo National Park, two in Banhine National Park, one in the Lebombo Conservancy and one in the Maunge Conservancy.

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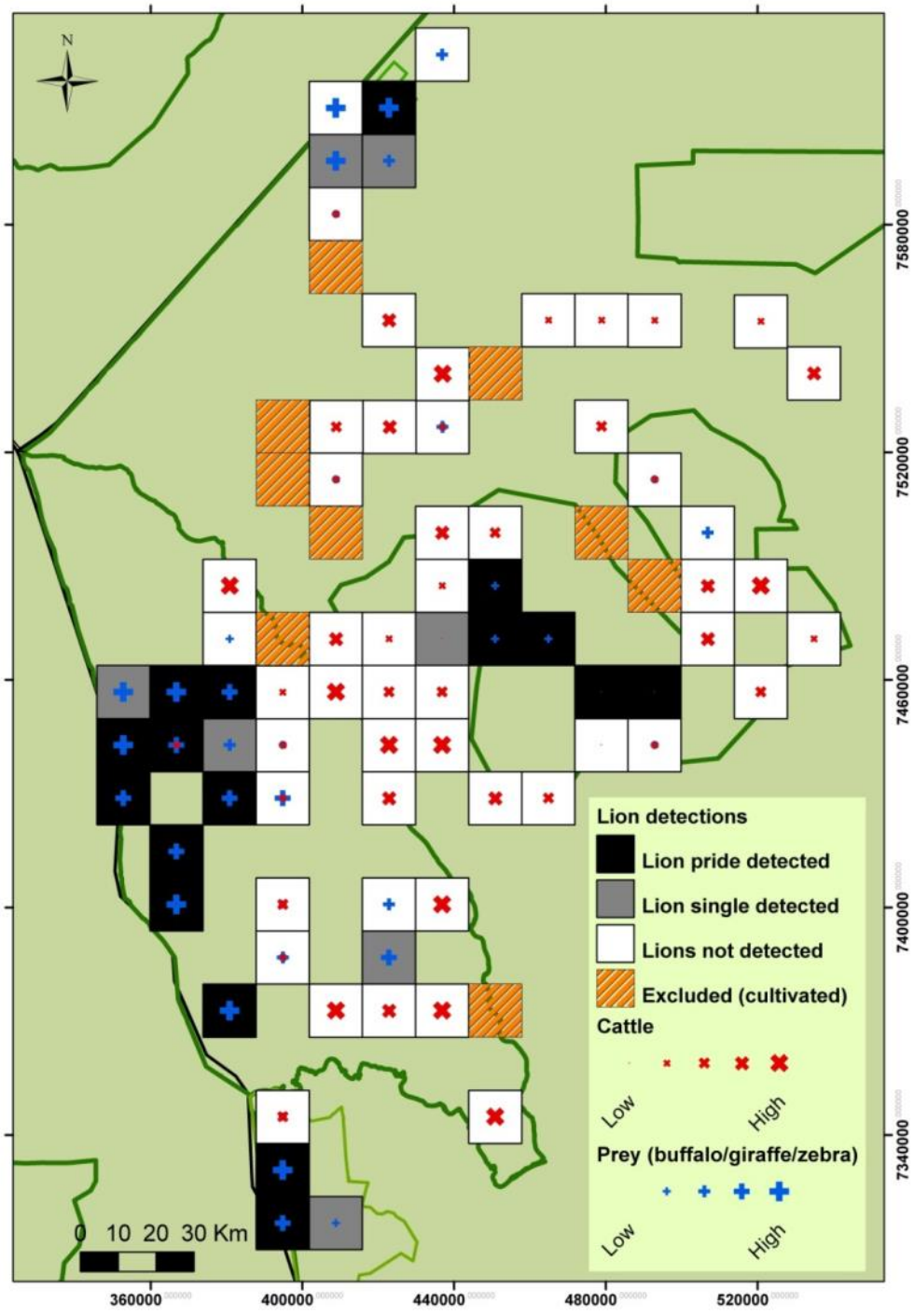

Figure 2. Relative occurrence (naïve occupancy estimates) of lions, showing two demographic categories; the detection of prides and the detection of single lions, shown with the relative occurrence of cattle (percent of 1km samples detected in 200km^2 grid cell) and the relative occurrence of preferred prey (buffalo, giraffe, zebra).

Bushmeat poaching is widespread throughout the Mozambican components of the GLLCU including within the National Parks. We documented the presence of bushmeat poaching across 11% of 1 km transects in Limpopo, 11% in Banhine, 9% in the conservancies and 18% in the community lands. Poaching detections recorded during occupancy surveys included; snare sets or traps, butchered carcases, hunt camps and encounters with poachers.

The nature and impact of bushmeat poaching varied across the landscape; including marked differences in the commercialization of activities, the methods employed (Fig. 3) the species selected (Fig. 4). We found evidence of large-scale commercial bushmeat poaching in central Limpopo Park, western Banhine and the potential Banhine-Gonarezhou corridor area (e.g., Fig. 5). Differences in poaching techniques can be expected to result in differences in the impacts on local prey and predator populations (i.e., the use of snares or poison *vs.* bows and guns).

Figure 3. Wire snares were the most commonly used hunting method detected (76%) in Limpopo National Park, while shotguns or bow and arrows were the most commonly used methods detected (53%) in Banhine National Park.

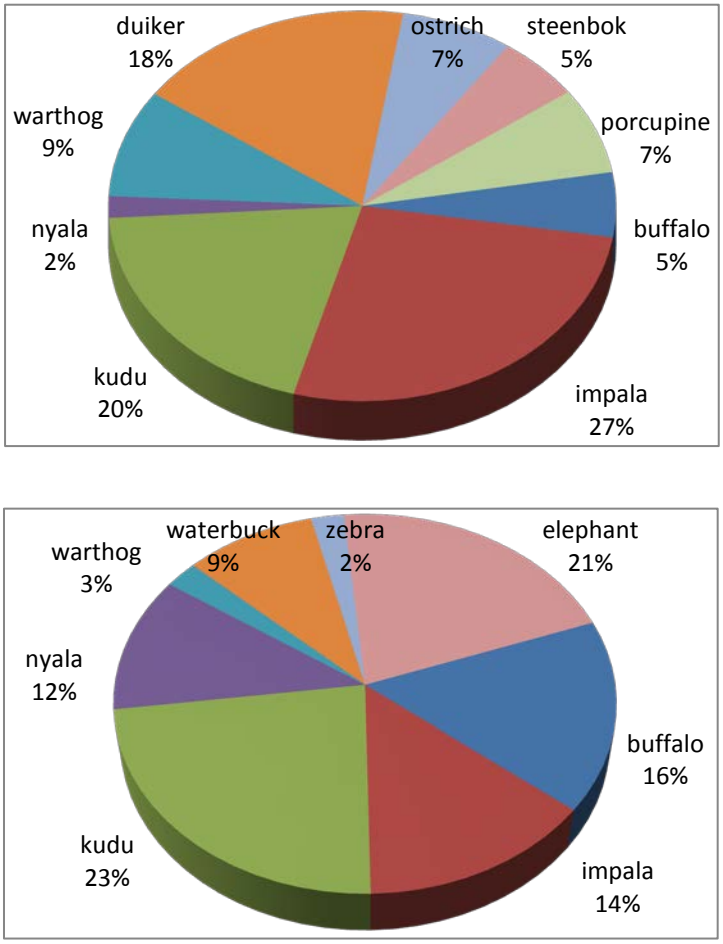

Figure 4. Species composition of poacher kills in Banhine National Park (top) and Limpopo National Park (bottom).

Figure 5. Example of large scale commercial bushmeat poaching between Banhine and Gonarezhou National Parks, which included a 650m long brush fence (red line) containing 38 wire snares set for kudu (circles). The meat was being dried, packed into bundles and hauled out with donkeys and bicycles.

In an effort to assist managers to reduce the impact of bushmeat poaching on predator populations, we have provided Limpopo and Banhine National Park management and the federal wildlife protection manager with reports on bushmeat poaching hotspots and important predator areas threatened by poaching (generalized example, Fig. 6). Our information has led to ambushes and arrests and further commitments to routinely patrol these areas. In addition, we have removed a total of 135 wire snares while conducting occupancy surveys.

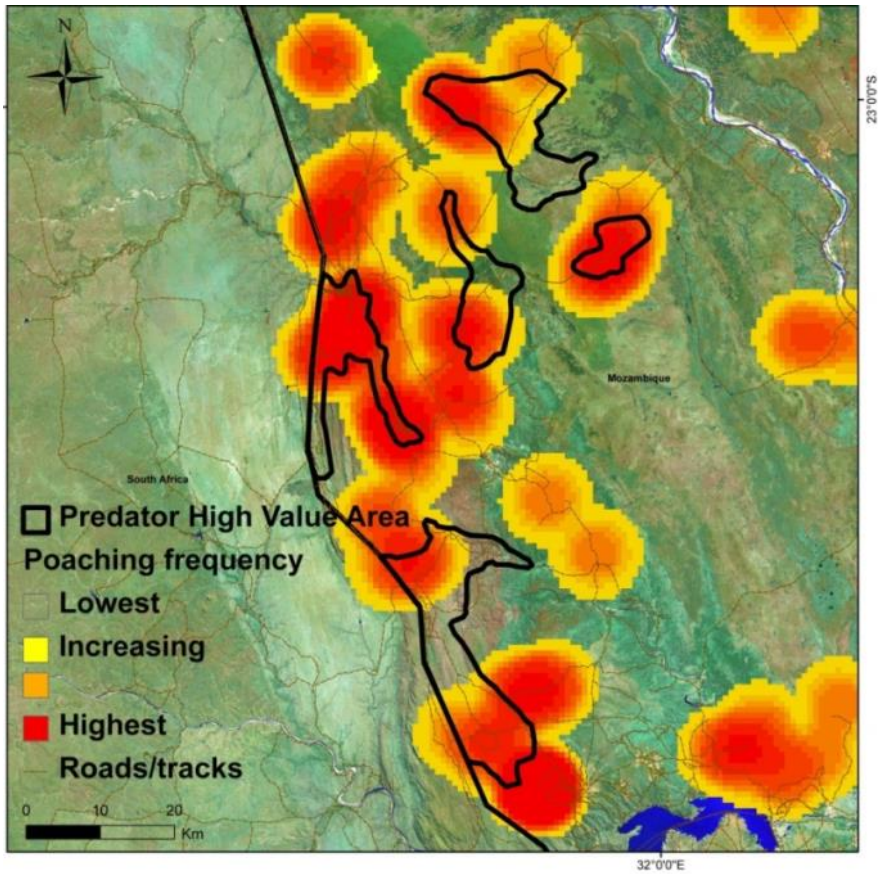

Figure 6. High value predator areas (determined from data collected 2012-2015) and relative bushmeat poaching frequency from occupancy surveys August-September 2014 in Limpopo National Park. This map was created to assist park management with directed anti-poaching efforts.

Of concern, the targeted poaching of lions has been the greatest recorded source of lion mortality in the Mozambican portions of the GLLCU (Table 1). In Limpopo National Park and neighbouring Lebombo Conservancy we have documented poaching of lions for their heads, feet, tails, skins and claws to supply local demand for 'muti'(superstitious beliefs) (see Appendix 2; Table 1). We have not, however, found evidence of an international trade in lion bones or the local use of lion bones.

Young male lion killed in a snare set outside of a cattle boma in Lebombo Conservancy (September 2013). Meat (hanging in rear) and skin were then sold for muti, illustrating an overlap between the threats posed to lions by retaliatory killing for livestock depredation and the threats from the muti trade.

Table 1. Direct threats to lions in Limpopo National Park and Lebombo Conservancy (south of Limpopo) during 2011-2015.

Threats	Incidences recorded	Demographics
Killed for body parts used in superstitious beliefs "muti"	**3 lions poisoned, with heads, feet, tails and organs removed** **2 lions killed unknown method, with skin and teeth removed**	**2 males** **1 female** **2 unknown**
Killed in retaliation of livestock depredation	**3 lions snared while attempting to access cattle in boma (1 lion also used for muti)**	**3 males**
Killed as by-catch in bushmeat snares	**1 lion photographed with a snare** **1 lion found snared**	**1 female** **1 male**
Killed for unknown reasons	**1 shot claws removed for muti**	**1 male**

The majority of the Mozambican GLLCU, including within the National Parks, are impacted by free grazing cattle. During the dry season we documented unattended cattle herds regularly ranging 10 km from villages. Areas used by cattle are closely inversely related to the areas most used by lions in Limpopo and Banhine (Fig. 7). Each of the lion prides that we have identified in the region have ranges that overlap with cattle grazing areas and are therefore at risk of conflict. However, to date all of the lion predation events that we have documented during occupancy surveys (n=19) have been of wild prey (Appendix 3). Future GPS cluster analysis will provide detailed information into the extent and circumstances of livestock depredation.

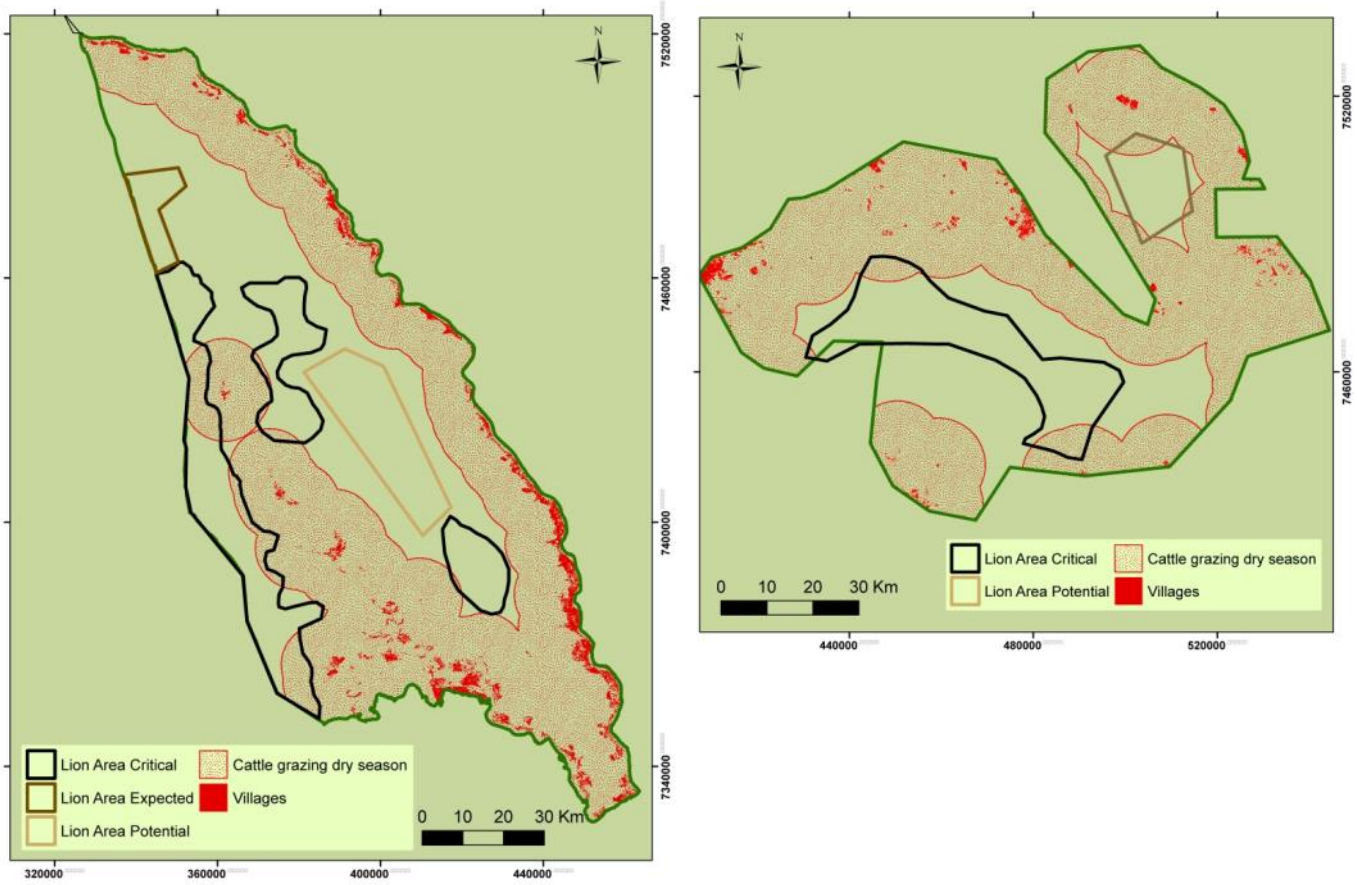

Figure 7. **Lion critical areas**, defined as an approximate minimum polygon around lion detections from occupancy and capture-recapture surveys (2014-2015) and occupancy surveys (2012-2014); **Lion expected area**, defined as an area with comparable habitat as critical area but has not yet been surveyed; **Lion potential area**, defined as an area with relatively good habitat (prey and space) but where lions were not detected during occupancy surveys. Maps show 10km buffer around villages approximating the extent of land used by cattle in the dry season from occupancy data (2014).

Our surveys to date have found that the highest densities of large bodied ungulates in the Mozambican GLLCU occur close to the Kruger and Gonarezhou borders and in some of the more remote sandveld regions of Limpopo (Fig. 2 but see Appendix 4 & 5 for landscapes). This included detecting buffalo on 37% of 1 km transects in Limpopo, on 9% Banhine, on 40% in conservancies and 4% in community lands (Fig. 8). The most productive habitats in the Mozambican GLLCU (i.e., riparian plains and Banhine floodplains) are dominated by subsistence agriculture and livestock, including within the National Parks. However four lion prides do inhabit sections of riparian habitat close to the Kruger border in Limpopo.

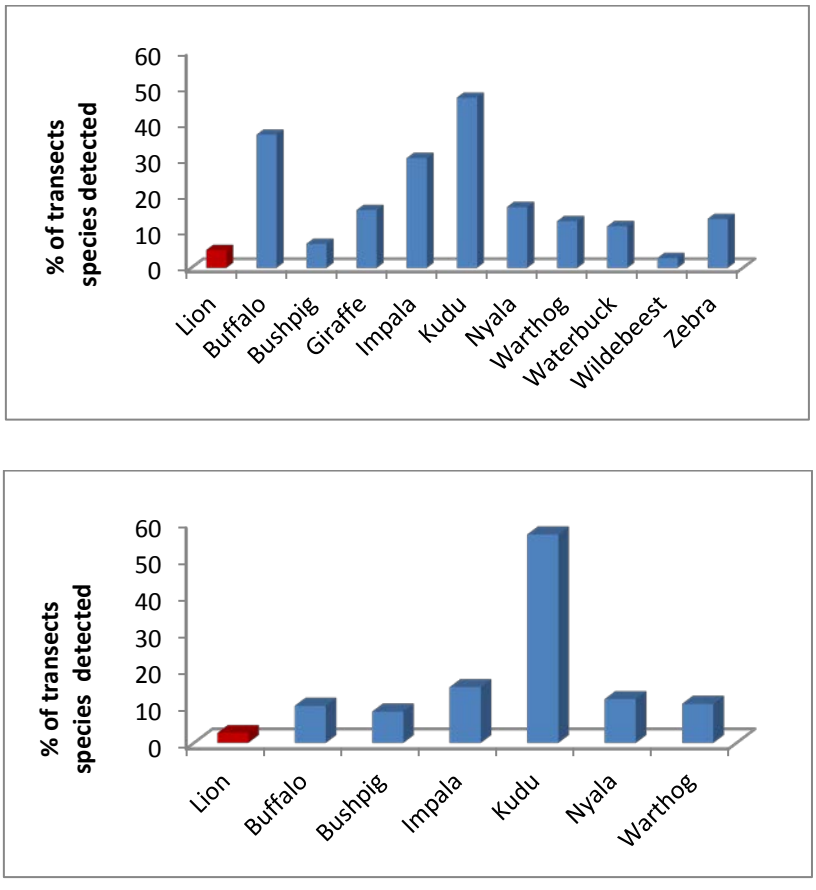

Figure 8. Relative occurrence of lions and their prey in Limpopo National Park (top) and Banhine National Park (bottom) from detections on 1km spoor transect samples.

There is a small refugia of grasslands in Banhine (200km^2) with high density of impala and some buffalo. However lions are currently absent from this area (Andresen, Everatt & Kerley, 2015). Active management, including increased protection, reintroduction of wildebeest, zebra and giraffe and potentially the strategic use of (page wire) cattle fencing, could facilitate re-colonization by lions.

Sandveld is the most common landscape type in the Mozambican GLLCU and is characterized by a lack of permanent water resulting in relatively lower levels of human impact. We have documented high occurrence of kudu, giraffe and impala and seasonal occurrence of buffalo in the sandveld of Limpopo, and high occurrence of kudu with limited occurrence of buffalo and impala in the sandveld of Banhine. Notably, three of the seven lion prides in Limpopo and both of the lion prides in Banhine occur in more remote regions of sandveld.

The matrix surrounding lion (sub)-populations is heterogeneous in human disturbances and available prey base. Within the community lands, we documented relatively high occurrence of kudu and limited occurrence of buffalo, impala and eland patchily distributed in sandveld habitats, while the riparian habitats are dominated by livestock (Fig. 2). Some areas outside of the parks may function to facilitate connectivity across the landscape and offer increased lion range (i.e., with the expansion of reserve networks), while other areas may be detrimental to lion viability (via edge effects or ecological traps).

Our information will be used to quantify connectivity and inform land use strategies to increase lion (meta)-population viability. Of concern, potential corridors are being quickly degraded by poaching and the expansion of settlements, and it is therefore important that areas with potential for connectivity are demarcated as quickly as possible. In order to assist the Mozambican government and the National Parks to make an informed designation of a conservation corridor linking the Limpopo and Banhine National Parks we have produced a short report highlighting our preliminary findings and indicating where the best corridor options may be (Fig. 9; Andresen, Everatt & Kerley, 2015).

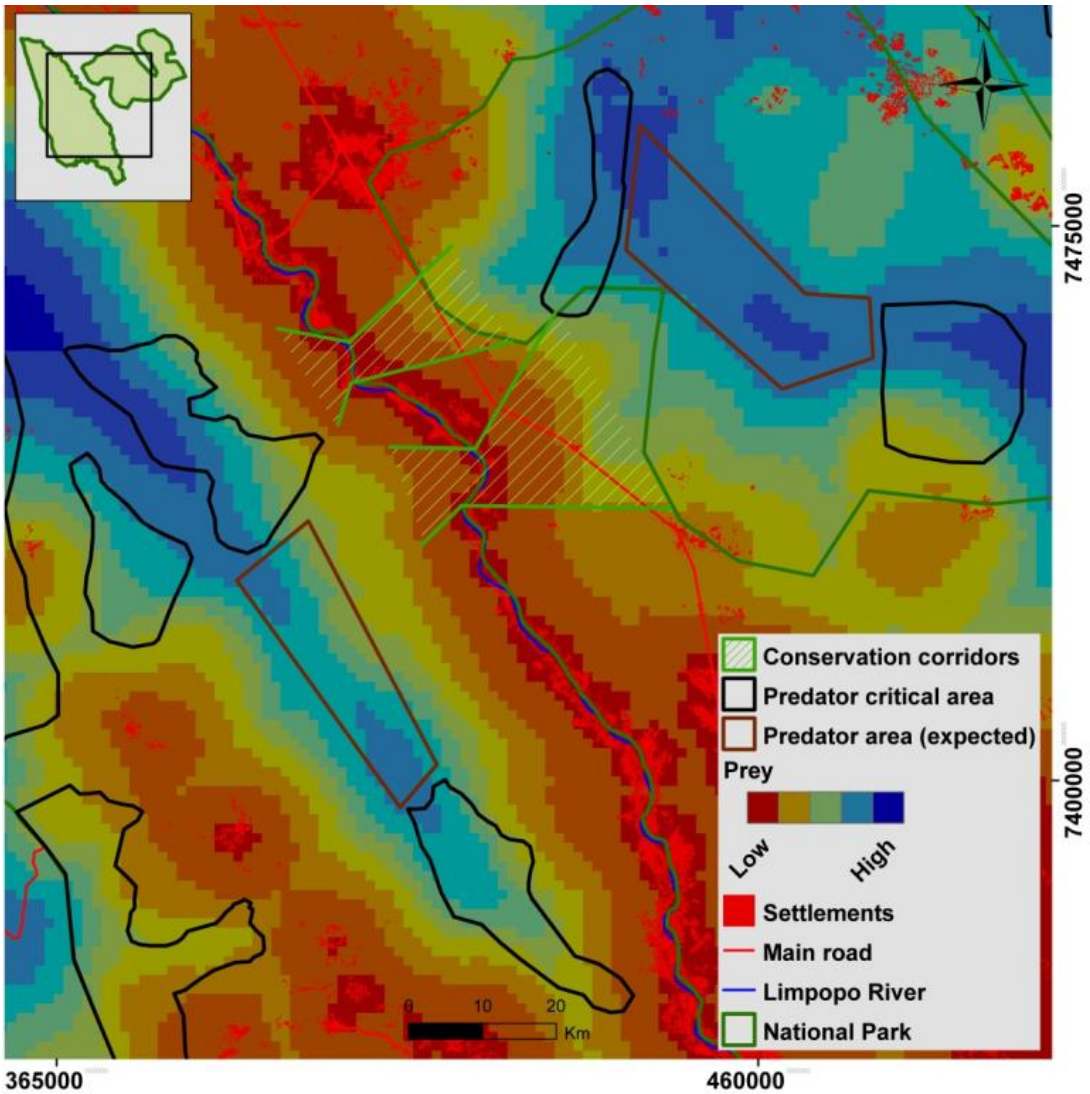

Figure 9: Recommended Limpopo-Banhine conservation corridor, identified as area with the highest likelihood of facilitating apex predator connectivity. Assessment is based on critical areas for cheetah, lion and African wild dog (this study), and occurrence of important prey from logistic regression model (this study) and human land-use. Expected predator areas have not yet been surveyed but share important characteristics with critical predator areas. From Andresen, Everatt & Kerley, 2015.

Progress towards meeting the project objectives:

Objective 1: Quantify the impact of poaching on habitat availability and population viability of lions in the GLLCU.

In order to meet the above objective, we have completed extensive occupancy spoor surveys across 14, 600 km^2 area in the Mozambican GLLCU, including Limpopo and Banhine National Parks and adjacent community lands, private reserves and conservancies (Fig. 1). Our efforts constitute the most comprehensive survey of lion habitat in the region. The material and data obtained will be used to quantify the extent of bushmeat poaching and its impact on lion prey availability, lion distribution and demographics. A total of 525 bushmeat poaching events were recorded, including 196 butchered carcasses. Preferred prey of lions (buffalo, giraffe, wildebeest and zebra) were recorded in 58% of grid cells in Limpopo, 20% in Banhine, 100% on conservancies and 6% on community lands. To quantify the population density of lion prey, we conducted distance sampling in Limpopo and Banhine Parks. The localized prey density estimates will be used to inform the large-scale occupancy surveys to predict lion prey availability across the GLLCU landscape. To quantify lion population size and sex ratios, we have conducted rigorous genetic capture-recapture surveys with the assistance of a detection dog in Limpopo and Banhine National Parks. These efforts resulted in the collection of 143 and 46 lion scats in Limpopo and Banhine, respectively (Fig. 2). To quantify the extent of lion poaching we are investigating all lion mortalities that are encountered during occupancy surveys or that are reported to us by Park and reserve management and community members. To date we have recorded 11 lion mortalities (2011-present). Evidence of targeted poaching for body parts was found in 73% of incidences.

The material and data that we have obtained will be used to determine the current available habitat (including prey) for lions in the Mozambican GLLCU and the impacts of bushmeat poaching on lion population viability. This information will be used to identify key areas where interventions are required to increase protection of lions and their prey. Our information will inform conservation management plans and regional strategies to improve habitat quality for lions in the Mozambican GLLCU, thereby ensuring the growth and persistence of at risk populations and simultaneously increasing the viability of protected populations in Kruger and Gonarezhou National Parks by reducing edge effects.

Objective 2: Quantify the impact of conflict on habitat availability and population viability of lions in the GLLCU.

The sampling required to quantify the impact of livestock grazing on lion habitat availability has been completed across approximately 50% of the selected sample sites in the GLLCU. We have documented the free ranging of cattle in 52% of surveyed grid cells in Limpopo, 65% in Banhine, 11% in conservancies and 100% in the community lands (Fig. 3). Cattle were detected on 28% of 1 km transects in Limpopo, 19% of transects in Banhine, 4% of transects in conservancies and on 44% of transects in the community lands.

The material and data that we have obtained will be used to determine the degree that livestock impacts have resulted in habitat fragmentation for lions in the GLLCU. This information will be used to critically evaluate the best management and land use strategies to ensure the growth and persistence of lion populations in the region. Our results show that all of the identified lion prides in the Mozambican GLLCU have exposure to cattle and are therefore at risk of conflict. It is therefore crucial to identify regionally appropriate conflict mitigation strategies. To understand lion space use in relation to pastoralist activities and to quantify lion selection or avoidance of cattle as prey, we are preparing to fit GPS collars on lions from seven focal prides in the Mozambican GLLCU. We have recently made progress towards this aim and have captured and collared a lioness from the Lebombo Conservancy (Animal Ethics Approval A13-SCI-ZOO-014). The information obtained will be used to determine the minimum wild prey and space requirements and pastoralist husbandry practices for conflict avoidance (see Appendix 6).

Objective 3: Quantify connectivity (i.e., dispersal barriers and functional corridors between sub-populations), and source-sink dynamics for lions in the GLLCU.

Connectivity

The sampling required to quantify connectivity for lions in the GLLCU has been completed across a 14, 600 km^2 area, which represents approximately 50% of the selected sample sites in the GLLCU. Occupancy spoor surveys have been completed in Limpopo and Banhine National Parks and associated potential corridor. We have also initiated occupancy surveys in the community lands and private reserves that may facilitate connectivity between Banhine, Zinave and Gonarezhou National Parks. These surveys have yielded considerable information on lion occurrence, prey availability and anthropogenic disturbances, which will enable us to critically evaluate the permeability of the landscape for lions between important protected (sub) populations. In addition, we have completed intensive sampling for scats in Limpopo and Banhine Parks and the majority of the Lebombo and Maunge Conservancies that border on Kruger and Gonarezhou National Parks. We have collected a total of 230 lion scats across these areas.

The material and data obtained will be used to critically evaluate landscape barriers between (sub) populations of lions and corridor feasibility using a combination of landscape genetics (Segelbacher *et al*., 2010) (from scats), occupancy data (Barber-Meyer *et al*., 2013), habitat suitability models (Hebblewhite *et al*., 2011) and least-cost path analysis (Squires *et al*., 2012). Our information will feed into regional conservation strategies and land-use zoning initiatives (i.e., corridor demarcation and reserve planning) to increase lion viability in the GLLCU.

Source-sink dynamics

The sampling required to quantify source-sink dynamics for lions in the GLLCU has been completed in Limpopo and Banhine and the majority of the Lebombo and Maunge Conservancies. The majority of these lands are impacted by poaching and pastoralism and border on important protected populations in Kruger and Gonarezhou. Differing levels of human disturbance and persecution experienced by the Kruger/Gonarezhou and Mozambique lion populations may result in source-sink dynamics. We will be using a landscape genetics approach (material obtained from scats) to identify source-sink dynamics between lion sub-populations (Andreasen *et al.*, 2012) in relation to differences in habitat and human disturbances (habitat selection determined from occupancy surveys and GPS tracking of collared lions).

The material and data that we have collected will be used to distinguish whether human-impacted lands in Mozambique are beneficial extensions of (low quality sink) habitat or detrimental attractive sink habitats. Identifying source-sink dynamics will inform regional conservation strategies and management interventions towards 1) protecting critical source populations, and 2) promoting the expansion of lion populations in Mozambique by improving the quality of sink habitats (i.e., reducing persecution) or reducing the attractiveness of sink habitats (i.e., improving livestock husbandry practices and strategic fencing).

Collecting lion scat in the Limpopo National Park with detector dog

Objective 4: Evaluate management and land-use strategies required to maintain a viable lion meta-population across the GLLCU.

We have obtained the majority of the material and data required to perform a critical evaluation of the best management and land use strategies to ensure lion population viability in Limpopo and Banhine National Parks. We have also obtained additional information from community lands and conservancies that will inform meta-population management and increase lion population viability in Kruger and Gonarezhou National Parks. Specifically, we have obtained material and data that will be used to provide reliable information on:

1. Lion population size and demographics
2. Habitat availability
3. Threats to lions
4. Connectivity
5. Source-sink dynamics
6. Edge effects

Our information will be used to identify where conservation interventions are required and to determine appropriate solutions to ensure lion population growth and persistence in the Mozambican GLLCU. This will be critical to ensuring the viability of the regional meta-population. Our information will be used to develop appropriate lion-livestock conflict mitigation strategies, increase protection of lions and their prey, secure critical lion habitat and dispersal corridors and to increase community socio-economic benefits from living with lions and government benefits of protecting lions.

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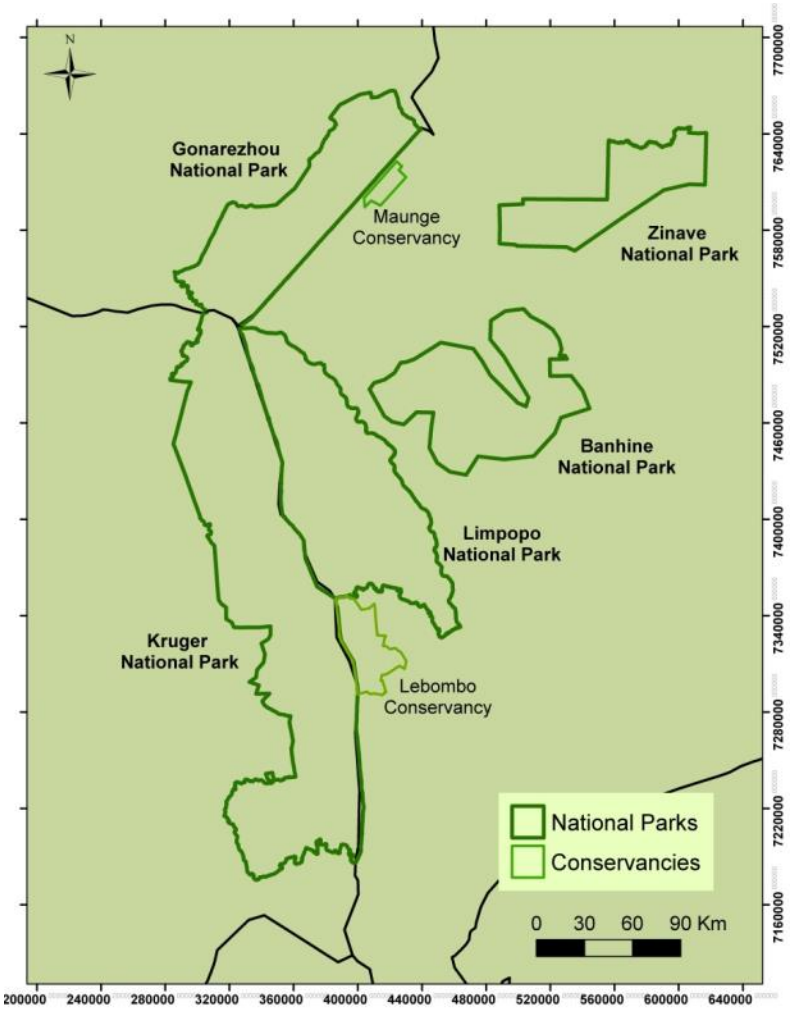
Appendix 1



National Parks and conservancies discussed in report.

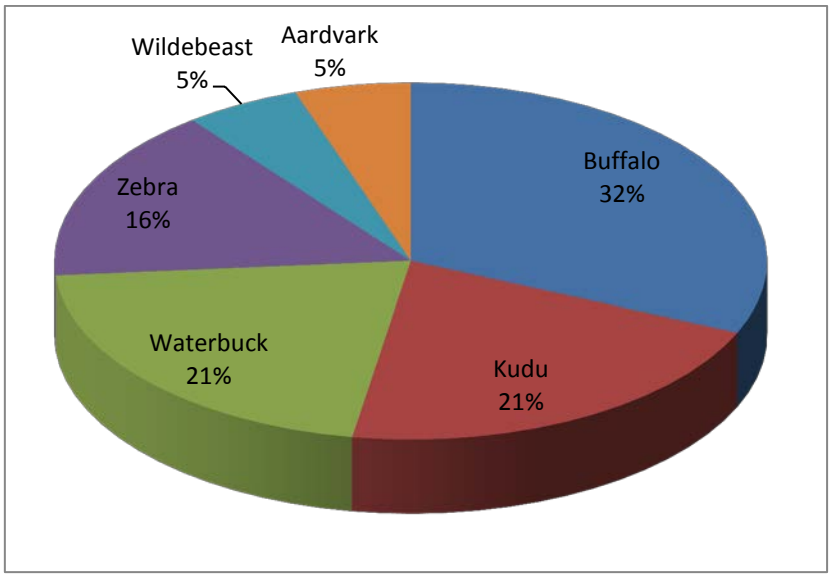
Appendix 2

Box 1:

A poisoning indcident in Limpopo National Park killed three lions and seven vultures in August 2015. The animals were targeted for their body parts. The perpetrators are from a community actively involved in rhino poaching in Kruger and we suspect were acting on a superstitious belief that carrying a piece of a lion will give luck to a hunter, including the ability to avoid capture by rangers. We are concerned that such an association between rhino poaching in Kruger and lion poaching could increase the pressure on lions in Limpopo. The incident also revealed that the park is lacking in the capacity to prevent or respond to poisoning. In this case, we motivated for the help of two rangers, and along with our two volunteers burnt the carcasses in order to reduce further poisoning. We are motivating for the development of a Limpopo Park Poison Response Unit.

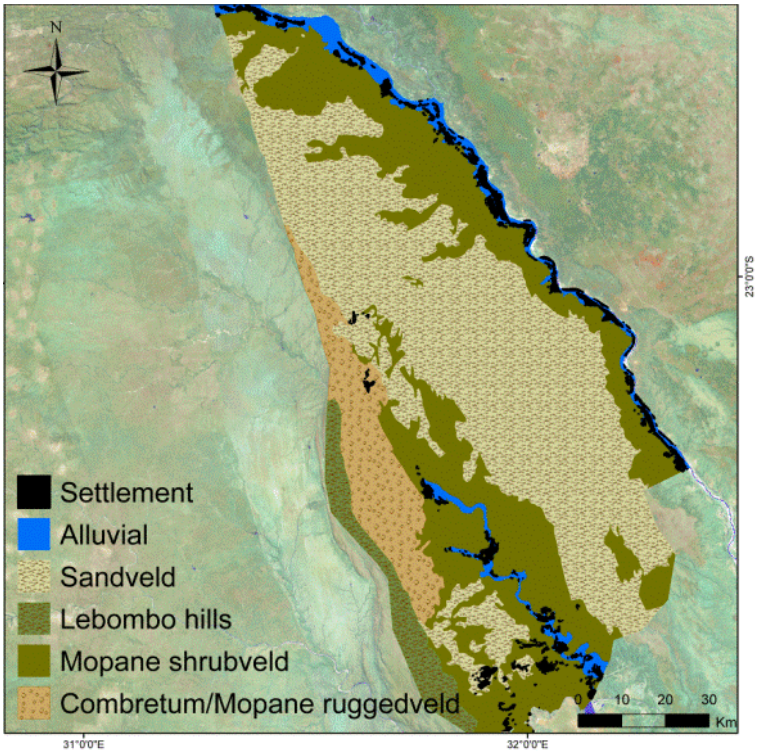
Because the death of the above lions may have violated the closure assumption of occupancy models we decided to re-survey the area in May 2015. On the second survey we documented the presence of a pride with cubs. We also documented high levels of snaring of lion prey. We motivated the park to send a team of rangers into the area and to follow up with continued patrols.

Appendix 3



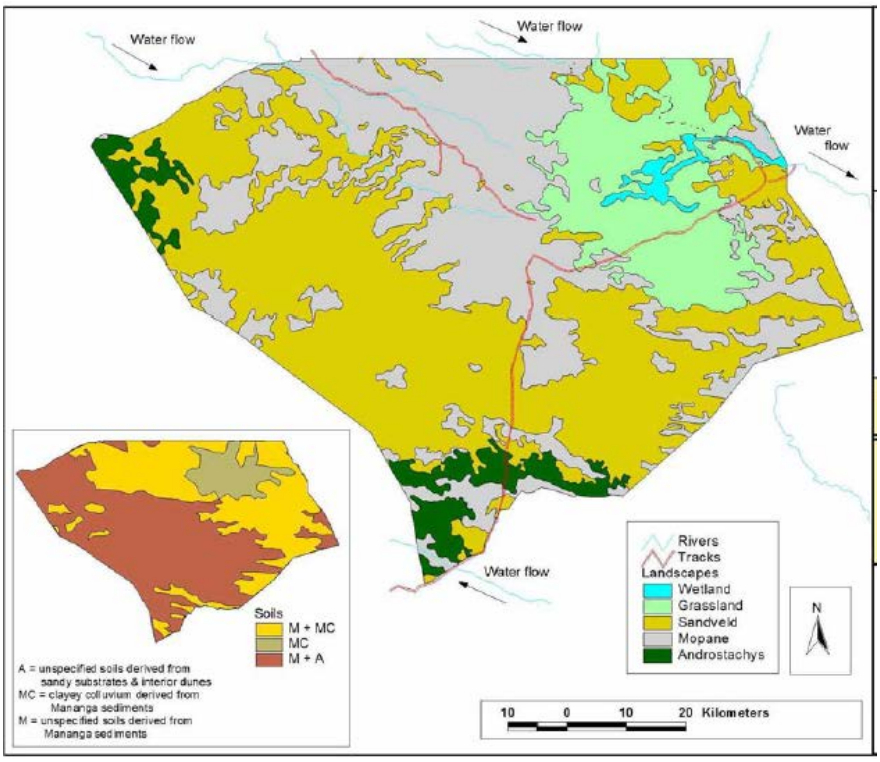
Prey composition from nineteen lion kills detected during occupancy surveys (2014-2015).

Appendix 4



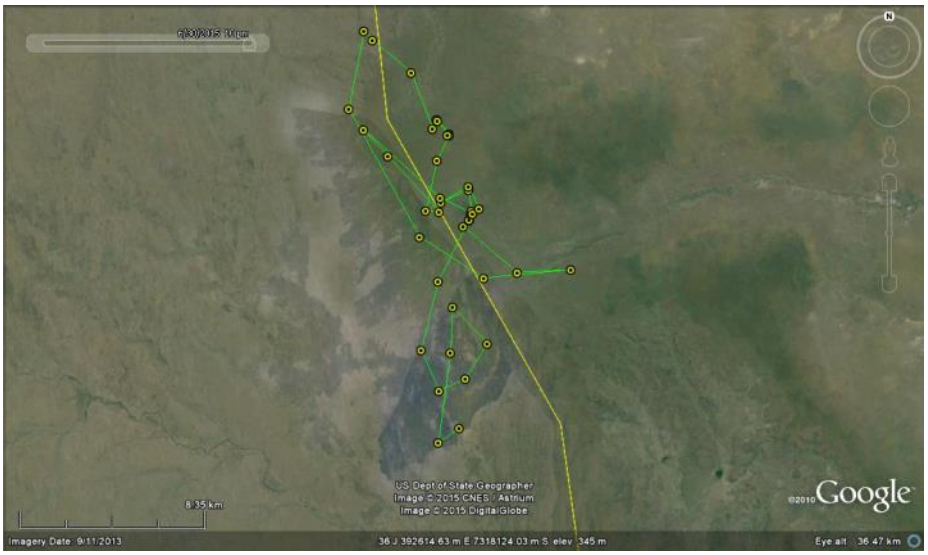
Landscapes of Limpopo National Park.

Appendix 5



Landscapes of Banhine National Park (from Stalmans, M. (2003). Plant communities and landscapes of the Parque Nacional de Banhine, Moçambique. Technical report).

Appendix 6



The first week of GPS points from one collared female in a group of two females and three sub-adult cubs ranging across the Kruger-Mozambique border (yellow line) including areas used by wild prey and cattle.