2018

Hwange Lion Research Project,
PO Box 44, Dete, Zimbabwe

Hwange Lion Research Project

Annual Report

Andrew Loveridge

Jane Hunt

Liomba Mathe

Lovemore Sibanda

Hwange Lion Project Annual Report

Index

Supporters, Donors and Collaborators

Dawn Properties Limited

BRAINWORKS

General overview and summary of activities

The core lion research project in Hwange National Park (HNP) was started in 1999. We work in close association with the Zimbabwe Parks and Wildlife Management Authority (PWMA). We have monitored the lion population in a 5000km^2 study area in the North East of HNP lions and currently monitor around 15 prides and 12 male coalitions using radio-telemetry. This may be one of the most intensive and long term lion projects outside the Serengeti, providing long term insight into the dynamics of an important population. The HNP lion study has contributed significantly to the science that underpins the current understanding of lion conservation biology, with the study having published in excess of 70 peer reviewed journal articles making it one of the most productive large carnivore research projects in the world.

HNP is of central importance because it is one of the largest protected areas in the region, part of the Kavango-Hwange lion conservation unit (one of the last lion population strongholds in Africa) and is a significant source population for many wildlife species. Based on detailed demographic data, the project in close partnership with PWMA, has succeeded in changing the way lion trophy hunting is managed and has helped to implement a biologically sustainable system of allocating hunting quotas. It has also collected data to increase our understanding of anthropogenic impacts on lion populations on large park boundary.

The project employs 4 local Zimbabwean field staff on a full time basis, along with several part time field staff. We currently employ 10 ‘long shields’ lion guardians in the local community around HNP. We believe that future conservation is dependent upon providing training to local Zimbabweans and we pride ourselves in providing training and employment opportunities for Zimbabweans.. To this end we have supported Dr Moreangels Mbizah’s D.Phil. studies at Oxford, trained several Zimbabwean ecologists at the Oxford Postgraduate Diploma in International Conservation Practice (PGDip.ICP). In 2016, we began our support of Mr Lovemore Sibanda’s D.Phil. studies and Mr Liomba Mathe attended the PGDip ICP. These men are both Zimbabweans who have and continue to make significant contributions to lion conservation in Hwange.

In the 2018 research season the project aimed to continue to undertake research in the following areas: camera trapping, lion monitoring and monitoring of human wildlife conflict

and expanding the work in the wider conservation landscape by verifying population trends in surrounding protected areas.

Monitoring of core study animals within the 5000km^2 study site in the Northern and eastern portion of Hwange National Park has continued where possible. This component of the study has been operational for 20 years and continues to add to an extremely valuable dataset on lion population demographics and behaviour. Long term studies are essential to understanding the population biology and conservation of long lived species. The project has continued work started in 2012 on exploring the linkages with the wider KAZA lion population, including transboundary work and lion population surveys in the wider Okavango-Hwange lion conservation unit. The project continues to camera trap surveys to estimate the density of the lion population in the different ecotypes within the park and surrounds and to monitor trends. This work links with similar research undertaken in Botswana, under the umbrella of the Trans-Kalahari Predator Programme.

A key focus of the project aims to understand the extent of human-lion conflict in the areas surrounding the National Park. Conflict potentially has extensive effects on carnivore populations as well as impacting the lives and livelihoods of people living in the surrounding areas. People whose livelihoods are negatively impacted by wildlife are less likely to support conservation and conservation initiatives. Over the last 11 years the project has sought to expand on the baseline understanding (through detailed surveys and a system of reporting conflict) of the sources and magnitude of human- lion conflict- in order to implement locally appropriate measures to ease conflicts. In collaboration with Parks and Wildlife Management Authority (PWMA) and local stakeholders have worked towards the development of appropriate mitigatory measures in communities surrounding the park, as well as continuing to monitor lions living close the park boundaries to identify behaviours that could lead to conflict situations. A key component of this work is the 'Long Shields' lion guardian programme, which began at the end of 2012 and has since recruited 10 'lion guardians' in the local community to spearhead livestock protection and community conservation. In addition to the research aspects of the project we continue to assist PWMA wherever possible with operational activities, including where requested assistance with deployment of PWMA anti-poaching patrols and assistance with fire management.

1. Core Lion Research in Hwange and Surrounds

1.1 Lion Population Monitoring

Mopane NEHeM4.

1.1.1. Monitoring of lion population demographics

Monitoring of all collared lions and core research prides has been carried out, sightings and photographs collected where possible for ID purposes. While there have been disease challenges in the form of rabies and anthrax identified in the Park this year we have not recorded any lion mortalities. However, several domestic rabid dogs were destroyed and rabies was also identified in spotted hyaena, honey-badgers and wild dogs. Logistically there have also been challenges, in the later part of the year with chronic fuel shortages, no cash available, and the economic down turn of the country making procurement of most things very difficult and time consuming.

It has been a very hot year with a mild winter. We have had an extended wet season from 2017, with a long dry period in December/January 2018, then rain starting again in February and continuing till mid-April 2018, a few showers of rain in November 2018, so the bush was thick and visibility and the locating of prides limited and quite difficult this year. The lions are roaming over large areas in search of dispersed prey due to the weather conditions this year with water availability having been good, not a stressful year water wise. There was very little killing of elephant calves by the lions this year, we only had about 2 – 3 weeks of this behaviour starting in late October to mid-November as there was very little water stress. We

have witnessed many of the lion prides taking advantage of the numerous elephant carcasses, both inside and outside of the Park, deaths caused by poaching, being hit by the train, and natural causes.

The rainy season conflict was extended due to late rains, with another spate in mid-year due to dispersal males arriving from Chizarira. These three young males have caused significant problems in the communal lands North of the park. Tsholotsho seems to have been better, conflict wise, this year, we think mainly due to the stability of the prides there, as no Ngamo males were hunted this year on quota from that area. There has also been a good reaction team set up between Imvelo and the Lion Guardians early warning system, to assist with chasing lions back to the park when they stray out of the security of the park.

1.1.2 Core study prides and monitoring

This year we have concentrated on the 7 core study prides plus the 5 sub divisions of these prides, so 12 groups of females, and 6 core males/male coalitions plus 6 surrounding male/male coalitions, in our core study area, covering about 5000 km^2 in the North and East of Hwange National Park. We also try and maintain records on another 15 prides from across Hwange National Park, and 9 other males or male coalitions. The core prides are summarised as follows:

- **Guvalala pride**, with collared lioness Heidi, GUVgF1. Five adult females with 11 juveniles. This is a very important photographic safari pride centred on the Main camp area, but this year they have ranged widely to as far afield as Kennedy 2, Manga 1, 2 and 3, Nora, Chivisa, Dete, Hwange Safari Lodge, Sinanga. This ranging behaviour is probably a pride of 16 needing to access more resources and food. As the pride's young cubs are sired by Seduli and Mopane, two males that have been absent protectors a lot of this year, they have also been avoiding the three immigrant Chizarira males. The youngest adult female, GUVjF1, was separate from the pride for a few months this year and we thought she may have cubs hidden in the Livinge/Sibya area, but if this is so, we never saw the cubs, and she later rejoined the pride, so may have lost her cubs. From late October this year GUVhF1 and GUVjF1 have sometimes been seen with the 3 new Chizarira males in the Nyam/Dom area. Heidi's collar has recently failed at the end of November 2018, so we are trying to replace this collar.
- **Guvalala, Buster's sisters**, (GuvgF4 & GUVgF3) have 4 juveniles (3F, 1M) and

been both inside and outside of the Park. Seduli and Mopane are the fathers of their cubs. GUVgF4's collar stopped working in September 2017 and we have been trying to change this collar without any success this year as she is a very shy female and hard to access. We will continue to try and change this collar.

- **Balla Balla pride,** collared female Yin, BALfF3. On 26.04.18 we managed to dart and collar this conflict lioness on the Dete Vlei. At the time she was with her dispersal aged sub adult male, BALlM1, and Seduli and Mopane. She originally had 3 young males in the l cohort but 2 seem to have disappeared by 2018. This is a conflict pride and several other members are also missing. Some of them could be the occasionally reported as a group of 3 or 4 lions in the Gwaai but we have been unable to positively identify these individuals this year. She has just recently been seen again in the Ivory Lodge and Sikumi Tree Lodge areas with 2 cubs. She has recently killed cattle in Forestry lands near Ganda/Ivory, after a period with little conflict with people. Seduli and Mopane are fathers to her cubs.
- **Caterpillar pride** has proved very difficult to see this year. We continue to try and replace the collar in this pride, after the old collared female disappeared in 2015. At present, there are two adult females with one juvenile male and one cub. There is a 5-year-old male CATdM1 who we had wanted to collar last year to monitor his dispersal, but so far been unable to do this due to the ZPWMA ban on collaring male lions. He seems to have already dispersed and may be with 3 females with 5 cubs in the Manga 3 area. These cats are shy and seldom seen, so no positive ID on them yet.
- **Somadada pride**. At the end of 2018 there are 2 females and 1 sub adult male left in this pride, as the other sub adult male was bow hunted from this pride in June this year. This pride has been on the move this year trying to keep alive the last 3 youngsters, fathered by Jericho. They have been seen out in the Gwaai, towards Half way house, at The Hide, Kennedy 1 and Makwa. We continue to try and get one of the lionesses collared after we lost the old pride female Kathy (MAKF1,) in January 2017. The remaining young male should be collared to monitor his dispersal, as he will most likely become a conflict cat. SOAeF1 mated with Kakori before he was trophy hunted this year and then a few months later was seen mating with Bhubesi. She has not been seen for some time and may be hiding with cubs or she may have been moved out of her range in the park by other prides in the park that are now using her range. (Mak Spice/Cecil's pride, and Backpans prides).

- **Nora pride** has also been very difficult to monitor this year. The split of this pride of 2 adult females is believed to have 3 – 5 cubs of 2 sizes. We are not sure at present to which male. Sub adult males, Humba and Netsayi left this pride and fought with Bhubesi, at Ngweshla in the middle of this year, to take over the 5 young females, Cecil's cubs.
- The second split of the Nora Pride spend time in the Shapi, Guvalala and Nehimba areas and are now with the 2 Acacia males. Not much has been seen of these lions this year.
- **Mak Spice**, otherwise known as **Cecil's Pride**, consisting of a core of three adult females with 1 related adult female, SPIgF2, sometimes joining them. There are 7 sub adults (2males and 5females) fathered by Cecil, these sub adults are now 4 years old and the males are dispersing. We had hoped to put a collar on one of these young males to monitor their dispersal. This pride is of major photographic importance to Wilderness Safaris, Somalisa and The Hide safari operators. Nomvelo, SPIhF1lost her 3 cubs, first seen in November 2017, sired by Bhubesi, in late February 2018, it is thought to a snake. Jackals were seen eating the carcasses in a blue bush at Ngweshla. She mated again with Bhubesi and had 2 cubs that are still alive and are the 2 smaller cubs of the five Bhubesi sired. SPIgF3 has the 3 larger male cubs. These 2 females with their five cubs frequent The Hide, Kennedy vlei and Mbiza areas at present. They stay away from Humba and Netsayi as their cubs were sired by Bhubesi. The 3rd adult collared female, Sisi, SPIgF1, also lost her cubs and has been mating with Humba and Netsayi for several months. She tries to stay with the 5 young females and the males, Humba and Netsayi, but is often chased out by the young females and then the males. This is very strange behaviour as at least one of these young females is her offspring.
- **Back Pans pride** now has 4 sub-groups. **Group 1**. 4 adult females, including collared female Tengwane, BACfF1, with 7 juveniles (5M, 2F) to Butch and Ngqwele males at Ngamo area. **Group 2**. 2 adult females with 6 cubs to Butch and Ngqwele mostly in Back pans Linkwasha area. **Group 3**. 2 – 3 adult females in the Wexcau area reported to have 3 cubs to Butch and Ngqwele (these females were in the Stumpy Tail group till early in 2018) We believe BACF1 is still alive in this group and is now 16 years old. **Group 4**. Collared adult female Stumpy Tail, BACaF1, with 6 sub adults sired by Xanda. Xanda was a male lion trophy hunted in Forestry in 2017 so females have had

to move out of the pride range protect their cubs from Butch and Ngqwele). Unfortunately, Stumpy was hit and killed by the train in September this year so the 6 sub adults are by themselves at present. There are 3 M and 3 F sub adults. They mostly use the area from Mbiza to Back pans and into Ngamo Forestry. There is one other adult female who goes between groups 2, 3 and 4 and she has 1 cub in poor condition.

Sub adult male of Back pans pride on rail line.
BACaF1 (Stumpy Tail) hit and killed by the train 21.09.18.

Core Males/male coalitions:

- **Nehimba**, collared male, **Seduli** (NEHeM1) and **Mopane** (NEHeM4). These males have spent a lot of the time outside of the Park this year, in the Gwaai and Forestry areas, Dete and Sikumi vleis. They cover 5 prides of lionesses, namely, Buster's sisters, Guvalala - (Heidi's pride), Ballaballa and Gwaai/Chimwara. They have also been tracking and searching for the Somadada pride in The Hide area and chasing singleton males Kakori and Bhubesi in this area. Recently they have been harassing the two females, two young males and five cubs from Cecil's pride. These males are around 10 years old now and remain core territorial males.

Mopane & Seduli patrolling their territory.

- **Nyamanhlovu,** collared male**, Kakori**, NYMfM2, spent most of this year near and at The Hide, Sinanga, Mbiza and Kennedy 1, until he was trophy hunted on 02.06.18 in Sikumi Forest, close to the railway line and Antoinette boundary. He was 11.1 years old at that time. He had recently mated with the older Somadada female, just before being shot. He still occasionally spent time with the Caterpillar pride. The **Airstrip II,** STRM1**,** male who used to be with Kakori has not been sighted in 2017 or 2018, so it is likely he has died.

Kakori NYMfM2 mating with Somadada SOAeF1 at The Hide.

- **Balla Balla,** collared male**, Bhubesi**, BALfM1, was ousted from the Ngweshla area and the territory of the Mak Spice pride of females in June this year, by newly dispersed males Humba and Netsayi. He moved extensively for a while, roaming his old home ranges of Main Camp area, Dete vlei, Mbiza and Makalolo/ Ngamo area. He then seemed to spend most of his time in the area where Kakori had been, prior to being shot, and also mated with the older Somadada female. Seduli and Mopane quite often came into that area and chased him out. In the last few months of this year he has spent time in the Wilderness concessions around Madison pan and Davison's camo as well as at Mbiza. He is now 11 years 2 months old. The two Mak Spice females at present still have 5 cubs sired by Bhubesi. Cecil's two sub adult males are sometimes still seen in close proximity to Bhubesi.
- **Nora,** collared male **Humba**, NORcM1, and **Netsayi** NORdM1 spent the early part of the year in the Nora, Jambili and Manga 1 - 3 areas. They from time to time went into Bhubesi's area and confronted him. Then in June they eventually chased him from the pride of females and the Ngweshla area. Two of the adult females in this pride escaped with the five cubs they have to Bhubesi. Sisi, the collared female, who had lost her cubs to Bhubesi and the five young females sired by Cecil have remained around the Ngweshla/Somalisa area and have been mating with both these males since June.
- **Back Pans, Bomani Boys,** collared male**, Ngqwele** (BAChM3) and **Butch** (BAChM2), cover 3 groups of Back pans females at present, in the Ngamo, Linkwasha and Wexau areas. They have a total of 17 cubs to these 3 groups of females so far and are the dominant territorial males in this area and, as they spend time in the Forestry hunting area are vulnerable to being hunted. This would cause significant disturbance to the pride social structure in this area.
- **Caterpillar,** CATdM1. This male seems to have joined with a group of three adult females probably from the Nora pride, and has five cubs with these females. They have been seen in the Manga 3 area. They are very shy and we have yet to positively identify which females these are.

Other males:

- **Chizarira** males. ALERT collared male CHZM1 with CHZM2 and CHZM3. These three sub adult males dispersed from the pride of lions that live around the

Headquarters area of Chizarira National Park. All were identified from the HLR camera trap survey carried out in 2017 in Chizarira. They spent two months travelling through the communal lands, frequently killing livestock, and eventually entered the Hwange area via Dinde. This is very important data as it details the connectivity/corridor landscape, between wildlife areas, in the KAZA Sebungwe region. They arrived in the Hwange area in July this year. They have ranged both inside and outside of the park and caused a lot of conflict in the Makwandara, Lupote, Magoli, Dete, Mambanje and Dingani areas. They have been a serious concern, as they break into bomas to kill livestock and move around villages at night with not much concern for humans. The local authorities have been alerted to this potential danger and both they and Lion Guardians have been kept busy trying to mitigate the activities of these lions. Thankfully, at present they seem to be staying mostly within the Park and are in the Nyamanhlovu, Dom, Boss Long One, Chivisa areas, with 2 of the Guvalala females. On the 24.11.18 the collared male was darted to remove a copper wire neck snare. This snare we presume he picked up on the 26.09.18 in the Mambanje area as we noted, whilst tracking their spoor in this community, that one of the lions was dragging something at that time. The collar seems to have saved this lion and the snare was not too tight or cut into his neck. The collar was loosened and replaced. It is hoped that these 3 young males will settle and find a range with in the Park and not continue to cause conflict in the surrounding communities.

CHZM1, Collared Chizarira male, carrying copper wire neck snare.

- **Guvalala**, collared male **Mvuu**, GUVhM1, was caught on the camera trap survey last year near Josavinine. His collar has failed now, but he still seems to be around this area. We have not seen any evidence of his brother **Umoya**, GUVhM2, who dispersed from Main Camp area with him.
- **Back Pans**, BAChM4, hM6 and hM7 together with **Mak Spice** SPIiM4 are still believed to be in the Sitcheche, Mandeseka, Makona, Libuti area of the park. Unfortunately, the collared male **Phezulu,** BAChM5, was trophy hunted in Tsholotsho South in Oct 2017, so we no longer have a collar in this coalition of males.
- **Umtshibi,** collared male **Njabulo**, UMTcM2, and **Mak Spice**, collared male **Pape**, SPIgM2 with **Umtshibi, Drop Dot**, UMTcM5 and another adult male together with 3 sub adult males range over the Josavinine to Mtambonyati, Leasha, Bulungeti areas of the Park. Several of these lions were seen and caught on camera traps last year. The collars satellite components have failed but we still have VHF signals on these collars.
- **Acacia males** ACAM1, ACAM2. These males live in the Shapi, Nehimba area and cover the Nehimba and split group of the Nora prides.
- **Nehimba**, collared male **Vusi**, NEHcM1. This male has been with the Big Tom's pride of females in the Robins area since late 2016. He is 13 years and 4 months old now.

1.1.3 Captures and collaring of lion carried out:

- 01.12.17 Nehimba, Vusi, NEHcM1, AWT SAT collar changed at Big Toms pan in Robins area.
- 26.04.18 Balla Balla, Yin, BALfF3 conflict cat collared with AWT SAT on Dete Vlei.

Jane Hunt collaring Balla Balla, Yin, BALfF3 fitted with satellite collar on 26.04.18.

- 21.05.18 Back Pans, Tengwane, BACfF1, AWT SAT failed collar replaced at Ngamo, conflict cat. fitted with a Satellite collar.
- 14.11.18 Nora, Humba, NORcM1, AWT SAT failed collar replaced with AWT TAG collar at Kennedy 2 area.
- 29.11.18 Chizarira, CHZM1, darted to remove copper wire neck snare. At same time AWT SAT collar belonging to ALERT from Chizarira was loosened by one notch.

Removing snare and loosening collar on the Chizarira male CHZM1 at Livinge on 29.11.18.

We had also hoped to get collars onto potential dispersal males and potential conflict cats as a priority, but to date have been under instruction from ZPWMA Head Office not to collar any

new male lions. Dispersal and potential conflict cats that should be collared in order to facilitate monitoring and their ages at December 2018 listed below:

- Balla Balla, BALlM1, 3 years, already involved in conflict.
- Somodada, SOAfM1, 3 years 2 months.
- Caterpillar, CATeM1, 3 years 6 months.
- Mak Spice/Cecil's cubs, SPIkM1 or kM2, 4 years 1 month.
- Back pans, BACjM1, jM2 or jM3, 2 years 10 months.
- Guvalala, GUVlM1, 2 years 4 months. In conflict area outside of park.
- Back pans, 5 x l cohort males, nearly 2 years so due by end of next year.
- Guvalala, 'm' cohort males, 2 years 2 months old.

1.1.4: Hwange Ecosystem Camera Trap Surveys 2018

Park management requires accurate estimates of wildlife populations and population trends in order to make appropriate management decisions. Several methods are available ranging from aerial surveys (best for large easily observable species such as elephant and hippo) and sighted line transects (best for large diurnal species). Methods such as camera trapping and spoor surveys provide good estimates of carnivores and smaller less easily observed nocturnal mammal species. These methods are repeatable over time and can provide robust estimates of population trends. Both lion and leopard are species for which more information is required and surveys are recommended actions in the 'Conservation Strategy and Action Plan for the Lion in Zimbabwe and the 'Preliminary Non-detriment finding assessment for leopards in Zimbabwe' respectively for these species. The population sizes, distribution and co-occurrence with other carnivores and mammalian species is critical for long term management.

This year's camera trap Survey team comprised of, Justin Seymour Smith, Andrea Sibanda, Andrew Wilkinson and Dr Rob Rees. A pre-planned grid of camera traps was set up as per the layout in the accompanying maps. The traps were approximately 4-5kms apart as this appears optimal for effective detection of large and medium sized carnivores and allows comparison with other surveys undertaken by the team.

In collaboration with Conservation Wildlife Fund a population survey of the north-eastern portions of HNP and the adjacent Forest areas was undertaken in early 2018 (Figure 1.1). The areas surveyed comprised two surveys within the Forest areas (Ngamo and Sikumi) to the North of the railway line (boundary of Hwange National Park) and two to the South, within the park. Surveys located on either side of the park boundary provide an opportunity to directly compare differences in management and land-use within the same ecosystem.

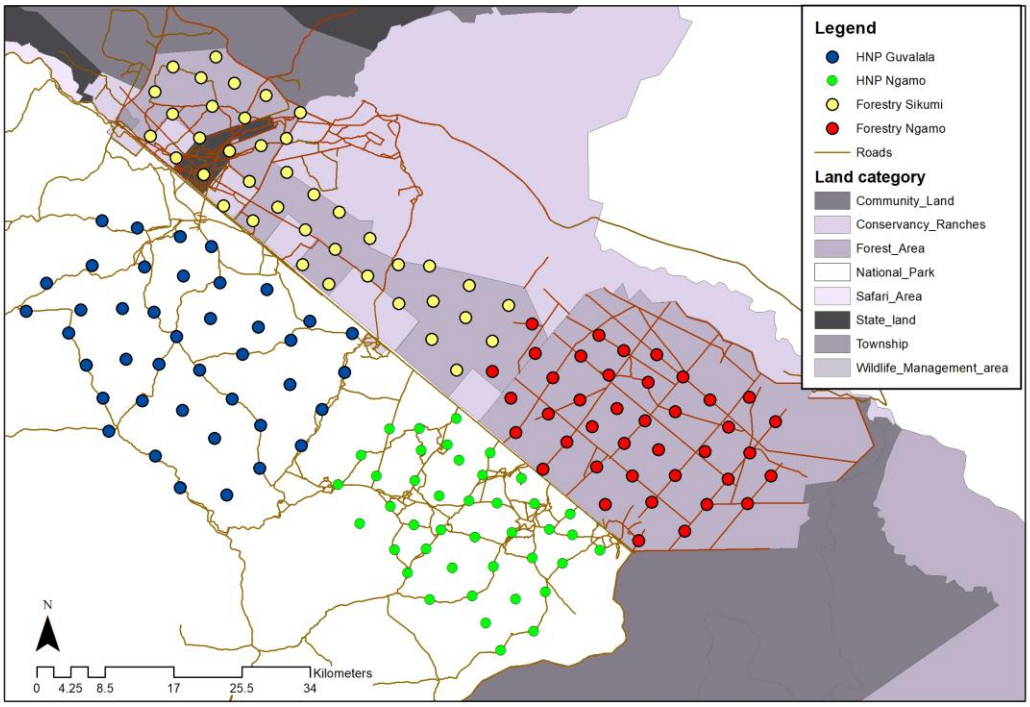


Figure 1.1: Map showing the location of the four camera trap surveys. The Ngamo Forest survey (camera stations = red circles) was within an area predominantly used for trophy hunting. The western side of the Sikumi Forest survey (yellow circles) was within an area zoned for photographic tourism, while the eastern side of the area was used for trophy hunting. Both lions and leopards were on hunting quotas in these areas. The HNP Ngamo survey (green circles) covered the eastern most part of Hwange National Park and the HNP Guvalala survey (blue circles) the area around Hwange Main Camp. Both areas are fully protected and used for photographic tourism.

A permit was issued by the Forestry Commission for this survey to take place in Sikumi and Ngamo Forests (ref number: FHO/E/60/0040), however, after set-up had been completed, permission was withdrawn at the insistence of trophy hunting operators using the area and the surveys had to be dismantled after 17 and 14 days respectively. Therefore, the usual survey period of ≥ 40 days was not completed. However sufficient detections of identifiable species did allow population estimates of large carnivores to be calculated using spatially explicit

mark recapture (SEMR) methods (SPACECAP software results presented here). The Ngamo Forest survey ran from 25/3/18 to 10/4/18 and consisted of 44 traps stations, deployed for a mean of 14 days (maximum 17). Sikumi Forest survey ran from 21/3/18 – 10/4/18 consisting of 43 trap stations were deployed for a mean of 17 days (maximum 22).

Survey sites within HNP, HNP Ngamo and HNP Guvalala repeated two surveys previously undertaken in 2014 and 2015 respectively using the same camera trap stations for comparability between surveys. HNP Ngamo ran from 16/5/18 to 17/7/18 with 41 camera stations deployed for a mean of 51 days (max. 61). HNP Guvalala ran from 8/5/18 to 11/7/18, with 44 camera trap stations deployed for 53 days (max. 64). Detections of leopards have been analysed using SEMR to estimate population density, data from the other large carnivores is currently being analysed.

Lions

In the Ngamo Forest survey, 10 lions were detected on 16 occasions with population estimates from SEMR analysis of 2.5/100km^2 (CI= 1.0 to 4.6). The wide confidence intervals are indicative of the small number of recaptures during this survey due to limitations imposed on the survey period. Estimates could have been significantly improved had the survey been completed as planned. It is notable that most lions were captured close to the national park boundary, particularly in the vicinity of the Ngamo flats area of HNP (figure 1.2). All lions detected were known individuals from study prides monitored in the national park (Table 1.1). No new lions, unknown to HLR and potentially resident solely within the forest area were found.

Collared study lion BACfF1, on camera trap in Ngamo Forest survey

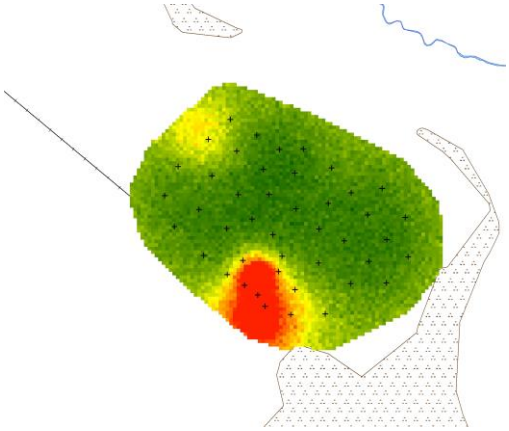


Figure 1.2. Lion density map derived from camera trap surveys in Ngamo Forest. It is notable that most lion detections in this survey are in the South of the survey area, directly adjacent to the HNP boundary. No lions were detected in the North and East of the area. Crosses show camera positions. Red indicates predicted higher density areas, green low.

In Sikumi Forest, 10 lions were detected on 38 separate occasions, with most captures occurring in the protected photographic region of the forest area (Figure 1.3). As in Ngamo, all lions detected were known study animals (Table 1.2), most of which are known residents of the Ganda area of Sikumi Forest and surrounds or, in the case of the adult males, had home ranges spanning the northern parts of Hwange National Park, parts of the Gwaai ICA and Sikumi Forest. Lion density for this survey was estimated at 0.8 lions / 100km^2 (CI = 0.5 - 1.3).

LION PRIDE	LION ID OR NAME	AGE/SEX	COLLARED
Back pans	BACfF1, Tengwani	AF	Yes
Back pans	BACdF2	AF	
Back pans	BACaF2	AF	
Somadada	SOAfM1	SAM	
Somadada	SOAfM2	SAM	
Back pans	BACdF3, Nandi	AF	
Back pans	BACfF2, Nomvelo	AF	
Back pans	BACfF3	AF	
Back pans	BAChF2	AF	
Back pans	BAChM3, Ngqwele	AM	Yes

Table 1.1: Identification of lions detected in the Ngamo Forest survey between 25/3/18 and 10/4/18.

The 2018 camera trap data have not yet been analysed for the lion population in HNP Guvalala and Ngamo surveys, however comparisons with surveys at these sites in 2015 and 2014 respectively suggest that lion densities are 1.8 times higher in HNP Guvalala compared to the adjacent Sikumi Forest and 1.6 times higher in HNP Ngamo than Ngamo Forest (Figure 1.4).

Figure 1.3. Lion density map derived from camera trap surveys in Sikumi Forest. It is notable that most lion detections in this survey are in the Nouth of the survey area, within the photographic zone of the Forest area. No lions were detected in the Sorth or East of the area. Crosses show camera positions. Red indicates predicted higher density areas, green low.

LION PRIDE	LION ID OR NAME	AGE/SEX	COLLARED
Balla Balla	BALfF3, Yin	AF	
Balla Balla	BALlM1, Yin's son	SAM	
Nehimba	NEHeM1, Seduli	AM	yes
Nehimba	NEHeM4, Mopane	AM	
Guvalala, Buster's Sisters	GUVlF1	juvF	
Guvalala, Buster's Sisters	GUVgF3	AF	
Guvalala, Buster's Sisters	GUVlF2	juvF	
Guvalala, Buster's Sisters	GUVlF3	juvF	
Guvalala, Buster's Sisters	GUVgF4	AF	yes
Guvalala, Buster's Sisters	GUVlM1	juvM	

Table 1.2: Lions identified from camera trap survey detections in Sikumi Forest between 21/3/18 and 10/4/18.

A general comparison between surveys on either side of the HNP boundary suggests that sites within the Ngamo and Sikumi Forest have lower densities of lion than corresponding sites within the National park. Causes of lower population density are likely to be lower prey density, larger edge effects from illegal poaching in the surrounding areas (Tsholotsho Communal Land and Gwaai Farms) and forest periphery and potentially also disturbance of pride structures from trophy hunting. It is unclear from the current results which threats are most important.

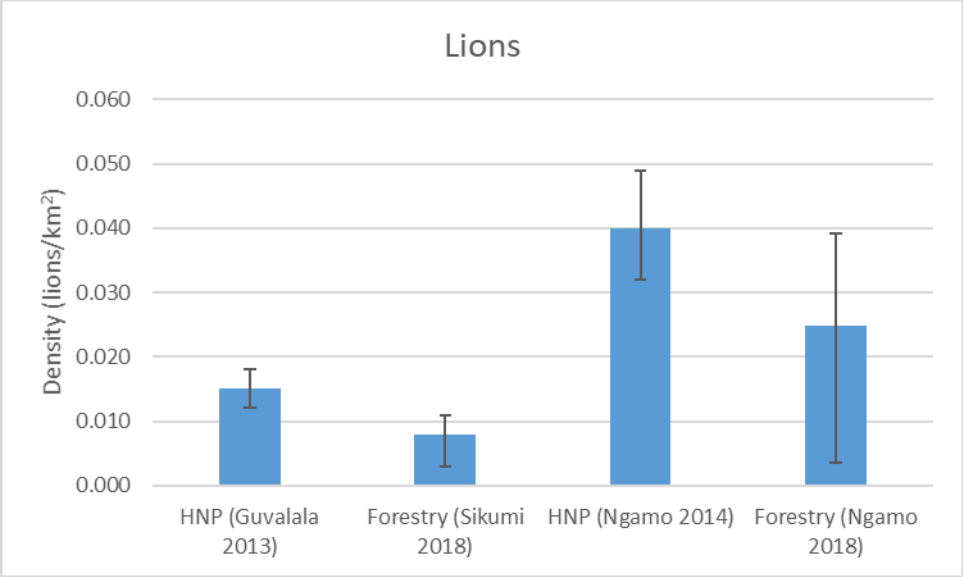


Figure 1.4. Graph comparing lion population density at survey areas in the North and East of the Hwange ecosystem. Lower population densities were found in the forestry areas compared to corresponding sites within the national park surveyed in 2014 and 2015. Error bars represent 95% confidence intervals.

Within the Ngamo Forest site it appears that there are no lions entirely resident within Ngamo Forest, with lions detected in the survey resident in both HNP and Ngamo Forest and mostly located directly adjacent to the park boundary (Figure 1.5). These lions all belong to long-term study prides (Backpans and Somadada) and are all individually recognisable from project records.

Lions detected in the Sikumi survey belonged to three long term study prides, Ballaballa, Nehimba and a split of the Guvalala pride known as 'Buster's sisters', along with two pride males, Seduli and Mopane. The female prides are likely resident outside the national park within the zoned photographic tourism to the West of Sikumi Forest and the adjacent Dete Vlei area (Figure 1.5).

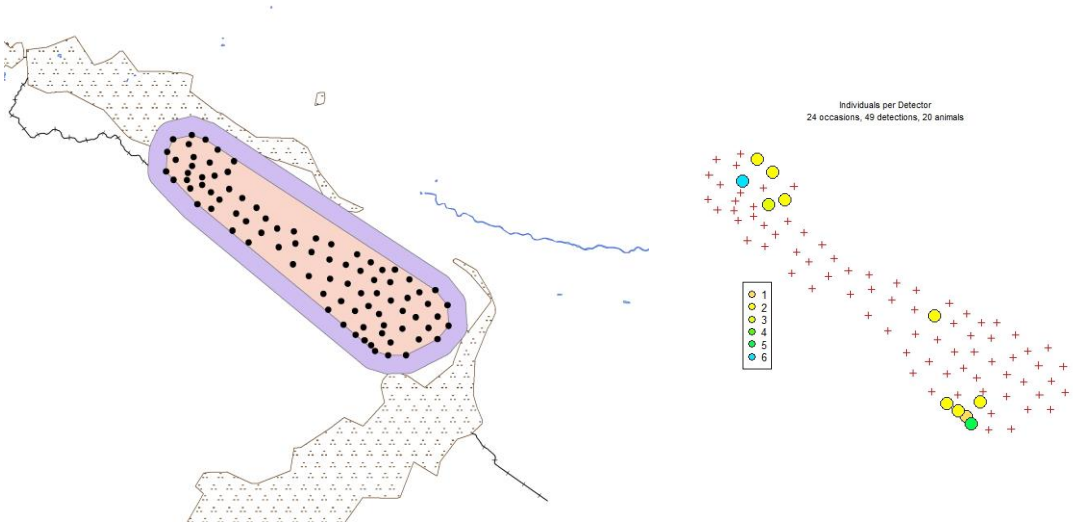


Figure 1.5. Left: position of camera traps in Sikumi and Ngamo Forests (black circles) and the survey buffer used in analysis. Right: number of detections of individual lions at each camera trap location (crosses), showing the clumped distribution of lions adjacent to the national park boundary and in the photographic zone of Sikumi Forest.

Leopards

Nine individual leopards (3 male, 6 female) were detected on 18 occasions in Ngamo Forest and 7 leopards (4 male, 3 female) were detected in Sikumi Forest. Due to the limited number of individuals detected leopard density was analysed across both surveys with estimates of 1.2/ 100km^2 (CI = 0.7-1.7, Figure 1.6). Higher densities were calculated for the national park surveys, with 26 leopards (10 male, 16 female) detected on 47 occasions in the HNP Guvalala survey and 27 leopards (7 male, 20 female) on 75 occasions in HNP Ngamo survey with densities of 3.0/ 100km^2 (CI= 1.9-4.0) and 4.5/ 100km^2 (CI= 3.0- 6.0) calculated respectively for these sites. The leopard density outside the park was therefore less than half that estimated in adjacent sites within HNP. Densities across sites are compared in Figure 1.7

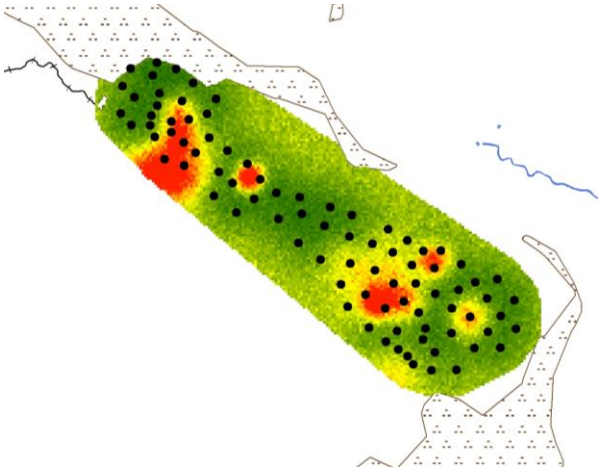


Figure 1.6. Leopard density map derived from camera trap surveys in Ngamo and Sikumi Forest. Red indicates predicted higher density areas, green low.

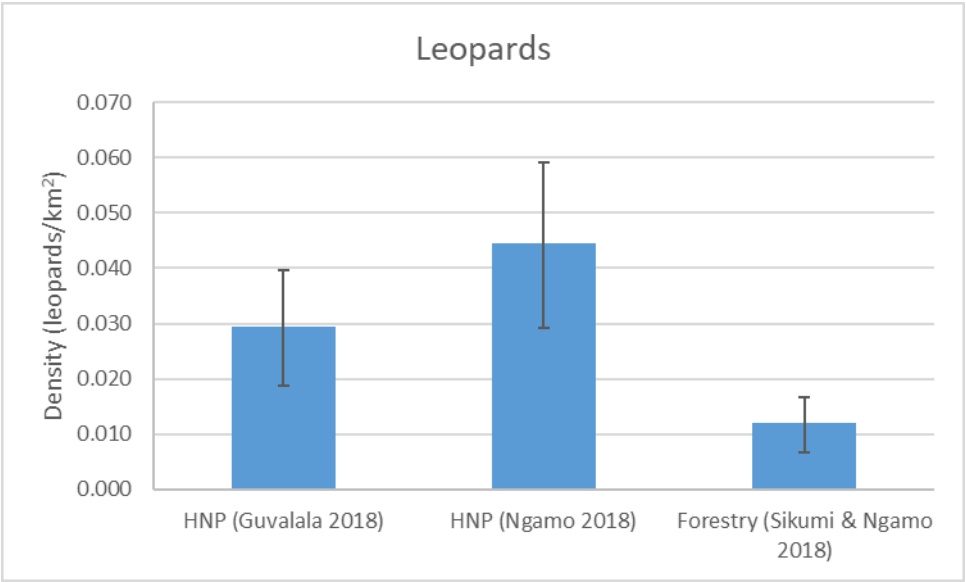
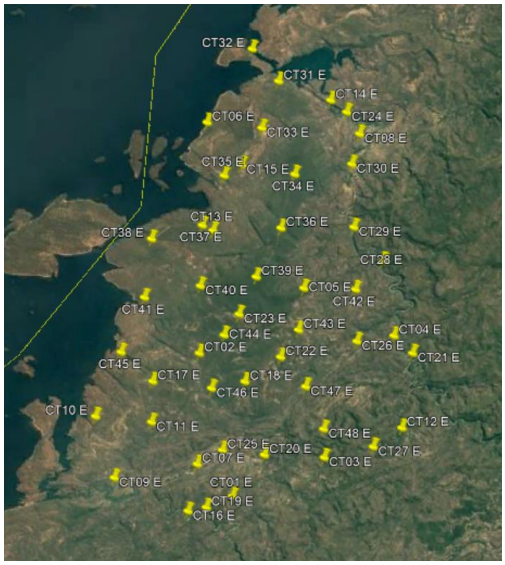


Figure 1.7: Graph comparing estimated densities of leopards across survey areas. Lower population densities were found in the forestry areas. Error bars represent 95% confidence intervals.

Leopard on camera in Ngamo Forest

Chete Safari Area camera trap survey

A camera trap survey was undertaken in Chete Safari Area between August and October 2018. A total of 48 camera stations were deployed in the western part of the safari area (Figure 1.8). The eastern side of the area was largely inaccessible at the time of the survey, with poor roads. The survey team found limited evidence of lions in the area, with only one visual record of a young male. Due to ongoing fieldwork at the end of 2018 the data from this survey have not yet been assessed and will be analysed in early 2019.



Figurex8: Google earth image of the camera trap layout in Chete Safari Area

1.2 Monitoring demographic processes

An understanding of demographic processes (births, deaths, immigration and emigration) is critical to understanding the long term viability of populations. Careful monitoring of prides allows the project to monitor birth and survival of cubs in study prides. The project is one of the only lion projects to specifically investigate emigration (dispersal) of young lions which gives a unique picture of this population's demographic profile. An important determinant of population viability are levels and sources of mortality. In naturally regulated populations lions die of old age, disease and of natural causes such as fights with other lions and accidents when hunting dangerous prey species. However many lion populations are also subjected to sources of mortality that are caused by humans (e.g. conflict/ PAC, trophy hunting, snaring). To a large extent, this mortality does not replace natural forms of mortality and thus occurs in addition to mortality that the population would anyway experience. If human caused (anthropogenic) mortality is high population persistence and viability can be impacted. This is why it is critical to monitor this.

During the period of January and December 2018, we recorded 5 lion mortalities this year. Cause of mortalities 2 x trophy hunted,1 x PAC in Zambia after translocation, 1 x hit by train, 1 x poached.

- 13.02.18 – BALiF3, known as a conflict cat in Lupote, Cross Mabale area, where she had been killing livestock. She was caught on 26.06.17 by Paul de Montille and

translocated and kept at Umtshibi and then moved to Kazuma and released there several months later. She crossed the Zambesi River into Zambia in the area between Kazangula and Livingstone and was eventually killed as a problem animal there, as she continued to kill livestock. She had 3 cubs at this time and they were taken into captivity in Zambia.

- 02.06.18 – NYMfM2, Kakori. Trophy hunted in Sikumi Forest on quota. Near Antoinette and NP boundary. 11.1 years old.
- 25.06.18 – SOAfM2. Bowhunted on Farm 35 in the Gwaai ICA, on the NP boundary with The Hide concession. This was a young male still with his natal pride, the Somodadas. He was 2.5 years old.

Somadada SOAfM2 bow hunted in the Gwaai ICA, 2.5 yrs old.

- 21.09.18 – BACaF1, Stumpy Tail of the Back Pans pride. Hit and killed by the train near Ingwe siding at 4 am in the morning. 11.8 years old. (Another sub adult member of this pride was reported hit by the train near Mukwa siding on 07.10.18, whilst they fed on an elephant calf that had been killed earlier by the train. The train driver said the lion had run off after being hit and we found no evidence of mortality)
- 12.11.18 – to date unidentified individual. Police reported to us that a poacher was caught from the Mambanje/Magoli area in possession of a lion skin. This is still being followed up.

2. Transboundary and landscape conservation of lions

2.1 The African lion landscape connectivity

A landscape connectivity workshop was held by WildCRU and ZPWMA at Victoria Falls Safari Lodge on the 18 and 19th of October. It was attended by around 40 delegates from the conservation and tourism sector and including PWMA ecologists and area managers from region and executives from the local rural district councils.

Background

Across Africa, growing human and livestock populations are driving an increased demand for resources and conversion of land uses from those favouring native wildlife to those maximizing economic value. Resulting fragmentation of natural habitat can threaten the long-term viability of increasingly isolated wildlife populations, intensifying vulnerability to local extinctions and inbreeding depression. Simultaneously, increasing levels of human-wildlife conflict see rural communities suffering from livestock and crop losses with retaliatory killing of conflict species contributing significantly to isolation of wildlife populations and population declines. A landscape of interconnected protected areas is an important requirement for healthy and viable wildlife populations and ecosystems. Viable wildlife areas are critical for tourism, one of the main contributors to GDP in many African countries. Management policies thatfacilitate the natural movement of individuals between isolated populations have the potential to increase effective population size and reduce human-wildlife conflict risks.

As an important key stone species, African lions are a significant economic asset as they are a major tourism attraction. However, they also come into conflict with humans in neighbouring agro-pastoral areas. Due to their wide ranging movement and dispersal behaviour, the ecological requirements of African lions and the prerequisites for their co-existence with humans can be used to inform land use management decision making at a landscape level. Such management facilitates vital wildlife movements and uplift human communities by promoting human-wildlife co-existence.

Map of Kavango-Zambezi Transfrontier Conservation Area with protected areas (green) and national boundaries of partner countries (© Peace Parks Foundation)

2.2 Prioritizing conservation efforts in a rapidly changing landscape

Computerised connectivity models allow the conceptualisation of long-term process over large spatial scales and test possible land use scenarios to inform future land use management decisions. These biological models, based on biological and behavioural data and integrating environmental and human development data, allow decision makers to take animal behaviour into account and avoid ad hoc assignments of corridors based on subjective preconceptions of what is important. WildCRU, in partnership with the Botswana Department of Wildlife and National Parks, the Zimbabwe Wildlife Management Authority has made use the cutting edge science to predictively model patterns of landscape connectivity for lions in the Kavango-Zambezi (KAZA) landscape (see Figure 2.1, Cushman et al. 2018). The model prioritises core connected habitats and critical movement pathways between them against empirical criteria.

Based on the model's outputs the following key recommendations can be made to maximise connected habitat for this species in KAZA. It should be noted that these are biological priorities that should be considered for incorporation into conservation management policies.

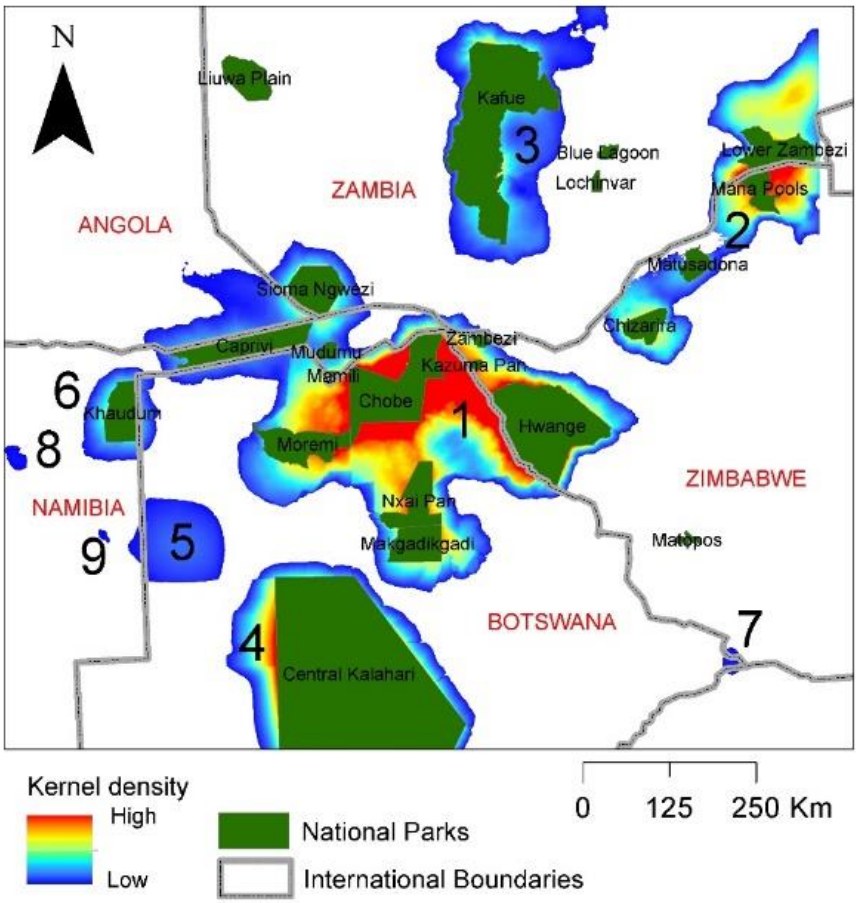


Figure 2.1*: Ranked core connected habitat outside protected areas. Highest priority areas are given a ranking of 1.*

- The highest priority is to continue to manage and protect nationally designated protected areas (PAs). Outside PAs, the 'core areas of connected habitat' are critical for long term conservation of lions. Prioritisation based on the size and strength of the core connected areas, outside national protected areas, is indicated by numbers set in Figure 1. The Okavango-Hwange system, incorporating the Okavango Delta, Chobe, Hwange and Zambezi National Parks and adjoining wildlife management, forest and safari areas is the highest biological priority, followed by the Sebungwe- Zambezi Valley region and the Central Kalahari.
- 'Movement corridors' between core habitats allow population and genetic exchange between core areas and efforts to maintain these connectivity linkages should be

encouraged to enhance connectivity. Biological prioritisations are given in Figure 2.2A. The most important and third ranked corridors link the 'Okavango-Hwange' core area with the Central Kalahari. The second most important corridor links Hwange with the Sebungwe system to the North-East.

- The model identifies and predicts potential conflict hotspots as areas where high probabilities of movement fall directly adjacent to areas of high landscape resistance (indicating high human population, development and infrastructure). These are prioritised according to the intensity of potential conflict (Figure 2.2B).
- To aid uptake of the model's outputs in land use management and decision making by regional and local policy makers a google Earth / GIS visualisation tool was provided to workshop participants.

(A) (B)

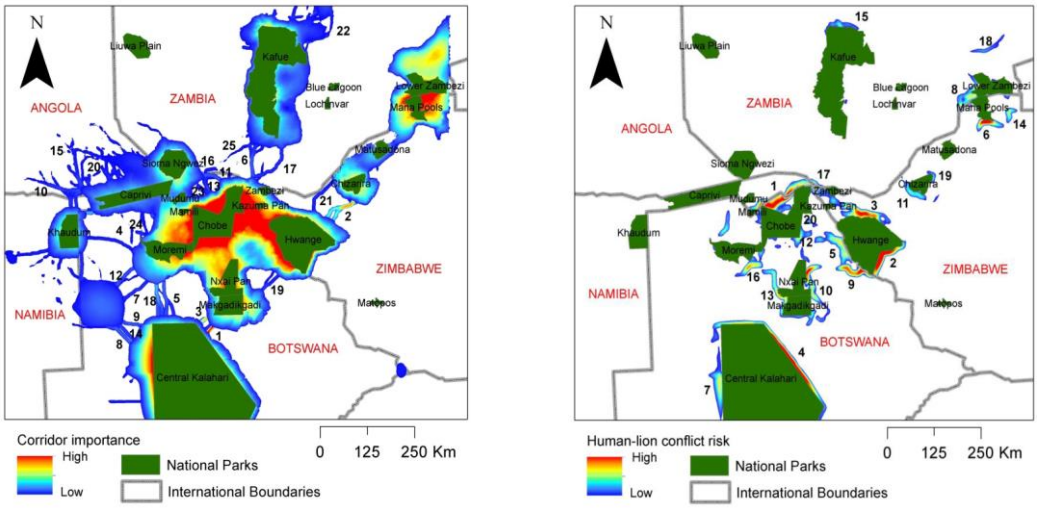


Figure 2.2. *Output predictions of the KAZA lion landscape connectivity model. Left: 2A, Linkages and corridors between lion core areas outside national parks/game reserves (green) in and adjacent to the KAZA TFCA ranked by their relative strength and vulnerability, with the highest priority corridor given a ranking of 1. Right: 2B, Human-lion conflict risk in and adjacent to the KAZA TFCA ranked by their relative intensity with the highest risk area given a ranking of 1.*

2.3 Connectivity workshop outputs

The purpose of the workshop was to present the model to stakeholders and colleagues and thereafter identify areas where the model and broader landscape connectivity and genetics

methods could be used to address practical conservation needs in the region. The following outputs and action points were identified.

Immediate priorities for further work:

1) Improve the model by including more data. This is currently being undertaken by WildCRU student Genevieve Finerty in collaboration with other stakeholders. This will result in a new more detailed resistance surface and greater confidence in the model's predictions.
2) Further validate the model using camera trap, spoor and genetic data. This work is ongoing and implemented by WildCRU along with wider collaborators.
3) Use the existing model to test conservation management scenarios. The following uses for the model in informing management policy were suggested by workshop participants:
    i) Integrate the model with KAZA TFCA Master Integrated Development Plan (Master IDP), particularly with reference to the dispersal areas defined under this plan.
    ii) Workshop participants highlighted the need to understand landscape connectivity in the context of multi-species landscape use. The current landscape connectivity modelling methods could be used to generate a generalised multi-species understanding to facilitate more effective policy making.
    iii) The Sebungwe region between the Hwange-Matetsi complex and the Zambezi Valley was highlighted as a critical part of landscape connectivity in the region. The loss of this connectivity would isolate the Okavango-Hwange system from the Zambezi Valley system, severely fragmenting natural habitats. Threats such as dam building (Gwaai/Shangani and Batoka), urban development, roads, coal mining (Liberation and Sunlight mines) and agricultural expansion could be modelled to provide policy makers with insights.
    iv) Similarly, development in the Caprivi and Kwando areas could threaten habitat connectivity, including roads (Caprivi-Zambezi highway from Kongola-Katima, Linyanti Road), extraction of water, agricultural development and increased livestock density.

Capacity Building:

Professor Macdonald offered to host colleagues from ZPWMA at Tubney House in Oxford in early 2019 to work with the WildCRU Landscape Ecology team to facilitate actions on incorporating national priorities into the modelling framework and to acquire skills and training in this arena.

It was noted that further capacity building and relevant training was available through the WildCRU Diploma in International Wildlife Conservation Practice at the Recanati Kaplan centre. Suitable candidates from Zimbabwe are encouraged to apply. The course is fully funded in circumstances of need (see www.wildcru.org/courses/diploma/).

3. Human Predator conflict around HNP

Livestock predation by large carnivores is a significant problem in certain hotspot areas in Africa. In many cases, villages are situated inside or in close proximity to wildlife areas with no surrounding buffer zone, which can lead to intense human-wildlife conflict due to the predation of livestock by carnivores such as lions, leopards and hyenas. To many local communities, livestock represents the main source of wealth and livestock losses due to predators routinely result in retaliatory killing of globally threatened predators which are critical components of biodiversity. This can cause population declines and measureable impact to biodiversity and ecosystem function in protected areas. Aside from intrinsic value to natural systems, large predators are economically valuable and attract significant revenue to host countries through tourism, which is frequently the largest and most viable local revenue generator.

This component of the lion project aims to provide practical conservation outcomes to address issues of human- lion conflict around Hwange National Park. Our approach is to gain a thorough understanding of the drivers of conflict and work with the community to try to limit conflict incidents. Conflict between carnivores and human communities poses a serious threat to the persistence of carnivores in the wild, as well as impacting the lives and livelihoods of impoverished people living in the vicinity of protected areas. The Hwange Lion Project has, over the last five years, gained a solid understanding of the magnitude and

importance of conflict. Data collected systematically since 2008 suggests that livestock losses to predators largely occurs when domestic animals are left grazing unattended at night (instead of protecting animals in protective enclosures during the night when predators are most active). Indeed 80% of depredation events occur when animals are outside protective bomas and 60% occur when animals are left outside bomas during the night (Loveridge et al. in review). Keeping animals in bomas at night and supervising them when grazing during the day greatly reduces the chances of depredation by large predators. Additionally, using grazing areas in or close to wildlife habitat increases the chances of encountering predators. This is particularly problematic on the boundary of HNP/ Tsholotsho communal land during the wet season (Kuiper et al. 2015) and in the Sikumi Forest to the North of HNP (Loveridge et al. in review).

3.1 The Long Shields Lion Guardian Programme

The practical interventions that we are implementing and testing are part of the 'Long shields Lion Guardian Programme that employs local men and women to provide an interface between conservation and the community.

The scheme has been modelled on the successful Living with Lions, lion guardian project in Kenya. Here young Maasai men (lion guardians) are recruited and trained to mitigate conflicts between carnivores and people- by both actively protecting the carnivores, but also working indirectly to reduce the conflict by advising and assisting the local community on livestock protection and by warning herders when lions are in the vicinity.

Around Hwange we have two particular foci in this project. Firstly we have initiated an early warning system, where lions are fitted with GPS satellite collars to allow us to monitor the cats when they leave the National Park and this in turn allows us to warn the local community via the lion guardians. Our second focus has been to introduce a novel 'mobile boma' project to try to encourage people to herd their livestock more effectively. The Longshields Lion guardian programme consists of nine men and women working in two main areas. In the Mabale area (North of HNP and adjacent to Sikumi Forest Area) we have recruited three men and one woman and in Tsholotsho (East of HNP) we have four men and one woman. The programme is managed by Lovemore Sibanda and Liomba Mathe.

To implement an early warning system to alert livestock herders to the presence of lions and thereby limit lion-livestock interactions it is crucial that a network of people in the

community is set up. Each lion guardian is a 'hub' for information within their respective community as well as providing an on the ground interface between the local people and the Hwange Lion Project team. The programme works closely with local traditional leaders (Chief Nelukoba-Dingani and Chief Mlevu) and their advisors and with the Rural District Councils (local government). Lion Guardians collect information on how well livestock are protected in their village area, they record wildlife seen and collect reports on any conflict incidents, as well as providing help, training and advice on livestock protection to local people. Each lion guardian is equipped with a mobile phone and is able to report problems to the research team and receive information about any lions in the area. Each guardian is supplied with a mountain bike to patrol his or her area of responsibility.

The long shields are the first port of call for their communities in the event of any predator-cattle conflict. The project currently employs 8 men and 2 women in the Hwange (n=5) and Tsholotsho (n=5) communal lands who provide an interphase between conservation and the communities. Equipped with a vuvuzela, GPS and 3G smart phone, the long shields form a 'hub' between research and communities through an early warning system that alerts herders to the presence of collared lions along community and protected area boundaries thereby limiting lion-cattle interactions which normally result in losses of livestock and/or lions through retaliation.

Lion guardian duties also include:

- Spoor counts: Recording spoor of key carnivore species and their prey on a 5 km route each month.
- Conflict data and mitigation: Collecting incident reports (Table 3.1, 3.2, 3.3) and actively reducing conflict through the use of methods such as noise makers to chase away lions, warning communities of lions in the vicinity through messages, assisting farmers to recover lost livestock and reinforcing/improving weak bomas (Table 3.4).
- Kraal (boma) assessment: Scoring kraal vulnerability to lion attacks based on visibility, height and strength of timber used to build the structure.
- Herd sighting data: Monitoring livestock herds in the field and record whether people guard their livestock and which measures are taken to protect livestock during herding times. We hope to use this information to analyse the effectives of interventions.

Since the beginning of this year the lion guardians have been operating in Hwange and Tsholotsho communities directly adjacent to Sikumi & Ngamo Forestry Area (SFA/NFA) and Hwange National Park (HNP). During this time, we have recorded a total of 196 warning alerts between sent and received incidents.

Table 3.1. Total livestock losses to predators between January & December 2018

Species	Mabale	Tsholotsho	Totals
Goats	54	12	66
Cattle	63	31	94
Donkeys	17	22	39
Sheep	9	0	9
Dog	0	0	0

**Total conflict incidents recorded = 164 (Mabale=108 and Tsholotsho=56)*

Table 3.2. Livestock losses at MABALE COMMUNAL LANDS between January & December 2018

	Day	Night	Inside boma	Outside boma
Goats	24	30	8	46
Donkey	0	17	6	11
Sheep	0	9	2	7
Cattle	34	29	2	61

Table 3.3. Livestock losses at TSHOLOTSHO COMMUNAL LANDS between January & December 2018

	Day	Night	Inside boma	Outside boma
Goats	4	8	0	12
Donkey	0	22	0	22
Cattle	7	24	0	31

Table 3.4. A summary on lion guardian intervention to reduce livestock depredation around HNP: NOTE that the figures are between January & December 2018

Measurement of success	Mabale	Tsholotsho	Total
Early Warning System*	150	46	196
Kraal reinforcements	9	0	9
Livestock recovered***	170	0	170
Lion chases**	3	1	4

This is a combination of warning alerts recorded between sent or received conflict incident related events both in the Mabale and Tsholotsho areas.* ***We refer to successful chases where lion/s is chased away from the communities using the 'vuvuzela system'. ****Of the 170-livestock recovered from the bush, **only 4 where found killed by predators**.*

3.2 Mobile Boma Concept: A lion-friendly agro pastoral model

Mobile Bomas

Left: Traditional static boma made of natural materials, usually heavy poles; Right: Mobile boma of UV resistant PVC sheeting, set-up in a fallow field

The housing of livestock in bomas overnight is a critical factor that is highly effective in reducing lion predation. Our recent innovation replaces traditional bomas with boma 'walls' made from opaque white plastic sheeting (PVC) which is supported by poles and strung on ropes or cables like a curtain. This exploits a technique used in the live capture of game animals – the fact that many wild species are intimidated by the ruse of a flimsy opaque

barrier – and being naive to it, therefore will not challenge it. And so far no lion has yet breached these bomas around Hwange and Tsholotsho to kill cattle. An added bonus is both the reduced environmental cost of cutting the indigenous timber for traditional bomas and another innovation – the siting of these bomas on fallow crop fields where livestock collected together from a number of households can deposit soil-nourishing manure and trample it into the soil. Moving these bomas around to different peoples' crop fields gives each a turn to be naturally fertilized.

The project currently monitors 11 mobile bomas in communities bordering the SFA and HNP (Figure 3.1, Table 3.5). About 94 families are supported with a total herd of 971 cattle.

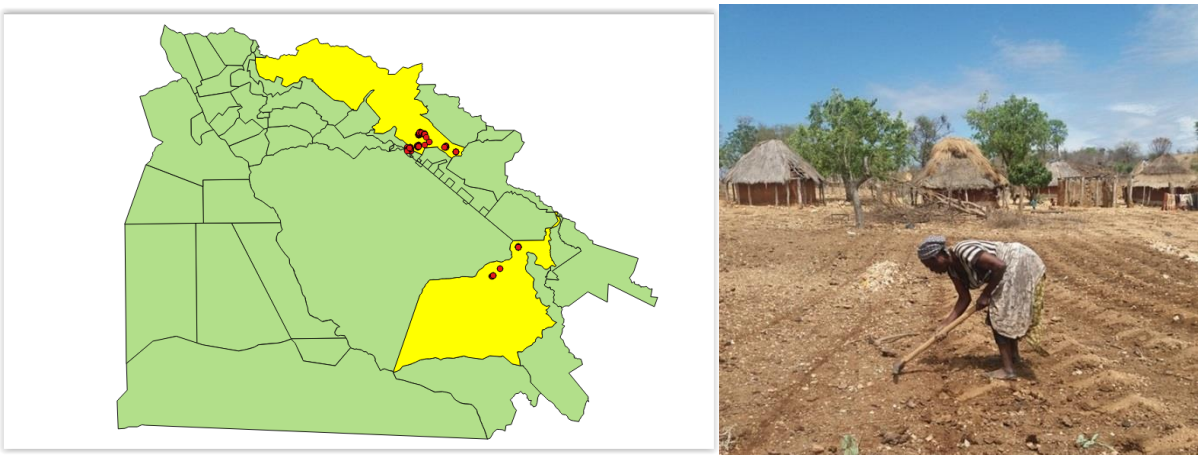


Fig 3.1. Spatially monitored mobile bomas in Mabale and Tsholotsho communal lands

Mabale bomas

Most bomas are in the Hwange District which has seen the greatest demand from neighbouring communities. About 87% of livestock killed in Mabale occur in traditional kraals at night according to Loveridge *et al* 2017. This is because the Mabale area is devoid of hard wood and timber to build strong predator proof kraals. With the lack of adequate grazing for livestock in communal lands, there is heavy dependence of protected area grazing by communal livestock which increases the risk of encounter with predators in the wild. Recently we have seen a high demand for mobile bomas with requests from communities further afield areas such as Chimwara, Mazwa, Greater Mabale, Dopota, Lupote, and Jotsholo. The housing of livestock is therefore profound in these areas. The mobile bomas have however succumbed to severe heating in the sun and are now more than 4 years old. Replacement sheets have been taken from Tsholotsho un-used bomas.

Table 3.5. Currently monitored mobile bomas between June to December 2018

No	Village	District	No. families	Herd size
1	Chiguswi	Hwange	13	97
2	Chamabanda	Hwange	10	51
3	Mansuma	Hwange	12	128
4	Chezhou	Hwange	5	82
5	Mambanje 1	Hwange	10	101
6	Mambanje 2	Hwange	13	89
7	Mambanje 3	Hwange	9	76
8	Masikili	Hwange	3	10
9	Janiza	Tsholotsho	3	65
10	Mansuma 2	Hwange	7	98
11	Machonisa	Hwange	9	97
	TOTAL		**94**	**894**

*Also note that **77 herds** also monitored as part of the control herd are not included here. This brings the total number of livestock in the study to **971 cattle**.*

Tsholotsho bomas

On the eastern boundaries of Hwange National Park lie Tsholotsho communal lands with abundant grazing areas and large wood timber forests. Traditional kraals are therefore much strongly built with a low visibility score of 37.3% and high mean height of 102cm compared to Mabale. We have seen increasing reluctance of agro pastoral farmers to make use of mobile bomas in Tsholotsho communities. We decided to move two bomas from this area to support bomas in Mabale which are crumbling in state.

Field fertilisation using mobile bomas and veterinary care

48 fields where treated in preparation for the 2018/19 season. 363 cattle have been vaccinated this year against botulism, anthrax and black-quarter to increase the levels of immunity and protection.

Site visits from interested stakeholders and donors

We had 5 visits ranging from local to International parties between June and December this year (*see below*):

07.06.18. Dick Houston (guest with African Bush Camps lodges) visited Mambanje bomas in Hwange

21.07.18. WildCRU Coordinator Jess Isden and Botswana Community Guardians visited Mambanje bomas during their training in Hwange

19.09.18. Collin and Clare (guests at The Hide Safaris) visited Chezhou bomas and the Lion Guardian Project in Hwange

02.11.18. Hwange Conservation Safari group with Paul Funston from PANTHERA visited our Mansuma boma 1 near Cross Dete.

23.11.18. The KAZA press trip included a group of German journalists, KAZA Secretariat, Zimbabwe Tourism Authority and Boundless Southern Africa delegates visited our project office and the Long Shields Lion Guardian and mobile boma projects.

4. Project training, workshops and meetings

This year Dr Moreangels Mbizah, a Zimbabwean student who had been working on the project since 2014 was awarded her Doctorate at the University of Oxford.

Zimbabwean, Lovemore Sibanda is currently working towards his Doctorate as a member of WildCRU, Oxford.

19.05.18. Liomba Mathe gave a talk on Lion Guardians and the Mobile Boma concept to a group of Safari Clients from Wilderness Safaris, Davison Camp, Zimbabwe

18.06.18. WildCRU-Botswana Coexistence Coordinator Jess Isden and Botswana Community Guardians where trained in Zimbabwe by the Lion Guardians

16.07.18. "*Women in Science*" documentary by National Geographic Explorers Gabby Salazah and Clare Feiseler featuring WildCRU's PhD Moreangel's work on lions and the Long Shields Lion Guardians in Zimbabwe. (https://news.nationalgeographic.com/2018/06/women-harassment-outnumbered-clare-feiseler-gabby-salazar-explorers-science/)

26.07.18. Liomba gave a talk on Lion Guardians and the Mobile Boma concept during the Conservation Wildlife Fund (CWF) meeting at Hwange National Park, Main Camp, Zimbabwe

23-25 Sept 2018. SMART software training for lion/community guardians was conducted at Hwange Farm 41 by Xia Stevens from PANTHERA

26.09.18. Lion/Community Guardian – Ranger Forum held at Hwange National Park, Main Camp, Zimbabwe

25.10.18. Annual General Workshop for lion & community guardians held at Victoria Falls Wildlife Trust and this time joined by the Binga lion guardian

02.11.18. Hwange Conservation Safari group with Paul Funston from PANTHERA visited our Mansuma boma 1 near Cross Dete

05.11.18. Community guardians training for Chobe and ALERT guardians held in Victoria Falls Wildlife Trust

22.11.18. Jane Hunt, Liomba Mathe and Lovemore Sibanda attended the KAZA Carnivore Conservation Coalition (KCCC) focal group meeting in Victoria Falls. Leo and Lovemore gave update talks on conflict mitigation and mobile bomas in Zimbabwe and Botswana.

23.11.18. The KAZA press trip included a group of German journalists, KAZA Secretariat, Zimbabwe Tourism Authority and Boundless Southern Africa delegates visited our project office and the Long Shields Lion Guardian and mobile boma projects.

5. 2017-2018 Publications

Published and in press

Arraut, E. M., A. J. Loveridge, S. Chamaillé-Jammes, H. Valls-Fox and D. W. Macdonald (In Press). 2013-14 vegetation structure map of Hwange National Park, Zimbabwe, produced with free satellite images and software. Koedoe.

Courbin, N., A. J. Loveridge, H. Fritz, D. W. Macdonald, R. Patin, M. Valiex and S. Chamaillé-Jammes (In Press). Zebra diel migrations reduce encounter risk with lions at night. Journal of Animal Ecology.

Cushman, S. A., N. Elliot, D. T. Bauer, K. M. Kesch, L. Bahaa-el-Dinn, H. Bothwell, M. Flyman, G. Mtare, D. W. Macdonald and A. J. Loveridge (2018). Prioritizing core areas, corridors and conflict hotspots for lion conservation in southern Africa. PLoS ONE **13**(7): e0196213.

Kushata, J., S. Periquet, T. Tarakini, M. Muzamba, B. Mafuwa, A. J. Loveridge, D. W. Macdonald, H. Fritz and M. Valeix (2017). Drivers of diurnal rest site selection by the spotted hyaena in Hwange National Park, Zimbabwe. Journal of Zoology.

Lindsey, P. A., J. R. B. Miller, L. Petracca, L. Coad, A. Dickman, K. Fitzgerald, M. Flyman, P. J. Funston, P. Henschel, S. Kasiki, K. Knight, A. J. Loveridge, D. W. Macdonald, R. Mandisodza, S. Nazerali, A. Plumptre, R. Stevens, H. VanZyl and L. Hunter (2018). The price of protection: More than $1 Billion needed annually to secure Africa's protected areas with lions. Proceedings of the National Academy of Sciences.

Lindsey, P. A., L. Petracca, P. J. Funston, H. Bauer, A. Dickman, K. Everatt, M. Flyman, P. Henschel, A. Hinks, S. Kasiki, A. Loveridge, D. W. Macdonald, R. Mandisodza, W. Mgoola, S. Miller, S. Nazerali, L. Siege, K. Uiseb and L. Hunter (2017). The performance of African protected areas for lions and their prey, determinants of success and key conservation threats. Biological Conservation **209**: 137-149.

Loveridge, A. J., T. Kuiper, R. Parry, L. Sibanda, B. Stapelkamp, J. E. Hunt, E. Makuwe, L. Sebele and D. W. Macdonald (2017). Bells, bomas and beefsteak. Complex patterns of human predator conflict at the protected area- agropastoral interface. PeerJ **5:e2898**.

Macdonald, D. W., A. J. Loveridge, A. Dickman, P. J. Johnson, K. Jacobsen and B. DuPreez (2017). Lions, trophy hunting and beyond. Known unknowns and why they matter. Mammal Review **47**(4): 247-253.

Miguel, E., V. Grosbois, H. Fritz, A. Caron, M. Garine-Wichatitsky, F. Nicod, A. J. Loveridge, B. Stapelkamp, D. W. Macdonald and V. Valeix (2017). Drivers of Foot and Mouth Disease in cattle at wild/domestic interface: insights from farmers, buffalo and lions. Diversity and Distributions **23**: 1018–1030.

Pooley, S., M. Barua, W. Beinart, A. Dickman, G. Holmes, J. Lorimer, A. J. Loveridge, D. W. Macdonald, G. Marvin, S. Redpath, C. Sillero-Zubiri, A. Zimmermann and E. J. Milner-Gulland (2017). An interdisciplinary review of current and future approaches to improving human-predator relations. Conservation Biology **31**(3): 513-523.

Valls-Fox, H., S. Chamaillé-Jammes, M. deGarine-Wichatitsky, A. Perrotton, N. Courbin, E. Miguel, C. Guerbois, A. Caron, A. J. Loveridge, B. Stapelkamp, M. Muzamba and H. Fritz (2018). Water and cattle herding shape habitat selection by wild herbivores at the edge of a protected area. Animal Conservation **doi:10.111/acv.12403**.

Vucetich, J., D. Burnham, J. D. Johnson, A. J. Loveridge, M. P. Nelson, J. T. Bruskotter and D. W. Macdonald (In Review). Some ethical considerations on trophy hunting and lion conservation. Biological Conservation.

Williams, V., A. J. Loveridge, D. Newton and D. W. Macdonald (2017). Pan-African Survey of the Trade in Lion Body Parts. PLoS ONE.

Williams, V., A. J. Loveridge, D. Newton and D. W. Macdonald (2017). A roaring trade? The legal trade in Panthera leo bones from Africa to East-Southeast Asia. PLoS ONE **PONE-D-17-09755R1**.

In Review

Bahaa-el-Dinn, L., S. A. Cushman, M. Flyman, Z. Kaszta, G. Finerty, N. Elliot, A. J. Loveridge, D. Keeping, K. M. Kesch, D. T. Bauer and D. W. Macdonald (In Review). Dezoning Botswana's Wildlife Management Areas compromises critical lion populations. Animal Conservation.

Loveridge, A. J., J. L. Seymour-Smith, A. L. Sibanda, C. Mabika, E. Ngosi and D. W. Macdonald (in Review). First confirmed record of a Cape fox, Vulpes chama, in Zimbabwe. African Journal of Ecology.

Mbizah, M., M. Valeix, D. Farine, J. E. Hunt, D. W. Macdonald and A. J. Loveridge (In Review). Effect of ecological factors on fine-scale patterns of social structure in African lions. Proceedings of National Academy of Sciences.

Mbizah, M., M. Valiex, D. W. Macdonald and A. J. Loveridge (In Review). Applying the Resource Dispersion Hypothesis to a fission-fusion society: A case study of the African lion (Panthera leo). Animal Behaviour.

Preston, E., P. J. Johnson, D. W. Macdonald and A. J. Loveridge (In Review). Hiding in the shadows. Hunting success is affected by vegetation cover and moon illumination. African Journal of Ecology.

6. Assistance provided to ZPWMA in 2018

In August WildCRU donated a research vehicle, a 4 x 4 Nissan Patrol diesel, for use by the Hwange research unit of ZPWMA. This was delivered Parks HQ in Harare and accepted by the Chief Ecologist and Director General.

Research vehicle donated by HLR to ZPWMA on 31.08.18 at Harare HQ

Additional assistance provided, over and above the research contributions made by the project was:

- Investigation teams transported at ZPWMA request in Gwaai and Matetsi areas.
- Transport and helping ZPWMA to shoot, sample and dispose of rabid domestic dogs found in the Park.
- Loan of fuel drums for ZPWMA to collect fuel supplies from Hwange town.
- The project regularly assists Hwange National Park management with transport for water pump maintenance, ration runs and ranger deployment.

7. Proposed Research in 2019

Continued long term monitoring of the lion population in HNP

The project will aim to maintain the valuable long term monitoring data collected for the last 19 years. This is crucial information and central to our understanding of lion

population trends and demographics both in Hwange and, more widely, in other populations across Africa. It is also key to implementing sound and sustainable conservation strategies for this species. These core areas extend from Ngamo in the East to Robins Area in the West. Our research teams will continue to monitor lion behaviour, movements and interactions. We will continue to undertake camera trap surveys. Lion prey preferences will continue to be monitored across the park by investigation of lion kills identified from GPS collar data. To achieve this we will continue to monitor radio-tagged lion prides, tag additional lions in the population, maintain the current radio-collars and record all observations, demographic parameters and pride and coalition structures. We will fit cutting edge accelerometers to standard GPS collars in order to record fine scale motion. These loggers allow even more detailed understanding of lion behaviour in relation to their environment, prey and human interactions.

Human –Lion Conflict- understanding and mitigating conflict

As outlined above conflict between lions and human communities-usually over livestock loss is a serious conservation problem. We have compiled extensive records of this problem over the last 10 years. We aim to continue monitoring conflict in partnership with PWMA managers and ecologists and conservation NGOs (Victoria Falls Wildlife Trust). In order to further our understanding on this issue and begin to provide solutions we aim to achieve the following:-

1) Radio- tag lions in 'problem' areas, identified by our research to date, so that movements can be closely monitored and reasons for livestock raiding can be more clearly understood. These collars will be deployed outside tourist areas, largely on the eastern boundary of Hwange National park, the northern buffer zone between HNP and Hwange Communal land, and the southern region of Zambezi National Park which will limit exposure of collars to photographic tourists. Detailed monitoring of collared animals will provide an 'early warning system' if lions leave the park. This will allow appropriate actions to be taken by PWMA managers and the community.

2) We will work with all the local stakeholders and PWMA managers to assist, through the Long Shields Lion Guardian Programme, local communities to better protect their livestock from lions. This will include continued recruitment of 'lion

guardians' in the local community to assist with both conservation and livestock protection. We will also provide assistance and training to local people to provide better solutions to livestock protection. As outlined above better livestock protection and fewer losses will remove the need to kill lions and also provide fewer opportunities for lions to take people's livestock.

Population surveys and identification of regional movement corridors

Up until now the project has focused its activities to a large extent along the Northern and North eastern areas of the park. In these areas we have detailed information on prides, distributions and numbers of lions. However, in other areas of the park and surrounding region very little is known about the lion population and lion movements. This is particularly the case in the north-western and southern areas of HNP and some of the key protected areas adjacent to HNP. To investigate these issues we aim to:

1) Continue to validate potential habitat corridors predicted by the 'Landscape resistance model' within Zimbabwe and in the new study site in Botswana. This will be achieved through spoor surveys and camera trapping and existing and new sites in the Hwange region.
2) We aim to continue surveys of the lion population in HNP and other protected areas using spoor transects and camera trap surveys to monitor trends in the population. This will provide valuable information on the size of the lion population in these areas and this information can be used to inform management strategies for this species.

Detailed Research Plan for 2019

Ongoing camera trap surveys in HNP :It is anticipated that we will undertake a surveys in the Sinamatella Area of HNP this year. This is the only sector of the park that has yet to be surveyed with camera traps. In addition, resources being available, we would aim to repeat the Shakwanki and Robins surveys, which were last done in 2013.

Lion monitoring: Lion prides will be routinely located and observations of pride demographics made through out HNP. Lion mortality data will be collected and collated, with skulls collected, measured and tooth samples of known age lions collected for analysis.

Disease monitoring: There have been several incidences of disease in the lion population in 2014 to 2016 and more recent outbreaks of rabies and anthrax in 2018. To date the disease

mortalities in lions is unidentified, though anthrax is suspected in several cases. We would like to capture and take samples (serum and tissue biopsies) from any suspected disease cases (which would be treated and released). This work will be undertaken by a qualified veterinarian and samples will be processed at a local veterinary facility.

Collaboration with CNRS-HERD: We plan to collaborate with the CNRS-HERD project on a funded project to understand the foraging strategies of lions and spotted hyaenas, using collar mounted bio-sensors. The biosensors include accelerometers, magnetometers and audio sensors to detect fine scale movements. These units are bolted onto existing telemetry collars. This work will align with existing monitoring and research and will not require additional collars to be deployed beyond those outlined below. The details of this will be discussed in more detail with PWMA researchers and ecologists.

Lion Captures: The project will continue to use GPS radio-collars to monitor lions in four key study locations. Captures will be required to remove old collars, replace failed collars, are fit collars in areas where collared animals have been lost. It is difficult to plan these capture operations in detail as most lion captures are opportunistic and cannot be easily planned beforehand.

Area of operation	**Number of captures**	**Period**
Ngamo, Wilderness and Tsholotsho boundary	3-4 potential 'problem lions captured over year to facilitate lion guardian 'early warning'. Capture and replace collar batteries on 6 existing study lions	Throughout the year as opportunities or needs arise
Main Camp Area and surrounds (including Forestry and Gwaai ICA)	3-4 potential 'problem lions captured over year to facilitate lion guardian 'early warning'. Capture and replace collar batteries on 6 existing study lions.	Throughout the year as opportunities or needs arise
Shapi, Nehimba and	Removal of any remaining	Throughout the year as

Shakwanki areas	collars in the Shakwanki area as intensive monitoring of these areas comes to an end.	opportunities or needs arise
Robins and Sinamatella areas	Removal of collars in this area to begin as ecological monitoring protocol comes to an end.	Throughout the year as opportunities or needs arise, with major focus in the early dry season
Zambezi National Park and Matetsi	5-6 lions collared to monitor HWC in the Victoria Falls area	Undertaken by Roger Parry, VFWT

Acknowledgements

We thank the Zimbabwe Parks and Wildlife Management Authority for permission to undertake this work on PWMA estate. We are grateful for the support of the Area Manager Mr E. Ngosi and Ecologists L. Sebele and C. Mabika. We thank the ecologists and research section rangers at Hwange Main Camp, Sinamatella and Robins stations for their assistance and support in undertaking this research. Sections of this report were compiled from interim reports provided by HLR project staff Jane Hunt, Justin Seymour-Smith, Lovemore Sibanda, Lisanne Petracca and Liomba Mathe. We thank HLR field staff Andreas Sibanda, Liomba Mathe, Lowane Mpofu and the APU and Lion Guardian teams for their hard work in 2018. We thank our primary donors, Robertson Foundation, Recanati-Kaplan Foundation for their continued support. We particularly thank Dawn Properties for their generous support of our project base.