Leopard Ecology & Conservation

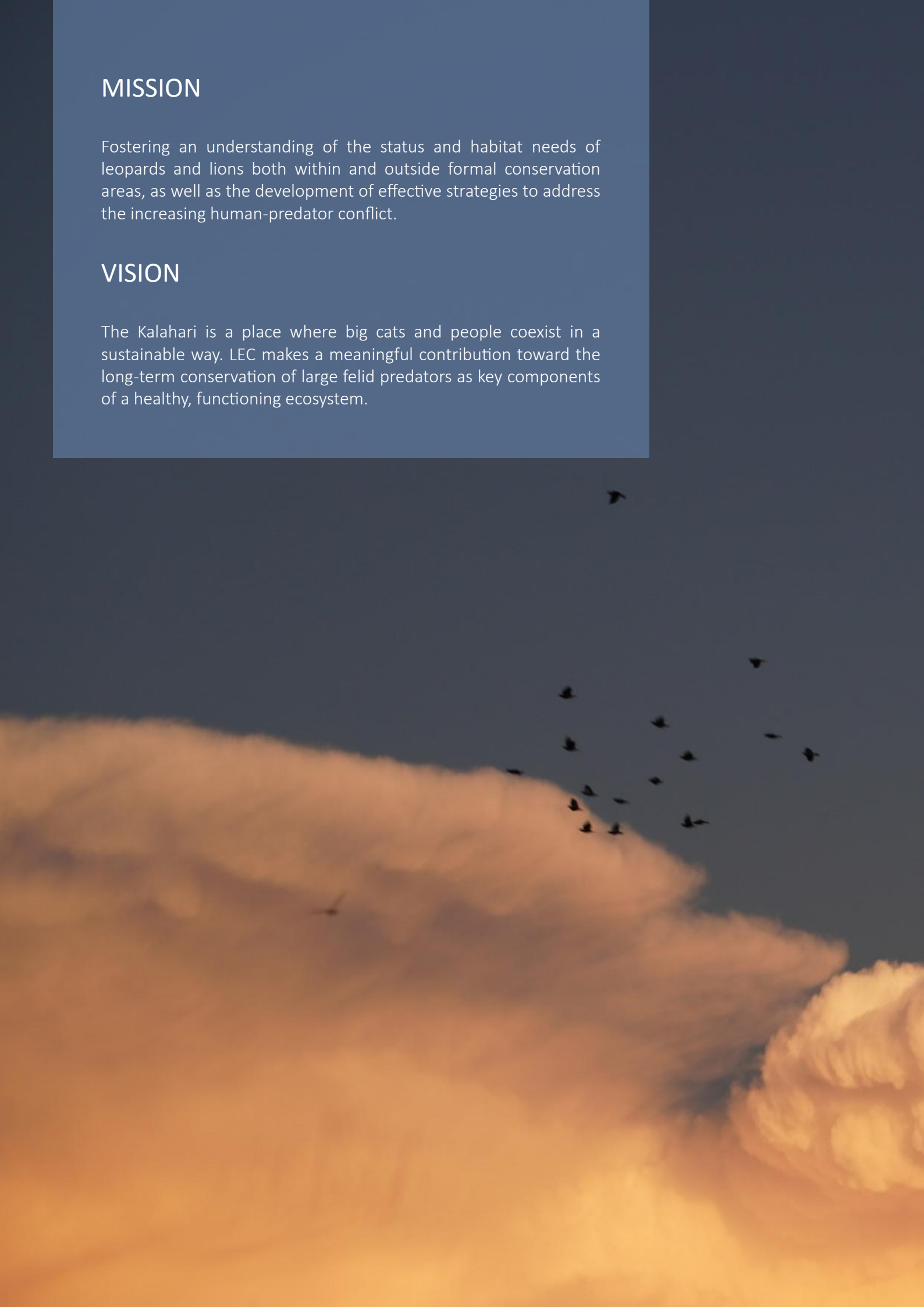
Annual Report 2022

MISSION

Fostering an understanding of the status and habitat needs of leopards and lions both within and outside formal conservation areas, as well as the development of effective strategies to address the increasing human-predator conflict.

VISION

The Kalahari is a place where big cats and people coexist in a sustainable way. LEC makes a meaningful contribution toward the long-term conservation of large felid predators as key components of a healthy, functioning ecosystem.



OBJECTIVE

Leopard Ecology & Conservation strives to make a meaningful contribution toward the long-term conservation of large felid predators as key components of a healthy, functioning ecosystem in Botswana. This requires an understanding of status and habitat needs of leopards and lions both within and outside formal conservation areas, as well as the development of appropriate and effective strategies to address the threats they face.

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Leopard Ecology & Conservation Trust
Botswana

People and Wildlife Trust
Botswana

African Cats & Conservation Foundation (ACACF)
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A map showing most of the places mentioned in the text can be found on page 48.

Letter from LEC Founder: Monika Schiess-Meier

> I am convinced that
> understanding traditional knowledge
> is part of the solution
> for successful conservation.

MONIKA SCHIESS-MEIER, Founder and Director

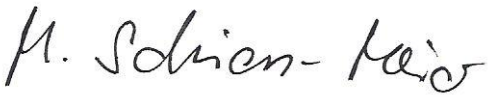
The world today faces a great challenge, with biodiversity being lost at an alarming rate. At LEC, we are doing our best to counteract this by mitigating human-wildlife conflict through research, education, and community engagement. In this way we hope to achieve our vision of coexistence and help to protect the leopard and lion populations and their habitat in the Kalahari.

Knowledge for Conservation. Conservation of Knowledge. Our research combines technology and traditional knowledge from indigenous people to learn about the behaviour of leopards and lions in the Kalahari. Together, we follow the lives of these big cats to better understand their life histories, spatial distribution and demographic trends, the threats they face, and how these are connected to changes in the environment and resources. With every year, we are expanding our knowledge for conservation.

Gaining knowledge alone, however, will not be the solution. We need to ensure that this knowledge, which already exists among the indigenous San people, and the knowledge we generate is used, shared, and passed on to the community. Only then, coexistence between humans and wildlife can flourish.

As a team and together with our partners, we hope to contribute not only to the conservation of leopards and lions in the Kalahari but also to the objective to halt the loss in biodiversity.

With this in mind, I am pleased to present you our Annual Report for 2022.



What we do

The **LEC Research Programme** is made up of six core projects (see p. 7) studying the habitat of leopards and lions, their population status, and the human-predator conflict that exists between them and the local community. These core projects have produced long-term datasets on predator ecology and human-wildlife conflict, providing a longstanding perspective on the evolving ecological needs of, and threats to, predators in the Kalahari.

While we maintain continuity in data collection methods, we also adapt and modify our activities to ensure that the research topics and methodologies remain relevant and up to date, allowing us to inform current management strategies appropriately.

The **LEC Community & Education Programme** employs a team, made up of local residents and individuals with expertise in social science and community-based conservation. They work with farmers and herders to provide education about livestock predation mitigation measures. They also work with residents of the local village, Kaudwane, on a number of community projects, such as an organic vegetable garden, a community conservation club, a solar cooker project and practical animal husbandry education. LEC is particularly proud of the relationship which has developed over the past 22 years with the local community.

2022 in Numbers

Organisation

22 years operational

22 individuals from Botswana working at field site in Khutse GR

9 international collaborations

2 external trainings for LEC staff

2 international post graduate students and interns

Leopards

11 sightings of leopards

16 wildlife predation events by leopards

6 translocated leopards

Lions

681 sightings of lions older than 6 months

111 wildlife predation events by lions.

221 sightings of collared lions

4 sightings of lion matings

2 lion litters with **9** cubs

244 cluster visited, with **83** lion hunting paths recreated

Community and Education

13 backyard gardens created as a result of the organic garden project

5 dogs and cats vaccinated against rabies

120 indigenous trees planted in the community

31 dogs steriliised

87 visits to cattle posts

25 educational workshops with farmers

263 farmers attending the workshops

83 hoof-trimming equipment borrowed

143 livestock trimmed

17 horses taking part in the horse evaluation

Promoting young talents

44 school children from Botswana participated in an educational game drive inside Khutse GR

8 school children were recognised for excellence in their studies and awarded prizes

Research

207 individual sets of tracks of lions and leopards collected (for library WildTrack FIT algorithm)

371 km of roads surveyed every month for our spoor and prey survey

6923 sets of tracks from carnivores, herbivores and large terrestrial birds

25 trackers from accross Kalahari attended the CyberTracker workshop

1380 fixed-point photos of vegetation collected from **37** locations in the LEC study area

Research Programme

Research is one of the founding pillars of LEC. Climate change and increasing anthropogenic pressure are certainly the major threats to the long-term survival of leopards and lions in the Kalahari, but we need scientifically strong evidence to better understand the details of such threats. To understand the impact, we need to monitor the population status parameters such as the population size, spatial distribution, and demographic trends and how these link to changes in the environment and resources. Simultaneously, we have to comprehend the entirety of existing and new factors which will affect the ecology and conservation of wild carnivores. Only through long-term studies, it is possible to collect the needed data to then derive appropriate management strategies for the Kalahari ecosystem.

LEC is a long-term research project. In six core projects, we maintain continuity in our data collection for the key parameters of the leopard and lion populations within our study area. LEC is continuously striving to update our research methodologies as well as integrate innovative technological and methodological advances to maximise the value of our research activities. We contribute to a number of research collaborations and support students in their research beyond these six projects.

Project 1:
Landscape and habitat monitoring

- To define the Khutse landscape in terms of the key environmental features and their interactions.
- To monitor changes in landscape conditions that are biologically relevant, and which vary in both space and time.
- To monitor key climatic drivers of landscape change.

Project 2:
Prey Availability

- To monitor the distribution and relative abundance of potential prey species.
- To monitor the demographics (age class and sex ratios) and physical condition of the principal leopard and lion prey species.

Project 3:
Predation

- To describe leopard and lion predation patterns across the study area.
- To identify drivers that best predict leopard and lion predation patterns across the study area.
- To quantify the extent to which domestic and wild prey sources contribute towards the diet of leopards and lions in the study area.
- To quantify predation of livestock in terms of prey species, age class and sex.

Project 4:
Predator Movement and Habitat Selection

- To determine leopard habitat selection patterns inside and outside the protected area.
- To identify key resources across the study area for leopards and lions.

Project 5:
Predator Demographics

- To calculate population size of leopard and lion populations inside the protected area.
- To calculate population size of the leopard population outside the protected area.
- To understand sex ratios and age classes of both territorial and dispersing leopards.
- To determine the population structure, pride size and pride structure of the lion population, and how these change over time.

Project 6:
Human-Predator Conflict

- To identify the intensity and trends of human-predator conflict in the study area.
- To determine environmental and social factors affecting the coexistence of human activities and wild carnivores.
- To identify effective mitigation strategies.

Project 1.
Landscape and Habitat Monitoring

The Kalahari is a dynamic ecosystem in which changes might be seen only if the time frame considered is in the order of decades. Many factors combine to shape this unique and fragile landscape and their impact is evident only after many years. Such factors include global climate change, variation in the wildlife community composition, natural fires as well as human activities. Botswana, as many other African countries, is experiencing a growth in population and an increasing need to reduce its dependency for food products from neighbouring countries. This translates in a change in land use policies and consequent loss of areas for wildlife. This is why, since 2000, LEC has monitored the evolution of the landscape in the study area to determine if the habitat for leopards and lions is changing and how these changes are affecting their ecology, knowing that changes in the neighbouring parts of the country can affect even the protected areas. In 2022, we continued our long-term data collection on the vegetation and climate.

During the extensive spoor and prey survey, we were able to intensify our efforts to document the vegetation structure in our study area across seasons. In 2022, every month we collected fixed-point landscape photographs from 37 different locations, including the most important pans. From a preliminary qualitative analysis of 1380 images, it is evident that the continuous presence of elephants in Khutse GR and the southern section of CKGR has heavily impacted the tree populations. The area between Molose and Kukamma waterholes have lost many of the tall acacias and the areas immediately surrounding the pans are intensively searched by elephants for digging roots and tubers. In Khutse 1 pan, many shepherd trees have been pushed down, but their impressive physiological plasticity has allowed them to survive and continue producing new branches developing from the horizontal logs (Fig.1.3). The changes in vegetation caused by the elephants are certainly altering the habitat for many species favouring certain ones and negatively impacting others. Although elephants have been reported as using Khutse more intensively since 2017, there are reports from the beginning of the 20th century documenting that relatively large number of elephants were present in the area. The main difference is probably due to the changes in the surrounding environment where now the anthropogenic pressure has limited the dispersal in more fertile lands towards south. For this reason, during the rest of the 20th century, elephants moved less towards the south and only in the recent years, the creation of waterholes inside the Kalahari

Figure 1.1. and 1.2. Molose waterhole in February 2015 (above) and in February 2022 (below).

protected areas and the elephant population growth have favoured the return of dispersal individuals towards Khutse GR. For example, when Ghaghoo Diamond Mine opened in 2014 at Gope inside CKGR, a large water basin was created for mining purposes inside the fenced area. The mine stopped operating between 2017 and 2018 and the reduced maintenance of the perimeter fence allowed elephants to access the water basin transforming Gope into an important stepping stone for elephants moving south towards the waterholes in Khutse GR. (Figs.1.1,1.2)

The vegetation images collected outside the protected area provided another important confirmation that livestock is overgrazing the communal land with very few herbaceous plants and a growing presence of bush encroachment.

Fig 1.3 Shepherd tree pushed down by elephants at Khutse 1 pan.

Fires are certainly a key element in shaping the Kalahari habitat. The natural fires are needed to facilitate the renovation of grasses and to keep the savanna environment open. In 2022, Khutse GR and CKGR experienced a high number of fires and large sections of the protected area were burnt. In 2021, Botswana recorded an extremely high number of VIIRS (Visible Infrared Imaging Radiometer Suite) fire alerts (21'668 in total). In 2022, the total number has notably decreased reaching a total of 11'665 VIIRS fire alerts, nevertheless a very high number comparing the monthly data since 2012 (Figs.1.4,1.5). The peak was towards the end of September, when the grass is dry enough and the first thunder storms appear. (https://www.globalforestwatch.org/)

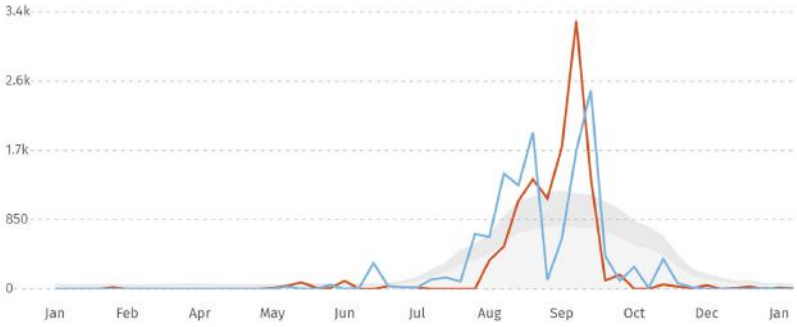


Figure 1.4. Monthly VIIRS fire alerts in Botswana in the period January 2022-January 2023 (red) and the period January 2021–January 2022 (blue) (https://www.globalforestwatch.org/).

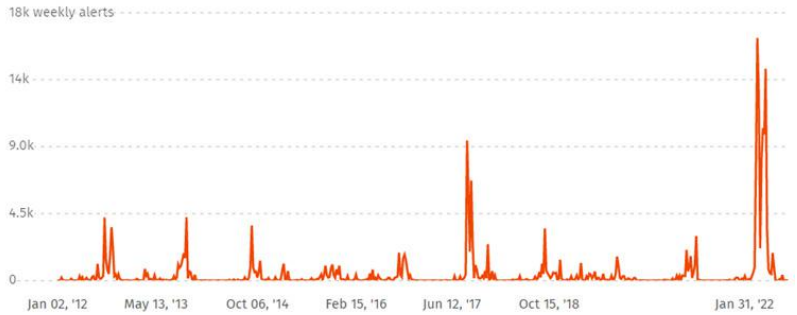


Figure 1.5. VIIRS fire alerts recorded between January 2012 and January 2023 (https://www.globalforestwatch.org/).

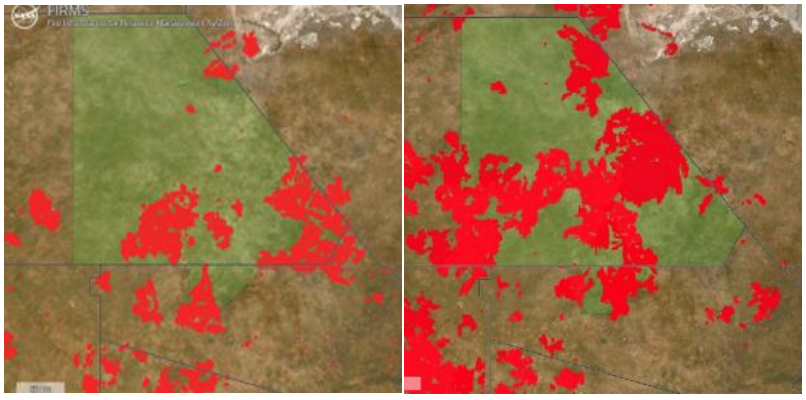


Figure 1.6. Fires active in Khutse GR, Central Kalahari GR and their surroundings between July and October 2022 (left) and in the same period in 2021. (FIRMS-NASA).

When comparing the burnt area maps of 2021 and 2022, it is evident that they are complementary. In Khutse GR and the southern section of CKGR, the areas affected by fires in 2022 are the ones which were untouched in 2021. This is proof that between 2021 and 2022, all study area was subject to fires which have potentially renovated the vegetation, especially the herbaceous plants and the bushes. The herbivores could find food in the areas burnt in 2021. One main difference between 2021 and 2022 is that the fire period was characterized by slightly less intense winds creating fires which burnt slower and, therefore, which impacted more the trees.

Our weather station at the entrance of Khutse GR and the set of rain gauges deployed across the study area allowed us to monitor temperature, rainfall and windspeed throughout the 2021–2022 austral seasonal year.

After the above-average rainfall of 2020–2021, the total recorded rainfall (387 mm) for 2021–2022 was just below the average (424 mm) for the last 22 years (Fig. 1.7). It is important to note, that the biggest portion of the rain was quite late comparing to the previous years. In 2021, most of the rain was recorded in February (283 mm), while February 2022 recorded only 10.7 mm, with April being the rainiest month in 2022 with 120 mm (Fig. 1.8). May and June 2022 also recorded some rain which is extremely rare comparing to the past years. Overall, in 2022, we observed a longer rainy season with two peaks around December 2021 and April 2022. The highest mean temperatures have been reached in February 2022 (26.7°C) probably due to the lack of rain to mitigate the heat. Nevertheless, November confirmed to be one of the hottest months with 26.2°C as observed in November 2020 (26.1°C) and in November 2019 (28.1°C).

Khutse GR and CKGR do not have any natural surface water during the driest months since human populations established themselves in the Kalahari region. Many Kalahari animal species have evolved and developed specific behaviours to cope with such limited water availability. Kalahari was known for large herbivores seasonal migrations between the Kgalagadi Transfrontier Park (KTP) and the Okavango Delta – Chobe area to find the needed resources throughout the year. Unluckily, these ancient corridors have been slowly disappearing because of the creation of fences in the north, east and south-east boundary of CKGR and because of the increasing pressure from cattle post farming in the Wildlife Management Areas between CKGR and KTP. For this reason, Botswana authorities have created a system of artificial waterholes inside the protected areas to allow some herbivores to survive without migrations. This solution has not avoided the crash of wild herbivores populations, but

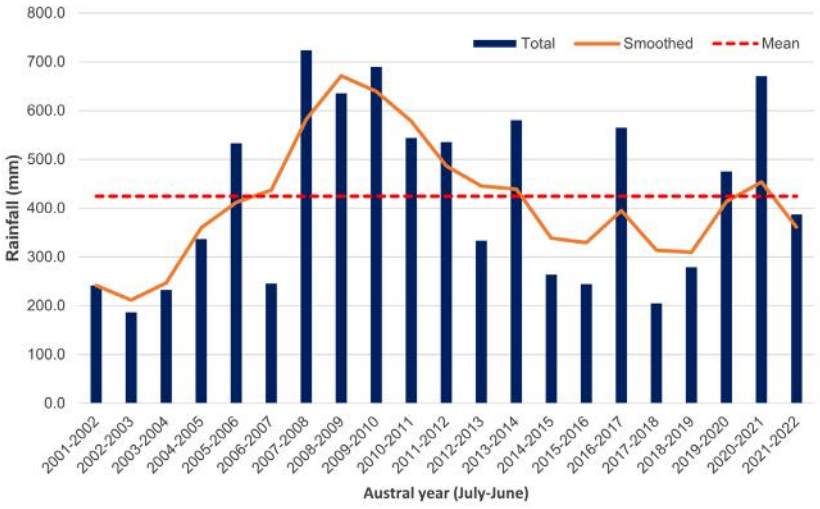


Figure 1.7. Annual rainfall recorded at the LEC research station (histogram). To highlight the trend within variable rainfall data these were smoothed (line) using a three-point weighted interpolation where annual rainfall (R) is the product of the current year's rainfall (R0) as well as the previous and following year's values (R-1 and R+1 respectively)
(R = 0.25xR-1 + 0.5xR0 + 0.25xR+1).

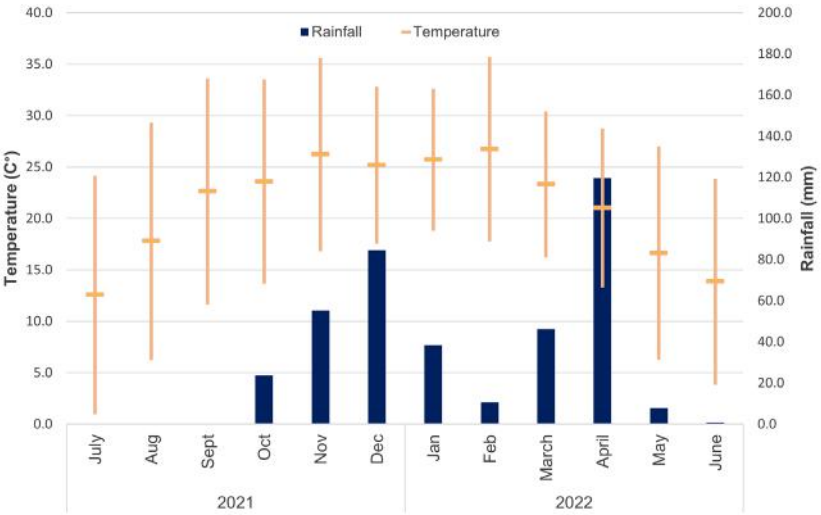


Figure 1.8. Monthly temperature and rainfall as recorded at the LEC research camp, Khutse GR, for the 2020–2021 seasonal year. The average median daily temperature is shown as a point, with the average daily minimum and maximums as bars.

waterholes are now key hotspot for wildlife and fundamental sites for management of the protected areas. In 2022, LEC continued assisting DWNP in monitoring the waterholes in the study area. As observed in the last years, elephants have taken full control of Molose area and caused damages to the waterholes at Moreswe and Kukamma. In Khutse GR the artificial waterhole has been replaced 500 m east of the former one. The new location might favour carnivores ambushing potential prey at the waterhole as it is closer to a densely vegetated area in the pan.

As it transpires from above, elephants are having a major and fast impact on Khutse GR landscape and LEC is continuing to record any opportunistic sighting of them. In 2022, we could confirm that most of the elephants moving in the study area are bulls. As observed since 2019, they move in groups of 4–6 individuals and gather at waterholes in groups up to 30–35 individuals.

Project 2.
Prey Availability

Studying large carnivores in the wild must include a good understanding of the prey population and its dynamics. Our study area presents such low animal densities that a slight shift in the numbers or the distribution of prey species has a major impact on the behaviour and the immediate and long-term viability of large carnivores. Moreover, a change in prey availability might directly translate in a change in the intensity of human-carnivore conflict within the local community. For example, eradication of wild prey from the communal grazing land due to competition with livestock and unsustainable hunting practices will force the resident predators to shift their home-range or, most probably, to start predating livestock. The same logic is applicable to the protected areas, where a reduced prey availability might push lions and leopards to cross the permeable existing fences and explore the surrounding communal grazing lands in search of prey.

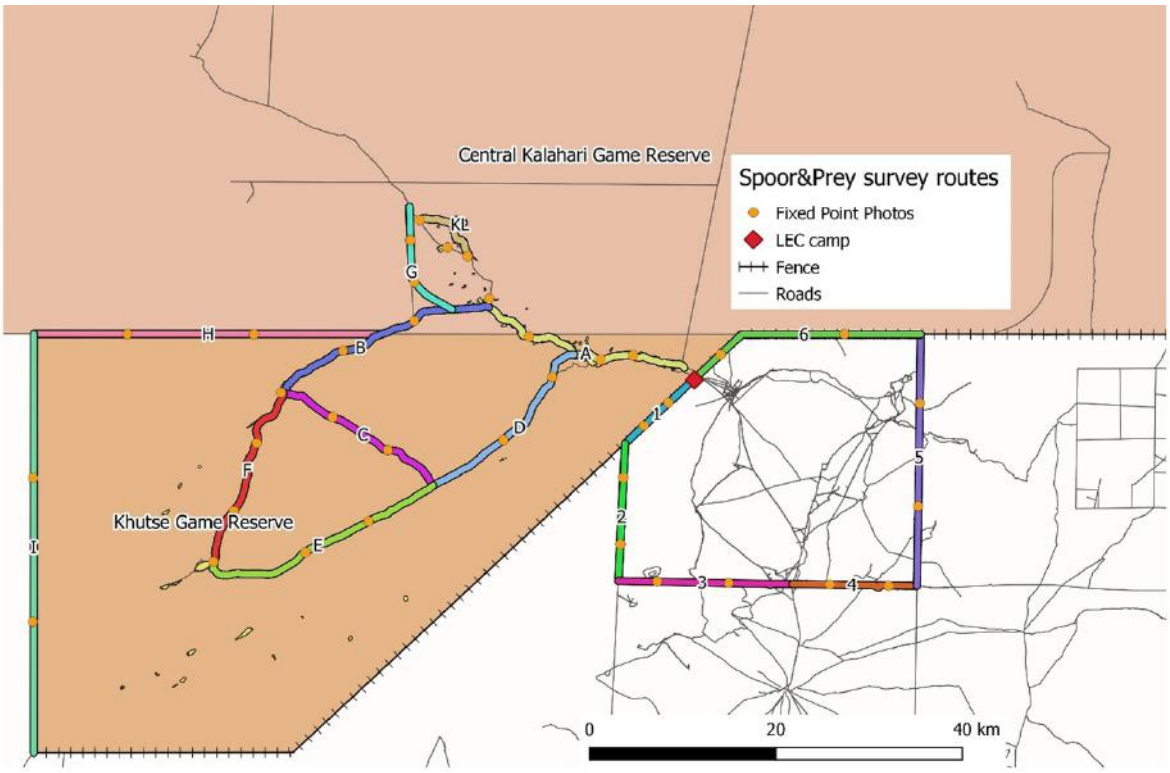


Figure 2.1. Map of the routes sampled monthly during the extensive spoor and prey survey 2021–2022.

Therefore, one of LECs main research projects is the continuous monitoring of relative abundances of key prey species in the study area. The task is made particularly complicated by the low density of animals and the road network within the study area, so LEC aims to continue innovating its approach and methodologies for obtaining realistic estimates which can be comparable with the historic LEC datasets.

From October 2021 to October 2022, LEC has implemented the extensive prey and spoor count inside and outside Khutse GR. The survey has been

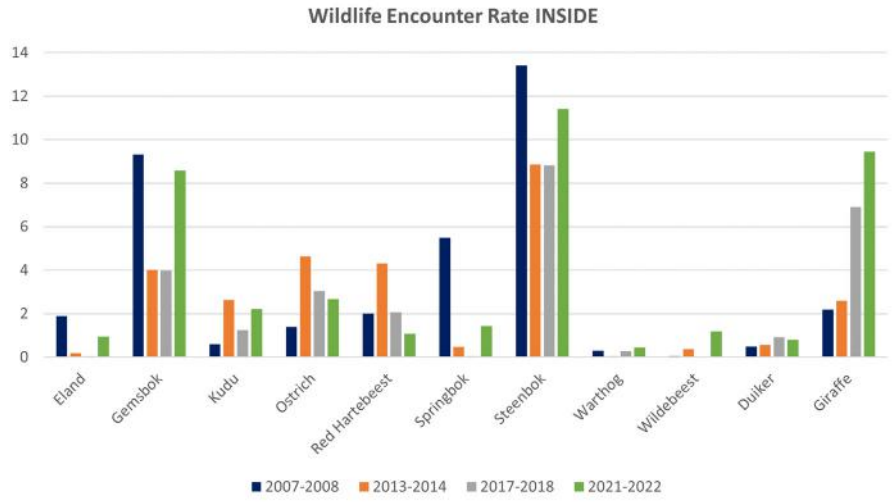


Figure 2.2. Histogram presenting the encounter rate (number of individuals every 100 km) for wild prey along the survey routes inside the protected area.

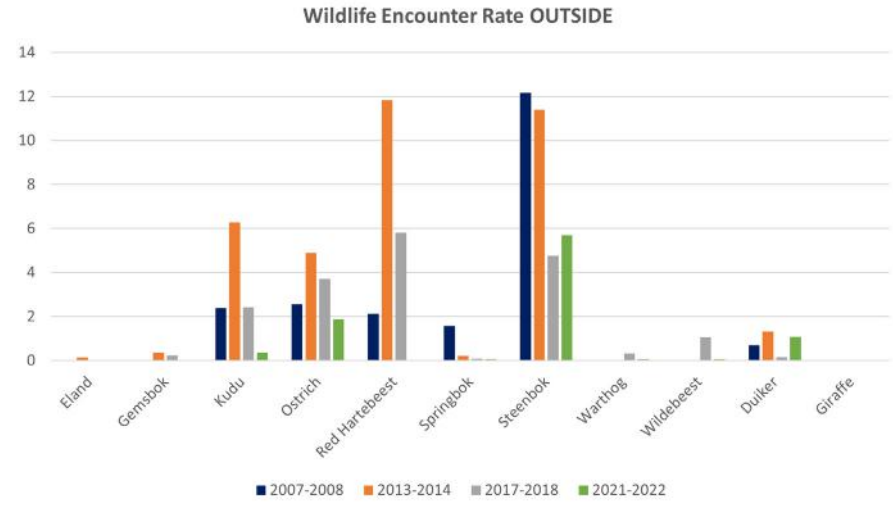


Figure 2.3. Histogram presenting the encounter rate (number of individuals every 100 km) for wild prey along the survey routes in the communal grazing land.

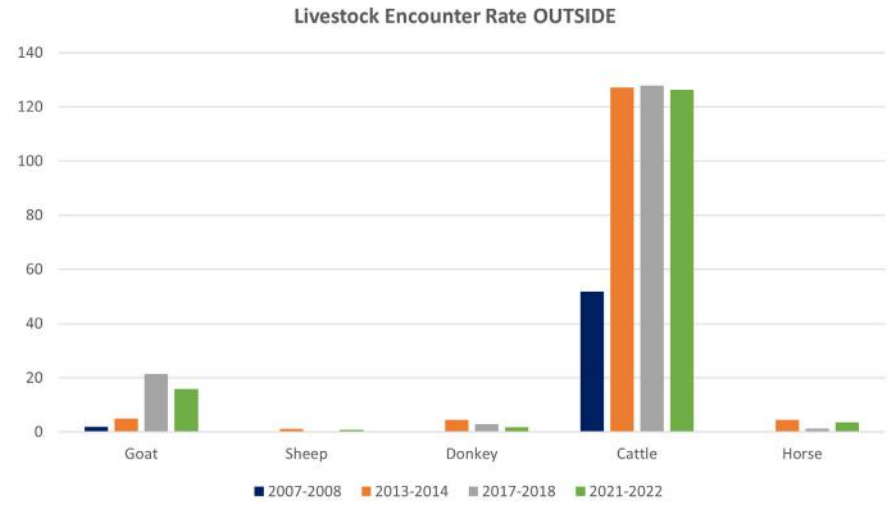


Figure 2.4. Histogram presenting the encounter rate (number of individuals every 100 km) for livestock along the survey routes in the communal grazing land.

carried out every four years since 2000. This survey collects data of spoors on a fixed set of routes driven monthly for one year (Fig.2.1). Simultaneously, the team record any direct observation of preys along routes and at pans. In comparison with the past surveys, the first novelty is that all tracks of hoofed prey species are collected as well. Secondly the data protocol has been modified to allow us to interpret the data through a new analytical framework, the Formozov-Malyshev-Pereleshin (FMP) formula, without losing the possibility to compare the data from the old existing datasets. During this survey, we added two new routes (H and I) to the historic set to increase the sampling effort and to have better coverage of the west section of Khutse GR. All data collection has been implemented through a customized Cybertracker app which has resulted in a much faster data collection and, even more important, in a reduced number of errors in the final digitalized dataset. The Cybertracker app has allowed the research team to avoid the extremely time-consumptive data entry from paper to excel, allowing a faster and more effective checking of the collected data.

As mentioned above, hoofed prey tracks were not recorded in the previous surveys, but the prey populations were calculated using direct sightings of prey and applying the Distance Sampling methodology. Due to the reduced number of direct observations, the estimates resulted to be imprecise. Nevertheless, the historic data and the direct observations from 2023 can be used to investigate trends. By comparing the encounter rates of individual preys recorded along the roads during the surveys across the same period (November to October), we could highlight the population trends of some key prey species from 2007 to 2022 (Figs. 2.2, 2.3). Inside the reserve, Eland and Springbok seems to have decreased in presence. Most of the other antelopes show that the trends seem stable or mainly affected by the dry years. On the other hand, giraffe presence in Khutse GR seems to have increased throughout the overall period. Outside the reserve, we observe a general decreasing trend. It is interesting to note the peak of observations of ostrich, kudu and red hartebeest in 2013–2014. In 2010, the Khutse GR fence was completed and many observations of large antelopes outside the reserve were collected along the fence sections. A possible explanation is that the large antelopes outside found themselves pushed towards the fence by the growing competition with livestock but could not enter the protected area due to the new fence. Within the coming year, the large antelope numbers outside

Table 2.1. Prey population density estimates for 2021–2022 calculated with FMP formula.

Species	Density Inside (Bca 95%)	Estimated population size (2830 km²)	Density Outside (Bca 95%)	Estimated population size (1830 km²)
Gemsbok	0.077 (0.062-0.103)	218.89	NA	NA
Wildebeest	0.007 (0.003-0.015)	20.91	NA	NA
Hartebeest	0.030 (0.022-0.045)	85.18	0.011 (0.006- 0.011)	20.81
Kudu	0.019 (0.013-0.030)	55.05	0.012 (0.007- 0.020)	21.27
Springbok	0.004 (0.000-0.014)	12.63	NA	NA
Aardvark	0.004 (0.003-0.007)	10.96	0.005 (0.003- 0.009)	9.15
Duiker	0.041 (0.025-0.063)	114.92	0.058 (0.035- 0.089)	106.75
Steenbok	0.093 (0.075-0.128)	264.52	0.078 (0.059- 0.113)	142.63
Eland	0.012 (0.006-0.028)	32.60	NA	NA
Giraffe	0.021 (0.013-0.053)	60.20	NA	NA
Kori Bustard	0.008 (0.005-0.012)	22.20	0.008 (0.005- 0.014)	15.02
Porcupine	0.081 (0.035-0.292)	228.83	0.076 (0.032- 0.279)	139.24
Ostrich	0.021 (0.014-0.032)	59.43	0.009 (0.006- 0.016)	17.19

the reserve have decreased. After the creation of the fence, the presence of cattle has grown exponentially (Fig. 2.4).

The preliminary results from the application of the FMP formula to the track dataset from 2022–2023 are presented in table 2.1. The calculations with the FMP formula confirm that the large antelope population is indeed small in the study area. Duikers and steenbok being smaller antelopes seems to cope better with the current conditions both within and outside the reserve. For most of the large herbivores we had to use allometric estimates of their average daily distance, value needed to estimate the densities in FMP. The allometric estimates are rough estimates based on the average body mass of the species. For this reason, the presented resulted must be considered as preliminary rough estimates. In 2023, LEC will run a study to obtain empirical estimates of the daily travel distance for five species (kudu, springbok, ostrich, eland, red hartebeest) in the attempt to refine the population density estimates.

In 2023, the new extensive camera-trap survey will cover the entire Khutse GR and part of Southern CKGR. The camera-trap survey is aimed to better understand leopard population trends and leopard behaviour. Nevertheless, the designed grid will allow to estimate relative abundances of some of the prey species. Such results will be used to validate or correct the estimates obtained from the spoor surveys.

Project 3.
Predation

Since 2000, LEC has been recording leopard and lion predations inside and outside the protected area. Monitoring predations allows us to have a better understanding of what prey species lions and leopards rely on the most to thrive in this part of the Kalahari. Furthermore, predation records outside the reserves are essential information on which predators target which type of livestock, providing further insight on how carnivores impact on livestock and therefore, on which strategies might be the most effective to mitigate the human-carnivore conflict. Detecting predations in such a low density environment is extremely complicated and we have to rely mostly on opportunistic observations, planned resighting observations, visiting ad hoc GPS clusters of collared lions, and by responding to livestock predation reports. The task is made even more complicated by the fact that carcasses are quickly and completely used by both the predator and the subsequent scavengers. Each kill is used at its fullest in the harsh Kalahari environment.

Since September 2021, in collaboration with the Max Planck Institute for Animal Behaviour (MPI-AB), a team of trackers led by Trevor Balone has focused on the hunting in lions and how they collaborate during the hunt. The team targets clusters of GPS fixes from collared lions. Visiting the site, the team assesses if it's a resting cluster or a kill site. If the kill site is confirmed and the lions have left the area, the experienced trackers reconstruct the "crime scene" identifying where and how each lion has been involved in the hunt. Handheld GPS devices are used to record the exact track of each animal participating in the hunt (Fig.3.1). The data collection will end in August 2023, but the increased effort in investigating GPS fix clusters has already increased the number of recorded lion predations within the reserve.

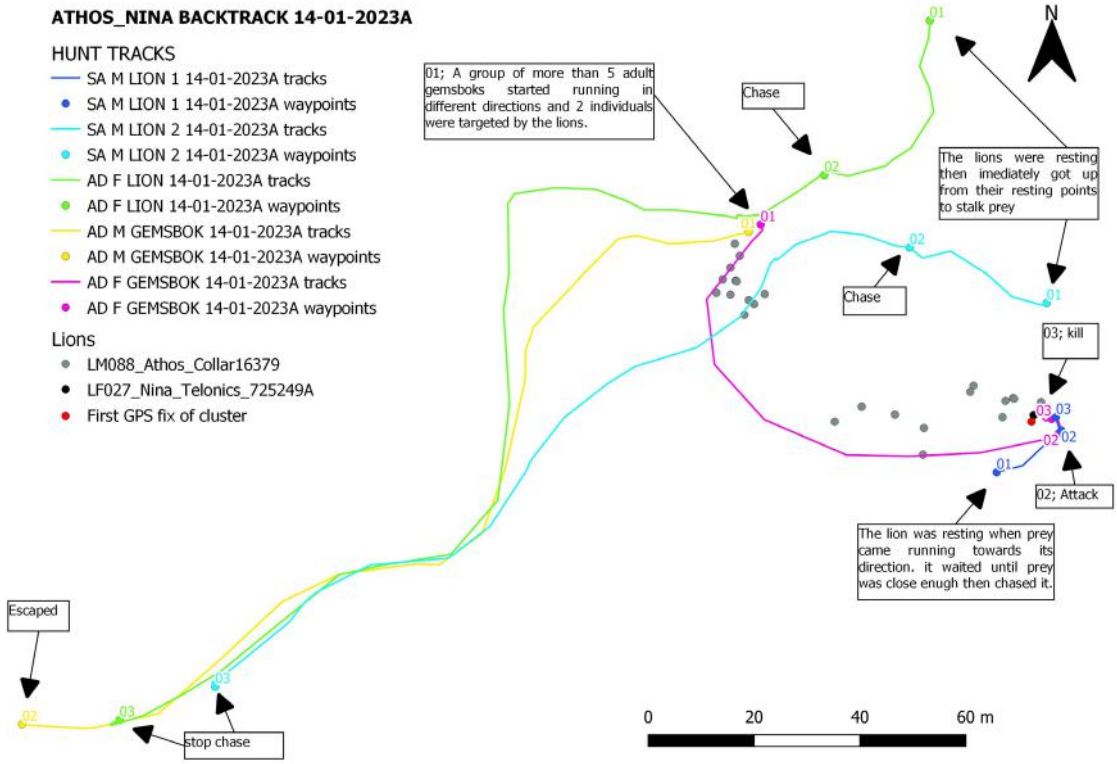


Figure 3.1 Example of the reconstruction of a lion hunt from the tracking data collected in the collaborative project with the MPI team. The map shows how the group of Nina and Athos have been hunting an adult female gemsbok. The lions were resting when a group of gemsboks passed in proximity, two lions (adult female and subadult male) chased a male gemsbok (yellow track) unsuccessfully. In the while, another subadult male successfully ambushed a female gemsbok (pink track) who ran towards him. The grey and black spots represent the GPS fixes received from the collars.

Leopard predations are extremely difficult to detect because they are generally smaller and hidden to other predators. Only in December 2022, we managed to have a collared leopard inside the reserve, all the other collared leopard were outside. For this reason, most of the recorded leopard predations are in the communal grazing land.

From the data collected, we can observe certain patterns:

- In 2022, lion predations recorded inside of the protected areas are 114 (75 in 2021). As observed in the last three years, the main prey species are gemsbok (39) and eland (20). The two species together represent more than 50% of the recorded lion predations.
- The number of killed giraffes has grown, passing from a total of two in 2021 to 10 in 2022. Both Desi's group and Alice's group seems to be very successful in hunting giraffes.
- Lion predations are mainly recorded in the savanna environment with a woody canopy cover between 25% and 75%. No lion predations were observed in the thicket and very few in the open of the pans.
- Combining the data for targeted resighting to Rena and Feeli with the data from cattle post reports, leopard recorded predations outside the reserve are a total of 18. From such predations, only four were on livestock and they were all on subadult or juvenile individuals. Most of the predations were on duikers (11) which is undoubtedly the most resilient antelope species in the shrubland outside the protected area.
- Predation on livestock data (Table 3.3) shows that leopards are far from being responsible for most of the losses. Black-backed jackals are certainly having a big impact on the small livestock including goats and sheep. While large livestock (cattle, donkeys, horses) is mainly predated by wild dogs (24) and lions (53). The predations on livestock by lions is in line with the numbers from the past years (48 in 2021). Such higher number of predations from lions comparing to

Table 3.1. Predations by lions inside and outside the reserve.

Species	adult		subadult		juvenile		**TOTAL**	
	in	*out*	in	*out*	in	*out*	in	*out*
Aardvark (*Orycteropus afer*)	2						2	
Blue wildebeest (*Connochaetes taurinus*)	6						6	
Cattle (*Bos taurus*)	1	9		3		4	1	16
Donkey(*Equus asinus*)	2	16		1		4	2	21
Duiker (*Sylvicapra grimmia*)	2						2	
Eland (*Taurotragus oryx*)	15		3		2		20	
Gemsbok (*Oryx gazella*)	31	2	7		1		39	2
Giraffe (*Giraffa giraffa*)	4	1	2		4		10	1
Goat (*Capra sp.*)		2						2
Hartebeest (*Alcelaphus buselaphus*)	9	1			2		11	1
Horse (*Equus ferus*)	4	7		1		1	4	9
Kudu (*Tragelaphus scriptus*)	8		1				9	
Porcupine (*Hystrix africaeaustralis*)	5		1				6	
Warthog (*Phacochoerus africanus*)	1						1	
African Wild dog (*Lycaon pictus*)	1						1	

Table 3.2. Predation by leopards inside and outside the reserve.

Species	adult		subadult		juvenile		**TOTAL**	
	in	*out*	in	*out*	in	*out*	in	*out*
Black backed jackal		1						1
Cattle (*Bos taurus*)				1				1
Duiker (*Sylvicapra grimmia*)		9		2				11
Goat (*Capra sp.*)		1						1
Hartebeest (*Alcelaphus buselaphus*)	1						1	
Horse (*Equus ferus*)				1		1		2
Ostrich (*Struthio camelus*)	1						1	
Steenbok (*Racipherus campestris*)		2						2

Table 3.3. Livestock predation.

	Prey Age Class	Cattle	Chicken	Goat	Sheep	Horse	Donkey	**TOTAL**
Lion	adult	10		2		11	18	41
	subadult	3					1	4
	juvenile	4					4	8
Leopard	subadult	1		1		1		3
	juvenile					1		1
Black backed jackal	adult		2	9	1			12
	subadult			2				2
	juvenile			9				9
Brown Hyena	adult			8	5			13
African Wild dog	adult	6						6
	subadult	6	1					7
	juvenile	10					1	11

the other carnivore can be partially due to several factors. Livestock losses caused by lions is compensated at the highest rates, hence pushing farmers to report immediately to PAC. Unless promptly checked, farmers will prefer to falsely or incorrectly report that the predator was a lion instead of another species for the reason mentioned above. To partially limit such events, LEC tries to verify as many reported kills as possible and has attached an experienced tracker with the C&E team to teach the farmers how to correctly identify the predator species. Finally, having collars on lions provides us more opportunities to investigate kill sites outside the reserve even before the farmer realizes the loss of any livestock.

- The fact that one cattle and two donkeys were killed inside the reserve but far from any of the CKGR settlements, confirms that the fence has become too permeable and that livestock is actively entering the protected areas from the communal grazing land.

Project 4.
Predator Movement and Habitat Selection

One of LEC's main research topics is the study of movement patterns in leopards and lions. Our long-term data obtained with the collaring of resident individuals have proven that in our study area the home-ranges are the largest in the world for both leopards and lions. Large carnivores strictly depend on prey availability and the Kalahari is characterized by low density prey populations forcing predators to cover long distances and to shift their activity core areas across seasons and years. In addition to the dependency to prey, both species are territorial animals and males have to actively patrol and defend these huge territories from other conspecific competitors. Since 2000, LEC has used the most advanced GPS collars available on the market to investigate how leopards and lions move and what environmental variables affect the patterns of space use and habitat selection patterns of these two species. The newest collars allow us to have more frequent GPS fixes and fine accelerometer data which allows us to better investigate not just the areas where the animals move but also how they move and how they behave.

In 2022, we continued collecting movement data by deploying GPS collars on resident lions and leopards as well as on translocated carnivores released by DWNP within our study area. After having focused on analysing lion movement patterns with the extensive work of Dr Genevieve Finerty (2016–2021) and of LEC student Shani Baumgartner (2021), in 2022 we wanted to further investigate the consequences of a translocation event on the movement patterns of leopards in the Kalahari region. MSc student Vera Lucia Alessandrello, UZH, has analyzed LEC telemetry data from collared translocated leopards and compared their movement patterns with the ones of resident individuals.

In her thesis, she assessed 13 leopard translocations from across Botswana. All translocated leopards were released into LEC study area. After evaluating the translocation success, she explored the differences in the spatial behaviour of translocated versus resident leopards to gain a deeper understanding of how translocation may affect the leopard's movement. When leopards are translocated, there are three main responses to their release in nature

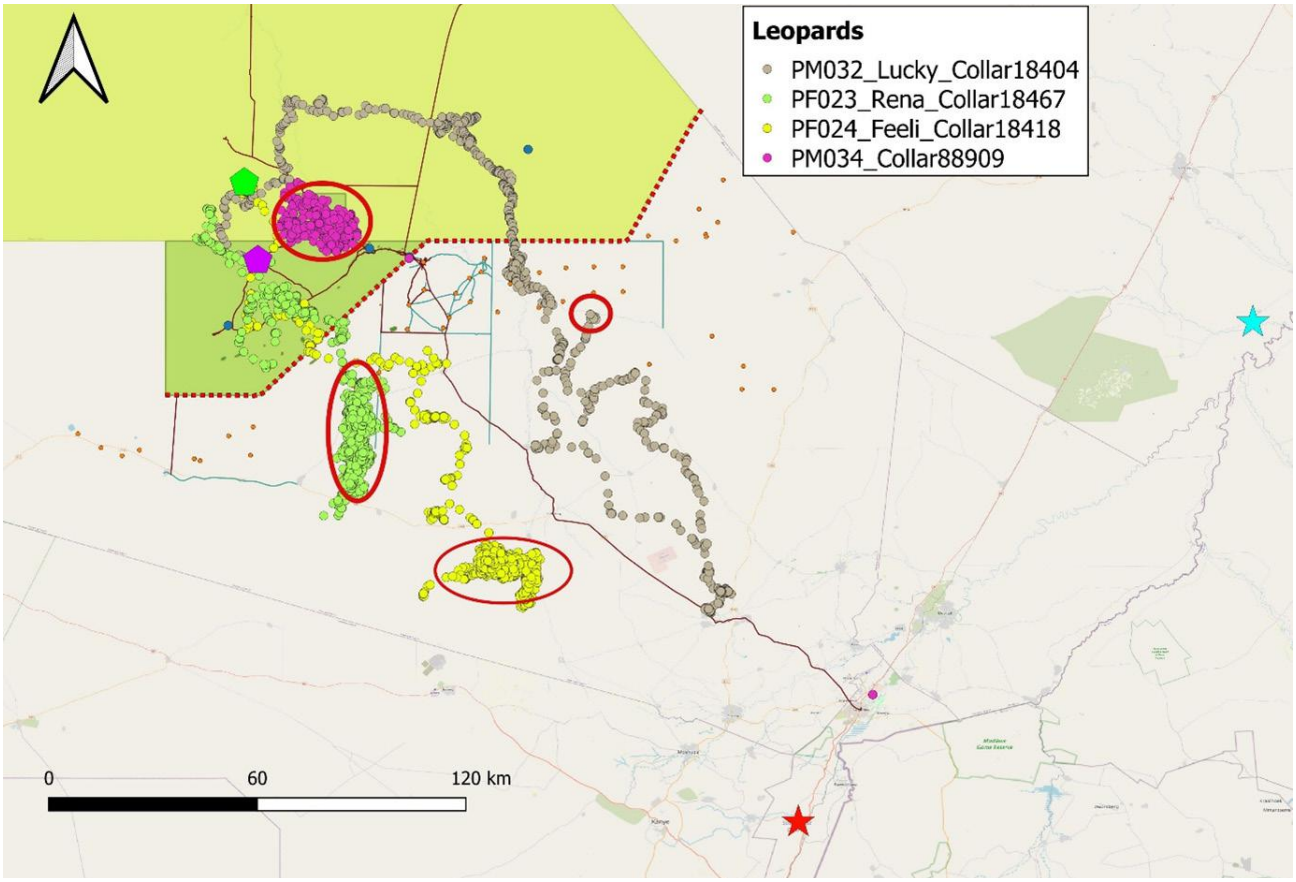


Figure 4.1 Map of different typologies of leopard movement patterns.
In pink, the movement pattern of a resident male. In grey, the post-release movement pattern of a male translocated leopard (Lucky) showing a clear tendency in "homing" behaviour. He was captured in Otse (red star) and he was aiming towards it before being blocked by the presence of the urban development of Molepolole. He returned back north where he was shot at a cattle post. In yellow, the movements of Feeli translocated female leopard from Otse. As per Lucky, she showed "homing" behaviour right after her release in CKGR (green pentagon), before "settling" outside the protected area (marked by the red circle). She managed to give birth to two cubs, before being snared by herders for killing a juvenile goat. In green, Rena, a translocated female leopard from Dovedale Ranch (blue star). Rena showed "wandering behaviour" after her release at Molose (pink pentagon) exploring the area north of the release site before moving rapidly outside the protected area and "settling" in a very densely vegetated shrubland between cattle posts where she is actively hunting small antelopes mainly.

(Fig.4.1). We talk about "homing" when they return to the site where they were captured. Otherwise, the leopard may range widely and seemingly randomly ("wandering behaviour") or may establish a home range in a new area ("settling"). The three responses are not exclusives and leopards may partially show each behaviour at different phases. Across all translocated collared individuals, the individuals that "settled" were only adult females and did so outside of the protected area network. While the home range size of resident and settled translocated leopards did not differ, the two groups differed in their habitat selection. Residents were mostly found inside of the protected areas whereas translocated leopards spend most time outside the reserves. This might be due to the fact that the release site was already saturated with resident leopards. All leopards in this study were more likely to select shrubland over grassland however residents were more likely to be found closer to roads and closer to pans in comparison to translocated leopards.

Khutse GR has rarely been selected as a release site for lion translocations in the last 20 years, so there is not enough telemetry data in our archives to implement any serious analysis on lion translocations. Nevertheless, in 2022 LEC has continued monitoring a young lioness (LF070, Fig.4.2) which was collared and

translocated away from LEC study area. When in July 2021, the lioness Peggy was shot as a problem animal outside Khutse Gate, three subadult sisters were left wandering the cattle post areas without a guide and, therefore, killing cattle and donkeys. DWNP managed to translocate two sisters (LF070 and LF069) to Bape in CKGR and LEC deployed a collar on LF070 on the occasion. In the while, the third sister (LF069: Poona) moved back inside the reserve and later joined Sarah and Verity in the East Khutse pride. The three sisters were born in Khutse GR, and after two weeks LF070 and LF068 were back along Khutse GR fence, showing clear "homing behaviour". In December 2021, DWNP translocated LF070 to Sunday pan in northern CKGR, but she rapidly left the protected area and started roaming in the cattle farms in Hainaveld till the 6th April 2022, when she was captured again and translocated to Moremi GR. As soon as, LF070 was released she rapidly moved East and, then, South in the direction of CKGR where she was shot on the 30th April 2022. Such fast and long displacement from her last release site was probably due to the presence of large local prides of lions which pushed her away. The summary of this extraordinary translocation operation is anecdotal evidence of the limited effectiveness of translocations in mitigating human carnivore conflict and in securing a future for problem animals, especially if subadults.

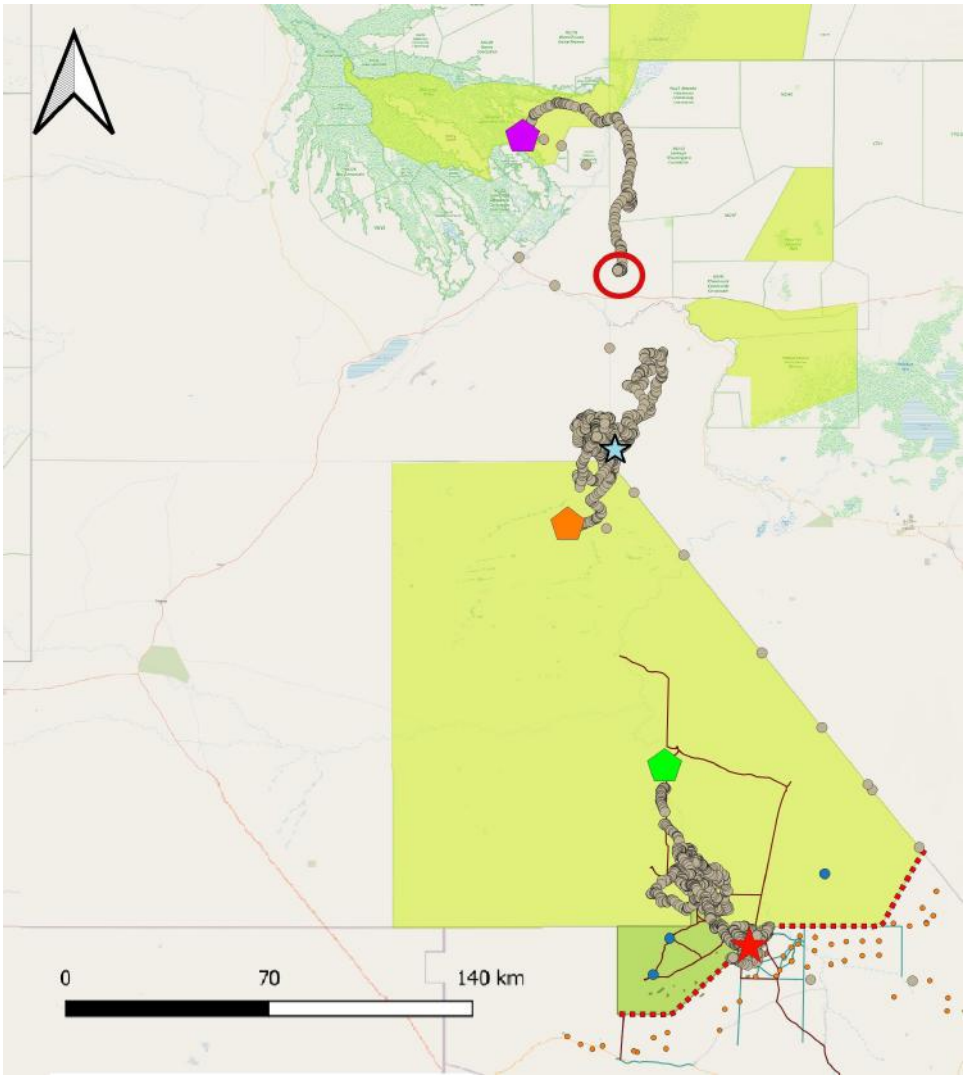


Figure 4.2 GPS fixes from subadult lioness LF070 since the 31/07/2021.
The red star marks the area where she was darted for the first two translocations. The blue star is the darting site on the 05/04/2022. The green pentagon is the release site (Bape) on the 31/07/2021. The orange pentagon is the release site (Sunday pan) on the 01/12/2021. The purple pentagon is the release site (Moremi GR) on the 06/04/2022. The red circle marks her latest location where she was shot on the 30/04/2022.

Project 5.
Predator Demographics - Leopard

Due to their cryptic behaviour and the low densities in our area, leopards are very difficult animals to study. Opportunistic direct observations are very rare in Khutse GR and CKGR. For these reasons, LEC relies on two main methods to study these majestic carnivores: spoor surveys and telemetry.

In 2022, we successfully completed the extensive spoor and prey survey (see Project 2-Prey availability). The results obtained in relation to the leopard population are extremely important to understand the trends and the related conservation strategies for the area.

The leopard spoor density outside the protected area has remained approximately constant since the 2007–2009 survey. It has not been reduced by the erection of the park fence. However, within the KGR the density on many routes has decreased (Fig. 5.1). The density was 37 per 1000 km in the 2007–2009 survey; it dropped to 15, 13 and 24 in the subsequent three surveys. In the last 15 years the spoor density of leopards in the KGR was reduced by 35% of its value in 2007–2009.

Across the period October 2021–October 2022, detected leopard spoors were ubiquitous inside Khutse GR with a slightly higher number of tracks recorded in Khankwe area, Molose and the junction of roads C, D and E in the South-West. While tracks resulted more concentrated in certain areas in the communal grazing land such as the cutline North-South from the fence (Fig.5.2).

The data concerning opportunistic resighting of leopards or records of detected tracks outside of the spoor survey are not included and presented, as they are biased by the frequency each area is visited. Instead, the data from the spoor survey take into account the same sampling effort and can provide a more realistic distribution of leopards in our study area.

Preliminary analysis, using the Formozov–Malyshev–Pereleshin (FMP) to estimate population densities, produced an estimated leopard density inside the protected area of 0.30 (0.21-0.42, Bca 95% CIs) per 100km², while outside the density seems lower with 0.16 (0.07-0.30, Bca 95% CIs) per 100km².

In 2022, we planned to start deploying a new grid of camera-traps to obtain estimates of the leopard population without the constraint of sampling on roads only. In 2021, the pilot project provided important insight on how to redesign the whole camera-trap survey. Moreover, Botswana DWNP in collaboration with the University of Texas A&M decided to implement a national survey to establish leopard numbers across the country. This decision was part of the new Leopard Management Plan created by DWNP and to which LEC and the other BCF members contributed. The national survey

promoted by DWNP is based on camera-trap surveys designed following the Spatially Explicit Capture – Recapture (SECR) analytical framework. As LEC, it was decided to design the most effective camera-trap survey to study leopards in Khutse GR, but also being able to have comparable datasets to the data collected across the country. In collaboration with Prof Chris Sutherland, CREEM – University of St.Andrews, a new SECR camera-trap survey was designed and will be implemented in May 2023.

In 2022, we were able to monitor the movement patterns and hunting behaviour of four leopards through the use of GPS collars. Three of the animals were females translocated into the reserve as problem animals. The fourth one is an adult male resident.

Rena

Rena (PF023) is an adult female translocated from Tuli block (Dovedale Game Ranch) in August 2021. She was collared and released at Molose area and after about a month moved south and left the protected area. She has since established her home range in the area between Salajwe and Takatokwane which is a densely vegetated livestock farming area. Despite the high presence of livestock in her home range, in 2022 we have observed that her predation is mainly on natural prey and on one occasion a juvenile goat. She mainly hunts small game such as steenboks, duikers and juvenile ostriches. Even if we have attempted direct sightings almost every week, no direct sightings were possible due to the very dense vegetation and her shy behaviour. Furthermore, it was decided to not push for direct sighting which may result in scaring her away from her established territory. She has settled well in a cattle post area and the herders have never reported losses due to leopards, this is a fragile balance which we do not want to impact.

Feeli

Feeli (PF024) was an adult female, translocated from Moroekwe farm in Otse in September 2021 and released in the CKGR at Kukamma waterhole. About two weeks after her release, she moved south and out of the reserve and established her new home range in a rocky ridge south of the Ditshegwane village which is 18km west of Letlhakeng village. Our predation investigations indicate that she mainly preyed upon small game (duikers and steenboks) and only on two occasions on goats. Feeli gave birth to two cubs in April 2022. Unfortunately, she was snared and killed by herders in June 2022. The herders reported that she was raiding their livestock. Efforts to locate the cubs which were about eight weeks old at the time were futile. They are suspected to have died as they were still too young to be independent from maternal care.

PF026

PF026, a sub adult female with an estimated mass of 20 – 25kg was cage trapped and collared in Moroekwe farm (Otse) in October 2022 as a problem animal. She was released in the CKGR at Mahurushele Pan. After her release she moved about a kilometer west of Mahurushele, where she found a hole that she used for about one week until she was found dead. Her body was retrieved and a necropsy performed. The probable cause of death is a lung aneurism caused by translocation stress.

PM034

PM034 is the resident adult male leopard that was captured and collared on the 7th December 2022. He is quite a big male for his estimated age (4–5 years) in the Kalahari area weighing more than 45 kg and we foresee he will get bigger in the coming years looking at his body structure. His GPS fixes show extensive use of the area around Mahurushele and Khankhe pans. It's evident the completely different movement pattern after collaring of a resident male comparing to a translocated animal (Fig. 5.3). Translocated leopards need to establish territories between existing territories of resident males. From the initial data collected between December 2022 and January 2023, he has been predating on small game such as juvenile ostriches and juvenile antelopes.

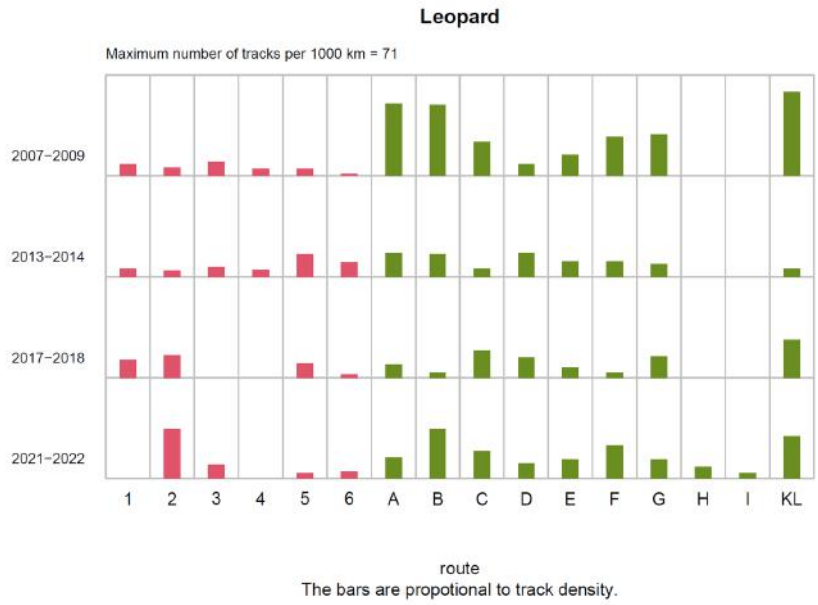


Figure 5.1 Leopard track density according to sampled routes across the last 4 extensive spoor surveys. In red, the roads outside the protected area; in green, the routes inside the protected area. Routes H and I were not sampled before 2021. The bars are proportional to track density.

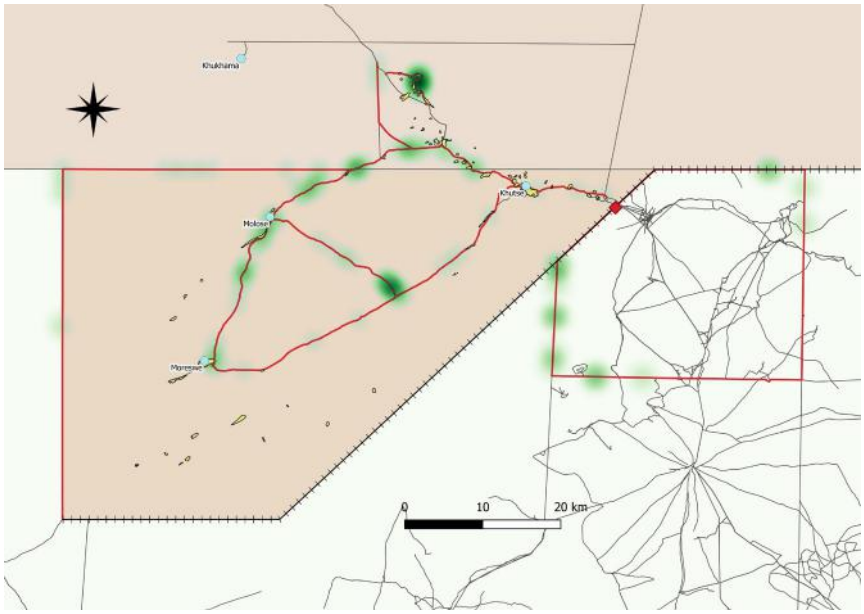


Figure 5.2. Leopard spoor distribution during extensive spoor survey (October 2021–October 2022). The intensity of the green buffer represents the number of leopard track sets recorded at that point.

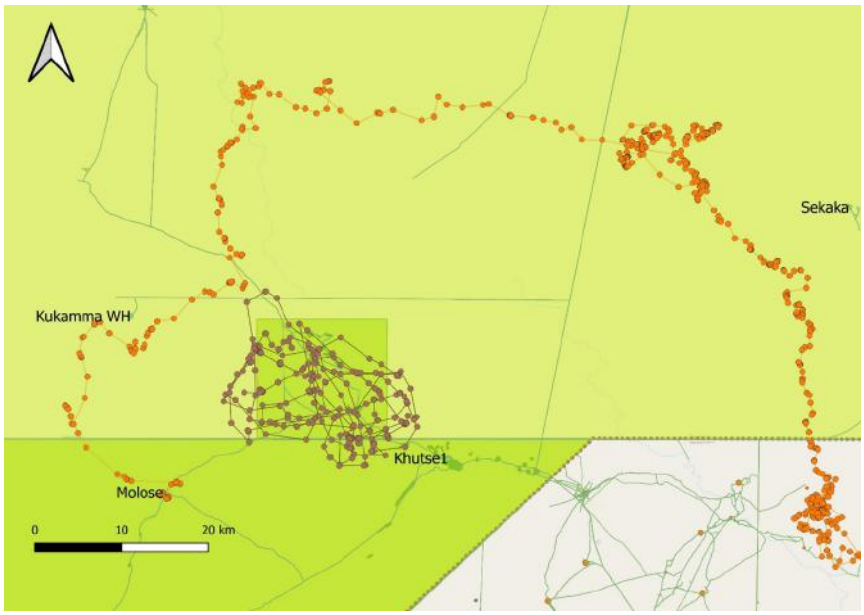


Figure 5.3. Movement patterns after collaring of two male leopards. PM034 is a resident leopard collared on the cutline between Khutse GR and CKGR (brown dots). Lucky (PM032) was a translocated leopard released at Molose waterhole (orange dots).

Project 5.
Predator Demographics - Lions

Lions in the Kalahari ecosystem have one of the largest home-ranges for the species. This is mainly due to low density prey population which characterizes LEC study area and, therefore, lions need to cover long distances and change their core area of activity according to where the prey shift across seasons. Overall, the lion population in the Khutse GR is small in size and any fluctuation in the number of lions may seriously impact the long-term survival of the species in the area. A rigorous and continuous monitoring study of the population structure and its demographic trends is essential to quickly determine any changes on the lion status in this area. In its long-term research approach, LEC has monitored the lion population through the combination of extensive spoor surveys and frequent direct observations of the study prides.

The extensive spoor survey completed in October 2022, has confirmed the overall density of lion spoors is in line with what was observed in the last two surveys in 2013–2014 and 2017–2018 (Table5.1, Fig. 5.1). The lion population results are quite small in size but stabilized since the erection of the fence along the eastern and southern border of Khutse and CKGR, completed 2010. The fence certainly had an effect on the lion population in the unprotected areas. The spoor density dropped from 40 (2007–2009) to less than three per 1000 km. Only a few single lions now cross into the grazing land through gaps in the fence and remain close to the fence to feed on livestock before returning to the Khutse GR, as confirmed by the data from collared lions. Such low spoor density for lions outside the protected area across almost 10 years (2013–2022) is the empirical proof that there are no more resident lions in the grazing land areas. The lion spoors were evenly distributed along the roads inside the protected area with a slight concentration close to waterholes and road junctions, while the few tracks detected outside were along the fence in proximity of large gaps in the fence (Fig.5.2) The absence of resident lions outside the fenced areas represents not only a reduction in the geographic range for the species, but it has several implications in the human-wildlife conflict situation. For example, this reduction of lion spoors has been accompanied by a substantial increase in the abundance of meso-carnivores, specifically black-backed jackals, in the communal grazing land (increased by 70% in the eight years between the 2013–2014 and the 2021–2022 survey). Species like jackals are deemed responsible for most of the attacks on smaller livestock, creating an overall impact much bigger than large carnivores.

Direct observations through LEC resighting protocols allows us to understand the social dynamics within and between the study prides. We can monitor the association as well as when individuals mate or give birth to new litters and, by consequence, having a better understanding of offspring survival rates and recruitments. As mentioned above, lion densities are extremely low and with the poor system of roads in our study area, it becomes fundamental to use GPS collars to optimize the possibility to collect enough observations to study the lions in Khutse GR.

In 2022, we managed to keep a stable number of collared individuals achieving a good coverage of the prides moving in the study area. As in the past years, we aimed to collar at least one female in each pride group, one

male from each coalition, and one individual from each dispersing group. In 2022, we also managed to collar Nina and one of her adult male cubs to study when and how the male cubs would split from the mother without relying only on direct resighting observations. Simultaneously, that allowed us to test other brands of collars, without the risk of losing track of one of the most interesting lion groups in our area. In general, collars allowed us to continue to monitor the uncollared animals as well. Thanks to the fact that lions are social animals, by visiting collared individuals we are also able to observe the other members of the group they associate with. For example, by targeting Sarah's collar fixes, we could observe that a new male (Xlara) has been establishing his territory in Khutse GR mating with Poona and Sarah. We could also detect where Poona gave birth to her first litter three months later. By collaring Desi for the first time, we could also discover that she and her sister LF047 had a litter of five cubs born in 2021 and we could start following the whole group recording very interesting movements of members between the litter of Alice and Alexa and the litter of Desi and LF047. To be able to fully describe the group dynamics and which individuals are changing coalitions or areas of activity, our team maintains very detailed ID kits of all individuals to be sure the observed individuals are all fully identified. This is crucial especially for cubs and subadults which change rapidly between resighting observations. Luckily, the whisker spot patterns are unique to each individual and they are the same across the entire life of the lion.

In 2022, we experienced a lower failure rate of the collars comparing to the recent years. Nevertheless, even one single collar failing or stopping to communicate via satellite has major impact on our possibility to constantly monitor the study individual. LEC has extremely rigorous and strict technical and ethical collaring protocols and the health of the animal is our priority. So, when a collar fails it might take several months before the same individual is eligible for a new sedation and it can be found in the study area.

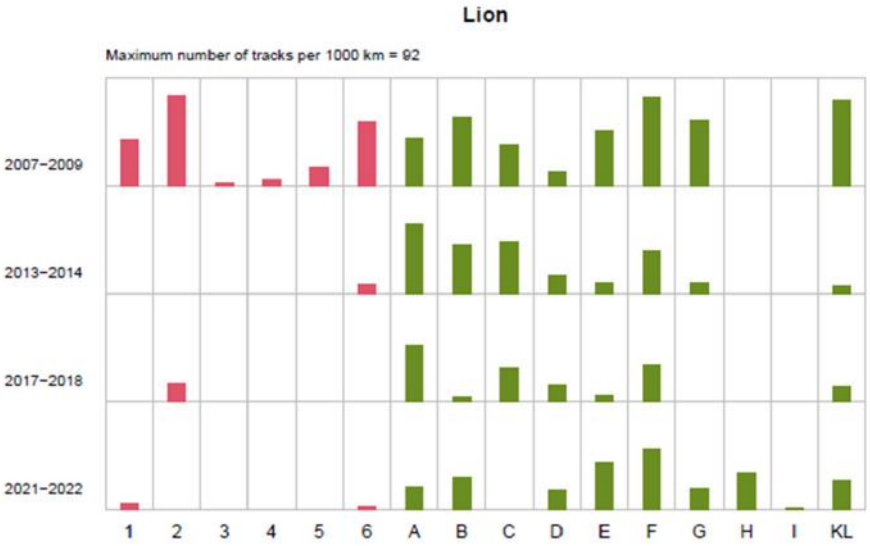


Figure 5.1. Spoor density for lions (spoor count per 1000 km) presented in a graph. It is evident the disappearance of lions outside the protected areas after the completion of the fence in 2010. Routes H and I were not sampled before 2021.

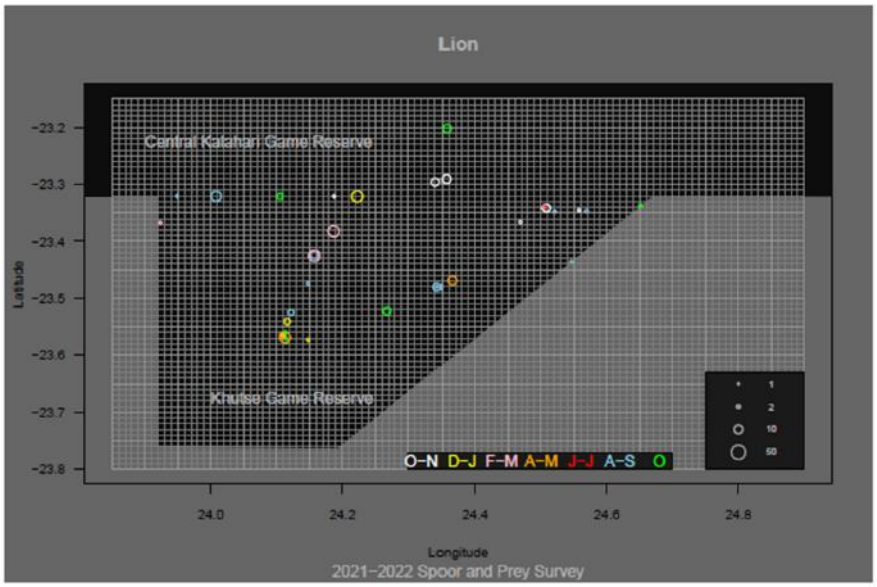


Figure 5.2. Distribution of recorded tracks in the study area.

Meet the class of 2022

East Khutse Pride

The East Khutse Pride originally comprised of five related adult females, four of which are sisters from the same litter and their cubs. The pride was born into the Molose pride around 2007 (Verity) and 2010 (Notch, Nina, Peggy and Sarah). The group however dispersed east and left their natal pride when they were subadults and has been resident in the eastern part of Khutse since around 2012. Notch was last sighted in October 2021.

Peggy was destroyed as a problem animal and two of her cubs were translocated and released in the CKGR at Sunday Pan at the end of 2021. One cub died and the other one LF070 was monitored remotely via a GPS satellite collar. After her release, she moved east and left the protected area into one of the Hainaveld farms (North East district) around April 2022 where she was darted and translocated to Moremi GR. She was later euthanized by the DWNP after she was found in a bad condition. The remaining cub LF069 Poona has since successfully joined Sarah and Verity.

Verity's body condition was observed to be deteriorating from mid-year due to potential kidney failure and old age (15 years). Several resighting observations of her without the other members of the pride were made in October around Khutse 1 waterhole. Even though she was in a bad health condition, she managed to successfully defend herself from attacks from a pack of 15 wild dogs that stayed around the waterhole for close to a month. She was last sighted at the end of October and it is suspected that she is dead.

Sarah and Poona have often been seen together moving across their usual range in the reserve but from around September they started to spend more time along and outside the boundary fence probably attracted by the easy preying opportunities of livestock roaming along the fence. Poona was sighted with her four cubs for the first time in early November north east of the Mahurushele pan area and the cubs were last sighted at the end of the same month. Xlara, the new resident male collared at the end of July 2022 has been sighted with the duo on several occasions. From September, the three lions have been using the numerous gaps in the fence to exit the protected area and kill livestock, mainly donkeys in close proximity to the reserve.

Nina and her three-sub adult male cubs (Athos, Aramis, Portos) have spent more time further north in the CKGR in the last three years, reaching the settlements of Gope, Mothomelo and Metsiamanong. A collar on one of Nina's cubs Athos was deployed to enable monitoring when the cubs will disperse from their mother. During 2022 the group has moved constantly together (except when Portos was not sighted with the group during October), covering long distances and making successful hunts.

Xlara

Xlara (LM103) is a resident male lion collared in July. He has been observed moving with the East Khutse pride females (Sarah and Poona) and mating with them. Therefore, Poona's four cubs are suspected to have been sired by Xlara. He moves in the area between Khutse 1 pan and the reserve entrance gate. He also occasionally moves north into the CKGR, east of Khankhe. There are records of him being moving outside the protected area and being part of the livestock kills in the grazing area adjacent to the reserve.

Kukama Dispersal group

The Kukama dispersal group comprised of two young males (Spiderman & John) and a young female (Levia). They are estimated to be born in 2017/2018 and likely to be related. Their group composition and age estimates indicate that it is a group of subadults dispersing from their natal pride. Spiderman was collared at the end of 2020 to monitor the activities and movement patterns of the group. He was observed to be moving in the area between Gope and Kukama until his collar stopped working at the beginning of January 2022. Efforts to date to try and locate the group for possible recollaring have all failed.

Molose Pride

Once known as the largest pride in the Khutse GR, the group has since collapsed due to younger cohorts' dispersal and natural death of some adult members of the group. The increased presence of elephants in the Molose area and mainly at the waterhole for the last eight years or so has greatly impacted on the pan, the water availability and the plant/animal community dynamics in the area. Despite these challenges, Alice and Alexa continue to raise their now two-year-old six (5 males and 1 female) cubs successfully. The group moved outside the reserve (KW2 WMA) some time at the end of the first quarter of the year for less than a month and moved back in. They have exclusively used the protected area in the area between the Molose and Kukamma waterhole. Desi (LF041; collared on the 14th May 2022), LF047 and their five cubs have been active between the Molose, Moreswe and the western boundary area. Interestingly, two male subadult cubs from the Alice/Alexa group joined the Desi/LF047 group since early November this year. Four unidentified adult females were seen in the Molose – Moreswe area on different occasions. One was seen once with Rocket and Snooks.

Rocket and Snooks

Rocket and Snooks, have been the prime resident males of the Khutse GR in the last years. They are estimated to be nine years old and are probably brothers. Rocket was recollared at the end of October after his initial collar stopped working in April 2022. During 2022, their movements covered most of our study area and they were seen together all the time. The southern part of the reserve as well as the Moreswe pan form part of their core activity area. They would occasionally move closer to the eastern boundary of the reserve to exit and raid livestock on the adjacent livestock areas. At the end of March this year, Rocket was observed following and presumably mating with Sarah. Compared to the last years, it seems the lions prefer to move far away from the water points and only make very short visits to drink. The increased presence of the elephants could be the reason for this observation.

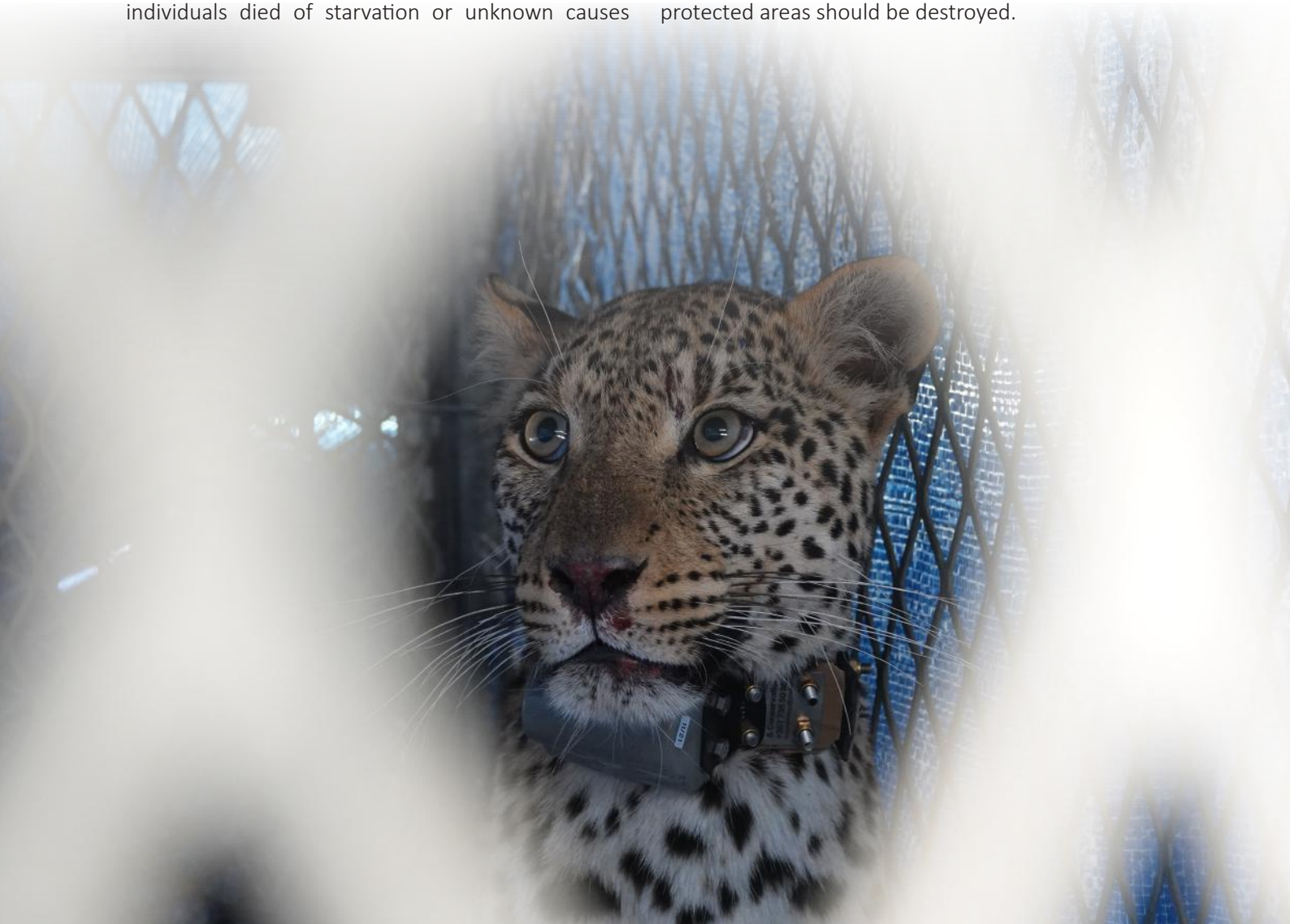
Project 6.
Human-Predator Conflict

Our research projects all have the common aim to provide the needed knowledge to find the right strategy to fulfill LEC vision of a long-term and sustainable coexistence of large carnivores and people in the Kalahari. It's therefore not a surprise that elements which fall within this section have already been presented in the previous pages. The study of post-release movement patterns in translocated leopards was partially presented in "Project 4: Predator Movement and Habitat Selection", while the results of the extended cattle post survey on carnivore perception from herders are shown in the "Project in Focus".

Both studies have major implications in designing future conservation activities in the Kalahari. Vera Alessandrello's thesis results showed that none of the monitored translocated leopards managed to settle within the protected area where they were released, suggesting that the current resident population is probably at carrying capacity. Furthermore, our data highlighted the limited success rate of such translocations. Out of 13 leopards monitored, four individuals died of starvation or unknown causes within 40 days from release, four individuals were shot as a result of human carnivore conflict, two leopard have survived. For the remaining three individuals the fate is unknown as the collar stopped working after less than 220 days from release.

Two of the individuals (Tsholofelo and Feeli) who were shot, were females who managed to successfully settle outside the protected area and reproduce giving birth to a litter. Unluckily, the cubs of both litters were too young when the mothers were destroyed at their first livestock kill in the new area. These events are proof that even when the environmental conditions outside a protected area are suitable for a translocated leopard to settle and produce offspring, the lack of tolerance is still resulting in a fatal ending.

This is in line with what the extensive cattle post survey has highlighted concerning the perception of carnivores. Most of the interviewees recognize that leopards and lions deserve protection but within the borders of the protected areas. The general opinion is that both leopards and lions which leave such protected areas should be destroyed.

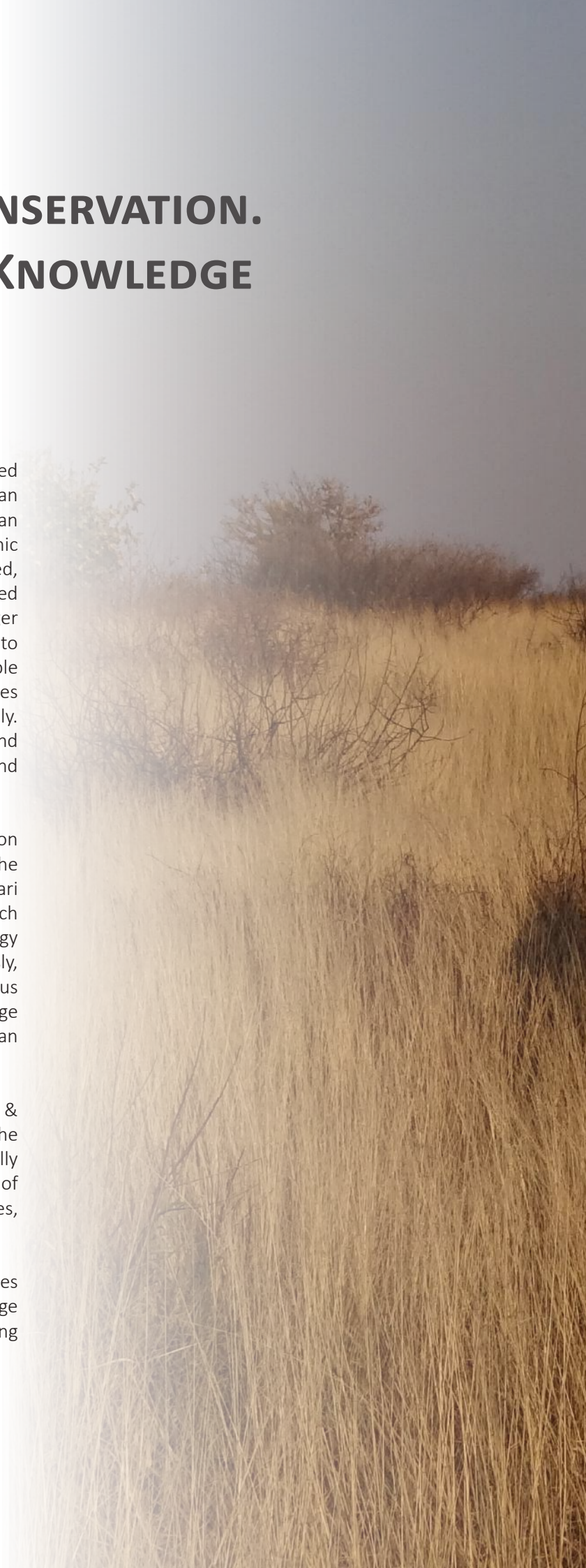


As LEC, we discourage the use of translocations of large carnivores as a tool to mitigate the human carnivore conflict in Botswana. Translocations of leopards might have positive outcome in very specific situations, such as the restoration of new protected areas where the leopard population was partially or totally eradicated, and with detailed protocols to assess the feasibility and to grant the monitoring of such translocations.

LEC believes that a sustainable coexistence of large carnivores and human activities is achievable through education and support of wildlife-friendly economic activities. The need for such education programmes aimed to mitigate the conflict is urgent as the encroachment of human activities in formerly wild areas is growing across the whole of Botswana.

Project in Focus.

Knowlege for Conservation. Conservation of Knowledge



After two years, where the pandemic has slowed down the rapid development of most African countries, 2022 has been characterized by an impressive return of fast and uncontrolled economic development. Once the emergency status was lifted, many developing countries had to face impoverished economies extremely dependent on other larger economies. Such a situation has pushed countries to partially forget important aspects for a sustainable development and the pressure on natural resources and consumption of land have grown exponentially. It is, therefore, crucial for conservationists and researchers to continuously investigate the social and economic changes in their study area.

Since its creation, LEC, being a research organization devoted to conservation, has been monitoring the different components of the southern Kalahari ecosystem, including the human component. Such knowledge is key to the implementation of any strategy based on human-wildlife coexistence. Simultaneously, we recognize that the local communities and previous research represent an immense source of knowledge which needs to be conserved and shared to avoid an irreparable loss.

In 2022, the Research and the Community & Education team have put the “knowledge” at the centre of their activities to provide scientifically informed suggestions for the long-term survival of the Kalahari, where we consider human activities, wildlife and habitat as one single community.

In the following section, we present two examples of our efforts to obtain fundamental new knowledge for conservation and to valorise and transmit existing knowledge within and outside the Kalahari.

“Tracking is an unspoken language and exciting science, learning it from the local trackers is like studying physics with Einstein.

ALESSANDRO ARALDI, Field Research Coordinator

“I love to work with trackers. I’m fascinated about their indigenous knowledge and how they transmit such rare skills through the school of life.

TREVOR BALONE, Research Assistant

Extensive Cattle Post Survey

At the end of 2021, the C&E team carried out an extensive cattle post survey to better understand the status, the practices and the carnivore perception in cattle posts in the south and south-east border of the Khutse GR. In 2022, the data was analysed by the Research team in collaboration with Prof. Zucchini and provided some insightful information.

The team has interviewed 193 herders from 57 cattle posts (Fig.P1). The average age of interviewed herders is 35 years and more than 54% of them had spent less than five years in the area, confirming the high turnover of herders. Moreover, the number of different owners using the same cattle post may vary enormously from one single owner up to 14 owners on average, with few cattle posts grouping 20–25 small owners at the same borehole.

The total number of cattle declared by herders is 21'280 individuals, while goats are 5'172 and sheep 1'759, confirming that cattle is the main livestock in the area, but goats are growing in numbers comparing to a few years ago.

But the most interesting results for conservation were the ones linked to the perception of the herders about the challenges in farming livestock in the area. More than 50% of the respondents considered predators as the main challenge and diseases as the second most relevant factor. Poor access to water and good quality grazing areas were marginal issues for the interviewees, even if they are both very limiting factors in the area. When asked about the causes of livestock losses (Table P1), the number of adult cattle lost to disease was much larger than the number lost to predators. While for all smaller livestock or calves, the number lost to predation was substantially larger than the number lost to disease.

The perception of predators and the related tolerance to them is a key aspect of our work with the community. In such perspective, it's important to understand how much the farmers know carnivores. Most of the farmers will probably never see any of the large carnivore directly, and most of the time the only evidence to identify the predator who killed livestock is their tracks on the ground. Unluckily except for Mosarwa herders, most of the interviewee were struggling in correctly assigning the carnivore to the shown track, especially for wild dogs, jackals and cheetahs. Obviously wrong identification of the predator causing livestock losses, might highly impact the tolerance towards that specific species. For examples, leopards are considered a major problem species for livestock in our areas, but the investigated livestock losses inside LEC study area tell us that they

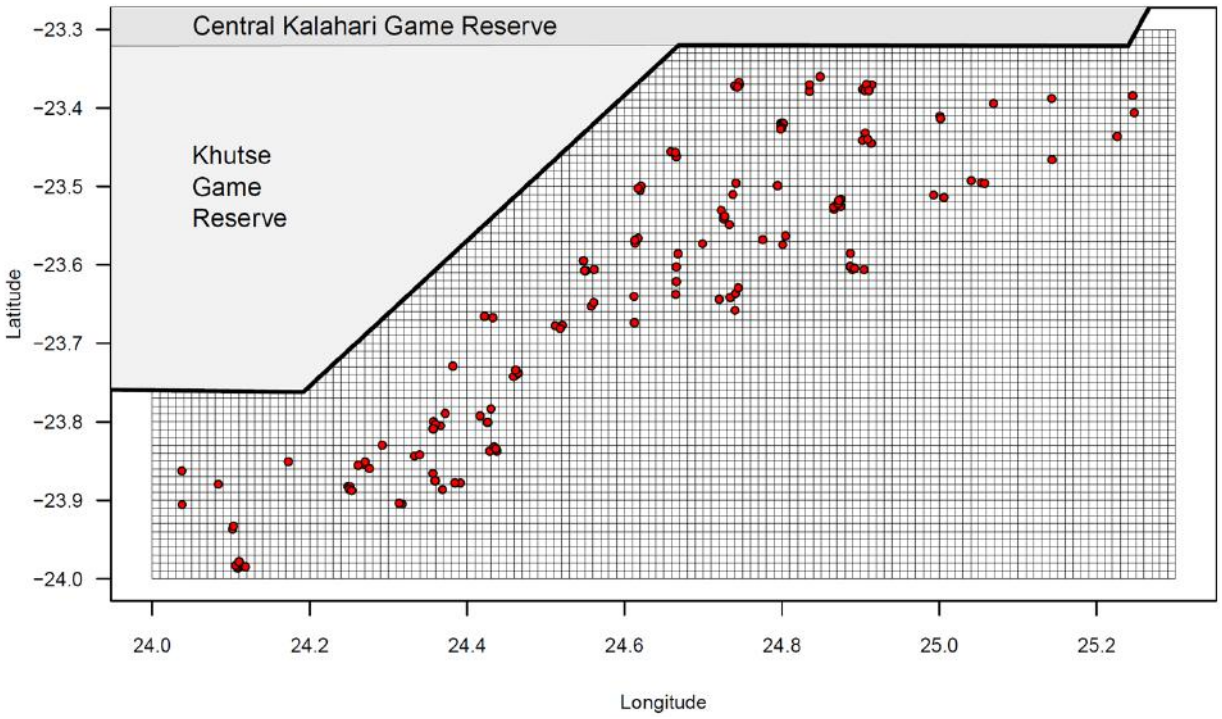


Figure P1. Cattle posts surveyed during extensive survey.

are far from being responsible for most of the losses.

When we investigated tolerance towards predators, most of the respondents stated that they would like the number of predators in the area to be decreased or decreased a lot (Table P2), even if they agree or strongly agree that lions and leopards benefit people by attracting tourists, and that lions and leopards deserve protection. If we look at the distribution of who agrees that lions deserve protection (Fig.P3), we can observe that the more the cattle post is far to the reserve the more the herders agree lions deserve protection. If we combine these results with the fact that more than half of the respondents are of the opinion that if a lion or a leopard leaves the protected areas, then it should be killed, we can state that we observe a so-called NIMBY (not in my backyard) syndrome. This is a dangerous trend as it is in opposition with coexistence conservation strategies.

We, also, observed that respondents who work further away from the Park and have less probability to encounter lions and leopards are more worried about lions and leopards attacking people than are respondents who work closer to the Park (Fig.P3–5). This highlights how lack of experience and knowledge may feed in unrealistic fears, such the risk of being attacked by wild carnivores.

Finally, it is important to note that only 91 of 191 respondents were aware of DWNP's Problem Animal Control services and they were focused in the area where LEC works and along park boundaries.

This information has been key in redesigning our cattle post education programme. It's evident that there is a need for a strong campaign to increase awareness on the ecological role of predators in any ecosystem. It is also essential to address how to continue farming livestock in a sustainable way redirecting the attention towards protecting young cattle and small livestock from predators and strengthening good health practices for adult cattle. It's also fundamental to train herders in identifying correctly the eventual problem animals to better respond to such challenges and to avoid useless retaliatory killing on other carnivores living in the area. Herders are the key stakeholders in building a future for large carnivores in the Kalahari, which is achievable only through coexistence. The high turnover of herders highly impacts the success probability of any conservation strategy in the area, this is why LEC aim to develop skilled herders who should be fairly compensated for their work.

Livestock loss	due to disease			due to predation		
	G5	G1	G0	G5	G1	G0
Cattle	440	231	61	260	99	24
Cattle calves	41	24	15	137	27	7
Small stock	185	95	14	472	118	59
Small stock calves	110	9	12	342	32	41
Donkeys	1	0	0	1	3	0
Donkey foals	8	0	0	14	4	0
Horses	20	3	0	19	0	1
Horse foals	1	1	0	41	23	2

Table P1. Reported livestock losses due to disease and to predators. Respondents were partitioned into three groups depending on the length of time they worked at their present cattle post: G5 at least five years (81 persons), G1 at least one year but less than five years (59 persons), G0 less than one year (53 persons).

	Lions	Leopards	Hyenas	Cheetahs	Wild dogs
Decreased a lot	76	78	77	70	83
Decreased	13	13	12	12	10
Stayed the same	6	5	7	7	3
Increased	2	1	2	1	1
Increased a lot	0	0	0	0	1
Don't know	3	2	3	10	2
Preferred not to answer	1	0	0	0	1

Table P2. What would you like to see happen to the respective carniovre numbers in this area? (Given as rounded percentages)

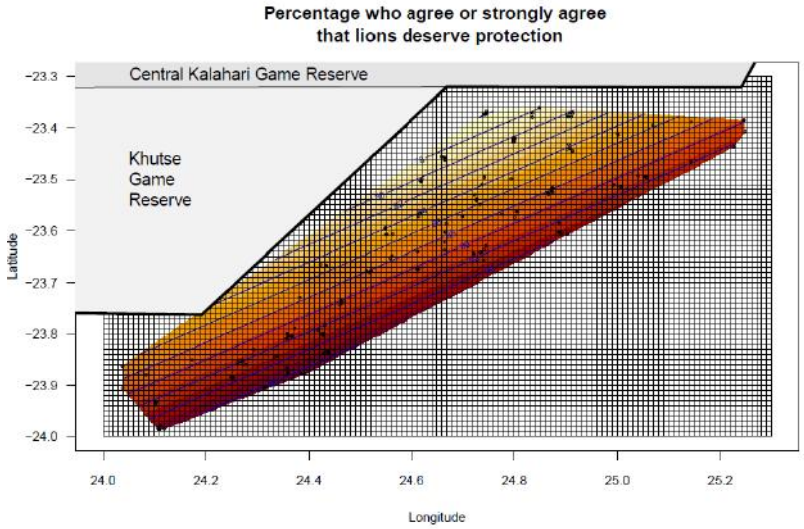


Figure P3. Distribution of respondents agreeing lions deserve protection. (red: more protection deserved)

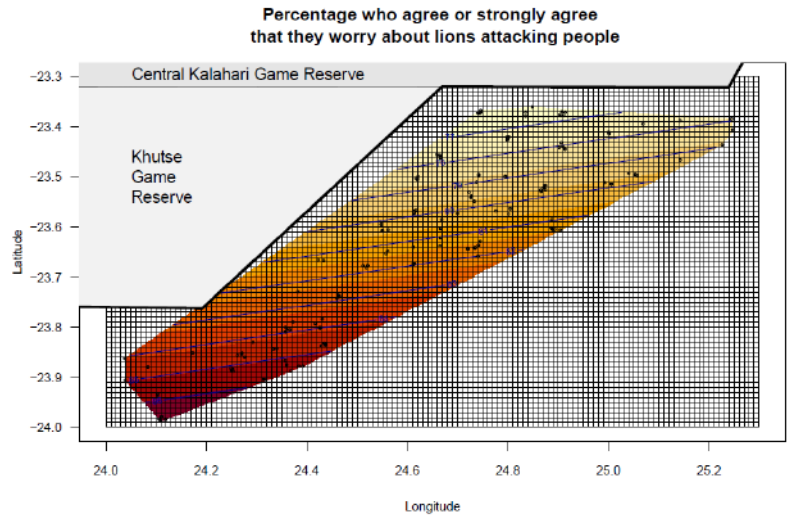


Figure P4. Distribution of respondents fearing of being attacked by lions. (red: higher fear)

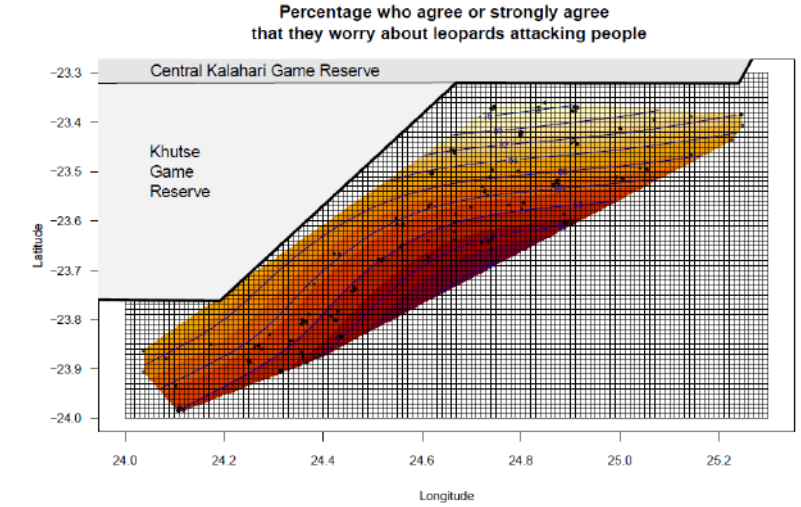


Figure P5. Distribution of respondents fearing of being attacked by leopards. (red: higher fear)

Tracker Workshop and CyberTracker Certification

As stated in many of our reports, LEC has the overall vision of contributing to the conservation of the Kalahari ecosystem. By Kalahari ecosystem we refer to all its components including the human community who has been living and thriving in this unique landscape since the beginning of *Homo sapiens* appearance. The knowledge developed in this area across centuries combined with the newest scientific findings is the key for the success of our mission. Unluckily, such knowledge is still only partially recorded and too often not passed across generations. LEC has the objective to bring together the existing knowledge and to support activities which can reinvent ancestral skills to make them useful for the current needs.

One of such ancestral skills is the art of tracking. In 2022, we wanted to do a next step in our long-term effort to valorise our trackers and their knowledge. So together with Dr Derek Keeping and Marie-Charlotte Gielen, LEC has hosted a tracking workshop in Khutse GR with CyberTracker founder Louis Liebenberg and senior assessor Adriaan Louw. For the first time, the workshop gathered in the same place 25 Basarwa trackers from seven different villages covering most of the southern Kalahari tracking community. Two Indigenous Master Trackers (Quashe Xhukwe and Nxjouklau Kashe) honoured us with their presence and together with CyberTracker assessors, they assessed and led the workshop. During five days, the trackers were tested for trailing and for track and signs identification, but most importantly the trackers could exchange their knowledge and finally see that they are part of a very special community who has the responsibility to keep these skills alive as well as LEC and other researchers have the responsibility to create opportunities and tools fitting the modern needs. Louis Liebenberg has shared his experience in documenting the culture of San communities in southern Africa and taught us how to discover the real “diamonds” of the Kalahari, elders who can open new horizons on a better understanding of how people have lived and can live in harmony in this landscape. LEC aims to keep fostering the transmission of such knowledge to the new Kalahari generations. In 2023, LEC will organize a new tracker workshop involving trackers from other villages and the long-term goal is to establish an Indigenous Tracking School and to introduce tracking in the local primary school with the CyberTracker Junior Certification. This is how we intend to build on our conservation of knowledge. (https://cybertracker.org/)

Community & Education Programme

With the Community & Education Programme, LEC endeavours to support the community in developing a system that allows them to coexist with wildlife and live sustainably. Central to this are two key areas of work: fostering an interest and passion for wildlife and conservation and minimising the conflict between farmers and carnivores. One highly appreciated aspect of this work is the level of trust and collaboration we have cultivated between LEC and the local farmers.

Over the past 20 years, we have learned that by integrating research and education we can more effectively reduce or mitigate human-wildlife conflicts in our study area. And by working hand-in-hand with the community, we are able to facilitate an effective and open interaction with the people living alongside the carnivores.

Objectives for the period 2020–2025

- Work together with the Research Programme to use the research findings to better inform our conservation and education activities.
- Undertake research to better understand the nature of the conflict between livestock farmers and predators and evaluate practical measures to minimise this conflict.
- Empower farmers and herders, through education and capacity building, so they become knowledgeable and effective managers of livestock and rangelands, to facilitate coexistence.
- Provide disease prevention and livestock management training opportunities, to building positive relationships with farmers and encourage effective and environmentally-friendly livestock production.
- Continue to support the people of Kaudwane via capacity development projects that encourage active community participation in conservation activities and the sustainable use of natural resources.

Working closely with the research department, our team strives to translate research findings into practical methods to combat the human wildlife conflict issue in our study area with our education programme designed to instruct rural farmers and herders in the concepts and techniques underlying the management of rangeland, livestock, disease and wildlife with an emphasis on the sustainable use of the resources.

Besides our work with farmers and herders, we also work with residents of the local village, Kaudwane, on a number of community projects. LEC is particularly proud of the relationship which has developed over the past 20 years with the local community: After many years of working closely with the community, we have become known and respected in the area and we see ourselves as providing the much needed resources to outlying areas.

How Covid impacted the work

After coming out of two years of lockdowns and restrictions put in place by the Botswana government to control the spread of Covid-19, we gained a greater appreciation for time, energy and perspective. We reviewed the C&E projects and conducted thorough assessments of our projects to align them with our strategy and its objectives. This meant that some projects were refocused and adjusted. Overall, 2022 was a year to use the research data to guide us on what tools the community needed to mitigate human wildlife conflict, and the answer was education. And so, 2022 saw us working towards building up the cattle post visits with systematic, regular educational lessons to equip farmers with the tools to better care for their livestock, and the introduction of the CyberTracker app to more accurately collect data.

Education and Capacity Building

At the start of 2022, we welcomed a new member to our team, this renewed energy was pivotal in our team creating the more impactful approach to the cattle post programme. We put a lot of time and energy into developing the educational structure to our cattle post visits so that each interaction with farmers and herders in these outlying areas focused on providing education on farming methods and to encourage cooperation amongst this sparsely populated region. The adapted structure now includes regular, structured lessons on various topics relevant to the herders and farmers - all lesson subjects were gathered from the cattle post survey data findings which was carried out at the end of 2021. At the end of June, we launched the cattle post educational programme with lessons on livestock vaccinations. In addition to that, our team was also trained in using CyberTracker which enables

> For me, 2022 was a success. We set goals and achieved them. We managed to accomplish in time every project we undertook that is Horse Evaluation, Dog Vaccination and Sterilization and Cattle Post Lessons. I think we have a strong foundation to map the way forward from this time onwards

OBAKENG JOHN OBOTSENG, Education Liaison Officer

uniform data collection on e.g. livestock mortality data. A specific database was created with help from the research team to provide the scope for frequent data collection and fast data processing.

Working closely with the Community Conservation Club (CCC) we were able to get the organic garden to a stage where it could run successfully without our supervision. Within the first six months of 2022, water had been connected, daily watering and management was run through the CCC and the garden was producing vegetables for sale. A storm in May wrecked the shade netting, and this was replaced by LEC. As this project was planned to be managed by the community in the long term, we set about putting the structures in place to hand this organic garden back to the community. As the garden was built on land owned by Village Development Committee (VDC), a plan was drawn up where the VDC and CCC would run the garden together. We held a handover ceremony in June which was the official ceremony to give the community ownership of the garden. Unfortunately, after some time, the CCC and VDC were at loggerheads and could not work together, the garden suffered and by the start of summer the garden lay dormant with no vegetables growing. LEC had to once again step in to mediate the situation. Unfortunately, by the end of 2022, things had not turned around and the garden still lay dormant. Despite this setback, we were delighted to see that the project was nevertheless having a strong impact on the community: Through our organic garden project, vegetable gardens were independently created in 13 private backyards. This is because the garden served as a demonstration space for what was possible, and we are proud that community members learned from the garden. For the end of year party for CCC, they requested that we rather use the party money to invest in backyard gardens for each of the members, we happily obliged and look forward to seeing more backyard gardens emerge in the village of Kaudwane.

For the second year running, we continued with the theme of tree planting at the annual World Nature Conservation Day event held on the 28th of July. We invited local stakeholders to share with the community their roles in conservation. LEC distributed 120 trees to the community (115 to individuals and 5 to the school). All trees, current and past, have been entered into our CyberTracker app to keep track of their location and progress.

We continue to support Kaudwane Primary School through the donation of clothes for them to sell and raise money towards the fundraising committee. The funds raised will be used for student benefit projects within the school.

In a bid to expand more learners' horizons, we embarked on taking the entire Standard 7 class of

44 students on a full day trip inside Khutse GR. By partnering with DWNP and SSG, we were able to accommodate all the students and spend a lovely day out in the reserve learning about animals, the history of the parks and people working in and around the park.

Community Support and Development

Leopard Ecology & Conservation collaborated with the Botswana Society for the Prevention of Cruelty to Animals (BSPCA) this year to carry out dog sterilization and vaccination. At the beginning, we encountered some resistance to sterilisation, but we are happy to report that the BSPCA team did a very professional job and we were able to sterilize 30 dogs and one cat, including vaccinations. We feel that the successful healing of the animals that underwent this procedure has ignited an interest in the community and we look forward to a greater participation next year.

In our traditional cattle post educational programme a next phase was launched last June. New educational sessions have been ongoing and we are satisfied that the farmers and herders overall seem to be interested in our lessons and see it as beneficial. The lessons that we were able to carry out in the eight cattle posts we work with were based on the themes: livestock vaccinations, beef measles and internal worms and heart-water diseases. The team has adapted well to the programme and we are now looking into possibilities to help them feel even more comfortable in their deliverance.

To better equip farmers with tools, we have a hoof trimming project where each cattle post has a box of hoof trimming tools that are shared amongst the herders. We offered training at the beginning of the year as a refresher and allocated a responsible person in each cattle post to monitor the tools and their use, our records show that the hoof trimming tools were used 83 times over the year.

We continued with our horse health evaluation training which sees a farrier visit us three times in the year to provide valuable training to horse owners on horse health and care. We held a meeting with the community where we officially handed over the horse race organisation to them, we as LEC will continue to educate farmers on the horse health which can feed into the animals fit for racing, but the organization and preparation of the race is now in the hands of the community.

The pilot beekeeping project came to an end in October 2022, and we were able to get some valuable findings to help with future growth. Through the pilot project, we gained interest from the Molepolole beekeeping office and Food and Agriculture Organization, and they offered some of our community beekeepers further training, they also partnered together with Asa Segootsane (the community lead of the LEC pilot project) and launched a farmer's field school on her farm with the purpose for her to train more community members in beekeeping. During the pilot phase, many resources of the C&E team were tied up by the beekeeping project. In order to maintain the impact of our work at a high level, the project steering committee decided to refocus the beekeeping project. Hence the research department took over the management of the bee project with a greater focus on the research aspect.

“Our team is very passionate about the projects that we run. Being part of the community themselves, there is great pride in fulfilling project goals as they can see the impact directly and see the improvement happening around them in their own community. This provides a great working environment and I am very proud of the growth and leadership that has taken place this year.

FRANCES HANNAH, Field Conservation Coordinator

Interview.

Oagile Keodumetse, Cattle Post Herder

> It is important for the lessons to continue for they empower us to know more about livestock management and the knowledge I gain from these lessons will remain with me forever.
>
> OAGILE KEODUMETSE, Herder

Can you tell us about yourself?
My name is Oagile Keodumetse. I come from Khudumelapye village.

What animals are you keeping in your cattle post?
Cattle.

How long have you been keeping livestock / looking after livestock?
I have been a herder since my youth and I am passionate about looking after livestock. I worked in Kitia, Khango and I have been working in Ditampana since August 2022.

Do you find cattle post lessons useful?
The lessons give an insight into better animal husbandry practices that, if put into practice, can become profitable to a farmer in the long run.

As a farmer or herder how has this cattle post lessons benefited you?
These lessons have upskilled me and given me confidence to discuss with my employers on different issues regarding livestock health and management such as disease symptoms, vaccination and hoof care. Before I attended these lessons, my knowledge was limited in many of these issues and I had a lot of misconceptions on disease diagnosis.

Interview conducted by Obakeng “John” Obotseng

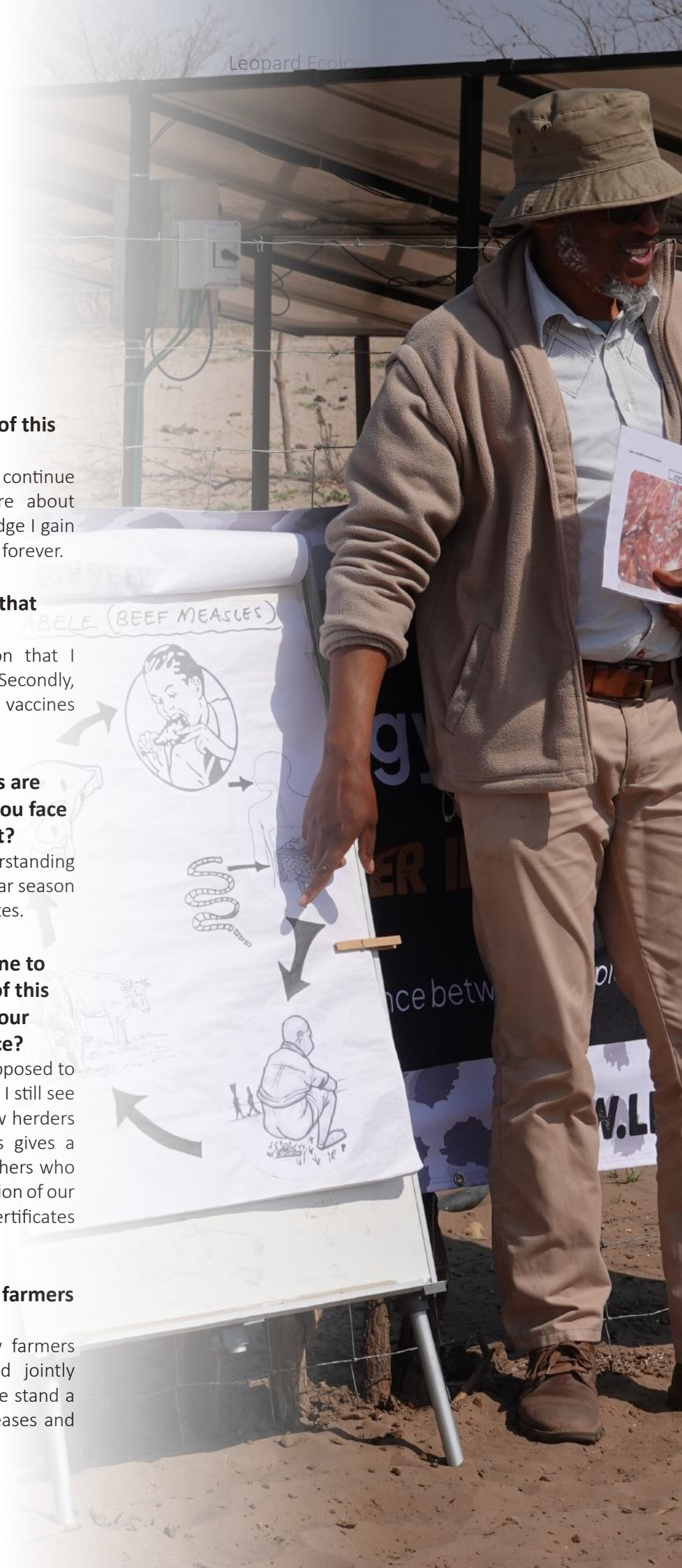
Would you recommend continuity of this cattle post lesson programme?
I think it is important for the lessons to continue for they empower us to know more about livestock management and the knowledge I gain from these lessons will remain with me forever.

What are the two main challenges that you face as a farmer in this area?
The main challenge is tick infestation that I suspect leads to many livestock deaths. Secondly, livestock owners are reluctant to buy vaccines and acaricides and this is frustrating.

Do you think the cattle post lessons are addressing some of the problems you face in your daily livestock management?
Yes. The lessons are helpful in understanding which vaccines to use on which particular season to control seasonal diseases and parasites.

What more do you think can be done to further improve the effectiveness of this cattle post lessons programme in your daily livestock management practice?
The challenge is with those who are supposed to benefit from these educational lessons. I still see a lot of reluctancy in many of my fellow herders in this cattlepost and this sometimes gives a wrong message and can demotivate others who attend, so maybe some form of recognition of our attendance by providing attendance certificates could be a motivation.

What advise do you have for other farmers regarding rearing of livestock?
Lastly, I appeal to herders and fellow farmers in Ditampana to come together and jointly purchase vaccines and drugs so that we stand a better chance of controlling these diseases and parasites.



Appendix I

Table Leopard Telemetry. Animals monitored by LEC during 2022.

ID	name	origin	colar active	notes
PF023	Rena	Translocation	1.1.-31.12.2022	on animal
PF024	Feeli	Translocation	1.1.-21.6.2022	Retrieved after she was killed by herders on the 21/06/2022
PF026		Translocation	7.10.-17.10.2022	Animal died and collar was retrieved on the 17/10/2022
PM034		Resident	7.12.-31.12.2022	on animal

Table Lion Telemetry. Animals monitored by LEC during 2022.

ID	name	group	colar active	notes
LF026	Sarah	East Khutse	1.1.-31.12.2022	on animal
LF027	Nina	East Khutse	1.1.-31.12.2022	on animal
LF041	Desi	Molose	14.5.-31.12.2022	on animal
LF060	Alice	Molose	1.1.-31.12.2022	on animal
LF070	Peggy's cub 3	East Khutse	1.1.-30.4.2022	Collar retrieved on 30/04/2022 after animal was euthenized (Darted and translocated as a livestock raider from OM60 farm in Hainaveld to Moremi GR on 05/04/2022)
LM085	Rocket	Snooks & Rocket	31.10.-31.12.2022	on animal. previous collar stopped communicating on 02/04/2022 and was retrieved on 19/05/2022 by remote drop off triggerd on the 17/05/2022. He was recollared on the 31/10/2022.
LM088	Athos	East Khutse	26.3.-31.12.2022	on animal
LM091	Spiderman	Kukamma DG	1.1.-2.1.2022	collar not working. on animal
LM103	Xlara	East Khutse	28.7.-31.12.2022	on animal

Acknowledgements

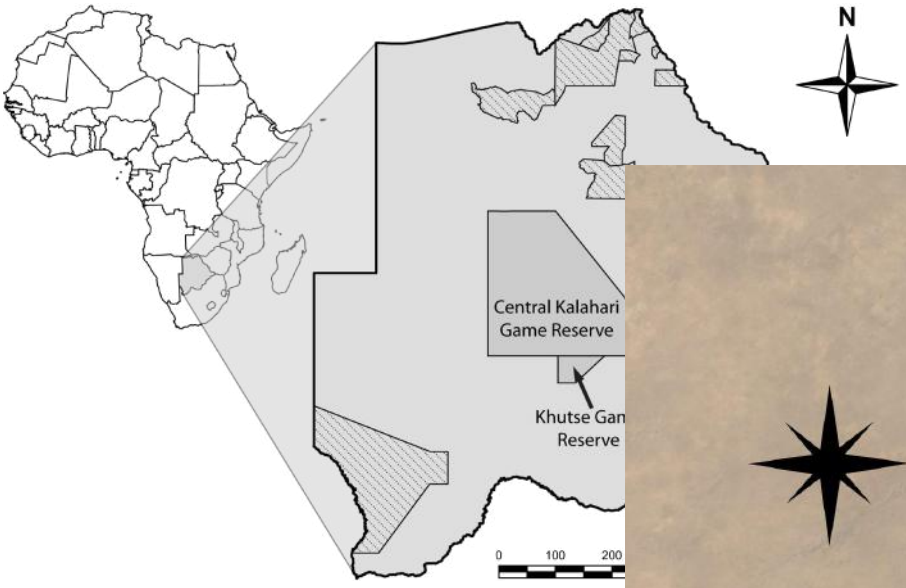
The Government of Botswana, through the Ministry of Environment, Natural Resources Conservation and Tourism and the Department of Wildlife and National Parks, has for over 20 years granted permission to Leopard Ecology & Conservation to undertake research and conservation projects. We appreciate the ongoing support received from all levels of these departments.

We also sincerely thank our sponsors for their commitment to the conservation of leopards and lions in the Kalahari. We wish to express our appreciation to the members of the African Cats & Conservation Foundation, the Leopard Ecology & Conservation Trust, the People and Wildlife Trust and the Act Now for Tomorrow Steering Committee for their ongoing support and guidance. We also value the support provided by the Institute of Evolutionary Biology and Environmental Studies of the University of Zurich.

Finally, our success is a direct result of the dedication shown by all members of the Leopard Ecology & Conservation team, both in Botswana and Switzerland, as well as the numerous individuals associated with this project.

ACACF	African Cats & Conservation Foundation
BSPCA	Botswana Society for the Prevention of Cruelty to Animals
BCF	Botswana Carnivore Forum
CCC	Kaudwane Community Conservation Club
C&E	Community & Education
CKGR	Central Kalahari Game Reserve
CREEM	Centre for Research into Ecological and Environmental Modelling
DWNP	Department of Wildlife and National Parks
FMP	Formozov-Malyshev-Pereleshin
GR	Game Reserve (as in Khutse GR)
KTP	Kgalagadi Transfrontier Park
LEC	Leopard Ecology & Conservation
MPI-AB	Max Planck Institute – Animal Behaviour
NP	National Park
PAC	Problem Animal Control
SECR	Spatially Explicit Capture – Recapture
VDC	Village Development Committee
VIIRS	Visible Infrared Imaging Radiometer Suite
UZH	University of Zurich

Study Area



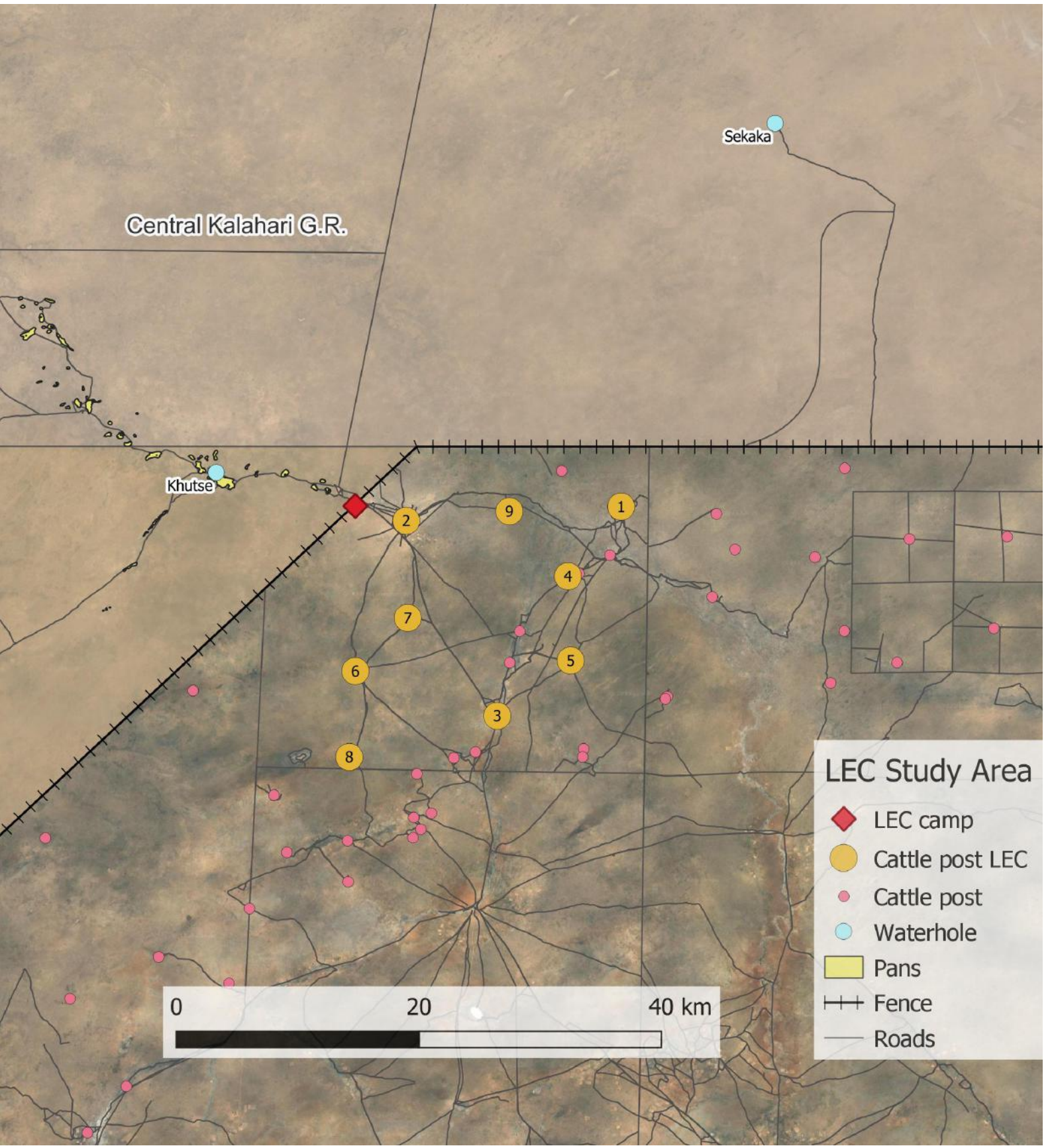
The study area covers Khutse GR (2'600 km²), the southern part of the CKGR (54'000 km²) and an area of communal land.

Climatically the area is semi-arid, with four seasonal variations in temperature and precipitation, primarily characterised by a hot and wet summer and a cool and dry winter.

The predator populations here live at low density, with some of the largest ranges exhibited throughout their global distribution.

Surrounding the reserves is the communal land used by famers for livestock, in some cases directly bordering the reserve. Although there is a fence present at the southeast border, there remains a degree of permeability to predators (Kesch, Bauer and Loveridge, 2013). The two reserves in our study system are contiguous and form part of a single large protected area.

Cattle posts LEC:
1 Ditampana, 2 Kaudwane, 3 Kungwane, 4 Mahuhumo, 5 Makakamare, 6 Mangadiele, 7 Moilwane, 8 Mokujwane, 9 Tshipidi


Sekaka
Central Kalahari G.R.
Khutse
1
2
3
4
5
6
7
8
9
0
20
40 km
LEC Study Area
LEC camp
Cattle post LEC
Cattle post
Waterhole
Pans
Fence
Roads

Collaborations and Students

Prof. Walter Zucchini has assisted LEC research team in the preliminary analysis of the extended cattle post survey as well as in investigating wildlife distribution using the spoor surveys datasets. In his role as an expert statistician, he has guided the MSc student Sebastian Aristizabal (University of Goettingen) in a project on the statistical implications of the FMP formula.

A new collaboration was created with Dr Simon Chamaille from Centre d'Ecologie Fonctionelle & Evolutive (CNRS Montpellier) to deploy state of the art audio loggers on the GPS collars on our study animals. The audio loggers will collect vocalizations of lions and any other sound for 45 days after deployment. Once the collar is retrieved, the data from the audio loggers will be analysed to have further understanding of how lions use vocalizations in our low-density environment and how they acoustically interact between conspecifics.

In 2022, the pilot phase of our collaboration on beekeeping with Fondazione Zoom has been completed. The pilot allowed us to better understand the feasibility of beekeeping in the Kaudwane community. Thanks to the efforts of Zoom and LEC, one beekeeper in Kaudwane was selected by Food and Agriculture Organization as beneficiary of the Farmer Field School programme. Such programme aims to empower local farmers to become teachers in the community and facilitate peer-learning. It was then decided to continue assisting a group of local women to start their apiary and simultaneously shift the focus on the research aspects of the projects. The aim is to better understand how bees are affected and affect the different habitat scenarios in our area (protected area, village, communal grazing land). The research activities will be carried on by a collaboration between LEC, Zoom and the

Botswana University of Agriculture and Natural Resources.

We welcomed our first intern, Mane Jerowe, from Women for Conservation Botwana, an organisation started to empower women in the conservation industry and give them hands on experience in the field. Mane assisted our Community & Education Programme in cattle post visits and putting together learning material for the educational programme.

We partnered with BSPCA in a dog sterilisation project. This was a first time for many dog owners, but a success and a good learning opportunity for them.

We continued with the horse evaluation and farrier Siku worked with us for three training sessions and a prize giving, passing on valuable insight into correct care and health of horses.

We embarked on taking the entire Standard 7 class on a game drive with the help of DWNP and SSG who assisted with vehicles and manpower – this was completed over two days.

As LEC grows, our Khutse camp requires upgrades to keep up with the load. In 2022, we engaged Solar International to install four new solar panels with eight new gel batteries. We also expanded the kitchen floor to cover a larger surface area and invited owners Wouter and Elsabe Mol from Lobatse Canvas to camp to assist in the installation and learn more about our project. We also fitted a new roof onto the ablution block, and setup a staff room tent. All staff brushed up on their first aid skills and techniques when Okavango Air Rescue carried out training. Finally, our IT technical support team (Dr Michel Nakano and Philipp Schiess) could visit the camp to establish the status of our computers and to assess how a local server could be set up in camp to improve data storage and sharing.

In 2023, we aim to increase our collaborations with the local universities. The objective is to soon have local MSc students to join several research projects such as the Daily Travel Distance study (Collaboration with Catholic University of Louvain), the extensive camera-trap survey in Khutse GR, the bee research monitoring project (BUAN – Fondazione Zoom) and many others.

Appendix II

The Leopard Ecology & Conservation Team

- Schiess-Meier Monika, MSc Zoology, founder and managing director, University of Zurich, Switzerland
- Araldi Alessandro, MSc Biology, field research coordinator, Italy
- Alessandrello Vera Lucia, Msc Student and Intern, Switzerland
- Balone Trevor, BSc, research assistant, Botswana
- Dr Finerty Genevieve, head of research, UK
- Gabaatlholwe Laone, external administration assistant, Botswana
- Gabaikanye Tebelelo, research and administration assistant, Botswana
- Gabanapelo Tefo, external community & education advisor, Botswana
- Gabotshwanelwe Sebakeng, housekeeper, Botswana
- Gagosimologe Tshoganetso Ernest, community conservation projects officer, Botswana
- Gana Moisapodi, tracker, Botswana
- Gaseitsiwe Babereki, contracted mechanic, Botswana
- Dr Gusset Nicole, programme management, UZH, Switzerland
- Haas Fabian, MSc, head community and education programme, Switzerland
- Hannah Frances, field conservation coordinator, SA
- Ithuteng Goitseone, camp administrator, Botswana
- Ithuteng Masente, camp maintenance and mechanic assistant, Botswana
- Ithuteng Pogiso Africa, field research assistant and tracking team leader, Botswana
- Jorowe Mane, Intern, Botswana
- Kegakilwe Ditshupo, housekeeping, Botswana
- Kegakilwe Phana Segametsi, BAcc, administration and operations manager, Botswana
- Köpfler Marianne, administration, University of Zurich, Switzerland
- Majafe Kobe, maintenance officer, Botswana
- Mamou Mosepele, tracker, Botswana
- Mokgwathi Kefilwe, BBA, education & community programme assistant, operations assistant, Botswana
- Monnaanoka Supula, tracker, Botswana
- Motlogelwa Binah Kobamelo, Research Officer, Botswana
- Motsididi Komano, community & education assistant, camp administration, Botswana
- Mosikare Neo, cook and housekeeper, Botswana
- Mosweu Kebaabetswe Alfred, BBA, community &

education programme officer, Botswana
- Mpofu Ronald, groundskeeper, Botswana
- Nkadima Phalatsa, senior tracker, Botswana
- Ndove Kevin, external administration assistant, Botwana
- Obotseng Obakeng John, Education Liaision Officer, Botwana
- Otukile Keolebetse, education & community liaison officer, Botswana
- Podidaroma Sokwa, tracker, Botswana
- Schiess Philipp, IT specialist, Zurich, Switzerland
- Seganaphofu Duela, contracted driver, Botswana
- Speedy-Dusty, project dog, Botswana
- Etna, project cat, Botswana
- Tshiama, Mpho, tracker, Botswana
- Tshiama, Meno, tracker, Botswana

The following people / institutions are involved

Research support and collaboration
- Dr Borrego Natalia, Lion Research Center, Universtiy of Minnesota, USA
- Botha Andre, Endangered Wildlife Trust EWT, South Africa
- Dr Dorward Leejiah, University of Bangor, UK
- Louw Adriaan, Cyber Tracker, South Africa
- Prof. Hofmann-Lehmann Regina, Clinical Laboratory, Vetsuisse Faculty, UZH, Switzerland
- Garbeli Jary, molecular genetic analysis, Institute of Evolutionary Biology and Environmental Studies, UZH, Switzerland
- Prof. König Barbara, Department of Evolutionary Biology and Environmental Studies, UZH, Switzerland
- Prof. Manser Marta, Department of Evolutionary Biology and Environmental Studies, UZH, Switzerland
- Max Planck Institute of Animal Behavior, Germany
- Maier Reto, Physik Werkstatt, UZH
- Dr Morris Gerrald, project veterinarian, Botswana
- Dr Neo-Mahupeleng Gosiame, Wildlife Ecology lecturer, Botswana University of Agriculture and Natural Resources, Botswana
- Prof. Ozgul Arpat, Department of Evolutionary Biology and Environmental Studies, UZH, Switzerland
- Snapshot Safari, USA
- Prof. Packer Craig, Lion Research Center, University of Minnesota, USA
- WildCRU, University of Oxford, United Kingdom
- WildTrack, USA
- Prof. Zucchini Walter, Department of Economic Sciences, Georg August University Göttingen, Germany

Support in Botswana (permits, information and logistics)
- Minister of Environment, Natural Resources Conservation and Tourism
- Dr Kabelo Jacob Senyatso, Director, DWNP
- Dr Cyril Taolo, Deputy Director, DWNP
- Mrs Malebogo Somolekae, Head of Research, DWNP
- Dr Michael Flyman, FAO
- Mrs Oganeditse Dintwa, Park Manager, Khutse GR
- Dr Mmadi Reuben, Principal Veterinary officer, DWNP
- Dr Mmolotsi Dikolobe, Veterinary Officer, DWNP
- Special Support Group (SSG), Khutse Base Camp
- Mrs Mercy Munyadzwe, Regional Wildlife Officer Molepolole
- Department of Veterinary Services, Letlhakeng

Professional, logistical and material support
- Aebersold Digitaldruck, Switzerland
- Albrecht Druck, Switzerland
- Fly Away Reiseerlebnisse GmbH, Germany
- Glättli Thomas, Switzerland
- Hilti, Switzerland
- Holzinger Rosmarie, Switzerland
- LC Lenz Caemmerer, Switzerland
- Maier Reto, Universität Zürich, Switzerland
- Nakano Michel, technical support, University of Zurich, Switzerland
- Schiess Fritz, Switzerland
- Schmid Peter & Susanne, Switzerland
- Solar International and Solar West, Botswana
- Toyota Motor Centre, Botswana
- Vernier, Lydie Luxembourg
- Wagner Elicar, Luxembourg
- Wehrli-Oehler Hannelore & Bernhard, Switzerland
- Vectronics Aerospace GmbH, Germany
- Zoom Foundation, Italy

Leopard Ecology & Conservation Trust
- Monika Schiess-Meier (Chair), Switzerland
- Fritz Schiess, Switzerland
- Dieter Gutmann, Germany
- Phana Segametsi Kegakilwe, Botswana

People and Wildlife Trust
- Tefo Gabanapelo (chair), Botswana
- Dr Michael Flyman, Botswana
- Monika Schiess-Meier, Switzerland
- Fabian Haas, Switzerland

African Cats & Conservation Foundation Switzerland
- Eveline Bissegger (chair), Switzerland
- Catherine Oeri, Switzerland
- Willi Schrepfer, Switzerland
- Dieter Gutmann, Germany
- Monika Schiess-Meier, Switzerland

Educational Project (ANFT) Steering Board
- Chief Scientific Officer (ruminants), Department of Animal Production, Botswana
- Chief Wildlife Officer, Community and Extension Services, Department of Wildlife and National Parks, Botswana
- Deputy Director, Department of Veterinary Services (disease control), Botswana
- Chief Forest Resources Officer, Department of Forestry and Range Resources, Botswana
- Kweneng Land Board Secretary, Botswana
- LEC, Education Programme Officer, Botswana
- People and Wildlife Trust
- Farmer representatives (Pako Keokilwe and Boometswe Mokgothu), Botswana
- Edwin Dintle, former Land Registration Officer of Rolong Land Board (now with Botswana Housing Corporation), Botswana

Scientific Publications, Workshops & Media
- V. L. Alessandrello. A Second Chance? Movement Pattern of Resident versus Translocated Leopards (*Panthera pardus*) in Botswana – MSc Thesis University of Zurich
- S. Aristizabal. Variability analysis of animal density estimates in the Khutse Game Reserve region calculated using the Formozov-Malyshev - Pereleshin formula. MSc Statistics Course Paper, University of Goettingen

Collaborating Institutions from Botswana in 2022
- Department of Wildlife and National Parks
- Community of Kaudwane
- Kaudwane Primary School
- University of Agriculture and Natural Resources (BUAN)
- University of Botswana, Botany Department
- Cheetah Conservation Botswana
- Kalahari Research and Conservation
- Botswana Carnivore Forum BCF
- BirdLife Botswana
- Village Extension Team and Village Development Committee (Kaudwane)
- Kuanghoo Community Trust
- Letlhakeng Sub-District Council
- JICA, Botswana and Forestry Department

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- De Zanet Rena, Switzerland
- DeZeew Elisabeth, Switzerland
- Devilliers Lindy, Botswana
- Egger Sandra, Switzerland
- Department of Evolutionary Biology and Environmental Studies, UZH, Switzerland
- Fliedner Monika, Switzerland
- Fischer Annette, Switzerland
- Fraser Jill, Botswana
- Fly Away, Germany
- Furrer Marie-Theres, Switzerland
- FS Communication, Switzerland
- Gantner Fiona, Switzerland
- Getika Foundation, Switzerland
- Hofmann-Lehmann Regina and Michael, Switzerland
- Humbel Juliette und Tonio, Switzerland
- Iff Roland, Switzerland
- Interbit AG, Basel, Switzerland
- Jackson Lalage, Botswana
- König Barbara, Switzerland
- Kupferschmied Basil, Switzerland
- Libert Francoise, France
- Familie Lüthi, Switzerland
- Meister Claudia, Switzerland
- Moser-Meyer Gabriela, Switzerland
- Müller Eiselin Frances, Switzerland
- Rüegg Eveline, Switzerland
- Schäfer André, Swizterland
- Soroptimist International Club Rapperswil, Switzerland
- Staudenmann Martin, Switzerland
- Trüssel Rebekka, Switzerland
- Vernier Lydie, Luxembourg
- Wagner Elicar, Luxembourg
- Wehrli-Oehler Hannelore und Bernhard, Switzerland
- Numerous private and anonymous sponsors

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Find more information about LEC and our initiatives at
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